

## NANOCRYSTALS

Abrosimova, G. E., A. S. Aronin, et al. (2000). "Carrier conduction in a Si-nanocrystal-based single-electron transistor. I. Effect of gate bias." Superlattices and Microstructures **28**(3): 177-87.

We have successfully fabricated a single-electron transistor based on undoped Si nanocrystals having radii of approximately 3 nm. Gate voltage oscillation was observed from low temperature to room temperature and Coulomb diamonds found to decrease in size with increasing gate voltage. The 3D calculation of the energy band structure of the Si nanocrystals and the interactions among the nanocrystals shows the increase of the quantum confinement effect when the dimensionality of the system decreases. At the same time the reduction in the dimensionality causes a decrease in the interaction among nanocrystals in an exponential manner. The carrier transport properties observed experimentally have been well understood in terms of carrier tunneling and Coulomb blockade effects. It is concluded that for the present single-electron transistor, the energy separation of the first excited sublevel and the ground state is rather large so that the Coulomb diamonds observed in the carrier transport characteristics are determined mainly by the Coulomb charging effect. (18 References).

Adachi, D., S. Hasui, et al. (2000). "Very weak temperature quenching in orange luminescence of ZnS:Mn<sup>2+</sup> nanocrystals in polymer." Chemical Physics Letters **324**(4): 249-54.

A polyvinyl alcohol film containing ZnS:Mn<sup>2+</sup> nanocrystals is prepared by a chemical method, and the temperature dependence of the Mn<sup>2+</sup> luminescence intensity is investigated in the 9-305 K range. Under the interband excitation of the ZnS host crystals, the temperature quenching of the Mn<sup>2+</sup> luminescence in the nanocrystals is found to be remarkably weak in comparison with the commercially available bulk powder. Probable causes of this difference are discussed in terms of the thermally induced dissociation of the exciton, the exciton-phonon interaction, and the rate of the energy transfer from the exciton to the Mn<sup>2+</sup> ion. (17 References).

Alivisatos, A. P., K. P. Johnsson, et al. (1996). "Organization of 'nanocrystal molecules' using DNA." Nature **382**(6592): 609-11.

Patterning matter on the nanometre scale is an important objective of current materials chemistry and physics. It is driven by both the need to further miniaturize electronic components and the fact that at the nanometre scale, materials properties are strongly size-dependent and thus can be tuned sensitively. In nanoscale crystals, quantum size effects and the large number of surface atoms influence the, chemical, electronic, magnetic and optical behaviour. 'Top-down' (for example, lithographic) methods for nanoscale manipulation reach only to the upper end of the nanometre regime; but whereas 'bottom-up' wet chemical techniques allow for the preparation of mono-disperse, defect-free crystallites just 1-10 nm in size, ways to control the structure of nanocrystal assemblies are scarce. Here we describe a strategy for the synthesis of 'nanocrystal molecules', in which discrete numbers of gold nanocrystals are organized into spatially defined structures based on Watson-Crick base-pairing interactions. We attach single-stranded DNA oligonucleotides of defined length and sequence to individual nanocrystals, and these assemble into dimers and trimers on addition of a complementary single-stranded DNA template. We anticipate that this approach should allow the construction of more complex two- and three-dimensional assemblies.

Alivisatos, P. (2000). "Semiconductor nanocrystals: from scaling laws to biological applications." Quantum Electronics and Laser Science Conference **40**(IEEE Cat. No.00CH37089): 86.

Summary form only given, as follows. In recent years there have been significant advances in the preparation of semiconductor quantum dots by colloidal chemistry routes. CdSe and InAs are examples of materials which can be made as nanocrystals of high quality. These nanocrystals provide an excellent proving ground for examining size dependent scaling laws, and a few examples are described briefly. We have also found that these nanocrystals can play a useful role as luminescent probes for tagging biological molecules. Finally, efforts to use DNA to create complex spatial arrangements of nanocrystals are described. (0 References).

Alivisatos, A. P. (2000). "Biom mineralization. Naturally aligned nanocrystals [comment]." Science **289**(5480): 736-7.

Amato, G., L. Boarino, et al. (2000). "Observation of quantum-confined luminescence in partially oxidized porous silicon." Philosophical Magazine B Physics of Condensed Matter Structural Electronic Optical and Magnetic Properties **80**(4): 679-89.

The present paper deals with incomplete oxidation of mesoporous Si, in order to produce a nearly compact SiO<sub>2</sub> layer with Si crystals embedded in it. This is achieved by properly selecting the porosity, pores and nanocrystal sizes characterizing the starting layer. After oxidation in an O<sub>2</sub> atmosphere at 1000 degrees C, a well controlled oxide layer is formed. A model was used to predict, starting from transmission electron microscopy observation, the oxide thickness and the sizes of the residual nanocrystals. Intense photoluminescence in the visible region was observed, even in samples with a low starting porosity, and a correlation between the nanocrystal sizes and the emission wavelength is found. (19 References).

Anderson, T. S., R. H. Magruder, III, et al. (2000). "Fabrication of Cu-coated Ag nanocrystals in silica by sequential ion implantation." Nuclear Instruments and Methods in Physics Research Section B Beam Interactions with Materials and Atoms **171**(3): 401-5.

Metal nanocrystal glass composites were fabricated by single and sequential element implantations of Ag/sup +/ and Cu/sup +/ ions into high purity silica. Implantation doses ( $\times 10^{16}$  ions/cm<sup>2</sup>) were 3Ag, 9Cu and 3Ag/9Cu. Composites were analyzed using Rutherford backscattering techniques (RBS), transmission electron microscopy (TEM), energy dispersive spectroscopy (EDS), and optical spectroscopy. An optical density spectrum based on the size distribution observed in the sequentially implanted sample for Cu shell and Ag core nanocrystals has been calculated using the dipole and quadrupole terms in a Mie series summation and is compared with the observed absorption spectrum. Results from TEM and EDS as well as the optical simulations demonstrate that Cu shell and Ag core nanocrystals are formed by the sequential implantation of Ag and Cu. (19 References).

Anselm, L. and G. H. Frischat (2000). "Synthesis and characterization of ternary chalcogenides Ag<sub>8</sub>SnE<sub>6</sub>(E=S,Se)." Journal of Solid State Chemistry **149**(2): 338-40.

Nanocrystalline Ag/sub 8/SnS/sub 6/ and Ag/sub 8/SnSe/sub 6/ were directly synthesized by the reaction of AgNO/sub 3/, SnCl/sub 2/·2H/sub 2/O, and sulfur/selenium in a solvothermal process and 100 degrees C for 10 h, respectively. X-ray powder diffraction patterns, X-ray photoelectron spectra, and transmission electron microscope images show that the products are the Ag/sub 8/SnS/sub 6/ and Ag/sub 8/SnSe/sub 6/ phases which are well crystallized with the average size of about 20 and 25 nm, respectively. The possible mechanism for the formation of the nanocrystals in the solvothermal process was proposed. The solvent ethylenediamine played an important role in the growth of nanocrystals. (21 References).

Artemyev, M. V. and U. Woggon (2000). "Control of Coulomb blockade oscillations in silicon single electron transistors using silicon nanocrystal floating gates." Applied Physics Letters **76**(2): 209-11.

We have fabricated single-electron transistors (SETs) with Si nanocrystal floating gates, and experimentally demonstrated the control of the peak positions of Coulomb blockade oscillations. The positive voltage applied to the gate makes channel electrons tunnel into the floating dots, and the injected electrons raise the potential of quantum dots in SET, resulting in a shift of peak positions of Coulomb blockade oscillations. In addition, from the temperature dependence of device characteristics, it is confirmed that the potential fluctuations caused by random distribution of the Si nanocrystals have a slight influence on the shape of the  $I_{ds}/V_{g}$  curves at practical high temperatures. (19 References).

Bakkers, E. and D. Vanmaekelbergh (2000). "Resonant electron tunneling through semiconducting nanocrystals in a symmetrical and an asymmetrical junction." Physical Review B Condensed Matter **62**(12).

We studied resonant electron tunneling through individual CdSe and CdS nanocrystals in two types of configuration. With nanocrystals electrodeposited on bare gold, the spectra show resonant tunneling via discrete unoccupied (CB region) and occupied levels (VB region) at positive and negative bias, respectively. In this asymmetrical configuration, the bias is only distributed across the tip/dot barrier; this allows one, in principle, to derive the electronic structure of nanocrystals from tunneling spectra. With colloidal nanocrystals covalently anchored to a gold substrate via hexane dithiol, tip-to-gold and gold-to-tip tunneling occurs via the same set of unoccupied levels.

Baranov, P. G., V. S. Vikhnin, et al. (2000). "Suppression of the local Jahn-Teller effect in nanostructures: Self-trapped holes and excitons in AgCl nanocrystals." Pis'Ma: 475-80.

A strong decrease in the g-factor anisotropy was revealed by optically detected magnetic resonance for self-trapped Jahn-Teller holes (both isolated and forming self-trapped excitons) in AgCl nanocrystals embedded into the KCl crystal lattice. This is evidence for considerable suppression of the Jahn-Teller effect in nano-objects. The suggested mechanism of suppression of the Jahn-Teller effect in nanocrystals is associated with an additional deformation field arising in nanocrystals owing to a strong vibronic interaction at the interface. (9 References).

Baranov, P. G., N. G. Romanov, et al. (2000). "KCl crystals with a silver impurity: from point defects to oriented AgCl microcrystals in a crystalline host." Fizika Tverdogo Tela **42**(12): 2166-70.

This paper presents the first unambiguous optically detected magnetic-resonance (ODMR) evidence that AgCl crystals embedded in the KCl lattice and retaining the host orientation are formed in KCl crystals grown with a 2-3 mol% silver impurity. ODMR spectra were obtained of self-trapped holes, shallow electronic centers, and self-trapped excitons, which are typical of AgCl, and a number of substantially different ODMR spectra were also obtained. The differences between the ODMR spectra observed in samples cleaved from different parts of a KCl:AgCl crystal are probably accounted for by embedded AgCl crystals varying in size from large micro- to nanocrystals. (10 References).

Baranov, A. V., S. Yamauchi, et al. (2000). "Softening of the LO phonons in excited state of CuCl nanocrystals." Journal of Luminescence **87**(89): 500-2.

Resonant two-photon-excited luminescence spectroscopy has been used to study phonon structure in the excited state of CuCl nanocrystals. To make a reliable assignment we measured for the first time the two-photon excitation profiles of the bands in the spectra, which are supposed to be related to the phonon-assisted processes. It was found that the energy of the LO phonons in the presence of the exciton is reduced by 13% as compared to the ground state of the nanocrystal. (5 References).

Barmenkov, Y. O., C. Sifuentes, et al. (2000). "CdS and CdSe semiconductor nanocrystal doped glasses and their application in fiber-optic sensors." Revista Mexicana de Fisica **46**(2): 64-6.

We propose a temperature fiber sensor based on CdS- and CdSe-nanocrystal-doped phosphate glasses. These glasses demonstrate a reversible temperature-induced absorption edge shift at temperatures less than the annealing temperature of the glass (<370 degrees C). In order to eradicate the effects of variable signal losses in intensity-dependent sensor, a dual-wavelength detection scheme was proposed. A sensor, tested in the temperature range of -20 to +120 degrees C, is shown to exhibit a linear response to temperature variations. (10 References).

Barnes, M. D., A. Mehta, et al. (2000). "On-off blinking and multiple bright states of single europium ions in  $\text{Eu}^{3+}:\text{Y}_2\text{O}_3$  nanocrystals." Journal of Physical Chemistry B **104**(26): 6099-102.

We show that continuously illuminated single europium ions incorporated in yttrium oxide ( $\text{Eu}/\text{sup } 3+/\text{Y}/\text{sub } 2/\text{O}/\text{sub } 3/$ ) nanocrystals (5-15 nm diameter) undergo on-off blinking on a variable time scale ranging from hundreds of milliseconds to several seconds. We observe both a pump-intensity dependent "duty factor" (on-time as a percentage of total measurement time), and quantum jumps between at least three well-defined luminescence intensity levels (bright states) from individual nanoparticles. Interesting switching or oscillation between different bright levels was also observed with a modulation rate that is dependent on pump-laser intensity. These features of single-ion luminescence are not observed for larger particles with multiple chromophores. We propose that these effects derive from pump laser-induced fluctuations between different quasi-stable  $\text{Eu}/\text{sup } 3+/\text{ symmetry sites that effectively modulate the electric dipole transition moment. (19 References).$

Batson, P. E. and J. R. Heath (1993). "Electron energy loss spectroscopy of single silicon nanocrystals: The conduction band." Physical Review Letters **71**(6): 911-914.

Bertoni, E., A. Bigi, et al. (1998). "Nanocrystals of magnesium and fluoride substituted hydroxyapatite." Journal of Inorganic Biochemistry **72**(1-2): 29-35.

Hydroxyapatite nanocrystals synthesized in the presence of different concentrations of magnesium and fluoride ions in solutions--1, 5 and 10 at.% have been submitted to a structural and chemical characterization. The syntheses were carried out in the presence of low molecular weight polyacrylic acid, which has been verified to inhibit hydroxyapatite crystallization. The polyelectrolyte is adsorbed into the crystals during the synthesis and provokes a reduction of the mean crystal sizes. The reduction is greater along the direction orthogonal to the c-axis, suggesting a preferential adsorption of the polyelectrolyte on the crystalline faces parallel to the c-axis. Both magnesium and fluoride can be incorporated into the hydroxyapatite structure. On the basis of the values of the lattice constants and of the magnesium relative content of the solid phase, it can be suggested that probably just a part of magnesium is substituted for calcium, the remainder being adsorbed on the crystal surface. However, magnesium destabilizes the apatitic structure favouring its thermal conversion into beta-tricalcium phosphate, and displays an inhibiting effect on the crystallization of hydroxyapatite. This last effect is enhanced by the simultaneous presence of polyacrylic acid. Fluoride substitution for hydroxyl ions into hydroxyapatite structure induces a slight increase of the crystal sizes along the c-axis direction. The data indicate that the experimental approach can be successfully used to prepare nanoapatite with crystallinity, crystal dimensions, composition, structure and stability very close to those characteristics of biological apatites.

Bhargava, R. N., D. Gallagher, et al. (1994). "Optical properties of manganese-doped nanocrystals of ZnS." Physical Review Letters **72**(3): 416-419.

Bhargava, R. N. (2000). "Structures and fluorescence of nanocrystalline  $\text{MSO}_4:\text{xSm}^{3+}$  (M=Ca, Sr, Ba; x=0.001~0.005) with gamma -ray irradiation." Optical Materials **15**(2): 143-8.

A series of nanocrystalline  $\text{MSO}/\text{sub } 4:/\text{xSm}/\text{sup } 3+/\text{ (M=Ca, Sr, Ba; x=0.001~0.005}$  were prepared by a co-precipitation method. Their crystal structures and fluorescence with and without gamma -ray irradiation are compared. It was found that their crystal structures have not changed and their lattice parameters of nanocrystals both with and without gamma -ray irradiation were increased with the augmentation of the content of doped  $\text{Sm}/\text{sup } 3+/\text{; however, their lattice parameters of the same nanocrystals with irradiation become smaller than that without irradiation. The characteristic emissions of both Sm}/\text{sup } 3+/\text{ ion and Sm}/\text{sup } 2+/\text{ ion are observed in the$

same nanocrystals after gamma -ray irradiation. The differences in their crystal structures and luminescent properties are also discussed. (15 References).

Bhattacharya, S., B. K. Chaudhuri, et al. (2000). "Raman characterization of CdTe/CdS-"core-shell"-clusters in colloids and films." Journal of Crystal Growth **214**(215): 782-6.

We present the Raman spectroscopic characterization of thermally sintered CdTe/CdS-colloids in thin films. From the spectral data one can conclude that the thermal sintering of the CdTe/CdS-films between 100 degrees C and 200 degrees C initiates the CdTe cluster growth. Sintering temperatures of 300-400 degrees C lead to a release of the Tributylphosphin-(TBP) capping ligands and to the formation of bare CdS- and CdTe nanocrystals. Above 400 degrees C, the CdTe part of the nanostructures sublimates, leaving behind nearly pure CdS nanocrystallites. (15 References).

Bian, Z., G. He, et al. (2000). "Mechanical properties of Zr<sub>52.5</sub>Cu<sub>17.9</sub>Ni<sub>14.6</sub>Al<sub>10</sub>Ti<sub>5</sub> bulk amorphous alloys after annealing isothermally." Chin Shu Hsueh Pao: Acta Metallurgica Sinica **36**(7): 693-6.

Zr/sub 52.5/Cu/sub 17.9/Ni/sub 14.6/Al/sub 10/Ti/sub 5/ bulk amorphous alloy with a diameter of 3 mm were annealed isothermally for 600 s at 673 K and 823 K, for 1500 s at 823 K, and for 3600 s at 723 K. The nanocrystal with a size of about 30-60 nm precipitates from the amorphous matrix after annealing. The partially crystallized alloy exhibits higher fracture stress (1.91-2.02 GPa) and lower ductility (0.1%) than as-cast amorphous alloy (1.78 GPa, 0.5%). The reason for the variation of mechanical properties of the alloy with the crystallized volume fraction of nanocrystals is that different volume fractions of nanocrystals correspond to different deformation modes of the alloy. The good mechanical properties of the partially crystallized alloy which the crystallized volume fraction are less than 50% are attributed to the mixed microstructure of nanocrystals embedded homogeneously in the amorphous matrix. (11 References).

Bigioni, T. P., R. L. Whetten, et al. (2000). "Near-infrared luminescence from small gold nanocrystals." Journal of Physical Chemistry B **104**(30): 6983-6.

A novel photoluminescence is reported for small metal nanocrystals in the near-infrared region (1.1-1.6  $\mu\text{m}$ ). Near-infrared photoluminescence spectra were measured at room temperature for 1.1 and 1.7 nm Au nanocrystals using a 1.06  $\mu\text{m}$  excitation source. This photoluminescence is attributed to sp to sp-like transitions, analogous to intraband transitions in bulk gold; however, the exact mechanism is unknown. A conservative estimate for the quantum yield for the 1.7 nm gold nanocrystals is  $(4.4 \pm 1.5) \times 10^{-5}$  at room temperature, more than 5 orders of magnitude greater than that of bulk gold. (32 References).

Bin, L., X. Yi, et al. (2000). "Shape change as an indicator of mechanism in the high-pressure structural transformations of CdSe nanocrystals." Physical Review Letters **84**(5): 923-6.

X-ray diffraction was used to monitor the structure of 45 AA diameter CdSe nanocrystals as they transformed repeatedly between fourfold and sixfold coordinated crystal structures. Simulations of the diffraction patterns reveal that a shape change occurs as the crystals transform. They also show that stacking faults are generated in the transition from the high- to the low-pressure phase. The shape change and stacking fault generation place significant constraints on the possible microscopic mechanism of the phase transition. (23 References).

Bin, L., X. Yi, et al. (2000). "Synthesis, characterization, and properties of nanocrystalline Cu<sub>2</sub>SnS<sub>3</sub>." Journal of Solid State Chemistry **153**(1): 170-3.

The preparation of nanocrystalline Cu<sub>2</sub>/SnS<sub>3</sub> at synthetic conditions of low temperature (<180 degrees C) was first reported. Nanocrystalline Cu<sub>2</sub>/SnS<sub>3</sub> was directly synthesized from the reaction of CuCl/sub 2/2H/sub 2O with elemental tin and sulfur through a solvothermal process in ethylenediamine at 140-180 degrees C for 15 h. X-ray diffraction (XRD) patterns, transmission electron microscope (TEM) images, and X-ray photoelectron spectra (XPS) were used to characterize the products. The mechanism of the formation of the Cu<sub>2</sub>/SnS<sub>3</sub> nanocrystals in the solvothermal process was proposed. The UV-vis absorption spectroscopy and the electric conductivity of products were also studied. (32 References).

Bisi, O., S. Ossicini, et al. (2000). "Porous silicon: a quantum sponge structure for silicon based optoelectronics." Surface Science Reports **38**: 1-3.

The striking photoluminescence properties of porous silicon have attracted considerable research interest since their discovery in 1990. Luminescence is due to excitonic recombination quantum confined in Si nanocrystals which remain after the partial electrochemical dissolution of silicon. Porous silicon is constituted by a nanocrystalline skeleton (quantum sponge) immersed in a network of pores. As a result, porous silicon is characterized by a very large internal surface area (of the order of 500 m<sup>2</sup>/cm<sup>3</sup>). This internal surface is passivated but remains highly chemically reactive which is one of the essential features of this new and complex material. We present an overview of the experimental characterization and theoretical modeling of porous silicon, from the preparation up to various applications. Emphasis is devoted to the optical properties of porous silicon which are closely related to the quantum nature of the Si nanostructures. The characteristics of the

various luminescence bands are analyzed and the underlying basic mechanisms are presented. In the quest of an efficient electroluminescent device, we survey the results for several porous silicon contacts, with particular attention to the interface properties, to the stability requirement and to the carrier injection mechanisms. Other device applications are discussed as well. (478 References).

Black, C. T., C. B. Murray, et al. (2000). "Spin-dependent tunneling in self-assembled cobalt-nanocrystal superlattices." Science **290**(5494): 1131-4.

Self-assembled devices composed of periodic arrays of 10-nanometer-diameter cobalt nanocrystals display spin-dependent electron transport. Current-voltage characteristics are well described by single-electron tunneling in a uniform array. At temperatures below 20 kelvin, device magnetoresistance ratios are on the order of 10%, approaching the maximum predicted for ensembles of cobalt islands with randomly oriented preferred magnetic axes. Low-energy spin-flip scattering suppresses magnetoresistance with increasing temperature and bias-voltage.

Bokarev, V. P. (2000). "Raman spectra and optimal absorption spectra of GaAs/SiO<sub>2</sub> nanocrystals embedded thin films." Acta Optica Sinica **20**(6): 847-51.

GaAs/SiO<sub>2</sub>/sub 2/ nanocrystals embedded thin films have been prepared on silicon (111) wafers and optical silica plates by radio-frequency magnetron cosputtering technique and post-annealing at 673 K in vacuum. Raman spectroscopy strongly suggest the existence of GaAs nanocrystals being 3 nm in average size dispersed in SiO<sub>2</sub>/sub 2/ thin films. Compared with that of the bulk GaAs crystals, the optical absorption edge of GaAs nanocrystals exhibits a blue shift as large as 1.78 eV, and a few absorption peaks, which are mainly caused by the quantum confinement effect. (15 References).

Booth, H. F. and J. H. Strange (1998). "Microdynamics and phase equilibria in organic nanocrystals." Magnetic Resonance Imaging **16**(5-6): 501-4.

The effects of confinement on various organic molecules have been studied by nuclear magnetic resonance (NMR) relaxation techniques (T<sub>2</sub> and T<sub>1</sub> rho) between room temperature and 77 K. Cyclohexane, pentadecane, squalane, and squalene have been constrained within 60 Å porous silica, and the behaviour of the resulting nanocrystals has been compared to that of the bulk material. In all cases the molecular dynamics of the confined material were found to be significantly different from the bulk, and there is evidence to suggest that the behaviour is largely dependent on the size and shape of the molecules and the resultant structural disorder present when constrained within the pores.

Bording, J. K. and J. Tafto (2000). "A model of amorphous tetrahedrally coordinated semiconductors based on deformed nanocrystals." Physica Scripta **62**(6): 499-502.

The radial distribution function (RDF) of amorphous Ge and Si is calculated by assuming that the materials consist of elastically deformed nanocrystals of diameter about 3 nm. Good agreement with the experimental RDF is achieved, in particular for deformed hexagonal rather than cubic nanocrystals. This model provides a continuous connection from amorphous via nanocrystalline to coarse-grained crystalline materials. (21 References).

Bording, J. K. and J. Tafto (2000). "Molecular-dynamics simulation of growth of nanocrystals in an amorphous matrix." Physical Review B Condensed Matter **62**(12): 8098-103.

Using germanium as an example we study the growth of crystalline nuclei by molecular dynamics. Starting with crystalline nuclei of different sizes embedded in an amorphous matrix we follow the evolution of the system at the atomic level. At a temperature about halfway between absolute zero and the melting temperature, we observe that crystallites of diameter larger than 2.0 nm grow, while smaller crystals disappear. (17 References).

Bottger, I. I., T. Schedel-Niedrig, et al. (2000). "Catalytic methanol oxidation over copper: observation of reaction-induced nanoscale restructuring by means of in situ time-resolved X-ray absorption spectroscopy." Chemistry **6**(10): 1870-6.

The catalytically active copper phase for the partial oxidation of methanol is studied by means of time-resolved extended X-ray absorption fine structure (EXAFS) spectroscopy combined with the detection of the catalytic turnover. It is found that the active form of the copper is a strained nanocrystalline form of the metal. The metal is no longer made up from large crystallites but contains a defect structure in which oxygen is already intercalated.

Brik, A., E. Haskell, et al. (2000). "Anisotropy effects of EPR signals and mechanisms of mass transfer in tooth enamel and bones." Applied Radiation and Isotopes **52**(5): 1077-83.

Peculiarities of the internal construction of tooth enamel and bones that cause anisotropy effects and mass transfer in these objects are described. It is shown that the composition of the mineral component of teeth and bones depends on a mechanical-electrical mechanism, which pumps ions into nanocrystals. Decrease in the efficiency of the mechanical-electrical mechanism results in demineralization of enamel and bones, which progresses most rapidly at a disease of the biomineral or under special conditions, such as in space flights.

Effects of signal anisotropy in the practice of retrospective EPR dosimetry are discussed.

Brongersma, M. L., P. G. Kik, et al. (2000). "Diamond synthesis by high-velocity thermal spray: the laboratory analogue of a meteorite impact." Journal of Materials Research **15**(1): 25-8.

Nanocrystalline-diamond particles were produced in the form of a coating by depositing Ni-clad graphite powder in a high-velocity thermal spray experiment. Particles were accelerated to impact and formed a thick film (>20 μm) on a steel substrate, with the high-velocity impact generating a shock wave, which propagates through the particle and the underlying deposits. Transmission electron microscopy revealed that this deposit contains cubic diamond nanocrystals having a size range of 5 to 10 nm in graphite. In addition to diamond, it was observed that a portion of the deposit contains "closed-curved graphite". (21 References).

Bruchez, M., M. Moronne, et al. (1998). "Semiconductor nanocrystals as fluorescent biological labels." Science **281**(5385): 2013-6.

Semiconductor nanocrystals were prepared for use as fluorescent probes in biological staining and diagnostics. Compared with conventional fluorophores, the nanocrystals have a narrow, tunable, symmetric emission spectrum and are photochemically stable. The advantages of the broad, continuous excitation spectrum were demonstrated in a dual-emission, single-excitation labeling experiment on mouse fibroblasts. These nanocrystal probes are thus complementary and in some cases may be superior to existing fluorophores.

Brun, T. A. and H. Wang (2000). "Coupling nanocrystals to a high-Q silica microsphere: Entanglement in quantum dots via photon exchange." Physical Review A **61**(3): 1-5.

Coupling nanocrystals (quantum dots) to a high-Q whispering gallery mode (WGM) of a silica microsphere, can produce a strong coherent interaction between the WGM and the electronic states of the dots. Shifting the resonance frequencies of the dots, for instance by placing the entire system in an electric potential, then allows this interaction to be controlled, permitting entangling interactions between different dots in a way analogous to the ion-trap computer of Cirac and Zoller. Thus, a more advanced system of this type could potentially be used to implement a simple quantum computer. (5 References).

Busmann, H. G., A. Pageler, et al. (2000). "Crystallisation of melt-spun Al-Fe-Nd-Cu alloys." Materials Science Forum **343**(346): 353-8.

Many high-strength Al-based alloys have been developed recently after it was found that for certain composition range, crystallisation from amorphous alloys could lead to a composite structure consisting of primary nanocrystals embedded in an amorphous matrix. However, even better values of mechanical strength was reported for Al-based fully crystallised alloys with a composite structure formed by a mixture of primary nanocrystals and quasicrystalline phases therefore, the development of new compositions continues to be of interest. In the present work we report on the crystallisation behaviour of amorphous melt-spun Al-Fe-Nd-Cu alloys. Crystallisation was studied by differential scanning calorimetry and the characterisation of samples partially and fully crystallised was performed by X-ray diffraction and transmission electron microscopy. For the alloy Al/sub 85/Fe/sub 4/Nd/sub 6/Cu/sub 5/ crystallisation occurred by multiple stage with the first peak being associated with primary Al and two DSC peaks observed at higher temperatures have been associated with metastable phases. These results are discussed in association with the effect of the Cu content in the crystallisation behaviour as compared with Al-Fe-Nd alloys. (9 References).

Busseret, C., A. Souifi, et al. (2000). "Discharge mechanisms modeling in LPCVD silicon nanocrystals using C-V and capacitance transient techniques." Superlattices and Microstructures **28**: 5-6.

Charging and discharging phenomena from silicon nanocrystals have been studied by means of capacitance-voltage characteristics on P-type metal-oxide-semiconductor (PMOS) capacitors with embedded self-assembled silicon quantum dots. The dots have a floating gate behavior as shown by the hysteresis on C-V curves. The Si-dots are charged or discharged by direct tunneling of carriers through a 3 nm thick oxide. The nanocrystals could be charged by electrons or holes, depending on the charging bias conditions. The discharge is studied by constant bias method and shows a logarithmic variation with time. Retention times higher than several hours are observed. A simple model is developed in order to evaluate the electric field within the tunneling oxide layer. Then, complete simulations are done for the different discharge paths. The barrier heights are extracted from the discharge data and possible confinement effects are discussed. The results confirm the high potentiality of silicon nanocrystal-floating gates for memory applications. (16 References).

Cabot, A., J. Arbiol, et al. (2000). "Organic nanocrystals embedded in sol-gel glasses for optical applications." Synthetic Metals **115**: 1-3.

We report a simple and generic preparation of stable organic nanocrystals embedded in sol-gel glasses. Nanocrystallization is obtained by instantaneous nucleation followed by controlled growth of the nuclei. In this process, the gel viscosity lowers the growth rate (slow solute diffusion) and inhibits coalescence of the crystals, and pores in the gel act as nanoscale growth reactors. The process is based on control of the nucleation and

growth kinetics of the organic phase. For bulk samples, transmission electron microscopy revealed monodisperse particles between 20 and 80 nm in diameter but lower particle diameters are certainly possible due to the nanometer size of pores in dense gel matrix. The generality of this process was demonstrated using various organic molecules selected for their luminescent and optical limiting properties. We have extended this method to the preparation of stable organic nanocrystals embedded in sol-gel thin films using the spin-coating method. These films, which are around 1 mm thick are transparent between 0.3 and 1.5 mm and contain organic crystals characterized by electron and confocal microscopies (100-500 nm in diameter). The targeted properties and applications are electroluminescence, microcavity lasers or nanocrystal spectroscopy. These materials not only combine the optical properties (nonlinear response and fluorescence) of organic molecules with those of inorganic compounds (high stability, wide transparency range) but also combine the advantages of crystals (size effects, photostability) with those of amorphous phases (convenient processing and shaping). (23 References).

Calderon Moreno, J. M., S. S. Swamy, et al. (2000). "Preparation of transparent anatase nanocrystals-dispersed silica films via sol-gel process at low temperatures." Proceedings of SPIE the International Society for Optical Engineering **3943**: 85-94.

Transparent and porous anatase nanocrystals-dispersed silica films have been successfully prepared by treating the poly(ethylene glycol), PEG, -containing SiO<sub>2</sub>/TiO<sub>2</sub> gel films with hot water. This process was done at temperatures lower than 100 degrees C under atmospheric pressure, and thus anatase nanocrystals-dispersed films can be formed on various kinds of substrates including organic polymers with poor heat resistance. The hydrolysis of Si-O-Ti bonds and dissolution of the SiO<sub>2</sub> component in the SiO<sub>2</sub>/TiO<sub>2</sub> gel films with hot water treatment were related to the formation process of anatase nanocrystals in the SiO<sub>2</sub>/TiO<sub>2</sub> gel films with the treatment. In addition, the porous film structure formed by leaching of PEG with hot water treatment led to homogenous dispersion of anatase nanocrystals in the films. (17 References).

Calin, M., A. Rudiger, et al. (2000). "Ion beam induced nanocrystallization of SiC." Materials Science Forum **338**(342): 897-900.

Ion-beam-induced crystallization (IBIC) was used to produce nanocrystals in the preamorphized region of a 6H-SiC bulk crystal. The precipitation was stimulated by high dose implantation with Al and Si at temperatures between 300 degrees C and 700 degrees C. The morphology of the nanocrystalline phase and its dependence on the implantation parameters were investigated by cross-sectional transmission electron microscopy (XTEM). Above a certain threshold dose, randomly oriented grains of 3C-SiC with almost spherical shape and mean diameters ranging from 4 to 25 nm are formed. The recrystallization is completed within a very narrow time window. Therefore, in our experiments the nucleation and growth process could not be observed directly. From the extrapolation of the kinetics of the secondary grain growth to zero time the window of suitable parameters for the observation of nucleation and primary grain growth was estimated. A critical temperature ( $T \leq 300$  degrees C) as well as an incubation time ( $t \geq 300$  s below 700 degrees C) for the beginning of the recrystallization were found. (11 References).

Cang, F. and A. Inoue (2000). "n-type colloidal semiconductor nanocrystals." Nature **407**(6807): 981-3.

Colloidal semiconductor nanocrystals combine the physical and chemical properties of molecules with the optoelectronic properties of semiconductors. Their colour is highly controllable, a direct consequence of quantum confinement on the electronic states. Such nanocrystals are a form of 'artificial atoms' that may find applications in optoelectronic systems such as light-emitting diodes and photovoltaic cells, or as components of future nanoelectronic devices. The ability to control the electron occupation (especially in n-type or p-type nanocrystals) is important for tailoring the electrical and optical property, and should lead to a wider range of practical devices. But conventional doping by introducing impurity atoms has been unsuccessful so far: impurities tend to be expelled from the small crystalline cores (as observed for magnetic impurities), and thermal ionization of the impurities (which provides free carriers) is hindered by strong confinement. Here we report the fabrication of n-type nanocrystals using an electron transfer approach commonly employed in the field of conducting organic polymers. We find that semiconductor nanocrystals prepared as colloids can be made n-type, with electrons in quantum confined states. (21 References).

Cang, F., L. Chunfei, et al. (2000). "Nanocrystal composites in Zr-Nb-Cu-Al metallic glasses." Journal of Non Crystalline Solids **270**: 1-3.

Adding Nb to Zr-Cu-Al amorphous alloys induces the primary transformation occurring on heating. Nanocrystalline-amorphous composites were produced by annealing Zr<sub>70-y</sub>Nb<sub>x</sub>Cu<sub>30-x</sub>Al<sub>y</sub> ( $x=5-7.5$  and  $y=8-12$  at.%) metallic glasses. Their structures, after completing the primary transformation by annealing, were found to consist of fine crystals with a scale less than 15 nm dispersed homogeneously in an amorphous matrix. The nanostructured alloys show increased tensile strength and hardness with good bending ductility at a volume fraction of nanoparticles less than 50%. We suggest that the stronger attractive interaction between Zr-Al is the reason for the presence of the quenched-in embryos in as-solidified samples, and the quenched-in embryos therefore provide nucleation sites for nanocrystal formation. (16 References).

Cang, F. and A. Inoue (2000). "Ductility of bulk nanocrystalline composites and metallic glasses at room temperature." Applied Physics Letters **77**(1): 46-8.

Mechanical properties of bulk Zr/sub 60/Cu/sub 20/Pd/sub 10/Al/sub 10/ nanocrystalline composite and Zr/sub 55/Ni/sub 5/Cu/sub 30/Al/sub 10/ metallic glass were measured by compression tests at room temperature. The Zr/sub 60/Cu/sub 20/Pd/sub 10/Al/sub 10/ as-quenched alloy obviously exhibits plastic strain while no distinct plastic deformation is recognized in the Zr/sub 55/Ni/sub 5/Cu/sub 30/Al/sub 10/ metallic glass. Moreover, the plastic strain increased by increasing the volume fraction of nanocrystals and achieved maximum value in the early stage of the nanocrystallization. High-resolution electron microscopy showed that, different from the microstructure of Zr/sub 55/Ni/sub 5/Cu/sub 30/Al/sub 10/ metallic glass, nanocrystals with main grain sizes of about 2 nm were embedded in the amorphous matrix of the bulk Zr/sub 60/Cu/sub 20/Pd/sub 10/Al/sub 10/ alloy which showed the maximum plastic strain. (10 References).

Cao, Y. W., J. Aksenton, et al. (2000). "Colloidal synthesis and properties of InAs/InP and InAs/CdSe core/shell nanocrystals." Semiconductor Quantum Dots. Symposium. **571**: 75-80.

High-temperature colloidal synthesis of InAs/InP and InAs/CdSe core/shell nanocrystal quantum dots is reported. InP and CdSe shells with several thicknesses were grown on InAs cores ranging in diameter between 20 to 50 AA. Optical spectra, X-ray photoelectron spectroscopy (XPS), transmission electron microscopy (TEM), and X-ray diffraction (XRD) were used to analyze the core/shell quantum dots and determine their chemical composition, average size, size distributions, and structures. The experimental results indicate that shell growth is uniform, epitaxial, and controllable. For both InP and CdSe shells, growth is accompanied by a red shift of the band gap energy as a result of the extension of the electron wavefunction into the shell region. An increase of the room temperature photoluminescence quantum yield by a factor of ~4 is observed with CdSe shell growth on InAs cores. The growth of InP shells, however, quenches the photoluminescence quantum yield. The difference is assigned to outer surface effects in core/shell nanocrystals. (12 References).

Carlisle, J. A., M. Dongol, et al. (2000). "Evidence for changes in the electronic and photoluminescence properties of surface-oxidized silicon nanocrystals induced by shrinking the size of the silicon core." Chemical Physics Letters **326**: 3-4.

Web-like aggregates of Si nanocrystals produced by laser vaporization-controlled condensation technique are allowed to oxidize slowly in air and the photoluminescence (PL) is measured. A significant shift in the PL red band from 1.83 to 1.94 eV is observed. The bonding structure is established by correlating the PL data with the photon-yield electronic structure measurements using soft-X-ray fluorescence (SXF) and photon-yield near-edge X-ray absorption fine structure (NEXAFS) techniques. The results indicate that as the nanoparticles oxidize, the radius of the crystalline core decreases, which gives rise to a larger bandgap and consequently to the observed blue shift in the PL band. (21 References).

Chae, K. H., J. H. Son, et al. (2000). "Photoluminescences from Si nanocrystals in ion-beam-mixed Si/SiO<sub>2</sub> layers." Journal of the Korean Physical Society **36**(3): 169-72.

Photoluminescence (PL) from Ar-ion-beam-mixed SiO/sub 2//Si/SiO/sub 2/ layers and SiO/sub 2//Si\*3/SiO/sub 2/ layers has been studied to elucidate the luminescence origins. The SiO/sub 2//Si/SiO/sub 2/ layers and the SiO/sub 2//Si\*3/SiO/sub 2/ layers were irradiated by 80-keV Ar ions with a dose of 1\*10<sup>sup 16/ ions/cm<sup>sup 2/ at room temperature (RT), which was followed by high-temperature annealing in N/sub 2/ ambient. In the case of the SiO/sub 2//Si/SiO/sub 2/ layers, the PL spectra excited by the Ar-laser (457.9 nm) showed an intense broad luminescent band with a peak near 720 nm at RT. The red-light emission is attributed to the luminescence from silicon nanocrystals produced by silicon precipitation. The formation of nanocrystals in SiO/sub 2/ matrices was confirmed by cross-sectional high-resolution transmission electron microscopy. The SiO/sub 2//Si\*3/SiO/sub 2/ layers shows a broad luminescent band with a peak near 600 nm. The orange-light emission is attributed to the luminescence from the Si nanocrystals produced by ion-beam mixing and subsequent annealing at high temperature. (15 References).</sup></sup>

Chang, S. S., G. J. Choi, et al. (2000). "Formation of size controlled Ge nanocrystals in SiO<sub>2</sub> matrix by ion implantation and annealing." Thin Solid Films **369**: 1-2.

The Ge nanocrystals were formed in a SiO/sub 2/ matrix by the multi-energy ion implantation and subsequent annealing. Utilizing the multi-energy ion implantation, the Ge atoms were uniformly introduced in the SiO/sub 2/ matrix. Transmission electron microscopy (TEM) observation showed that the nanocrystal size was more uniform than the case when the Ge nanocrystals were formed by the other methods, such as the single-energy ion implantation and the magnetron co-sputtering. This is due to the uniformity of the Ge concentration in a SiO/sub 2/ matrix introduced by the multi-energy ion implantation. In addition, TEM observation and Raman scattering spectra showed that the nanocrystal size varied with the annealing temperature and the implantation dose. The uniformity and the size of the Ge nanocrystals were controlled by the ion implantation energy/dose and the annealing temperature. Auger electron spectra showed that the variation of the nanocrystal size was related to the reduction of the Ge oxide. The reduction of the Ge oxide in the SiO/sub 2/ matrix might be related to the

strengths of the chemical bonds. (13 References).

Chang-Ming, C., L. Xinquan, et al. (2000). "Aligned silicon carbide nanocrystals at the SiO<sub>2</sub>/Si interface by C implantation into SiO<sub>2</sub> matrices." Journal of Vacuum Science and Technology A Vacuum Surfaces and Films **18**(5): 2591-4.

In this article, we report a specific feature for the distribution of silicon carbide nanocrystals formed by C implantation into SiO<sub>2</sub>/Si followed by thermal annealing. Cross-sectional transmission electron microscopy shows that silicon carbide nanocrystals (islands) are buried in the Si wafer at the SiO<sub>2</sub>/Si interface in a rectangular array (~40\*10 nm in dimension) and with a spacing of ~20 nm. High-resolution transmission electron microscopy examination shows that silicon carbide nanocrystals are epitaxial on the Si wafer and are absent in the SiO<sub>2</sub> matrix. Photoluminescence peaked at 580 nm is observed for samples annealed at 1100 degrees C under 514 nm excitation, which is thought to arise from the embedded silicon carbide nanocrystals. (26 References).

Chaudhuri, B. K. (2000). "High temperature superconductors from a pure glassy phase." Chinese Journal of Physics **38**(2): 211-24.

Homogenous (Bi<sub>1-x</sub>Pb<sub>x</sub>)Sr<sub>1-x</sub>Ca<sub>1-x</sub>(Cu<sub>1-n</sub>M<sub>n</sub>)O<sub>x</sub> type glassy precursors (M=Li, K, Cr, Mn, Zn, Ti, Ag; and n=0-0.5) show high T<sub>c</sub> superconducting behavior when they are annealed at 840 degrees C for 24 hrs in air. The superconducting behavior of a typical Cr doped sample is only discussed in this paper. Samples doped with other atoms also behave similarly. All these glasses contain nanocrystalline particles or clusters which grows into the superconducting or other phases by annealing. Single phase high T<sub>c</sub> superconductors are obtained from the glasses having nanocrystals size <20 nm. The suppression of transition temperature supports the pair-breaking mechanism of Abrikosov and Gor'kov. Depending on the measuring temperature, both positive and negative values of the Seebeck coefficients (S) are exhibited by the annealed superconducting samples. Interestingly, small positive peaks were shown by the thermoelectric power (TEP) data of all the doped samples just above T<sub>c</sub>. This peak was considered to be associated with the phonon-drag effect. Similar behavior is also exhibited by the corresponding superconductors doped with Mn, Fe and Ti. The linear part of the temperature vs. TEP data (above T<sub>c</sub>) can be well fitted with the two band model. (37 References).

Checchetto, R. and A. Miotello (2000). "Size-dependent electron-hole exchange interaction in Si nanocrystals." Applied Physics Letters **76**(3): 351-3.

Silicon nanocrystals with diameters ranging from approximately=2 to 5.5 nm were formed by Si ion implantation into SiO<sub>2</sub>/Si followed by annealing. After passivation with deuterium, the photoluminescence (PL) spectrum at 12 K peaks at 1.60 eV and has a full width at half maximum of 0.28 eV. The emission is attributed to the recombination of quantum-confined excitons in the nanocrystals. The temperature dependence of the PL intensity and decay rate at several energies between 1.4 and 1.9 eV was determined between 12 and 300 K. The temperature dependence of the radiative decay rate was determined, and is in good agreement with a model that takes into account the energy splitting between the excitonic singlet and triplet levels due to the electron-hole exchange interaction. The exchange energy splitting increases from 8.4 meV for large nanocrystals (approximately=5.5 nm) to 16.5 meV for small nanocrystals (approximately=2 nm). For all nanocrystal sizes, the radiative rate from the singlet state is 300-800 times larger than the radiative rate from the triplet state. (21 References).

Chen, C. C., A. B. Herhold, et al. (1997). "Size dependence of structural metastability in semiconductor nanocrystals." Science **276**(5311): 398-401.

The kinetics of a first-order, solid-solid phase transition were investigated in the prototypical nanocrystal system CdSe as a function of crystallite size. In contrast to extended solids, nanocrystals convert from one structure to another by single nucleation events, and the transformations obey simple unimolecular kinetics. Barrier heights were observed to increase with increasing nanocrystal size, although they also depend on the nature of the nanocrystal surface. These results are analogous to magnetic phase transitions in nanocrystals and suggest general rules that may be of use in the discovery of new metastable phases.

Chen, H. M., X. F. Huang, et al. (2000). "Evolution of the microstructure in microcrystalline silicon prepared by very high frequency glow-discharge using hydrogen dilution." Journal of Applied Physics **87**(6): 3137-42.

A series of samples was deposited by very high frequency glow discharge in a plasma of silane diluted in hydrogen in concentrations SiH<sub>4</sub>/(SiH<sub>4</sub>+H<sub>2</sub>) varying from 100% to 1.25%. For silane concentrations below 8.4%, a phase transition between amorphous and microcrystalline silicon occurs. Microcrystalline silicon has been characterized by transmission electron microscopy (TEM) and X-ray diffraction. The medium-resolution TEM observations show that below the transition, the microstructure of microcrystalline silicon varies in a complex way, showing a large variety of different growth structures. For the sample close to the phase transition, one observes elongated nanocrystals of silicon embedded in an amorphous matrix followed at intermediate dilution by dendritic growth, and, finally, at very high dilution level, one observes columnar growth. X-

ray diffraction data evidence a (220) crystallographic texture; the comparison of the grain sizes as evaluated from TEM observations and those determined using Scherrer's equation illustrates the known limitations of the latter method for grain size determination in complex microstructures. (19 References).

Cheyman, S., N. Langford, et al. (2000). "Gold, silver and copper nanocrystal formation in SiC by MeV implantation." Nuclear Instruments and Methods in Physics Research Section B Beam Interactions with Materials and Atoms **166**(167): 892-6.

Nanoclusters gold, silver and copper are produced in 6H-SiC by implanting 1.0 MeV Au, 2.0 MeV Ag and 2.0 MeV Cu into the Si face of SiC at room or elevated temperature followed by annealing at various temperatures. The absorption bands for each type of metal nanoclusters in SiC were determined using optical absorption spectrophotometry. Elevated temperature implantation reduces optical absorption due to ion implantation induced defects. Using the Mie theory, we determined the index of refraction in the implanted volume. (13 References).

Chi-Fa, L., T. Wei-Tsu, et al. (2000). "Preparation and characterization of oriented PbS crystalline nanorods in polymer films." Langmuir **16**(2): 389-97.

We report on the synthesis and characterization of rod-shaped PbS nanocrystals dispersed in a polymer film using a functionalized lead(II) salt of the surfactant anion AOT/sup -, Pb(AOT)/sub 2/, as the precursor. Essentially all the PbS nanocrystallites prepared using this method have been oriented with their (100) lattice planes parallel to the substrate surface. While the PbS nanorods with oriented lattice planes were produced in the polymer film, only cubic or spherical PbS nanoparticles were obtained when the preparation was carried out in solution. Possible mechanisms are briefly discussed for the growth of the rod-shaped PbS nanocrystals with the preferred orientation in the polymer film. (41 References).

Chieh-Ju, L., A. Mizel, et al. (2000). "Synthesis of nanocrystalline cobalt selenide in nonaqueous solvent." Journal of Solid State Chemistry **152**(2): 537-9.

Cobalt selenide nanocrystals have been synthesized by a solvothermal reaction between metallic cobalt and selenium at 140 degrees C. The products obtained have been characterized by X-ray powder diffraction (XRD) and transmission electron microscopy (TEM). According to the XRD analysis, the as-produced cobalt selenide adopted a NiAs structure analogous to that of Ni/sub 0.85/As. Therefore, it was termed Co/sub 0.85/Se. Elemental analysis showed a cation-deficient composition of about Co/sub 0.85/Se. TEM observation indicated that the obtained Co/sub 0.85/Se nanocrystals were of foliate morphology. IR analysis suggested that the product was free from contaminants such as ethylenediamine. The influence of various solvents on this synthetic process has been discussed. Ni/sub 0.85/As has also been synthesized with a similar synthetic process. (14 References).

Choi, W. K., H. H. Thio, et al. (2000). "Synthesizing germanium nanocrystals in amorphous silicon oxide by rapid thermal annealing." Philosophical Magazine B Physics of Condensed Matter Structural Electronic Optical and Magnetic Properties **80**(4): 729-39.

The Raman and photoluminescence (PL) characteristics of Ge nanocrystals embedded in amorphous SiO/sub 2/ films synthesized by rapid thermal annealing were presented. The nanocrystal size delta was estimated on the basis of the phonon confinement model. The Raman results showed that, for samples annealed at different annealing temperatures, a transition from amorphous to nanocrystalline Ge occurred at annealing temperature higher than 700 degrees C. delta was estimated to lie between 18 and 53 AA. Two PL peaks at 1.8 and 2.2 eV were observed for Ge nanocrystals with delta =18-53 AA. The PL results of the 2.2 eV peak agreed with that published in the literature. The origin of this peak is still under investigation. A comparison of the PL peak with delta and the results of the forming-gas annealing experiments suggest that the 1.8 eV peak is possibly related to both the Ge nanocrystals and Ge related defects in the SiO/sub 2/ network. (17 References).

Constantin, C., E. Martinet, et al. (2000). "Nanocrystalline Si thin films with arrayed void-column network deposited by high density plasma." Journal of Applied Physics **88**(1): 555-61.

High porosity nanocrystalline Si thin films have been deposited using a high density plasma approach at temperatures as low as 100 degrees C. These films exhibit the same unique properties, such as visible luminescence and gas sensitivity, that are seen in electrochemically etched Si (i.e., porous Si). The nanostructure consists of an array of rodlike columns normal to the substrate surface situated in a void matrix. We have demonstrated that this structure is fully controllable and have varied the porosity up to ~90% (as derived from optical reflectance) by varying the deposition conditions. In particular, the impact of plasma power has been found to reduce porosity by increasing the nuclei density and therefore the areal density of columns. Humidity sensors have been demonstrated based on the enhanced conductivity of our films (up to 6 orders of magnitude) in response to increase in relative humidity. Depending on the porosity, the conductivity-relative humidity behavior of our films shows variations which can be correlated with the nanostructure. Also, these variations indicate that the dominant charge transport is limited by the dissociation of water into its ions at the column surfaces. (28 References).

Cui, D. L., J. Q. Pan, et al. (2000). "Surface and size effects and energy transfer phenomenon on the luminescence of nanocrystalline  $X_1-Y_2SiO_5:Eu^{3+}$ ." Journal of Alloys and Compounds **303**(304): 371-5.

Optical luminescence of nanocrystalline  $Y_{2-x}Eu_xSiO_5$  arises from four distinct sites. We show that one previously uncharacterized site is a  $Eu^{3+}$  ion near the surface of the nanocrystal. The energy transfer rate between the two main sites varies with temperature and  $Eu^{3+}$  concentration and the dynamics of this transfer is explained theoretically. Luminescent quenching occurs at a much higher concentration and stronger luminescent intensity than in bulk  $Y_2SiO_5:Eu^{3+}$ . This is due to the hindering effects of particle boundaries to energy transfer. (9 References).

Czerwos, E., P. Dluzewski, et al. (2000). "Electron emission from  $C_{60}C_{70}+Pd$  films containing Pd nanocrystals." Journal of Vacuum Science and Technology B **18**(2): 1064-7.

$C_{60}/C_{70}+Pd$  films composed of 2.5 nm sized Pd nanocrystals situated in carbonaceous matrix were grown by thermal deposition of fullerenes  $C_{60}/C_{70}$  mixture ( $C_{60}:C_{70}$  ratio was 8:2) and Pd organic compound (from two separated sources). The structure of films was studied by transmission electron microscopy and electron diffraction. The composition of films was studied by energy dispersive spectroscopy. Binding energy of Pd and C atoms was obtained by electron spectroscopy for chemical analysis method. The bias voltage applied along the film caused the creation of electrical conductivity paths composed of 10-20 nm sized Pd nanocrystals. The electron emission was observed for the film after the formation of the electrical conductivity path. As a result of such structural changes we observed enhanced electron emission from the film. (12 References).

Dalba, G., N. Daldosso, et al. (2000). "Formation and structure of light-weight nanocrystalline alloys of the aluminium-nickel-RE system." Fizika Metallov i Metallovedenie **90**(2): 95-102.

X-ray diffraction, differential scanning calorimetry, and transmission electron microscopy were used to study the formation of nanocrystalline structure upon controlled crystallization of Al-based amorphous alloys containing Ni and rare-earths (REs) Y, Yb, and Ce. For the alloys examined, the temperature and the activation energy of the amorphous-phase crystallization were determined. In all the alloys, a nanocrystalline structure was formed as a result of crystallization. The nanocrystal size ranges from 5 to 20 nm and depends on the chemical composition of the alloy and the regimes of its heat treatment. The stability of the amorphous phase depends on the concentration of a rare-earth element and its type. When crystallized, the alloys contain aluminum nanocrystals randomly distributed in the amorphous matrix. The dependence of the average nanocrystal size on the chemical composition of the alloy and its variation upon isothermal holding are discussed. (10 References).

Danko, G. A., R. Silbergliitt, et al. (2000). "Electron diffraction of yttrium iron oxide nanocrystals prepared by the alkoxide method." Journal of Magnetism and Magnetic Materials **217**: 1-3.

Yttrium iron garnet (YIG) ultrafine particles of several nanometers in diameter were prepared by the alkoxide method. The phase transformation of the particles during the course of calcination was studied in detail by transmission electron microscopy. A small fraction of the uncalcined amorphous particles was spontaneously crystallized into epsilon- $Fe_2O_3$ . The amorphous phase undergoes incomplete crystallization by forming an intermediate phase at 660 degrees C calcination. Complete crystallization to YIG does not occur at temperatures lower than 675 degrees C. A small amount of  $YFeO_3$  and  $Fe_{32}Y_{12}O_{24}$  (intermetallic compound) nanocrystals were also formed at calcination temperatures as low as 660 degrees C. In selected area electron diffraction (SAED) experiment of the present  $YFeO_3$  nanocrystals, we found a peculiar selection rule; we observed strong diffraction from the lattice planes, (i, j, k), if the sum,  $i+j+k$  was odd, and weak or no diffraction from other planes. In the SAED experiment of YIG nanocrystals, we found that the diffraction rings fluctuated in the radial direction. (22 References).

De Aza, P. N., Z. B. Luklinska, et al. (2001). "Transmission electron microscopy of the interface between bone and pseudowollastonite implant." Journal of Microscopy **201**(Pt 1): 33-43.

This paper reports on the structural morphology of the interface in vivo between implants composed of bioactive synthetic pseudowollastonite ceramic and bone in rat tibias. Thin sections of the interfaces were examined after 6 and 8 weeks of implantation period in a high resolution transmission electron microscope up to the lattice plane resolution level. The interfaces developed normal biological and chemical activities and remained reactive over the 8-week period. The regions showing direct bone tissue bonding to the implant contained nanocrystals of hydroxyapatite-like phase growing epitaxially across the interface in the [002] direction. The nanocrystals were also identified in the bone tissue formed in the interfacial area. The reactivity of the implant caused in the first instance formation of an amorphous woven type of bone, which transformed into a crystalline lamellar type containing collagen fibres. The Ca/P ratio of the interfacial region was found to be between 1.67 in the mature bone tissue formed about 5 microm from the interface, and 2.06 in the regions right at the interface.

De Salvo, B., P. Luthereau, et al. (2000). "Transport process in thin  $SiO_2$  films with an embedded 2-D array of Si nanocrystals." Microelectronics and Reliability **40**: 4-5.

This work deals with the electrical characteristics and physical properties of novel dielectric systems based on silicon nanocrystals embedded in SiO<sub>2</sub> matrices. In particular, the transport phenomena of 10 nm thick SiO<sub>2</sub> capacitors with an embedded thin layer (5 nm) of LPCVD Si nanocrystals, located at different tunneling distances from the oxide-substrate interface, are studied. An original model based on an elastic tunneling phenomenon, which allows an efficient evaluation of the main structural characteristics of Si dots, is proposed. (5 References).

Delaunay, J. J., M. Tomita, et al. (2000). "Recombination of self-trapped excitons in silicon nanocrystals grown in silicon oxide." Fizika i Tehnika Poluprovodnikov **34**(10): 1254-7.

The kinetics of photoluminescence (PL) and steady-state PL from silicon nanocrystals formed in the SiO<sub>2</sub> matrix by silicon ion implantation were studied experimentally for the first time in the temperature range from liquid-helium to room temperature. A dramatic increase in the photoluminescence decay time, accompanied by PL intensity quenching, is observed below 70 K. The results obtained indicate that the silicon nanocrystal PL arises from radiative recombination of excitons self-trapped at the silicon nanocrystal-SiO<sub>2</sub> interface. (12 References).

Delerue, C., M. Lannoo, et al. (1996). "Comment on Size dependence of excitons in silicon nanocrystals." Physical Review Letters **76**(16): 3038.

Delerue, C., M. Lannoo, et al. (2000). "Excitonic and quasiparticle gaps in Si nanocrystals." Physical Review Letters **84**(11): 2457-60.

We present calculations of the one- and two-particle excitations in silicon nanocrystals. The one-particle properties are handled in the GW approximation, and the excitonic gap is obtained from the Bethe-Salpeter equation. We develop a tight binding version of these methods to treat clusters up to 275 atoms. The self-energy and Coulomb corrections almost exactly cancel each other for crystallites with radius larger than 0.6 nm. The result of this cancellation is that one-particle calculations give quite accurate values for the excitonic gap of crystallites in the most studied range of sizes.

Delerue, C., M. Lannoo, et al. (2000). "Collective magnetic properties of cobalt nanocrystals self-assembled in a hexagonal network: Theoretical model supported by experiments." Physical Review B Condensed Matter **62**(6): 3910-16.

Numerical calculations of magnetization curves versus applied field based on a simple model taking into account dipolar interactions were performed for cobalt nanocrystals deposited on a substrate and organized in a hexagonal network. A random distribution of the easy axes orientations of the nanocrystals is considered. The study is focused on the effect of the applied field orientation relative to the substrate surface. Two orientations were chosen: parallel and perpendicular to the surface. The corresponding hysteresis loops are compared to that of a volumic random distribution of nanocrystals at vanishing concentration. The calculation results are compared to experimental data for spherical cobalt nanocrystals coated by lauric acid (C<sub>12</sub>/H<sub>25</sub>/COO<sup>-</sup>). The particles are either dispersed in hexane (considered as randomly distributed) or deposited in a hexagonal network on a highly oriented pyrolytic graphite substrate. The changes in the magnetization curves with the applied field orientation on the one hand and when going from dispersed to deposited particles on the other hand were calculated and measured. Qualitative agreement is obtained. (33 References).

Desheng, F., H. Suzuki, et al. (2000). "Visible light emission from GaAs nanocrystals in SiO<sub>2</sub> films fabricated by sequential ion implantation." Physical Review B Condensed Matter **62**(8): 5100-8.

We have studied the mechanism of visible photoluminescence (PL) in GaAs nanocrystals in SiO<sub>2</sub> matrices formed by sequential ion implantation and thermal annealing. GaAs nanocrystal samples with the average diameter of ~6 nm show a broad PL in the red spectral region. The PL peak energy of GaAs nanocrystals is blueshifted from that of the bulk GaAs crystal. Under resonant excitation at energies within the red PL band, the fine structures related to the LO phonon of the GaAs crystal are clearly observed in the PL spectrum at low temperatures. The excitation energy dependence of resonantly excited PL spectra shows that there are two different components of GaAs-related luminescence. In addition, in persistent luminescence hole-burning spectra, a pronounced hole is observed at the energy of the burning laser. The hole burnt in the luminescence spectrum has two structures related to the zero-phonon-line emission and the one-LO-phonon-assisted emission of delocalized excitons in GaAs nanocrystals. From resonantly excited PL spectra and luminescence hole-burning spectra, it is concluded that visible luminescence comes from both delocalized excitons and excitons bound to impurities in quantum-confined GaAs nanocrystals. (47 References).

Desre, P. J. (2000). "A thermodynamic model for nanocrystallization in bulk metallic glasses." Philosophical Magazine Letters **80**(6): 401-9.

The structural complexity of glass-forming alloys, which generally contain more than three components, can lead by partial crystallization during annealing to a dispersion of nanocrystals in an amorphous matrix, giving the material a very high mechanical strength. In the present study, the evolution of the driving force for crystallization

is expressed as a function of the composition and the chemical potentials of the components. Application to Zr/sub 60/Al/sub 10/Cu/sub 30/ and Zr/sub 60/Al/sub 10/Cu/sub 20/Pd/sub 10/ bulk metallic glasses shows that the first crystallization step leads to a metastable equilibrium between nanocrystals of an intermetallic and a percolating amorphous phase. The effects of the number of components and of chemical bonding on the fraction crystallized is analysed and discussed. (9 References).

Devlin, J. P. (2000). "Synthesis and structure of nanocrystal-assembled bulk GaN." Journal of Crystal Growth **209**(1): 208-12.

A new condensed form of GaN, nanocrystal-assembled bulk (NAB) GaN, was obtained directly from reactions of metal Ga and NH/sub 4/Cl in liquid ammonia at 350-500 degrees C. High-resolution transmission electron microscopy observations reveal that the NAB GaN consists of well-crystallized nanocrystals with wurtzite structure. The synchronous densified NAB GaN is transparent to visible light while the constituted nanocrystals have an average size of about 12 nm. A possible synthesis mechanism is discussed. (18 References).

Deyneka, N. P. and L. N. Larikov (2000). "Photodarkening and photobrightening in glasses doped with CdS and CdS<sub>x</sub>Se<sub>1-x</sub> nanocrystals." Japanese Journal of Applied Physics Part **39**(11): 6290-2.

The photobrightening of photodarkened CdS- and CdS/sub x/Se/sub 1-x/-doped glasses has been investigated with luminescence experiments. Photobrightening depends on the wavelength of laser light, and is observed in all samples investigated, when the wavelength of laser light is longer than that of the absorption edge. Photobrightening is explained by considering the reexcitation of trapped electrons in glass. (5 References).

Dian, J., J. Valenta, et al. (2000). "Optical properties of Si<sup>+</sup>-ion implanted sol-gel derived SiO<sub>2</sub> films." Materials Science and Engineering B Solid State Materials for Advanced Technology **70**(19): 564-9.

Optical properties of commonly investigated Si<sup>+</sup>-implanted SiO/sub 2/ layers (thin SiO/sub 2/ films prepared by thermal growth on c-Si substrate) are compared with those of non-conventional SiO/sub 2/ layers fabricated by sol-gel process. The sol-gel films, deposited on different substrates, were implanted and annealed in a similar way as the thermal SiO/sub 2/ films on c-Si. Striking differences between these two types of samples were found. The conventional Si<sup>+</sup>-implanted SiO/sub 2//c-Si layers contain Si nanocrystals and their photoluminescence (PL) properties were found very similar to porous silicon (PL in the red/NIR spectral regions, PL decay time of the order of 10 μs, PL temperature dependence well described by the exciton singlet-triplet splitting model). On the other hand, the Si<sup>+</sup>-implanted sol-gel SiO/sub 2/ films exhibit room temperature PL spectra peaked in the blue-green region, PL decay is considerably faster (of the order of 1 ns) and also PL temperature dependence differs substantially from the samples of the first type. Possible influence of different substrates (silica, c-Si) is also investigated and it is shown that the observed PL is an inherent property of the implanted sol-gel SiO/sub 2/ layers. The slow red PL, in agreement with other authors, is ascribed to radiative recombination of excitons in Si nanocrystals, while the fast blue PL characteristic of ion-implanted sol-gel derived SiO/sub 2/ films is obviously of defect origin. (16 References).

Dimitrov, D., K. Starbova, et al. (2000). "Nanocrystallization through phase separation in binary alloy films." Vacuum **58**: 2-3.

Thin Sb-Se films with compositions ranging between 70 and 80 at% Sb were deposited onto glass substrates. During and/or immediately after deposition phase separation occurs. The observed characteristic wavelength of spinodal decomposition in these films was between 10 and 20 nm. The formation of nanocrystals, predominantly Sb nanocrystals, is induced by annealing at temperatures ranging from 120 to 200 degrees C. Using XRD and TEM the crystal grain size and microstructure development were elaborated. The estimated mean crystal grain sizes were between 12 and 20 nm depending on crystal orientation and film thickness. Using non-isothermal DSC measurements thermodynamic and kinetic parameters of nanocrystallization were obtained. The estimated enthalpies of crystallization, activation energies and peak crystallization temperatures depend on both film composition and thickness. Crystallization by nucleation and growth mechanism and crystal growth from crystal clusters, developed immediately after the phase separation, were observed in these nanocrystalline films. (13 References).

Dong-Soo, Y., B. Hong Koo, et al. (2000). "Electrical properties of the Ta-RuO<sub>2</sub> diffusion barrier for high-density memory devices." Journal of the American Ceramic Society **83**(4): 949-51.

The electrical properties of a Ta layer prepared with and without RuO/sub 2/ addition were investigated. The Ta+RuO/sub 2//TiSi/sub 2//poly-Si/SiO/sub 2//Si contact system exhibited lower total resistance and ohmic characteristics up to 800 degrees C. Meanwhile, the Ta/TiSi/sub 2//poly-Si/SiO/sub 2//Si contact system showed higher total resistance and nonohmic behavior after annealing at 650 degrees C, attributed to the oxidation of both Ta and TiSi/sub 2/ layers. In the former case, a Ta+RuO/sub 2/ diffusion barrier showed an amorphous Ta microstructure and embedded RuO/sub x/ nanocrystals in the as-deposited state. The conductive RuO/sub 2/ crystalline phase in the Ta+RuO/sub 2/ film was formed by reaction between the nanocrystalline RuO/sub 2/ and oxygen indiffused from air during annealing. When the Ta layer was deposited with RuO/sub 2/ addition,

therefore, both the electrical properties and the oxidation resistance of the Ta+RuO<sub>2</sub>/ diffusion barrier were better than those of TiN, TaN, and Ta-Si-N barriers. (8 References).

Donglin, L., K. Lingbin, et al. (2000). "Effect of nanocrystalline inclusions on the photosensitivity of amorphous hydrogenated silicon films." *Fizika i Tehnika Poluprovodnikov* **34**(6): 762-5.

Photosensitivity of amorphous hydrogenated silicon films containing inclusions of Si nanocrystals, along with spectral characteristics of photoconductivity, were studied. A correlation between photosensitivity and features of the Raman spectra was established. The highest photosensitivity is observed in films with medium-range order formed to the maximum extent. (9 References).

dos Santos, D. R., I. L. Torriani, et al. (2000). "In-situ small-angle scattering study on the formation of a nanocrystalline soft-magnetic alloy." *Journal of Applied Crystallography* **33**(1): 473-7.

A detailed study is presented on the nanocrystallization of the amorphous alloy Fe<sub>36</sub>Zr<sub>7</sub>Cu<sub>1</sub>B<sub>6</sub> (indices indicate at.%). Melt-spun ribbons were rapidly annealed by Joule heating, and the electrical resistance showed strong variations during thermal treatment. X-ray diffraction patterns indicate that these variations are related to the nucleation and growth of  $\alpha$ -Fe nanocrystals, and from peak profile analysis we obtained the average grain size and crystalline volume fraction for different annealing currents. The disorder-order transition was studied by in-situ small-angle X-ray scattering during conventional furnace treatments. SAXS intensity evolution for different temperatures, both below and above the crystallization temperature of the alloy, showed that a fast atomic rearrangement leads to the formation of atomic clusters before crystallization. The evolution of the size distribution function of these clusters as a function of time and temperature was obtained assuming a polydisperse system of spherical particles. (12 References).

Dunin-Borkowski, R. E., M. R. McCartney, et al. (1998). "Magnetic microstructure of magnetotactic bacteria by electron holography." *Science* **282**(5395): 1868-70.

Off-axis electron holography in the transmission electron microscope was used to correlate the physical and magnetic microstructure of magnetite nanocrystals in magnetotactic bacteria. The magnetite crystals were all single magnetic domains, and the magnetization directions of small superparamagnetic crystals were constrained by magnetic interactions with larger crystals in the chains. Shape anisotropy was found to dominate magnetocrystalline anisotropy in elongated crystals. A coercive field between 300 and 450 oersted was determined for one chain.

Dushkin, C. D., S. Saita, et al. (2000). "The kinetics of growth of semiconductor nanocrystals in a hot amphiphile matrix." *Advances in Colloid and Interface Science* **88**(1-2): 37-78.

The first comprehensive study on the kinetics of nanocrystal growth in a hot amphiphile medium is presented. An example is given with CdSe semiconductor nanocrystals grown after the injection of precursor (a mixture of Cd- and Se-reagents) in concentrated tri-octylphosphine oxide matrix (heated to more than 300 degrees C). The particle size distribution is reconstructed as a function of time from the absorption and photoluminescence spectra collected during the synthesis process. For this purpose a new expression is used relating the exciton energy due to quantum confinement with the nanocrystal radius. The growth kinetics is considered as a two-stage process in order to describe the time variation of nanoparticle size. During the first stage, called reaction-limited growth, the size of initial nucleus rapidly increases due to a sort of surface reaction exhausting the precursor in the nanoparticle vicinity. The growth in such conditions favors also a remarkable narrowing of the size distribution. The nanocrystal develops further on account of a slow precursor transfer from a distant space driven by the concentration gradient--classical diffusion-limited growth. The width of size distribution also increases proportional to the average particle size. Any growth will stop after the precursor concentration reaches a minimum value defining the limit for the final nanocrystal size in a batch. Solving the kinetic equations for the growth rate in each case of kinetics derives analytical expressions for the mean radius and variance of size distribution. Then the respective expressions are matched in a uniform solution valid during the entire synthesis. The theoretical model is in a good quantitative agreement with the experimental data for independent syntheses. Important characteristic scales of the processes (time-constant and length) and microscopic parameters of the reacting system (interfacial energy and reaction rate constant) are estimated from the data. It turns out that the fast reaction-limited growth is important to obtain well-defined nanocrystals of high optical quality by using less energy, time and consumable. However, to make them reproducibly uniform one should control also the ultra-fast nucleation process preceding the nanocrystal growth, which is still unknown. Nevertheless, our current findings allow the conceptual design of a new continuous-flow reactor for the manufacturing of a large amount of uniform nanocrystals.

Dutta, A., L. Shao Ping, et al. (2000). "Structural changes of boron carbide induced by Zr incorporation." *Journal of Materials Science* **35**(2): 387-90.

Zr doped boron carbide (B<sub>4.3</sub>C) semiconductor was prepared by hot pressing of mixture of boron carbide powder (B<sub>4.3</sub>C) and Zr nanocrystals (0.5 at%), to investigate influence of impurity incorporation on the

subtle structure of B/sub 4/C crystals. XRD analyses indicated that the hot-pressed sample was composed of B/sub 4.3/C, (BN)4H, and (ZrB/sub 2/)3H. Zr introduction does have modified the B/sub 4.3/C structure. Especially, remarkable vacancies were led into on the B(3) sites of the C-B-C chain centre. The effect of Zr incorporation seems to be unique because similar structural change was not observed by the same experimental procedure with Ni doping. XPS studies revealed that the Zr atoms existed in a state with unsaturated bonding. B/sub 4.3/C with interstitial Zr atoms is speculated. (20 References).

Dutta, A., Y. Hayafune, et al. (2000). "Single electron memory devices based on plasma-derived silicon nanocrystals." Japanese Journal of Applied Physics Part 39(8B).

Single electron nonvolatile memory devices are fabricated using a narrow and short channel transistor and silicon nanocrystals as a floating gate. The silicon nanocrystals are deposited by very-high-frequency plasma processing. This deposition technique offers not only control of the dot size but also promises precise control of the tunnel oxide thickness. A single electron charging effect is observed for such devices at 77 K. (11 References).

El-Sayed, M. A. (2001). "Some interesting properties of metals confined in time and nanometer space of different shapes." Accounts of Chemical Research 34(4): 257-64.

The properties of a material depend on the type of motion its electrons can execute, which depends on the space available for them (i.e., on the degree of their spatial confinement). Thus, the properties of each material are characterized by a specific length scale, usually on the nanometer dimension. If the physical size of the material is reduced below this length scale, its properties change and become sensitive to its size and shape. In this Account we describe some of the observed new chemical, optical, and thermal properties of metallic nanocrystals when their size is confined to the nanometer length scale and their dynamical processes are observed on the femto- to picosecond time scale.

Engelhard, T., E. D. Jones, et al. (2000). "Epitaxial growth of single-crystal ultrathin films of bismuth on Si(111)." Japanese Journal of Applied Physics 39(7B): 4567-70.

We have studied the epitaxial growth of bismuth overlayers on Si(111) surfaces by in situ reflection high-energy electron diffraction (RHEED) and scanning tunneling microscopy (STM). Lateral growth of textured two-dimensional (2D) nanocrystals takes place after the formation of an initial disordered wetting layer on the 7\*7 DAS structure. After the coalescence of the texture 2D nanocrystals, alignment in their azimuthal orientation takes place. At slightly more than 15 monolayers, the growth front of the overlayer exhibits a perfectly long-range ordered Bi(0001)-1\*1 surface. The films prepared on Si(111)-alpha - square root 3\* square root 3-Bi or on Si(111)-beta - square root 3\* square root 3-Bi do not show as good quality as those on Si(111)-7\*7. Thus, the initial disordered wetting layer formed on the 7\*7 surface successfully accommodates the large 18% lattice mismatch between the Si(111) and Bi(0001) planes and allows the 2D nanocrystal to grow laterally. (15 References).

Eychmuller, A. (2000). "Structure and photophysics of semiconductor nanocrystals." Journal of Physical Chemistry B 104(28): 6514-28.

Nanoparticle research is still a rapidly growing field of science. Semiconductor nanocrystals of a large variety of compositions have been prepared in exceedingly good quality. State-of-the-art preparations and standard characterization methods are discussed. The build-up of more complex nanoheterostructures is reported, and their structural and electronic properties are outlined. An overview is given on recent achievements in the photophysical investigations of single nanoparticles and the application of EXAFS spectroscopy to the study of structural properties of semiconductor nanoparticles. (158 References).

Fan, C., C. Li, et al. (2000). "Nanocrystallisation of amorphous alloys: comparison between furnace and current annealing." Intermetallics 8(3): 287-91.

The mechanism of nanocrystallisation of the amorphous Fe/sub 72/Cu/sub 1/Nb/sub 4.5/Si/sub 13.5/B/sub 9/ alloy has been studied with particular attention to the early stages of crystallisation. The specimens have been nanocrystallised by furnace (FA) and current (CA) annealing and analysed by Mossbauer spectroscopy. X-ray scattering, using the beamline 5.2L at Elettra Synchrotron Source, Trieste, has been carried out on the same FA and CA samples, as well as on a previously untreated sample current heated in situ. It is found that for the same amount of nanocrystalline phase, the crystallite size in CA samples does not differ significantly from that in FA samples. Analysis of the Mossbauer spectra shows that in FA and CA samples the nanocrystalline grains consist of nonstoichiometric partially disordered Fe/sub 3/Si phase, and that there is an indication of the presence of boron atoms in the nanocrystals of CA samples. This implies a lower segregation of boron atoms or of borides at the boundaries of nanocrystallites of CA samples and can be connected to their lower brittleness. (9 References).

Feltin, N., L. Levy, et al. (2000). "Unusual static and dynamic magnetic properties of Cd<sub>1-y</sub>Mn<sub>y</sub>S nanocrystals." Journal of Applied Physics 87(3): 1415-23.

Magnetic properties of Cd<sub>1-y</sub>Mn<sub>y</sub>S nanocrystals have been studied. They vary with the particle size and markedly differ from those observed in the bulk phase, in particular their interactions drastically increase compared to those observed in the latter case. A Mn<sup>2+</sup>-Mn<sup>2+</sup> interaction enhancement with decreasing size involves changes in the magnetic phase diagram. For 4 nm nanocrystals, a spin glass phase can be assumed. (42 References).

Ferrero, A., E. Ferracini, et al. (2000). "A new X-ray study of the quenched isotactic polypropylene transition by annealing." Journal of Macromolecular Science Physics(1): 109-29.

Isotactic polypropylene (iPP) samples, quenched and then annealed at 70 degrees C, 80 degrees C, 110 degrees C, 140 degrees C, and 150 degrees C, were investigated by X-ray diffraction. The transition from the quenched form (smectic) to the well-crystallized one is analyzed to explain better the morphological-structural changes that occur by annealing. For all the samples, both the quenched and annealed ones, the alpha -monoclinic structure was assumed, with different degrees of order and crystallite dimensions. The same alpha -monoclinic structure was also assumed for the so-called amorphous phase of the polymer, described here in terms of highly disordered nanocrystals. The high degree of disorder is due, in our interpretation, mainly to the disordered fraction inside the nanocrystals, which is considered wholly amorphous. The changes induced by annealing are interpreted as a rearrangement of the alpha -monoclinic structure, which presents both I and II types of disorder. The paracrystalline parameter  $\alpha^*$ , in its more detailed formulation, is introduced to obtain a more reliable estimation of the crystallite dimensions. The analysis of the transition process evidences two annealing temperature ranges: 70 degrees C-80 degrees C, involving a rearrangement in the chain axis direction mainly, and 80 degrees C-150 degrees C, with a prevalent rearrangement first in the directions normal to the chain axis and then in the chain direction again. During the whole process, the crystallites (crystalline phase of the polymer) undergo a remarkable increase of their dimensions, while the nanocrystals (microcrystalline phase) undergo significant changes in their degree of order only. The method adopted allows a more quantitative interpretation of the transition and provides a more structural criterion to define the amorphous phase and the crystallinity in the polymer samples. (38 References).

Fick, J., A. Martucci, et al. (2000). "High temperature mechanical behavior of YSZ nanocrystals." Key Engineering Materials **171**(174): 787-92.

Compressive deformation experiments were carried out at temperatures  $T \sim 0.5 T_m$  over a range of stresses and strain rates on fully dense samples of nanocrystalline 4 mol% Y<sub>2</sub>O<sub>3</sub>-partially stabilized ZrO<sub>2</sub> with an average grain size of 40 nm. The measured creep rates are comparable or even lower than the corresponding coarse-grain rates. Microstructural observations show the formation of cavities at moderate strains. These results are opposite to expectations of enhanced superplasticity in nanocrystalline ceramics. (13 References).

Filankembo, A. and M. P. Pileni (2000). "Shape control of copper nanocrystals." Applied Surface Science **164**(1): 260-7.

In this short paper, it is demonstrated that addition of various salts differing by their counter ions markedly changes the shape of copper metal nanocrystals. These follow the Hofmeister series. (41 References).

Finlayson, C. E., D. S. Ginger, et al. (2000). "Optical microcavities using highly luminescent films of semiconductor nanocrystals." Applied Physics Letters **77**(16): 2500-2.

Colloidally grown CdSe nanocrystals with epitaxial ZnS shells show highly efficient, size-tunable luminescence. We report the incorporation of films of these core-shell nanocrystals into wavelength-scale, high-Q, planar microcavities. Under optical excitation, we find that emission from the nanocrystals couples to the discrete optical modes of the microcavity. The broad free-space emission spectrum of the nanocrystals is modified by the presence of the microcavity, giving a series of sharp emission lines with wavelengths determined by the cavity dimension. Our experiments demonstrate that microcavities with semiconductor emitters can be conveniently fabricated using spin-coating techniques. We find that, at room temperature, the microcavity emission spectrum is independent of excitation intensity for excitation densities up to approximately one electron-hole pair per nanocrystal. (21 References).

Franceschetti, A. and A. Zunger (2000). "Heat flow through an insulating nanocrystal." Physical Review E. Statistical Physics, Plasmas, Fluids, and Related Interdisciplinary Topics **61**(3): 2902-8.

We calculate the low temperature, quantum mechanical rate of heat flow through a nanocrystal due to phonon transport by solving a many-body Schrodinger equation for oscillators in Fermi resonance. By analogy to Raman scattering through molecules, we find that normal processes due to anharmonicity of the nanocrystal give rise, over an intermediate range of lengths, to a largely length-independent thermal conductivity that resembles Fourier's law, but is in fact of a different origin. For longer crystals conductivity rises with length, as predicted for a harmonic solid. For shorter nanocrystals thermal conductivity also rises with length, followed by a turnover regime in which thermal conductivity is size specific. (27 References).

Franceschetti, A. and A. Zunger (2000). "Self-assembled metal-semiconductor compound nanocrystals on group IV semiconductor surfaces." Surface Science **454**(456): 837-41.

Nanocrystals of material B may form on a substrate of material A in order to relieve the strain from the B/A crystalline mismatch. In the most simplistic approximation, if such an elastic relaxation outweighs the additional surface energy due to the island walls, it will create the thermodynamic tendency for the nanocrystal formation. Hence one can "engineer" ultra-small and crystallographically perfect nanocrystal self-assemblies by careful selection of a film/substrate system under appropriate growth conditions. In this work, intentional nanocrystal creation is demonstrated in semiconductor/semiconductor and metal/semiconductor systems, such as Ge/Si, Co/Si, and Co/Ge/Si. The growth of the nanocrystals was observed using in situ scanning tunnelling microscopy and reflection high energy electron diffraction. In spite of the marked differences in surface thermodynamics and kinetic pathways, the different material combinations lead to remarkably similar nanocrystal arrays on the surface. (30 References).

Franzo, G., V. Vinciguerra, et al. (2000). "Room-temperature luminescence from rare-earth ions implanted into Si nanocrystals." Philosophical Magazine B Physics of Condensed Matter Structural Electronic Optical and Magnetic Properties **80**(4): 719-28.

Efficient room-temperature luminescence from rare earths contained in Si nanocrystals is reported. Si nanocrystals were formed by high-dose Si implantation into SiO<sub>2</sub> followed by high-temperature annealing. Er implantation was then performed both in pure SiO<sub>2</sub> and in SiO<sub>2</sub> containing the nanocrystals. Luminescence measurements showed that the Er signal at 1.54 μm is two orders of magnitude higher in the sample containing the nanocrystals than in pure SiO<sub>2</sub>. Excitation spectroscopy demonstrated that, while within SiO<sub>2</sub> Er is excited through direct photon absorption, excitation within the nanocrystals occurs via an efficient carrier-mediated process. These data demonstrate that the non-radiative processes usually limiting Er luminescence in Si are almost absent within the nanocrystals. Extension to other rare earths (namely Tm, Yb and Nd) is reported showing that the wavelength of emission can be properly tuned. The implications of these results are discussed. (16 References).

Franzo, G., F. Iacona, et al. (2000). "Size dependence of the luminescence properties in Si nanocrystals." Materials Science and Engineering B Solid State Materials for Advanced Technology **70**(19): 454-8.

We have observed strong room temperature photoluminescence (PL) from high temperature annealed, substoichiometric silicon oxide (SiO<sub>x</sub>) thin films, prepared by plasma enhanced chemical vapor deposition. The PL peaks have been found in the 650-950 nm spectral range; peak intensities increase with the annealing temperature up to 1250 degrees C. A marked redshift of the luminescence peaks has been observed by increasing the Si concentration of the SiO<sub>x</sub> films as well as the annealing temperature. Transmission electron microscopy analyses have demonstrated that Si nanocrystals (nc), having mean radius ranging between 0.7 and 2.1 nm, are present in the annealed samples, and that their size increases with increasing the Si content and the annealing temperature. Structural and optical data have been related and discussed in terms of quantum carrier confinement. (11 References).

Franzo, G., F. Iacona, et al. (2000). "Enhanced rare earth luminescence in silicon nanocrystals." Materials Science and Engineering B Solid State Materials for Advanced Technology **70**(19): 335-9.

Efficient luminescence from rare earths ions embedded within silicon nanocrystals is reported. Samples were prepared either by high dose Si implantation into Si dioxide or by plasma enhanced chemical vapor deposition of sub-stoichiometric Si-rich oxides. In both cases nanocrystals were formed by Si precipitation and phase separation induced by high temperature annealing. Erbium was then introduced in SiO<sub>2</sub> samples containing the nanocrystals by ion implantation. Luminescence measurements showed that the Er signal at 1.54 μm is two orders of magnitude higher in the sample containing the nanocrystals with respect to pure SiO<sub>2</sub>. Moreover, this enhanced luminescence is observed also for other rare earths (namely Yb, Tm and Nd). Excitation spectroscopy demonstrated that excitation within the nanocrystals occurs via an efficient carrier-mediated process. Indeed, with increasing rare earth luminescence the intrinsic nanocrystal luminescence is seen to decrease. Furthermore, the non-radiative processes usually limiting Er luminescence in Si, are shown to be almost absent within the nanocrystals. The implications of these results are discussed. (10 References).

Franzo, G., D. Pacifici, et al. (2000). "Er<sup>3+</sup> ions-Si nanocrystals interactions and their effects on the luminescence properties." Applied Physics Letters **76**(16): 2167-9.

A detailed investigation on the interaction mechanisms between Er ions and Si nanocrystals (nc) is reported. Silicon nc were produced by high-temperature annealing of substoichiometric SiO<sub>x</sub> thin films grown by plasma-enhanced chemical vapor deposition. Subsequently, some of the samples were implanted by Er. These samples show intense room-temperature luminescence at both 1.54 and 0.98 μm. High-resolution luminescence spectra of Er-implanted Si nc suggest that the emitting Er ions are located in the SiO<sub>2</sub> or at the Si nc/SiO<sub>2</sub> interface. The pump-power dependence and the time decay of the 1.54 μm emission in Si nc with different Er contents have evidenced the presence of several nonradiative decay processes due to Er-Er

and Er-Si nc interactions. Moreover, the number of Er ions per Si nc is shown to be a quite critical parameter in determining the final properties of the overall system. (11 References).

Fu, Y., M. Willander, et al. (2000). "Carrier conduction in a Si-nanocrystal-based single-electron transistor. II. Effect of drain bias." Superlattices and Microstructures **28**(3): 189-98.

We have successfully fabricated a single-electron transistor based on undoped Si nanocrystals having radii of approximately 3-5 nm. The energy band structure of the Si dot consists of a set of discrete sublevels and a quasi-continuous band. By self-consistently solving the 3D Schrodinger and Poisson equations we have shown that the undoped Si dots between the source and drain are not occupied at zero gate bias. The carrier transport properties observed experimentally at zero gate bias have been well attributed to carrier tunneling through a multiple-step potential barrier between the source and drain junctions. Each step in the potential barrier corresponds to the bottom of the quasi-continuous band in one Si nanocrystal. (21 References).

Fu, Y., M. Willander, et al. (2000). "Multiphonon hopping conduction in nonconventional chromium-doped Bi<sub>3</sub>Pb<sub>1</sub>Sr<sub>3</sub>Ca<sub>3</sub>Cu<sub>4-n</sub>Cr<sub>n</sub>O<sub>x</sub> (n=0.025-0.2) glasses with nanocrystalline particles and clusters." Journal of Applied Physics **88**(9): 5033-42.

Transport properties of Cr containing multicomponent oxide glasses Bi<sub>3</sub>/Pb<sub>1</sub>/Sr<sub>3</sub>/Ca<sub>3</sub>/Cu<sub>4-n</sub>/Cr<sub>n</sub>/O<sub>x</sub> (n=0.025, 0.05, 0.1, and 0.2) dispersed with nanocrystalline particles (5-20 nm depending on the values of n) have been reported in the temperature range of 250-450 K. Conductivity of this glass-nanocrystal composite system shows little decrease with increasing Cr content. Above  $\theta_D/2$  ( $\theta_D$  is the Debye temperature), conductivity data can be analyzed with small polaron hopping models. Interestingly, unlike undoped Bi<sub>4</sub>/Sr<sub>3</sub>/Ca<sub>3</sub>/Cu<sub>4</sub>/O<sub>x</sub> (or Bi-4334) glasses showing nonadiabatic small polaron hopping (SPH) conduction at  $T > \theta_D/2$ , the Cr doped glasses supports adiabatic SPH conduction mechanism above  $\theta_D/2$  indicating change of glass network structure due to partial substitution of Cu by Cr. But below this temperature Mott's or Greaves' variable range hopping models can be consistently used to fit the experimental conductivity data only with larger (compared to the usual transition metal oxide glasses) values of the density of states at the Fermi level  $N(E_F)$ . The most probable transport mechanism for the entire range of temperature and glass compositions is concluded to be due to multiphonon tunneling of large polarons between the nanoclusters present in the glasses which is also in sharp contrast to the behavior of the undoped (Bi-4334) glass. All the glass samples (except  $n \geq 0.2$ ) are found to become superconductors by annealing at higher temperatures. (45 References).

Fu, B. X., Z. Wenhua, et al. (2000). "Synthesis and characterization of segmented polyurethanes containing polyhedral oligomeric silsesquioxanes nanostructured molecules." High Performance Polymers **12**(4): 565-71.

Segmented polyurethanes based on diphenylmethane-4,4'-diisocyanate and polytetramethylene glycol were synthesized using a mixture of polyhedral oligomeric silsesquioxane (POSS)-diol and 1,4-butanediol as chain extenders. The polymers were characterized by differential scanning calorimetry, wide-angle X-ray diffraction (WAXD), small-angle X-ray scattering (SAXS) and tensile property tests. Microphase separation between the hard and soft segment domains was observed in all the samples by SAXS. The increase of the POSS concentration was found to weaken the microphase separation between the domains and increase the  $T_g$  of the soft segments. The WAXD results showed that when the BOSS concentration was greater than 10 wt%, the 101 diffraction peak from the POSS crystals could be observed, which suggested the formation of POSS nanocrystals in the hard domain. The tensile property tests showed that polyurethanes containing the nanostructured POSS molecules had higher moduli, but lower maximum elongation ratios. (10 References).

Fujii, M., S. Hayashi, et al. (1999). "Excitation of intra-4f shell luminescence of rare earth ions (Er<sup>3+</sup> and Yb<sup>3+</sup>) by the energy transfer from Si nanocrystals." Journal of Nanoparticle Research **1**: 83-90.

Fujii, M., D. Kovalev, et al. (2000). "Modelling for size-dependent and dimension-dependent melting of nanocrystals." Journal of Physics D Applied Physics **33**(20): 2653-6.

A unified model, free of any adjustable parameters, for the size-dependence and dimension-dependence of melting point depression and superheating of nanocrystals is developed. In terms of the consideration of the surface/volume ratio of nanocrystals, the suppression of melting point of nanocrystals and superheating of embedded nanocrystals are predicted. The model predictions for the melting temperatures of nanocrystals are consistent with the experimental results and molecular dynamics simulations. (34 References).

Fujii, M., S. Hayashi, et al. (2000). "Noninertial mechanism for electronic energy relaxation in nanocrystals." Physical Review B Condensed Matter **62**(14): 9398-401.

The low-frequency vibrational spectrum of an isolated nanometer-scale solid differs dramatically from that of a bulk crystal, causing the decay of a localized electronic state by phonon emission to be inhibited. We show, however, that an electron can also interact with the rigid translational motion of a nanocrystal. The form of the coupling is dictated by the equivalence principle and is independent of the ordinary electron-phonon interaction.

We calculate the rate of nonradiative energy relaxation provided by this mechanism and establish its experimental observability. (26 References).

Fujii, M., A. Mimura, et al. (2000). "Exciton self-trapping in AgCl nanocrystals." Physical Review B Condensed Matter **61**(3): 1847-52.

Self-trapping of excitons is reported in AgCl nanocrystals embedded in a crystalline KCl matrix. The particles, observed by atomic force microscopy, have radii of several nanometers. Due to the spatial confinement only recombination of the self-trapped exciton (STE) is observed. STE(Br/sup -/) and donor-acceptor pair recombination are absent. The time and temperature behavior of the emission is found to be significantly different from that in bulk AgCl. It is concluded that this is due to different self-trapped exciton configurations: The diffuse electron is spatially confined and centered in the nanocrystal whereas the compact hole, self-trapped at different lattice sites, causes variations in wave-function overlap in the different STEs. Optically detected magnetic resonance measurements reveal changes in g-values and a decrease by a factor of two in the magnitude of the zero-field splitting of the triplet state. They also demonstrate that the AgCl nanocrystal lattice axes are oriented along the axes of the KCl matrix. (20 References).

Fukuda, T., K. Shimamura, et al. (2000). "Growth of new fluoride single crystals for optical applications." Digest of Papers Microprocesses and Nanotechnology(00EX387): 258-9.

A new, highly reproducible crystal growth technique for high quality fluorides has been developed. A series of fluorides free from cracks and inclusions has been grown for UV optical applications. (0 References).

Furuya, K., N. Ishikawa, et al. (1999). "In-situ observation of shape and atomic structure of Xe nanocrystals embedded in aluminium." Journal of Microscopy **194**(1): 152-160.

An imaging technique to determine in situ the shape and atomic structure of nanosized Xe crystals embedded in Al is described using high-resolution transmission electron microscopy (HRTEM). The Xe nanocrystals, with sizes less than 5 nm were prepared by the implantation of 30 keV Xe<sup>+</sup> into Al at room temperature. The fcc Xe nanocrystals are mesotactic with the Al lattice and have a lattice parameter approximately 50% larger than that of Al. HRTEM images of the Xe were not clear in [110] zone axis illumination because of the small number of Xe atoms relative to Al atoms in any atom column. An off-axial imaging technique that consists of tilting the specimen several degrees from a zone axis and defocusing to suppress the Al lattice fringes is employed for the 110 projection of the Xe/Al system and the structure of the Xe nanocrystals is successfully imaged. The Xe images clearly represent projections of cuboctahedra with faces parallel to eight Al {111} planes truncated by six {100} planes. The results of multislice image simulations using a three-dimensional atomic model agreed well with the results obtained by the off-axial imaging technique. The usefulness of the technique is demonstrated with observations of crystal defects introduced into the Xe under intense 1000 keV electron irradiation.

Furuya, K., K. Mitsuishi, et al. (2000). "Size-induced phase transition in PbTiO<sub>3</sub> nanocrystals: Raman scattering study." Physical Review B Condensed Matter **62**(5): 3125-9.

We report a Raman scattering study of PbTiO<sub>3</sub> (PT) nanocrystals prepared by a sol-gel method at a low temperature of 400 degrees C. The Raman spectra indicated the existence of a stable ferroelectric phase in the PT nanocrystals at room temperature. The temperature dependence of the spectrum revealed the appearance of a new phase transition in the 7-nm PT nanocrystals in the region of 166 degrees C. This was attributed to the phase transition between C<sub>4v</sub> and C<sub>2v</sub> point groups induced by the size reduction of the PT crystals to nanoscale. This feature is significantly different from that observed for conventional PT materials in which only the tetragonal phase is detectable below 493 degrees C. (26 References).

Gang, X., W. Guobao, et al. (2000). "Synthesis of nanometer-sized hematite single crystals through NAC-FAS method." Journal of Materials Science **35**(4): 943-9.

Nanometer-sized spherical hematite single crystals were prepared by heating the precipitate which was synthesized from Fe(OH)(CH<sub>3</sub>/COO)<sub>2</sub> and NaOH in alkaline ethanol-water solutions without the deliberate addition of surfactants or adsorbing ligands. Hematite nanocrystals (5-10 nm in diameter) and ferrihydrite (<5 nm) were obtained from the mixture of H<sub>2</sub>O/EtOH (Rs)=100 ml/100 ml as a initial medium, whereas goethite, hematite (20-40 nm), and ferrihydrite were precipitated at Rs=200/0. Adsorbing ligands such as acetoxo groups and ethanol on particles retarded the hematite growth and goethite formation. TEM observation of the particles prepared at Rs=100/100 with heat treatment at 400 degrees C for 2 hours showed them consisting of single spherical hematite crystals 22 nm in mean diameter with narrow size distribution. Various individual effects were investigated for their contributions to crystal structure and size of precipitates; they included NaOH to Fe(OH)(CH<sub>3</sub>/COO)<sub>2</sub> ratio, solvent, dropping rate of alkaline solution, and aging time. (27 References).

Gang, X. and M. Zhen Hong (2000). "Preparation and magnetic properties of Ba<sub>2</sub>Co<sub>2</sub>Fe<sub>28</sub>O<sub>46</sub> nanocrystals." Journal of Applied Physics **88**(1): 519-23.

Ba<sub>2</sub>/Co<sub>2</sub>/Fe<sub>28</sub>/O<sub>46</sub> nanocrystals were synthesized through a stearic acid sol-gel method.

The reaction temperatures were notably lower than that of the conventional ceramic method. The nanocrystalline particles obtained at 750 degrees C were spherical in shape with grain sizes ranging from 10 to 25 nm. Their morphology became more cubic as the heat-treatment temperature was increased. The surface composition of the nanocrystals was found to be different from that of the bulk Ba/sub 2/Co/sub 2/Fe/sub 28/O/sub 46/, exhibiting a higher content of Ba and Co. The magnetic properties of these samples are clearly size dependent. The specific saturation magnetization is lower than that of bulk Ba/sub 2/Co/sub 2/Fe/sub 28/O/sub 46/ and inversely proportional to the grain size D. This can be explained by assuming the existence of a nonmagnetic layer on the surface of the particles. The coercivity of Ba/sub 2/Co/sub 2/Fe/sub 28/O/sub 46/ nanocrystals reaches a maximum when the particle sizes are approximately equal to 70 nm and then decreases by a factor of 3 as the particle size is further reduced. These results are attributed to superparamagnetic effects in a random distribution of single domain ferromagnetic particles. (29 References).

Gao, Y. and S. A. Elder (2000). "TEM study of TiO<sub>2</sub> nanocrystals with different particle size and shape." Materials Letters **44**: 3-4.

TiO/sub 2/ anatase nanocrystals deposited on carbon films from colloidal solutions have been characterized using transmission electron microscopy (TEM). The TiO/sub 2/ nanocrystals exhibit different sizes, shapes, and facets, depending on the pH value and the type of organic additives in the colloidal solutions. Typically, high pH value results in small cubic-like nanocrystals with {112} and {103} faces, while low pH value leads to truncated tetragonal nanocrystals with {101}, {001} and {010} faces. Excess dilution of the particle density appears to cause partial dissolution of the cubic-like TiO/sub 2/ nanocrystals to form spherical nanocrystals. (10 References).

Gaponenko, S. V., V. N. Bogomolov, et al. (2000). "Spontaneous emission of organic molecules and semiconductor nanocrystals in a photonic crystal." Journal of Luminescence **87**(89): 152-6.

Photonic crystals based on artificial colloidal silica crystals (opals) exhibit pronounced stop bands for electromagnetic wave propagation and the corresponding modification of the photon density of states in the visible range. Doping of these structures with dye molecules and semiconductor nanoparticles (quantum dots) provides a possibility to examine the predictions of the inhibited spontaneous emission in photonic band-gap materials. First experiments are reviewed in which pronounced modification of spontaneous emission spectra and noticeable changes in decay kinetics were observed. (20 References).

Garcia-Mendez, M., F. F. Castillon, et al. (2000). "Imaging and modeling of nanocrystalline Xe in Al containing defects." Materials Science and Engineering A Structural Materials Properties Microstructure and Processing: 1-2.

Morphological and crystallographic structures of a Xe nanocrystal embedded in Al were determined with off-Bragg high-resolution transmission electron microscopy (OB-HRTEM). The nanocrystals have a size in a range from 1 to 10 nm and precipitate with a FCC structure, mesotactically aligned with Al matrix. OB-HRTEM revealed Xe cuboctahedron crystals with faces parallel to eight Al {111} planes truncated by six {100} planes. Atomic resolution microscopy indicates that the nanocrystals often contain lattice defects, which consist of a stacking fault. Simulated images for a nanocrystal containing a stacking fault agreed well with experimental images. The process of a defect introduction into a nanocrystal was successfully recorded on videotape. A frame by frame analysis shows the introduction of a Shockley partial dislocation to form the fault. This introduction requires the motion of atoms in several layers in one side of the fault, to relax the strain caused by the change in stacking sequence. (13 References).

Garrido, B., M. Lopez, et al. (2000). "Electrical conductivity enhancement in nanocrystalline (RE<sub>2</sub>O<sub>3</sub>)<sub>0.08</sub>(ZrO<sub>2</sub>)<sub>0.92</sub> (RE=Sc, Y) thin films." Applied Physics Letters **77**(21): 3409-11.

Dense, crack-free, uniform, and homogeneous (RE/sub 2/O/sub 3)/sub 0.08/(ZrO/sub 2)/sub 0.92/ (RE=Sc, Y) nanocrystalline thin films were fabricated by a simple sol-gel method and characterized by impedance studies. At temperatures beyond 600 degrees C, the electrical conductivity of (Sc/sub 2/O/sub 3)/sub 0.08/(ZrO/sub 2)/sub 0.92/ and (Y/sub 2/O/sub 3)/sub 0.08/(ZrO/sub 2)/sub 0.92/ nanocrystals in pure cubic phase was ten times higher than that of the corresponding bulk materials. The decrease of grain boundary resistance related to interfacial effect is predominately responsible for the electrical conductivity enhancement. (20 References).

Ginger, D. S., A. S. Dhoot, et al. (2000). "Second-harmonic and sum-frequency imaging of organic nanocrystals with photon scanning tunneling microscope." Applied Physics Letters **77**(19): 2946-8.

Second-harmonic generation and sum-frequency generation with photon scanning tunneling microscopy and shear-force detection are used to map the nonlinear optical response and the surface topograph of N-(4-nitrophenyl)-(L)-prolinol crystals with a subdiffraction-limited resolution. The domain-size dependence of the spatial feature is obtained, which shows the local orientational distribution of the optical near field radiated by nonlinear nanocrystals and reveals the difference between nanoscopic and macroscopic second-order optical nonlinearities of molecular crystals. (27 References).

Ginger, D. S. and N. C. Greenham (2000). "Charge injection and transport in films of CdSe nanocrystals." Journal of

Applied Physics **87**(3): 1361-8.

We have studied charge injection and charge transport in thin disordered films of CdSe nanocrystals between metal electrodes. Current-voltage characteristics of these devices are investigated as a function of electrode material, nanocrystal size, and temperature. We measure the photocurrent response of these structures and find that the photocurrent action spectra follow the quantum-confined absorption spectra of the nanoparticles. For dissimilar top and bottom electrodes, we find that the devices are highly rectifying. High work function materials such as gold and indium-tin oxide are found to be poor electron injectors, consistent with the estimated conduction and valence band levels of the nanocrystals. We observe that the current-voltage characteristics exhibit a history and time dependence which is characteristic of persistent photoconductivity, with current at constant bias decaying with time according to a stretched exponential form. We propose a model based on space-charge limited current dominated by mobile electrons which slowly fill deep traps. Numerical simulations show that the model is able to describe the observed time dependence. We also find that the conductivity is strongly temperature dependent, and is qualitatively consistent with an activated hopping process at temperatures above 180 K. We use the data and simulations to estimate the electron mobilities to be in the range of  $\sim 10^{-4}$  to  $10^{-6}$  cm<sup>2</sup>/V s and the trap densities to be approximately  $2 \times 10^{16}$  cm<sup>-3</sup>. (35 References).

Glinka Yu, D., S. H. Lin, et al. (2000). "Dynamics of optical nonlinearity of Ge nanocrystals in a silica matrix." Applied Physics Letters **77**(24): 3926-8.

The optical nonlinearity and excited carrier lifetime in Ge nanocrystals (nc-Ge) embedded in a silica matrix have been investigated by means of single beam z scan and pump-probe techniques with laser pulse duration of 35 ps and 532 nm wavelength. The nc-Ge samples were prepared using magnetron cosputtering and postgrowth annealing at 800 degrees C. The nonlinear absorption coefficient  $\alpha$  and refractive index  $n$  were found to range between 190 and 760 cm/GW, and 0.0026 and 0.0082 cm<sup>2</sup>/GW, respectively, and be proportional to the Ge concentration in the film. The confined excited carriers were found to depopulate with a lifetime of  $\sim 70$  ps. The nonlinearity in Ge nanocrystals is deduced to originate mainly from excited carrier absorption, with two-photon absorption providing a small contribution. (17 References).

Gogolin, O., G. Mshvelidze, et al. (2000). "Photoluminescence and free-electron absorption in heavily phosphorus-doped Si nanocrystals." Physical Review B Condensed Matter **62**(19): 12625-7.

Heavily phosphorus-doped Si nanocrystals several nanometers in diameter are studied by photoluminescence (PL) and optical absorption spectroscopy. It is demonstrated that P doping results in the quenching of the PL. The quenching is accompanied by the appearance of the optical absorption in the infrared range. The absorption was assigned to the intravalley transitions of free electrons generated by P doping (free-electron absorption). The generation of free electrons and the resultant three-body Auger recombination of excitons is considered to be responsible for the observed PL quenching. (19 References).

Goldfarb, I. and G. A. D. Briggs (2000). "Dielectric confinement effects on nonlinear optical susceptibilities of semiconductor-dielectric composites." Japanese Journal of Applied Physics Part **39**(7A): 3971-6.

The dielectric confinement effect on the nonlinear optical properties of composite materials is studied using the effective medium approximation. It is shown that both off-resonance and resonance dielectric enhancement of nonlinear susceptibilities occur in semiconductor particles doped in linear dielectric materials. Resonance enhancement of third-order susceptibility is associated with excitations of the surface exciton polaritons of the electric multipole modes in the semiconductor particles. The resonance frequency shows a blue shift with the volume fraction of the semiconductor. The effect is numerically evaluated for direct band-gap semiconductors such as CuCl, CdS and GaAs nanocrystals doped in glass. (19 References).

Golikova, O. A. and M. M. Kazanin (2000). "On the grain size dependent solute and particle drag." Scripta Materialia **42**(12): 1199-206.

It is shown that the grain size dependent solute drag decreases the rate of grain growth in nanocrystals but is incapable to stop it completely. In the framework of uniform boundary model the parabolic grain growth law is transformed into a mixed cubic-parabolic law. The model of grain size dependent particle drag is developed. This model is relevant for the nanocrystal with the grain boundaries (GBs) saturated with impurities from the early beginning of grain growth process. The excess impurities precipitate in the GB particles which then exert the pinning force on GBs. The model demonstrates the dynamic behaviour very similar to the behaviour of the model with the grain size dependent solute drag. The process of grain growth cannot be stopped. It is shown that at the initial stages the grain growth process can be associated with the series of the breakaway events of the GBs from the dragged particles. At the later stages the steady-state growth is stable and no breakaway occurs. The kinetic grain growth diagram is constructed which describes the character of grain growth and GB migration (jerky or steady state). (9 References).

Gonzalo, J., R. Serna, et al. (2000). "Influence of the deposition parameters on the synthesis of nanocomposite materials

produced by pulsed laser deposition." Applied Surface Science **154**(155): 449-53.

Nanocomposite films formed by Cu nanocrystals (NCs) embedded in an amorphous Al/sub 2/O/sub 3/ host have been produced by pulsed laser deposition (PLD). The role of the laser fluence and the pressure of the Ar buffer gas, in the 10/sup -6/-10/sup -1/ Torr range, on both the structural and non-linear optical properties of the nanocomposite films have been studied. The analysis of the structural properties suggests that the nucleation and growth of the NCs occurs at the substrate, even if the deposition takes place in a low pressure of Ar. The non-linear optical response of the films is enhanced by increasing either the density or the anisotropy of the NCs. (18 References).

Goryachev, D. N., G. Polisskii, et al. (2000). "Wet chemical synthesis of highly luminescent HgTe/CdS core/shell nanocrystals." Advanced Materials **12**(2): 123-5.

Very strong, broad photoluminescence (PL) in the near infrared is displayed by colloidal HgTe nanocrystals. However, they are not stable over time-the PL moves to longer wavelengths, accompanied by an apparent drop in the quantum efficiency-which causes concern for the use of these materials in device applications. Here, capping of the HgTe nanocrystals with a layer of CdS, in order to produce a physically stable core/shell heterostructure, is reported. Optical absorption, PL, X-ray diffraction, and high-resolution TEM are used to characterize the resulting HgTe/CdS material. (15 References).

Goswami, R., H. Herman, et al. (2000). "Orientational and translational ordering of sub-monolayer films of passivated multiply-twinned gold clusters." Journal of Physics D Applied Physics **33**(2).

The influence of the substrate on the translational and orientational ordering in sub-monolayer films of passivated multiply-twinned gold clusters has been investigated using high resolution and dark field transmission electron microscopy. Although clear differences were observed in the degree of translational ordering on amorphous carbon and etched silicon substrates, there was no corresponding variation in the crystallographic orientation of the nanocrystal cores. The results demonstrate that the orientation of passivated clusters with multiply-twinned cores is effectively random with respect to both the superlattice and the substrate. (20 References).

Goto, T., T. Hosokawa, et al. (2000). "Self-trapped excitons in ultrathin Pbl<sub>2</sub> nanocrystals embedded in a polymer." Journal of the Physical Society of Japan **69**(2): 611-17.

We have found broad band luminescence due to a self-trapped exciton (STE) and disappearance of a free exciton luminescence in ultrathin nanocrystals of Pbl/sub 2/ embedded in ethylene-methacrylic acid copolymer at 77 K. This fact suggests that the STE becomes stable because of a rise in the lowest free exciton level due to size quantization. The Stokes shift in the two- and three-monolayer nanocrystals is found to be larger in comparison with that in more than four monolayer nanocrystals, from luminescence spectra in the size selective excitation. From this larger Stokes shift, it is imagined that a quasi-two-dimensional STE strongly interacts with an acoustic phonon characteristic of the ultrathin crystal. Moreover we observed temporal behavior of the STE luminescence in various excitation intensities. In very weak excitation, the STE luminescence shows a slow single exponential decay with a time constant of 330 mu s. This means that an isolated STE in a nanocrystal is in a spin-triplet state and annihilates radiatively. In strong excitation, the STE luminescence decays faster and shows non-exponential decay. From this fact and the additional fact that the quantum efficiency of the STE luminescence is independent of the excitation intensity, it is thought that wave functions of the nearest two STEs overlap with each other, resulting in a singlet-triplet mixing caused by a spin-orbit interaction. (13 References).

Grom, G. F., D. J. Lockwood, et al. (2000). "Preparation and optical properties of CdSe/polymer nanocomposites." Scripta Materialia **43**(6): 567-71.

It was shown that tri-n-octylphosphine oxide (TOPO) capped CdSe nanocrystals prepared by the single source approach may be successfully used as starting materials to produce inorganic/polymer nanocomposites. The CdSe/polymer composites still show optical properties that are associated to quantum size effects intrinsic to the CdSe nanocrystals used. This suggests that the preparation of a wide range of novel nanocomposites is possible once the particles surface becomes compatible with the polymer matrix by using a convenient capping agent, such as TOPO, during the synthetic process. (17 References).

Guha, S., S. B. Qadri, et al. (2000). "Characterization of Si nanocrystals grown by annealing SiO<sub>2</sub> films with uniform concentrations of implanted Si." Journal of Applied Physics **88**(7): 3954-61.

We have performed physical and optical characterization of Si nanocrystals grown by ion implantation of Si/sup +/ ions at multiple energies with varying doses into thermally grown SiO/sub 2/ films. The purpose of multiple implants was to achieve uniform composition of the added Si profile throughout the SiO/sub 2/ film to produce Si particles with a narrow size distribution upon annealing at 1000 degrees C in a nitrogen atmosphere. The depth distribution of the composition and sizes of the Si particles in SiO/sub 2/ films before and after the anneal were determined using Rutherford backscattering (RBS), forward recoil spectroscopy, small-angle X-ray diffraction (SXRD), and high-resolution transmission electron microscopy (HRTEM). From RBS we concluded that the amount of free silicon was reduced by annealing, presumably due to oxidation in the annealing process. The

mean cluster sizes of the annealed samples were determined by SXRD. HRTEM was also employed to determine the average size of Si particles. Photoluminescence spectra (PL) from these samples were broad and the peak positions of the PL spectra were blue-shifted with decreasing cluster size. The line shapes of the PL spectra were calculated with a quantum confinement model assuming a log-normal size distribution of Si nanoparticles and  $(1/D)^{1.25}$  dependence of the band gap energy as a function of particle size  $D$ . The band gap energy and the average particle size obtained from the calculated line shape spectra agree well with the quantum confinement model. (14 References).

Gupalov, S. V. and E. L. Ivchenko (2000). "Photoluminescence from mesoporous silica: Similarity of properties to porous silicon." Applied Physics Letters **77**(24): 3968-70.

Photoluminescence (PL) from mesoporous silica (MS) with the pore size of ~6 nm and the thickness of walls among pores of ~1 nm has been studied at room temperature. The heat pretreatment of MS in air at different temperatures and the variation of the excitation wavelengths allow one to shift the PL peak through the whole visible spectral range. The PL is suggested to originate from nonbridging oxygens (red bands), hydrogen-related species (green bands), and water-carbonyl groups (blue bands). The spectroscopic properties of MS are found to be similar to those of surface-oxidized silicon nanocrystals and porous silicon. (20 References).

Gupalov, S. V. and I. A. Merkulov (2000). "Size quantization of acoustic phonons in CuCl nanocrystals." Pis'Ma: 71-5.

It is shown that the mixed character of spheroidal vibrational modes of semiconductor quantum dots of spherical shape may lead to the appearance of a line in the low-frequency Raman spectra of nanocrystals whose spectral position is independent of the average radius of nanocrystals in the sample over a wide range of sizes. This effect is associated with the rapid saturation of the dispersion dependence for transversal acoustic phonons in the bulk semiconductor. The maximum radius of quantum dots at which the line indicated above is observed in the spectrum has been estimated. (14 References).

Gupta, A., N. Bhagat, et al. (2000). "Phase transformation and conductivity in nanocrystal PbS under pressure." Journal of Applied Physics **87**(5): 2658-60.

The grain-size effect on the phase transition induced by pressure in PbS was studied by in situ high-pressure electrical resistance and synchrotron radiation X-ray powder diffraction measurements. The mean transition pressure of the B1-to-B16 phase transformation was found to be  $6.3 \pm 1.3$  GPa in  $8 \pm 1$  nm PbS while it is  $3.1 \pm 0.7$  GPa for 10 nm PbS. The resistivity of the B16 PbS phase decreases exponentially with pressure in both samples at ambient temperature. They follow  $R$  varies as  $\exp(-CP)$ , where  $C = -0.64$  GPa<sup>-1</sup> for 10 nm PbS and  $C = -0.34$  GPa<sup>-1</sup> for  $8 \pm 1$  nm PbS. These results are discussed in terms of a decrease of energy band gap with increasing pressure. (16 References).

Gutierrez-Mora, F., M. Jimenez-Melendo, et al. (2000). "Improvement in photoluminescence efficiency of SiO<sub>2</sub> films containing Si nanocrystals by P doping: An electron spin resonance study." Journal of Applied Physics **87**(4): 1855-7.

SiO<sub>2</sub>/sub 2/ and phosphosilicate glass (PSG) films containing Si nanocrystals (nc-Si) as small as a few nanometers were studied by electron spin resonance (ESR) and photoluminescence (PL), and the correlation between the two measurements was examined. It is shown that the incorporation of nc-Si in SiO<sub>2</sub>/sub 2/ results in the drastic increase in the ESR signal; the signal is assigned to the Si dangling bonds at the interfaces between nc-Si and matrices (P/sub b/ centers). The ESR signal becomes weaker by doping P into SiO<sub>2</sub>/sub 2/ matrices, i.e., by using PSG as matrices. By increasing the P concentration, the ESR signal decreases further. By decreasing the ESR signal, the low-energy PL peak at 0.9 eV decreases, while the band-edge PL at 1.4 eV increases. These results suggest that the 0.9 eV peak is related to P/sub b/ centers, and that the decrease in the density of the P/sub b/ centers by P doping brings about an improvement in the band-edge PL efficiency of nc-Si. (11 References).

Haase, M., K. Riwotzki, et al. (2000). "Superheating of nanocrystals embedded in matrix." Chemical Physics Letters **322**(6): 549-52.

In terms of a model for size-dependent melting and the Lindemann criterion, a model to interpret superheating of nanocrystals embedded in a matrix has been developed. When a ratio,  $\alpha$ , between the mean square displacement of the surface atoms and that of interior ones for the nanocrystals, is smaller than 1, superheating arises when the nanocrystals have coherent or semi-coherent interfaces with the matrix which has a higher melting temperature than the nanocrystals. Moreover, the atomic diameter of the matrix should be smaller than that of the nanocrystals. The model prediction shows good agreement with the experimental evidence. (23 References).

Haase, M., K. Riwotzki, et al. (2000). "Synthesis and properties of colloidal lanthanide-doped nanocrystals." Journal of Alloys and Compounds **303**(304): 191-7.

Colloidal solutions and redispersible powders of nanocrystalline, lanthanide-doped phosphates and vanadates have been prepared in high-boiling coordinating solvents or by hydrothermal means in aqueous solution. Highly

crystalline materials were obtained by both methods despite the low temperature of 200 degrees C applied during the synthesis. The materials have been characterized by using high-resolution TEM, powder-XRD, absorption spectroscopy and luminescence spectroscopy. By analyzing line splitting and intensity pattern in the luminescence spectra of the europium-doped samples, we are able to verify that the dopant ions enter the same lattice sites as in the corresponding bulk material. Size-selected samples of hydrothermally prepared lanthanide-doped YVO<sub>4</sub> consist of particles ranging in size from about 10 to 30 nm. The nanoparticles exhibit the tetragonal zircon structure known for bulk material. In the case of LaPO<sub>4</sub> the hydrothermal method yields nanoparticles or nano-fibers (width of about 9 nm) depending on the synthesis conditions, while the synthesis in high-boiling solvents yields colloids with a very narrow size distribution and a mean particle size of 4.5 nm. All LaPO<sub>4</sub>-nanomaterials exhibit the monazite-structure, irrespective of their morphology or size. In all systems investigated, energy transfer between the host and the dopant ions is observed. Upon UV excitation, aqueous colloidal solutions of YVO<sub>4</sub>:Eu nanoparticles show a luminescence quantum yield of 15% at room-temperature. In LaPO<sub>4</sub>:Ce, Tb energy transfer is observed between cerium and terbium ions. (39 References).

Haiping, S., L. Dongmei, et al. (2000). "Zn nanocrystals discovered from pencil-core." Journal of Materials Science Letters **19**(10): 875-8.

The authors report a TEM investigation of Zn nanocrystals discovered by evaporating of pencil-core in a vacuum chamber. Growth mechanism of the Zn nanocrystals is discussed. (8 References).

Haishan, B., G. Faming, et al. (2000). "Crystallization and melting behavior of nanopolymeric particles containing single or a few chains." Journal of Macromolecular Science Physics(1): 93-108.

Samples of nanopolymeric particles, each containing a single chain or a few chains, were prepared by a freeze-drying method from dilute solutions of isotactic polystyrene (iPS) in benzene. Thermal analysis of the particle samples revealed that the cold crystallization temperature greatly decreases and the crystallization rate remarkably increases as the solution concentration decreases. The increase in crystallization rate can be attributed to fewer interchain entanglements within and between particles, thus proving experimentally for the first time that entanglements can be a large barrier to the crystallization of polymers. Annealing of the particle samples at 373.2 K slightly changed the crystallization behavior, indicating that the interdiffusion of chains between these particles is rather sluggish in the vicinity of T<sub>g</sub> of bulk iPS. Crystallization is assumed to be accomplished before the chain interdiffusion, and nanocrystals form in situ within compact single- and few-chain globules. The average size of crystals is larger than that of single-chain crystals because the single-chain crystals may initiate other chains to crystallize on the growing crystal surface. Meanwhile, we also found that the nanocrystals have a lower melting temperature than the bulk polymer as a result of their small size. (47 References).

Hall, C. S., J. N. Marsh, et al. (2000). "Analysis of the noble metal catalytic additives introduced by impregnation of as obtained SnO<sub>2</sub> sol-gel nanocrystals for gas sensors." Sensors and Actuators B Chemical: 1-3.

In order to clarify the role of the noble metal additives in the gas sensing mechanisms, three of the most common catalytic additives, such as Pd, Pt and Au, have been introduced in a sol-gel obtained tin oxide base material. The additives nominal weight concentrations used were 0.2% and 2%, and they were introduced in the precipitated tin oxide. A posterior calcination treatment was carried out, during 8 h, at the temperatures of 250 degrees C, 400 degrees C, 450 degrees C, 600 degrees C, 800 degrees C and 1000 degrees C. Structural and surface analysis of these nanopowders have been performed. Identification and localisation of metallic, 2+ and 4+ oxidised states of the used noble metals are discussed, and experimental evidence about their effects on the sensor performance is presented. Likewise, effects of their presence on the nanoparticle characteristics, and also on the material sensitivity to CO and CH<sub>4</sub>, are analysed and discussed. (40 References).

Hamanaka, Y., N. Hayashi, et al. (2000). "Dispersion of third-order nonlinear optical susceptibility of silver nanocrystal-glass composites." Journal of Luminescence **87**(89): 859-61.

We have investigated dispersion of third-order nonlinear optical susceptibility,  $\chi^{(3)}$ , for a silver nanocrystal-glass composite around the surface plasmon resonance band. A real and an imaginary part of  $\chi^{(3)}$  have been separately measured by a Z-scan method. The maximum value of imaginary  $\chi^{(3)}$  is  $-1.5 \times 10^{-10}$  esu at 2.97 eV and the real  $\chi^{(3)}$  value ranges from  $-4.4 \times 10^{-11}$  to  $+4.4 \times 10^{-11}$  esu. We have calculated dispersion curves of the composite assuming that the real and imaginary parts of dielectric constant of metal nanocrystals are changed due to the creation of hot electrons by optical excitation. The dispersion curves near the surface plasmon band show features characteristic of the composite system, which is not described by a two-level atomic model. (9 References).

Han, M., X. Gao, et al. (2001). "Quantum-dot-tagged microbeads for multiplexed optical coding of biomolecules." Nature Biotechnology **19**(7): 631-5.

Multicolor optical coding for biological assays has been achieved by embedding different-sized quantum dots (zinc sulfide-capped cadmium selenide nanocrystals) into polymeric microbeads at precisely controlled ratios.

Their novel optical properties (e.g., size-tunable emission and simultaneous excitation) render these highly luminescent quantum dots (QDs) ideal fluorophores for wavelength-and-intensity multiplexing. The use of 10 intensity levels and 6 colors could theoretically code one million nucleic acid or protein sequences. Imaging and spectroscopic measurements indicate that the QD-tagged beads are highly uniform and reproducible, yielding bead identification accuracies as high as 99.99% under favorable conditions. DNA hybridization studies demonstrate that the coding and target signals can be simultaneously read at the single-bead level. This spectral coding technology is expected to open new opportunities in gene expression studies, high-throughput screening, and medical diagnostics.

Hanzlik, M., C. Heunemann, et al. (2000). "Superparamagnetic magnetite in the upper beak tissue of homing pigeons." Biomaterials **13**(4): 325-31.

Homing pigeons have been subject of various studies trying to detect magnetic material which might be involved in magnetic field perception. Here we focus on the upper-beak skin of homing pigeons, a region that has previously been shown to contain nerves sensitive to changes of the ambient magnetic field. We localized Fe<sup>3+</sup> concentrations in the subcutis and identified the material by transmission electron microscopy (TEM) as aggregates of magnetite nanocrystals (with grain sizes between 1 and 5 nm). The particles form clusters of 1-3 microm diameter, which are arranged in distinct coherent elongated structures, associated with nervous tissue and located between fat cells. Complementary low-temperature magnetic measurements confirm the microscopic observations of fine-grained superparamagnetic particles in the tissue. Neither electron-microscopic nor magnetic measurements revealed any single-domain magnetite in the upper-beak skin tissue.

Harrison, M. T., S. V. Kershaw, et al. (2000). "Shape control of CdSe nanocrystals." Nature **404**(6773): 59-61.

Nanometre-size inorganic dots, tubes and wires exhibit a wide range of electrical and optical properties that depend sensitively on both size and shape, and are of both fundamental and technological interest. In contrast to the syntheses of zero-dimensional systems, existing preparations of one-dimensional systems often yield networks of tubes or rods which are difficult to separate and, in the case of optically active II-VI and III-V semiconductors, the resulting rod diameters are too large to exhibit quantum confinement effects. Thus, except for some metal nanocrystals, there are no methods of preparation that yield soluble and monodisperse particles that are quantum-confined in two of their dimensions. For semiconductors, a benchmark preparation is the growth of nearly spherical II-VI and III-V nanocrystals by injection of precursor molecules into a hot surfactant. Here we demonstrate that control of the growth kinetics of the II-VI semiconductor cadmium selenide can be used to vary the shapes of the resulting particles from a nearly spherical morphology to a rod-like one, with aspect ratios as large as ten to one. This method should be useful, not only for testing theories of quantum confinement, but also for obtaining particles with spectroscopic properties that could prove advantageous in biological labelling experiments and as chromophores in light-emitting diodes. (26 References).

Harrison, M. T., S. V. Kershaw, et al. (2000). "Wet chemical synthesis and spectroscopic study of CdHgTe nanocrystals with strong near-infrared luminescence." Materials Science and Engineering B Solid State Materials for Advanced Technology **70**(19): 355-60.

Several series of CdHgTe composite nanocrystals were prepared using a wet-chemical colloidal technique. The synthesis began using CdTe nanocrystal precursors stabilised using 1-mercapto-2,3-propanediol (1-thioglycerol) to which subsequent layers of HgTe and CdTe were added in an attempt to form both CdTe/HgTe core/shell and CdTe/HgTe/CdTe quantum dot quantum well (QDQW) structures. The room temperature photoluminescence (PL) spectra of the resulting hybrid nanocrystals all exhibited a significant increase in quantum efficiency (QE) over the pure CdTe material. In addition, the position of the 'excitonic' PL peak was red-shifted to the near infrared to give emission wavelengths ranging from 600 to 1350 nm depending on the composition. The possibility of alloying, and a redistribution of the mercury throughout the interior of the particles is discussed, along with the high resolution transmission electron microscopy (HRTEM) of some selected samples. (27 References).

Hartridge, A. and A. K. Bhattacharya (2000). "Preparation and homogeneity of lanthanide-doped ceria nanocrystal dispersions." Modern Physics Letters B **14**(3): 79-88.

Aqueous sols of solid solutions of the general formula Ce<sub>1-x</sub>Ln<sub>x</sub>O<sub>2-x/2</sub> (Ln=entire lanthanide range, x=0-0.50 and =anion vacancy) were synthesized using inorganic materials. The sols contained single-phase nanocrystals with particle sizes between 7-20 nm from photon correlation spectroscopy and crystallite sizes around 5 nm from X-ray diffraction. The nanocrystals were dispersed on an amorphous silica support and individual crystals examined for composition and structure by high-resolution TEM/EDAX. High-resolution pictures showed the nanocrystals to be between 4-6 nm in size, in agreement with X-ray diffraction results. Conical dark field and bright field pictures of the same area highlighted nanocrystals to be analyzed and microdiffraction of these crystals showed spot patterns of various individual planes of the fcc fluorite lattice giving lattice parameters, depending on dopant, between 5.6-5.9 AA. EDAX analysis of individual crystals compared closely to each other, to that of an average over a large area and to that of the nominal composition. (29 References).

Hashizume, K. I., M. Vacha, et al. (2000). "Preparation and optical properties of capped-CdSe nanocrystals." Journal of Luminescence **87**(89): 402-4.

Capped-CdSe nanocrystals were synthesized by colloidal method and almost monodisperse nanocrystals were obtained by size selective precipitation. Persistent spectral hole-burning (PSHB) effects of the CdSe nanocrystals suspended in an organic solvent glass matrix were examined at liquid-He temperature. Prominent spectral changes were not observed for the irradiation of the burning light of 15 mW/cm<sup>2</sup> at the peak position of the exciton absorption band. In single nanoparticle spectroscopy of dilute CdSe samples, the fluorescence emitted by small aggregates of the nanocrystals were observed and vanished continuously by the irradiation of strong laser beam. Detection of the single dot itself is not realized, mainly due to the background noise. (7 References).

Hermann, H., A. Heinemann, et al. (2000). "Experimental evidence for inhibitor-controlled mechanism of nanocrystallisation in amorphous metallic alloys." Europhysics Letters **51**(2): 127-32.

The very reason for the formation of nanocrystalline states from amorphous precursors is elucidated for a Fe-based soft-magnetic alloy of Finemet type by means of neutron small-angle scattering. It is shown that the Fe(Si) nanocrystals created in the amorphous matrix during annealing are covered by Nb atoms. The accumulation of Nb atoms or Nb-B aggregates acting as inhibitors at the surface of the nanocrystals has been assumed within the framework of a recent model to be the basic mechanism controlling the evolution of the nanocrystalline state. This model is shown to be correct. (23 References).

Hess, G., A. Bauer, et al. (2000). "Si/Ge-nanocrystals on SiC(0001)." Thin Solid Films **380**: 1-2.

The growth and structure of Si and Ge nanocrystals was investigated using high resolution X-ray diffraction (HRXRD) and atomic force microscopy (AFM). AFM images were used to determine the lateral and vertical dimensions of the nanocrystal. HRXRD measurements show clearly that Si- and Ge-nanocrystals grow on 6H-SiC(0001) preferentially in two different orientations- $\langle 111 \rangle$  and  $\langle 110 \rangle$ -with respect to the surface normal. The growth of Ge-nanocrystals on Si-rich 6H-SiC(0001) surfaces leads to the formation of Si/Ge-alloy nanocrystals. Both types of nanocrystals grow coherently with respect to the substrate. Hence, due to the respective lattice mismatch, the degree of coherence was found to be much better for Si nanocrystals. (3 References).

Hess, B. C., I. G. Okhrimenko, et al. (2001). "Surface transformation and photoinduced recovery in CdSe nanocrystals." Physical Review Letters **86**(14): 3132-5.

CdSe nanocrystals in solution and films can enter a metastable state in which the highly luminescent nanocrystals become dark. This change, which we attribute to a surface transformation, can be caused by heating or by changing the environment of the nanocrystals at room temperature. The metastable transformation is reversed upon illumination of above-band-gap light, at which point the nanocrystals are again highly luminescent.

Hill, N. A. and K. B. Whaley (1995). "Size dependence of excitons in silicon nanocrystals." Physical Review Letters **75**(6): 1130-1133.

Ho-Soon, Y., M. R. Geller, et al. (2000). "Nanocrystallization process of the Fe<sub>69.5</sub>Cu<sub>1</sub>Nb<sub>3</sub>B<sub>9</sub>Si<sub>13.5</sub>Cr<sub>4</sub> FINEMET-type alloy: an AFM study." Surface and Interface Analysis **30**(1): 305-8.

The different devitrification stages of Fe/sub 69.5/Cu/sub 1/Nb/sub 3/B/sub 9/Si/sub 13.5/Cr/sub 4/ (F-Cr4) amorphous alloy were studied by atomic force microscopy (AFM) on samples annealed at 400, 600 and 670 degrees C for different treatment times. The AFM images showed no topographic changes in the alloys treated at 400 degrees C, indicating that only structural relaxations took place at this annealing temperature. Samples thermally treated at 600 degrees C showed hemispherical features uniformly distributed on the surface, suggesting initiation of the nanocrystallization process. The nanocrystals formed had a size distribution of 15-40 nm, which is slightly affected by the annealing time. At 670 degrees C the crystallization phenomena occurred with the formation of large crystals and an increase in roughness. The corrosion behaviour of the nanocrystalline alloys in 2 M HCl solution was correlated with the AFM studies. The potentiodynamic experiments for these alloys showed a significant decrease of the current density peak at the active-passive transition in relation to the F-Cr4 amorphous alloy. The results indicated that the corrosion resistance and passivating ability of the alloys are improved by the thermal treatment. (12 References).

Hoffman, D. M., B. K. Meyer, et al. (2000). "Giant internal magnetic fields in Mn doped nanocrystal quantum dots." Solid State Communications **114**(10): 547-50.

We observed a giant splitting of exciton spin sublevels in CdS nanocrystals, each doped on the average by one Mn ion. The splitting, which exists in zero external magnetic field, is caused by the gigantic internal magnetic field of the Mn ion and results from the enhancement of the short range spin-spin interactions in nanocrystal quantum dots. The splitting is seen in the strong magnetic circular dichroism of the CdS band edge transitions. The magnitude of the observed band edge splitting is in good agreement with a theoretical calculation of the effective magnetic field. (19 References).

Hofgen, A., V. Heera, et al. (2000). "Nanocrystals at MBE-grown GaN/GaAs(001) interfaces." Applied Surface Science **166**(9): 317-21.

Molecular beam epitaxy (MBE) growth utilising an RF-plasma nitrogen source was used to study surface reconstruction and the effects of nitridation damage on the surface and interface morphology of GaN on GaAs(001) at 580 degrees C. Keeping both the N-flow and plasma excitation power constant, the grown layers were studied with the Ga-flux as a parameter. In the initial growth stage, a (3\*3) surface reconstruction was observed. Samples grown under N-rich, Ga-rich and stoichiometric conditions were characterised by high-resolution scanning electron microscopy (SEM) and atomic force microscopy (AFM) to reveal the surface morphology. The nitridation damage was characterised by Auger-electron spectroscopy (AES), X-ray diffraction (XRD) spectroscopy and high-resolution SEM, which revealed separated GaN and GaAs phases at interfaces deeply in the substrate region, bordered by {101} and {111} facets. The defect formation at the GaN/GaAs interface depended on the N/Ga-flux ratio. (20 References).

Hofgen, A., V. Heera, et al. (2000). "Ion-beam-induced crystal grain nucleation in amorphous silicon carbide." Nuclear Instruments and Methods in Physics Research Section B Beam Interactions with Materials and Atoms **161**(163): 917-21.

Ion-beam-induced crystallization (IBIC) was used to produce nanocrystals in the preamorphized region of a 6H-SiC bulk crystal. The precipitation was stimulated by high dose Al implantation at temperatures from 300 degrees C to 700 degrees C. Using cross-sectional transmission electron microscopy (XTEM) and X-ray diffraction (XRD) under grazing incidence, the morphology of the nanocrystalline phase and its dependence on the implantation parameters were investigated. After IBIC the morphology of the recrystallized material completely differs from that after thermal crystallization. Randomly oriented grains of 3C-SiC with almost spherical shape and mean diameters ranging from 5 to 20 nm are formed during Al implantation. A critical ion dose for the onset of the recrystallization is found at about  $1.9 \times 10^{16}$  Al/cm<sup>2</sup>. (10 References).

Hofman, D., C. Kleint, et al. (2000). "Investigation of thermoelectric silicide thin films by means of analytical transmission electron microscopy." Ultramicroscopy **81**: 3-4.

The microstructure of rhenium silicide thin films and its progress by annealing were investigated by means of analytical transmission electron microscopy. Sputtered amorphous films were characterised by analysis of the radial distribution function (RDF). The position of the first maximum of RDF represents the most probable distance between neighbouring atoms and decreases from 2.75 to 2.62 AA in films with an increasing Si-content from 60 to 75 at%. This decrease correlates with the change of the temperature coefficient (TC) of the electrical resistivity. During in situ annealing, the formation of nanocrystals in films with different Si-contents was observed. In thin films with 64 at% the quantity of nanocrystals increases after 1 h at 900 K whereas their sizes remain unchanged. The crystallisation in Re-rich thin films proceeds lower and produces larger crystals than in films near to the ReSi<sub>1.75</sub> stoichiometry. Sputtered epitaxial ReSi<sub>1.75</sub> films on Si (100) consist of crystals with nanometer size and an azimuthal torsion of 45 degrees. (11 References).

Hofmeister, A. M., L. J. Rosen, et al. (2000). "Ti-containing Zr based bulk amorphous/nanocrystalline composite alloys." Materials Transactions Jim **41**(11): 1467-70.

DSC curves show that the crystallization reactions change from a single exothermic peak to two exothermic stages by adding Ti up to 5 at% to Zr-Ni-Cu-Al amorphous alloys and bulk amorphous composites containing nanocrystalline particles were produced by annealing cast Zr<sub>70-x-y</sub>Ti<sub>x</sub>Ni<sub>10</sub>Cu<sub>20</sub>Al<sub>y</sub> (x=5-7.5 and y=10-15 at%) amorphous alloys. The microstructure after the precipitation of a primary crystalline phase consists of the crystals less than 10 nm in size embedded in the amorphous matrix. Both the compressive strength and plastic strain increased significantly with increasing volume fraction of nanocrystals, and the maximum plastic strain was obtained in the early stage of nanocrystallization. High-resolution electron microscopy showed that the bulk nanocrystalline Zr<sub>53</sub>Ti<sub>5</sub>Ni<sub>10</sub>Cu<sub>20</sub>Al<sub>12</sub> alloy with the maximum plastic strain includes nanocrystals with a much smaller grain size of about 2.5 nm. (10 References).

Hong, C., H. Rong-Bin, et al. (2000). "Single titanium crystals encapsulated in carbon nanocages obtained by laser vaporization of sponge titanium in benzene vapor." Applied Physics Letters **77**(1): 91-3.

A technique, laser vaporization by ablating at a solid target in the vapor phase, is developed to produce encapsulated titanium nanocrystals. By vaporizing sponge titanium in benzene vapor, the single titanium crystals encapsulated in carbon nanocages have been synthesized in good yields. The sizes of the encapsulated crystals are around 5-15 nm and the numbers of the wrapped graphitic layers are on the order of 3-10 layers. Characteristic lattice spacings and angles observed by high-resolution transmission electron microscopy identify two phases of the nanocrystals inside the carbon onion cavities as alpha -Ti and beta -Ti. The latter has never been stable below 850 degrees C until the experiment. The encapsulated titanium crystals adsorbed a large amount of hydrogen released in the synthesis. (9 References).

Hong-Bing, F., X. Rui-Min, et al. (2000). "Preparation and structural properties of Pd nanoparticles in layered silicate."

Colloids and Surfaces A Physicochemical and Engineering Aspects **174**(3): 387-402.

Pd nanocrystals in the 5-15 nm ranges were prepared on pillared clay minerals (PILCs) as supports by immobilizing Pd nanoparticles in the interlamellar space of montmorillonite and saponite by pillaring with aluminium hydroxide cations. Pd nanoparticles were generated via reduction by ethanol of Pd acetate present in the adsorption layer at room temperature. The structure of Pd-PILC samples was characterized by XRD and  $N_2$  gas sorption measurements. The Pd/H interaction was characterized by  $H_2$  sorption isotherms, which revealed extensive sorption hysteresis depending on particle size. This effect calls attention to the potential use of Pb-PILC adsorbents for storage of gaseous  $H_2$ . Microcalorimetry was carried out to determine  $H_2$  gas sorption enthalpy isotherms, which also exhibited a sorption hysteresis. By combining the data, H/Pd interactions are also expressed as molar sorption enthalpies. It is concluded that, due to differences in surface accessibility for hydrogen, H/Pd interactions are determined by the joint effect of the external to total atomic ratio of Pd nanoparticles and the microporosity of the support pillared clays. (58 References).

Hong-Bing, F., W. Yuan-Qun, et al. (2000). "Influence of the surface on the properties of macro- and nanocrystals." Kristallografiya **45**(3): 564-7.

The influence of the surface energy on the properties of macro- and nanocrystals has been considered. It is shown that the properties of small crystals (several microns and less) depend on their dimensions, which is explained by an increase of the number of surface atoms in the total number of all the atoms in a crystal. On the basis of the energy criterion of crystalline substance amorphization, a formula relating the surface energy of a crystal to its crystal-lattice parameters is derived. The surface energies of elemental crystals are calculated. It is assumed that anisotropy in the contact-melting temperature of single crystals can be observed experimentally. (19 References).

Hongkun, P., P. Jiwoong, et al. (2000). "A single-electron stochastic associative processing circuit robust to random background-charge effects and its structure using nanocrystal floating-gate transistors." Nanotechnology **11**(3): 154-60.

A new single-electron circuit using the unique features of single-electron devices is proposed, based on a basic strategy and circuit architecture for achieving large-scale integration. A unit circuit consisting of a single-electron transistor and a capacitor operates as an exclusive-NOR gate by the Coulomb blockade effect, and its transient behaviour is stochastic due to electron-tunnelling events. Using this unit circuit, a stochastic associative processing circuit is proposed, based on a new information-processing principle where the association probability depends on the similarity between the input and reference data. This circuit can be constructed by using a silicon nanocrystal floating-gate structure in which dots are regularly arranged on a gate electrode of a MOSFET. The simulation results of a simple digit pattern association demonstrate the successful stochastic operation. The background-charge effects on the proposed circuit are analysed and simulated, and it is shown that the circuit is much more robust to such effects than the conventional single-electron logic circuits. (18 References).

Hua, J., S. Skwirblies, et al. (2000). "Preparation and characterisation of organic-inorganic heterojunction based on BDA-PPV/CdS nanocrystals." Materials Science and Engineering B Solid State Materials for Advanced Technology: 1-3.

Cadmium sulphide nanoparticles have been obtained by using a quaternary 'water-in-oil' microemulsion. The nanoparticles properties have been investigated by absorption spectroscopy, photoluminescence (PL), and high resolution transmission electron microscopy (HR-TEM). With the aim of obtaining electro-optical devices, layered and blended heterostructures based on CdS quantum dots and a novel poly (2,5-dialcoxy-1,4-phenylenevinylene) with a 2,5 -O-(CH<sub>2</sub>)<sub>12</sub>- bridge (BDA-PPV), have been deposited on indium tin oxide (ITO) substrates. The film morphology has been measured by atomic force microscopy (AFM). The devices have been tested by current-voltage measurements after Al cathodes deposition on the top of the structure. The results have been related to the film morphology. (19 References).

Huang, J. Y., H. Yasuda, et al. (2000). "HRTEM and EELS studies on the amorphization of hexagonal boron nitride induced by ball milling." Journal of the American Ceramic Society **83**(2): 403-9.

We present a new approach, namely ball milling, to synthesize amorphous boron nitride ( $\alpha$ -BN). The amorphization kinetics are revealed by X-ray diffractometry (XRD), high-resolution transmission electron microscopy (HRTEM), and electron energy loss spectroscopy (EELS). HRTEM investigations indicate that, in the early stage of milling, the thick sp<sup>2</sup> layers are sliced into many thinner sheets because of cleavage along the basal planes. In the intermediate stage of milling, deformation is accommodated primarily by simultaneous shearing along the basal planes. As a result of sustained shearing, a number of defects, such as stacking faults, (0002) 1120 twinning, simultaneous shearing of lattice planes, and half Frank loops with Burgers vectors of  $1/2$  0001, are introduced in the hexagonal BN (h-BN) grains. Simultaneous shearing also causes significant change in the lattice symmetry of most grains. In the final stage of milling, the fiberlike tightly bonded sp<sup>2</sup> sheets are broken and refined further, until a nanocrystalline and amorphous mixture is formed. XRD of the sample milled for 180 h exhibits an amorphous halo pattern; nevertheless, HRTEM demonstrates that the end product is essentially a nanocrystalline and amorphous mixture. The grain sizes of the nanocrystals are <3 nm, and their stacking is turbostratic. EELS investigations of the  $\alpha$ -BN indicate that bonding is primarily sp<sup>2</sup>, but a small fraction

of  $\alpha$ -BN is also found, which is assumed to be the nuclei of the cubic phase (c-BN) in the high-pressure and high-temperature experiments and thus facilitates the hexagonal to cubic transition. The present  $\alpha$ -BN fabrication method can provide an effective way to facilitate the synthesis of sintered bulk c-BN materials. (35 References).

Huazhong, S., Z. Lide, et al. (2000). "Composition modulation of optical absorption in  $\text{Ag}_x\text{Au}_{1-x}$  alloy nanocrystals in situ formed within pores of mesoporous silica." Journal of Applied Physics **87**(3): 1572-4.

Nanoscaled  $\text{Ag}_x/\text{Au}_{1-x}$  ( $0.2 < x < 0.8$ ) alloy particles were synthesized by putting gold and silver particles into pores of monolithic mesoporous silica by soaking and annealing method. It has been found that in optical absorption spectrum, the surface plasmon resonance (SPR) maximum of  $\text{Ag}_x/\text{Au}_{1-x}$  alloy particles can shift from about 524 nm (SPR maximum of Au nanoparticles) to about 400 nm (SPR maximum of Ag nanoparticles) with increasing concentration of Ag in  $\text{Ag}_x/\text{Au}_{1-x}$  alloy particle. The simulation of optical absorption spectrum of  $\text{Ag}_x/\text{Au}_{1-x}$  alloy particles was conducted based on Mie theory. The calculated values are found to be consistent with the experimental results. (17 References).

Iacona, F., G. Franzo, et al. (2000). "Correlation between luminescence and structural properties of Si nanocrystals." Journal of Applied Physics **87**(3): 1295-303.

Strong room-temperature photoluminescence (PL) in the wavelength range 650-950 nm has been observed in high temperature annealed (1000-1300 degrees C) substoichiometric silicon oxide ( $\text{SiO}_x$ ) thin films prepared by plasma enhanced chemical vapor deposition. A marked redshift of the luminescence peak has been detected by increasing the Si concentration of the  $\text{SiO}_x$  films, as well as the annealing temperature. The integrated intensity of the PL peaks spans along two orders of magnitude, and, as a general trend, increases with the annealing temperature up to 1250 degrees C. Transmission electron microscopy analyses have demonstrated that Si nanocrystals (nc), having a mean radius ranging between 0.7 and 2.1 nm, are present in the annealed samples. Each sample is characterized by a peculiar Si nc size distribution that can be fitted with a Gaussian curve; by increasing the Si content and/or the annealing temperature of the  $\text{SiO}_x$  samples, the distributions become wider and their mean value increases. The strong correlation between structural (nanocrystal radius and width of the size distributions) and optical (wavelength and width of the PL peaks) data indicates that light emission from the annealed  $\text{SiO}_x$  films is due to carrier recombination in the Si nc, and it can be interpreted in terms of carrier quantum confinement. The possible reasons for the quantitative discrepancy between the experimentally measured luminescence energy values and the theoretical calculations for the enlargement of the band gap with decreasing the crystal size are also discussed. (46 References).

Ihara, M., T. Igaeshi, et al. (2000). "Preparation and characterization of rare earth activators doped nanocrystal phosphors." Journal of the Electrochemical Society **147**(6): 2355-7.

The photoluminescent intensities of nanocrystal  $\text{ZnS:Tb}$  and  $\text{ZnS:Eu}$  synthesized using a new technique were 2.5 and 2.8 times higher than those of bulk phosphors. Taking charge compensation into account, the luminescent efficiency of the nanocrystals can be improved. The cathodoluminescence of the nanocrystals was observed for the first time. These nanocrystal phosphors are promising for field emission display, electroluminescence, plasma-display panels, and cathode ray tubes. (7 References).

Ilinsky, A. G., V. V. Maslov, et al. (2000). "Aerosol synthesis of fullerene nanocrystals in controlled flow reactor conditions." Journal of Nanoparticle Research **2**(1): 53-74.

Fullerene nanocrystals in the size range 30-300 nm were produced starting from atomized droplets of  $\text{C}_{60}$  in toluene. The experiments were carried out under well-controlled conditions in a laminar flow reactor at temperatures of 20-600 degrees C. Particle transformation and crystallization mechanisms of polydisperse and monodisperse (size classified) fullerene aerosol particles were studied. The results show that fullerene particles are roughly spherical having pores and voids at temperatures of 300 degrees C and below. Particles are already crystalline and likely fine-grained at 20 degrees C and they are polycrystalline at temperatures up to 300 degrees C. At 400 degrees C monodisperse particles evaporate almost completely due to their low mass concentration. Polydisperse particles are crystalline, but sometimes heavily faulted. At 500 degrees C most of the particles are clearly faceted. In certain conditions, almost all particles are hexagonal platelets having planar defects parallel to large (111) faces. We suggest that at 500 degrees C fullerene particles are partially vaporized forming residuals with lamellar defects such as twins and stacking faults, which promote crystal growth during synthesis. Subsequently fullerene vapor is condensed on faces with defects and hexagonal particles are grown by a re-entrant corner growth mechanism. At 600 degrees C particles are single crystals, but they have a less distinct shape due to higher vaporization of fullerene. The final size and shape of the particles are mainly determined at the reactor outlet in the short time when the aerosol cools. (50 References).

Inoue, Y., A. Tanaka, et al. (2000). "Metal nanocrystal formation in magnesium aluminate spinel and silicon dioxide with high-flux  $\text{Cu}^+$  ions." Nuclear Instruments and Methods in Physics Research Section B Beam Interactions with Materials and Atoms **166**(167): 840-4.

Intense Cu<sup>+</sup> ions of 60 keV spontaneously grow nanospheres embedded within a shallow depth in insulators, which exhibit optical nonlinearity. The in-beam growth of nanoparticles is preferred but subjected to phase instability. Spinel oxides may be a candidate substrate to realize the phase stability, because of good radiation resistance and sufficient transparency. Spinel of MgAl<sub>2</sub>O<sub>4</sub> and amorphous(a-) SiO<sub>2</sub> were irradiated with Cu<sup>+</sup> at dose rates up to 100 μA/cm<sup>2</sup>, at a total dose of 3.0\*10<sup>16</sup> ions/cm<sup>2</sup>. Nanocrystal morphology and optical absorption (hν = 0.5-5 eV) varied depending on dose rate. At high dose rates, a-SiO<sub>2</sub> showed a strong tendency of depth-dependent rearrangement and particle coarsening. The MgAl<sub>2</sub>O<sub>4</sub> also showed spontaneous precipitation of nanoparticles but, in contrast, neither long-range rearrangement of implants nor particle coarsening, up to high dose rates. Therefore, the MgAl<sub>2</sub>O<sub>4</sub> spinel is a promising substrate to realize fine and stable nanostructures. (18 References).

Inoue, M. (2000). "Optical memory media based on excitation-time dependent luminescence from a thin film of semiconductor nanocrystals." Japanese Journal of Applied Physics Part 39(7A): 4006-12.

We describe the increase of photoluminescence intensity from densely packed semiconductor nanocrystals (quantum dots) with excitation time, which is clearly observed by the naked eye under ambient conditions. This enabled the invention of the first luminescence-based optical memory media feasible for practical applications. Bright luminescent images are stored and then read out by exciting the medium, a thin film of cadmium selenide nanocrystals, with blue or UV light. The increase in emission intensity is attributed to the trapping and accumulation of photo-generated electrons in the matrix of organic molecules capping the nanocrystals. (20 References).

Irmer, G., J. Monecke, et al. (2000). "Microstructure evolution, magnetic domain structures, and magnetic properties of Co-C nanocomposite films prepared by pulsed-filtered vacuum arc deposition." Journal of Applied Physics **88**(4): 2063-7.

Co-based nanocrystals encapsulated in carbon have potential applications in ultra-high-density magnetic recording media. In this work, Co<sub>x</sub>C<sub>1-x</sub> (x=60, 65, and 70 at.%) nanocomposite films were prepared by pulsed-filtered vacuum arc deposition. Subsequent thermal annealing was performed in vacuum at various temperatures. The films were characterized by non-Rutherford backscattering spectrometry, transmission electron microscopy, Raman spectroscopy, atomic-force microscopy, and magnetic-force microscopy. The as-deposited films were found to be amorphous. After annealing at appropriate temperatures, the films were found to be consisting of hexagonal close-packed nanocrystalline Co grains encapsulated in graphite-like carbon. Clear magnetic-force microscopy images were only observed in those films annealed at sufficiently high temperatures, indicating that there was perpendicular magnetic anisotropy in these films. The magnetic hysteresis loops of the films were measured by a superconducting quantum interference device magnetometer. The optimum annealing temperature for the maximum coercivity was found to depend on the cobalt concentration. For a Co<sub>65</sub>C<sub>35</sub> sample about 20 nm thick after annealing at 350 degrees C in vacuum for 1 h, the saturation magnetization was 500 emu/cm<sup>3</sup>, the coercivity was 460 Oe, and the ratio of the remanence to the saturation magnetization was 0.68 at 300 K. Our results are consistent with those of the sputtered Co-C films recently reported in the literature. (20 References).

Itoh, T., M. Nishijima, et al. (1995). "Polaron and exciton-phonon complexes in CuCl nanocrystals." Physical Review Letters **74**(9): 1645-1648.

Iwai, S., K. Hara, et al. (2000). "Comparison of microwave hybrid and conventional heating of preceramic polymers to form silicon carbide and silicon oxycarbide ceramics." Journal of the American Ceramic Society **83**(7): 1617-25.

Six different preceramic polymers were pyrolyzed via conventional and microwave hybrid heating; these polymers provide a range of carbon content and local atomic coordination. The products were compared with each other using X-ray diffractometry and transmission electron microscopy. Nanocrystalline beta -SiC was the principal crystal phase detected, and the amount and size of the nanocrystals increased as the processing temperature increased. Differences were observed in the amount and size of the beta -SiC nanocrystals and the graphitization of residual carbon between the microwave hybrid heating and the conventional oven heating of polycarbosilanes. Conventional heating of a high-carbon polysiloxane in an oven (in flowing argon) produced a greater amount of beta -SiC from carbothermal reduction at high temperature. Microwave hybrid heating led to better beta -SiC nanocrystal development for polyureasilazane. (29 References).

Iwayama, T. S., D. E. Hole, et al. (2000). "Characteristic photoluminescence band in Si<sup>+</sup>-implanted SiO<sub>2</sub> grown on Si wafer." Microelectronics and Reliability **40**: 4-5.

A possible mechanism for the photoemission from Si nanocrystals in an amorphous SiO<sub>2</sub> matrix fabricated by ion implantation is reported. We have measured the implantation dose dependence as well as the oxidation effect of the photoluminescence behavior of Si nanocrystals in SiO<sub>2</sub> layers fabricated by ion implantation and a subsequent annealing step. After annealing, a photoluminescence band, peaking just below 1.7 eV was observed. The peak energy of the photoluminescence was found to be affected by the dose of implanted Si ions, but to be independent of annealing time and excitation photon energy. We also present experimental results of an

oxidation induced continuous peak energy shift of the photoluminescence peak, up to around 1.8 eV. This peak energy, however, was found to return to its previous position with re-annealing. These results indicate that, whilst the excitation photons are absorbed by Si nanocrystals, the emission is not simply due to electron-hole recombination inside the Si nanocrystals, but is related to the presence of defects, most likely located at the interface between the Si nanocrystals and the SiO<sub>2</sub>, for which the characteristic energy levels are affected by cluster-cluster interactions or the roughness of the interface. (38 References).

Jacobsohn, M. and U. Banin (2000). "Reduced photo-instability of luminescence spectrum of core-shell CdSe/CdS nanocrystals." Journal of Materials Science **35**(6): 1375-8.

Coated CdSe/CdS nanocrystals have been synthesized through a new reaction routine in micelle solution. High resolution transmission electron microscope image demonstrated the monodispersity and core-shell structure of CdSe/CdS nanocrystals. Photooxidation experiments shown that by coating with a wider bandgap material CdS, the surface states of CdSe cores could be decreased and the photo-instability of their luminescence spectrum could be reduced. This phenomena were temporary interpreted that lack of carriers at the outlayer surface reduced photooxidation degradation of CdSe/CdS nanocrystals. (6 References).

Jacobsohn, M. and U. Banin (2000). "Size dependence of second harmonic generation in CdSe nanocrystals." Semiconductor Quantum Dots. Symposium. **571**: 253-8.

Second harmonic generation in CdSe nanocrystal quantum dots is observed by hyper-Rayleigh scattering. We use a Ti-sapphire femtosecond laser at 820 nm to induce the nonlinear optical response of the nanocrystals in solution. The unit cell normalized second harmonic coefficient  $\beta_{\text{eff}}/n^3$ , shows a substantial systematic enhancement in small sizes. The observed size dependence of the second harmonic generation process, is explained assuming two contributions. The first is a bulk-like contribution, from the noncentrosymmetric nanocrystal core, and the second, a contribution from the particle surface. The latter contribution is most significant in small nanocrystals with a substantial proportion of surface atoms. (13 References).

Jenekhe, S. A. and S. Yi (2000). "Second harmonic generation from silicon nanocrystals embedded in SiO<sub>2</sub>." Nonlinear Optics: Materials, Fundamentals, and Applications. Technical Digest. Postconference Edition. TOPS **46**(IEEE Cat. No.00CH37174): 215-17.

We present observations of optical second harmonic generation (SHG) from silicon nanocrystals embedded in SiO<sub>2</sub>. SHG sensitivity to Si/SiO<sub>2</sub> interface states, charge on the nanocrystals, and particle density gradients is demonstrated. (9 References).

Jeszka, J. K., A. Tracz, et al. (2000). "Preparation of organic metal nanocrystals in polymer matrix." Synthetic Metals **109**: 1-3.

Nanocrystals of bis(ethylenedithio)tetrathiafulvalene (ET) polyiodides in polymer matrices were obtained using different methods of crystallisation under limited diffusion conditions. Broadening X-ray diffraction (XRD) lines and atomic force microscopy (AFM) confirm the decreasing size of the crystals. The positions of the UV-vis absorption maxima are practically the same; IR peaks show a small shift of the CT band as compared with microcrystalline layers. Raman spectra and XRD show that, even above 390 K,  $\alpha$ -ET<sub>2</sub>I<sub>3</sub> is formed in contrast to  $\beta$ -ET<sub>2</sub>I<sub>3</sub> phase microcrystals formed above 370 K in solution. (12 References).

Jiang, J. Z., L. Gerward, et al. (2000). "Comparison of the decomposition and crystallization behavior of Zr and Pd based bulk amorphous alloys." Materials Science Forum **343**(346): 179-84.

The best metallic glass formers known so far are Vit1 (and similar alloys with a slight variation in composition) and Pd<sub>40</sub>Cu<sub>30</sub>Ni<sub>10</sub>P<sub>20</sub>, having critical cooling rates of about 1 K/s and glass transition temperatures  $T_g$  of around 636 K and 582 K, respectively, at a heating rate of 10 K/min. To compare the decomposition and crystallization behavior of these alloys, we performed small-angle neutron scattering (SANS) on the Vit1 derivative Zr<sub>42.6</sub>Ti<sub>12.4</sub>Cu<sub>11.25</sub>Ni<sub>10</sub>Be<sub>23.75</sub> (Vit1A) and on Pd<sub>40</sub>Cu<sub>30</sub>Ni<sub>10</sub>P<sub>20</sub> (PCNP) at temperatures near their  $T_g$ . The samples of Vit1A show interference peaks when annealed for several hours between 603 K and 643 K, giving evidence for decomposition on the nanometer scale. The SANS intensity monotonically increases in this temperature regime. An in-situ experiment, performed for 15 h at 621 K, with an average acquisition time of 20 min, resolves the time evolution of this decomposition. The SANS experiment on PCNP shows a completely different behavior. An in-situ SANS experiment performed on PCNP for 10 h at 571 K produced no scattering, but the SANS intensity changed drastically when the temperature was raised to 586 K. However, no interference maximum was observed in the SANS data for PCNP. X-ray diffraction data, measured after the in-situ experiments, resolve nanocrystals in Vit1A but a coarse-grained structure in PCNP. (12 References).

Jiang, C. Z. and X. J. Fan (2000). "In-situ TEM observation of silver nanocrystals in an Ag-implanted SiO<sub>2</sub> film." Surface and Coatings Technology **131**: 1-3.

The Ag ions were implanted in an amorphous SiO<sub>2</sub> film, which was placed in a sample chamber of TEM.

The concentration and size distribution of the Ag nanocrystals as functions of both the ion dose and the annealing temperature were examined in-situ by using this TEM. The selected diffraction pattern determined the Ag nanocrystal's presence and the dark field micrograph showed the shape and the concentration of the Ag nanocrystals. The implantation results demonstrated an average size diminution and a significant concentration increase of the Ag nanocrystals when the dose increased. The annealing results showed a loss of silver at 300 degrees C and above. (14 References).

Jiang, Q., Z. Zhang, et al. (2000). "Luminescence and X-ray diffraction studies of Ge nanocrystals in amorphous silicon oxide." Materials Science and Engineering A Structural Materials Properties Microstructure and Processing(1): 161-4. Ge nanocrystals embedded in a-SiO<sub>2</sub> films have been synthesized by rapid thermal annealing. Under excitation sources of different wavelengths, three photoluminescence (PL) peaks at 1.8, 2.2 and 3.1 eV were observed. A forming gas anneal on the samples resulted in a reduction of the intensity of the PL peaks. Studies of the annealed samples by X-ray diffraction revealed the formation of GeO<sub>2</sub> and Ge nanocrystals in the rapid thermal annealed system. The origin of the PL peaks is suggested to be due to defect related mechanism. (14 References).

Jiang, Q., Z. Zhang, et al. (2000). "The humidity sensitivity of La-doped BaTiO<sub>3</sub>-based nanocrystalline ceramic sensor." Journal of Functional Materials and Devices 6(2): 106-10. A series of La<sub>x</sub>Ba<sub>1-x</sub>TiO<sub>3</sub> nanocrystals were prepared by the sol-gel method under various processing conditions. An alkoxide was used as starting material and glacial acid, a non-alcohol agent, acted as homogeneous catalyst. Then the ceramic humidity sensor was formed through cold-pressing, sintering and capsulating. At room temperature, its electric resistance was measured by a RLC impedimeter DC bridge. An RQ-1 Gas meter was employed to determine the sensibility of alcohol, benzene, ethene, hydrogen and so on. The results showed that the sensor, sintered at 1300 degrees C/1 h, doped by 9 mol% La(OEt)<sub>3</sub>, had high humidity sensitivity and short response-time. The relationship between logarithmic resistance and relative humidity was linear. The sensor did not respond to the gases referred above. The microstructure was observed by scanning electron microscopy and the crystalline phase and its grain size was determined by XRD. (8 References).

Jiang, J. Z., J. S. Olsen, et al. (2000). "Structural stability in nanocrystalline ZnO." Europhysics Letters 50(1): 48-53. The grain-size effect on phase transition induced by pressure in ZnO nanocrystals has been investigated by in situ high-pressure synchrotron radiation X-ray powder diffraction, optical and electrical resistance measurements. The transition pressure of the B<sub>4</sub>-to-B<sub>1</sub> phase transformation for 12 nm ZnO is found to be 15.1 GPa while it is 9.9 GPa for bulk ZnO. Three components: the ratio of the volume collapses, the surface energy difference, and the internal energy difference, governing the change of transition pressure in nanocrystals, are uncovered. The enhancement of transition pressure in ZnO nanocrystals as compared with the corresponding bulk material is mainly caused by the surface energy difference between the phases involved. The high-pressure B<sub>1</sub> ZnO phase is not metallic in the pressure range up to 18 GPa at room temperature. (14 References).

Jiang, J. Z., L. Gerward, et al. (2000). "Electroluminescence of different colors from polycation/CdTe nanocrystal self-assembled films." Journal of Applied Physics 87(5): 2297-302. Water soluble thiol capped CdTe nanocrystals are assembled into ultrathin films in combination with poly(diallyldimethylammonium chloride) (PDDA) by the self-assembly method of layer-by-layer adsorption of oppositely charged polyelectrolytes. Electroluminescent devices, which produce different color emissions, are fabricated by sandwiching CdTe/PDDA films between indium-tin-oxide (ITO) and aluminum electrodes using CdTe nanocrystals of different sizes. It is shown that the electroluminescence (EL) spectra of the CdTe/polymer films are nearly identical to the photoluminescence spectra of the corresponding CdTe nanocrystals in aqueous solutions. The devices produce room-light visible light output with an external quantum efficiency up to 0.1%. Light emission is observed at current densities of 10 mA/cm<sup>2</sup> and at low onset voltages of 2.5-3.5 V, which depends on the thickness of the film indicating field-dependent current injection. A variation of the EL efficiency with the size of the CdTe particles is observed and explained by the size dependent shift of the CdTe energy levels with respect to the work function of the electron injecting Al electrode. This is confirmed by the behavior of two-layer devices prepared from two differently sized CdTe particles being spatially separated, i.e., one size CdTe near ITO and the other size CdTe near Al by using the self-assembly method. (22 References).

Jiang, J. Z., L. Gerward, et al. (2000). "Structural stability in nanocrystal ZnS." Materials Science Forum 343(346): 15-20. The grain-size effect on the phase transition induced by pressure in nanocrystals ZnS was studied by in-situ high-pressure electrical resistance, optical, and synchrotron radiation X-ray powder diffraction measurements. It is found that the semiconductor-to-metal transition pressure strongly depends on the grain size of ZnS crystals. The smaller the crystal, the higher the transition pressure. No obvious difference in compressibility was detected in ZnS samples with various average grain sizes. The enhancement of transition pressure in nanocrystals ZnS might be explained by the surface energy differences between the phases involved while the ratio of volume changes

for bulk and nanocrystal at transitions is found to be almost the same within experimental uncertainty. Our experimental data reveal that the dangers of using the transition pressures of the II-VI compounds as pressure calibrators without a detailed knowledge of their grain-size effects on the transition pressures cannot be overstressed. (14 References).

Jie, Y. X., C. H. A. Huan, et al. (2000). "Raman shift and broadening in stress-minimized Ge nanocrystals in silicon oxide matrix." Nanophase and Nanocomposite Materials III. Symposium **581**: 597-602.

Ge nanocrystals (nc-Ge) embedded in silicon oxide films were synthesized using RF magnetron sputtering and post-annealing procedure. To minimize the stress effect and inhomogeneity, we intentionally lower the cooling rates and reduce the temperature gradient during annealing. Significant Raman shifts ranging from 2.0 to 5.8 cm/sup -1/ have been observed from samples annealed at different temperatures. The size-dependent shift and broadening is found to be in good agreement with the phonon confinement mode together with the Gaussian weighting function, and the isotropic TO<sub>2</sub> phonon dispersion relation introduced by Sasaki et al. The Raman spectra can also be well-fitted using peaks calculated from the phonon confinement model. The inhomogeneous Raman peak broadening from our samples annealed at lower temperatures are attributed to the non-Gaussian size distribution of Ge nanocrystals. (19 References).

Jin-Young, K., S. Dong-Su, et al. (2000). "Prediction of resist non-uniformity caused by underlying pattern density and topology." Digest of Papers Microprocesses and Nanotechnology(00EX387): 98-9.

We developed a simulator that can predict spin coated resist thickness with different feature type, density and topology by using dimensionless parameter and liquid resist film thickness. The change of critical dimension with surrounding topology and pattern density is simulated for the non-uniform resist thickness. (6 References).

Jingbo, L. and X. Jian-Bai (2000). "Properties of CuI nanocrystallites embedded in a glass matrix: From quantum confinement to bulk-band parameters." Physical Review B Condensed Matter **62**(19): 13053-6.

We report the linear absorption spectra of relatively large copper iodide nanocrystals embedded in an alumina borosilicate host network structure. The spectra reveal pronounced exciton lines of both the zinc-blende and the layered hexagonal structures. In the approximation of the weak-confinement regime, the translational masses for the Z/sub 12/ and Z/sub 3/ excitons, as well as the anisotropy of the Z/sub 12/-exciton band, i.e., the exciton Luttinger parameters, are deduced from the spectral positions of the exciton lines. (16 References).

John, J. S., J. L. Coffey, et al. (2000). "Size control of erbium-doped silicon nanocrystals." Applied Physics Letters **77**(11): 1635-7.

This work describes the effects of pyrolysis oven length and erbium precursor on the preparation of discrete erbium-doped silicon nanoparticles. These doped nanoparticles were prepared by the co-pyrolysis of disilane and the volatile complex Er(tmhd)/sub 3/ (tmhd=2,2,6,6-tetramethyl-3,5-heptanedionato). The particle sizes and size distributions were determined using high resolution and conventional transmission electron microscopy. Erbium-doped silicon nanoparticles exhibit a selected area electron diffraction pattern consistent with the diamond cubic phase and a distinctive dark contrast in the transmission electron microscope. The presence of erbium is confirmed by X-ray energy dispersive spectroscopy. In general, the mean diameter of the individual nanoparticles increases as the length of the pyrolysis oven used during their preparation is increased. (12 References).

Joutsensaari, J., P. P. Ahonen, et al. (2000). "Size and interface control of novel nanocrystalline materials using pulsed laser deposition." Journal of Nanoparticle Research **2**(1): 91-6.

We have developed a novel method based upon pulsed laser deposition to produce nanocrystalline materials with an accurate grain size and interface control. Using this method, the grain size in the case of Cu thin films was controlled by introducing a few monolayers of insoluble elements having high surface energy such as W, which increases interfacial energy and provides more nucleation sites. The grain size is determined by the thickness of Cu layer and the substrate temperature at which it transforms into islands (nanocrystalline grains) of fairly uniform size which we designate as self-assembling approach. Using this approach, the grain size was reduced from 160 nm (Cu or Si(100) substrate) to 70-80 nm for a simple W layer (Cu/W/Si (100)) to 4 nm for a multilayer (Cu/W/Cu/W/Si (100)) thin film. The hardness of these films was evaluated using a nanoindentation technique, a significant increase in hardness from 2.0 GPa for coarse-grained 180 nm to 12.5 GPa for 7 nm films was observed. However, there is decrease in hardness below 7 nm for copper nanocrystals. The increase in hardness with the decrease in grain size can be rationalized by Hall-Petch model. However, the decrease in slope and eventually the decrease in hardness below a certain grain size can be explained by a new model based upon grain-boundary deformation (sliding). We also used a similar materials processing approach to produce quantum dots in semiconductor heterostructures consisting of Ge and ZnO dots or nanocrystals in AlN or Al/sub 2/O/sub 3/ matrix. The latter composites exhibit novel optoelectronic properties with quantum confinement of phonons, electrons, holes and excitons. Similarly, we incorporated metal nanocrystals in ceramics to produce improved mechanical and optical properties. (14 References).

Joutsensaari, J., P. P. Ahonen, et al. (2000). "Aerosol synthesis of fullerene nanocrystals in controlled flow reactor conditions." Journal of Nanoparticle Research **2**: 53-74.

Kachurin, G. A., S. G. Yanovskaya, et al. (2000). "The influence of irradiation and subsequent annealing on Si nanocrystals formed in SiO<sub>2</sub> layers." Fizika i Tekhnika Poluprovodnikov **34**(8).

Luminescent Si nanocrystals formed in SiO<sub>2</sub> layers were irradiated with electrons and He<sup>+</sup> ions with energies of 400 and 25-130 keV, respectively. The effects of irradiation and subsequent annealing at 600-1000 degrees C were studied by photoluminescence and electron microscopy. After irradiation with low doses (~1 displacement per nanocrystal), it was found that photoluminescence of nanocrystals was quenched but the number of them increased simultaneously. After irradiation with high doses (~10<sup>3</sup> displacements per nanocrystal), amorphization was observed, which is not characteristic of bulk Si. The observed phenomena are explained in terms of the generation of point defects and their trapping by Si-SiO<sub>2</sub> interfaces. Photoluminescence of nanocrystals is recovered at annealing temperatures below 800 degrees C; however, an annealing temperature of about 1000 degrees C is required to crystallize the precipitates. An enhancement of photoluminescence observed after annealing is explained by the fact that the intensities of photoluminescence originated from initial nanocrystals and from nanocrystals formed as a result of irradiation are summed. (27 References).

Kachurin, G. A., L. Rebohle, et al. (2000). "Electrical conduction in porous silicon: temperature dependence." Microelectronics Journal **31**(3): 187-91.

The temperature dependent conduction of electrons in a porous silicon film is theoretically investigated by using the fact that the electrical conduction is closely related to the formation of a continuous network of the conducting Si nanocrystallites. For the first time, an analytical expression for the electrical conductivity of porous silicon has been obtained, which demonstrates that the overall temperature dependence of electrical conductivity cannot be described by a single Arrhenius relationship, and there is a change in the electrical transport mechanism at a critical temperature  $T_c$ . The critical temperature  $T_c$  and the activation energy are found to be dependent on the mean size of Si nanocrystals as well as their size distribution. The present results are supported by several recent experimental observations. (34 References).

Kadavanich, A. V., T. Kippeny, et al. (2000). "Z-contrast stem imaging and EELS of CdSe nanocrystals: Towards the analysis of individual nanocrystal surfaces." Nanophase and Nanocomposite Materials III. Symposium **581**: 503-9.

We have applied Atomic Number Contrast Scanning Transmission Electron Microscopy (Z-Contrast STEM) and STEM/EELS (Electron Energy Loss Spectroscopy) towards the study of colloidal CdSe semiconductor nanocrystals embedded in MEH-PPV polymer films. Z-Contrast images are direct projections of the atomic structure. Hence they can be interpreted without the need for sophisticated image simulation and the image intensity is a direct measure of the thickness of a nanocrystal. Our thickness measurements are in agreement with the predicted faceted shape of these nanocrystals. Our unique 1.3 AA resolution STEM has successfully resolved the sublattice structure of these CdSe nanocrystals. In 010 projection (the polar axis in the image plane) we can distinguish Se atom columns from Cd columns. EELS measurements on individual nanocrystals indicate a significant amount (equivalent to 0.5-1 surface monolayers) of oxygen on the nanocrystals, despite processing in an inert atmosphere. Spatially resolved measurements at 7 AA resolution suggest a surface oxide layer. (14 References).

Kahler, U. and H. Hofmeister (2000). "Atomic dynamics of amorphous and nanocrystalline Ni<sub>80</sub>P<sub>20</sub>." Materials Science Forum **343**(346): 671-6.

Meltspun ribbons of the metallic glass Ni<sub>80</sub>P<sub>20</sub> were carefully annealed to obtain nanocrystalline samples. The structure of the samples were investigated by X-ray diffraction and the nanocrystalline samples were studied additionally by transmission electron microscopy, yielding a mean nanocrystal size of 20 to 60 nm. The inelastic neutron scattering experiments were performed at room temperature at the cold neutron time-focusing time-of-flight (t-o-f) spectrometer IN6 at the High Flux Reactor of the Institute Laue-Langevin in Grenoble. The generalized vibrational density of states  $G(\omega)$  of the nanocrystalline and of the amorphous sample determined from the t-o-f spectra consists of two main bands, of which the one at higher energies, centered at approximately=43 (46) meV (glass), is rather weak, while the main band, centered at approximately=22 (21) meV is dominant.  $G(\omega)$  of the metallic glass extends slightly to lower and to higher energies than does that of the nanocrystalline samples and the two subbands of it do not show any substructure. In the dominant band of the generalized vibrational density of states of the nanocrystalline sample the subdivision in at least 3 further subbands is indicated. We discuss these differences in the atomic dynamics in the context of our specific heat experiments done with the same samples. (10 References).

Kanemitsu, Y., H. Tanaka, et al. (2000). "Surface passivation and enhanced quantum-size effect and photo stability of coated CdSe/CdS nanocrystals." Physica A **8**(2): 129-33.

Coated CdSe/CdS nanocrystals have been synthesized through a new reaction routine in micelle solution. High-

resolution transmission electron microscope (HRTEM) images demonstrated the monodispersity and core-shell structure of CdSe/CdS nanocrystals. After CdSe nanocrystals were passivated by CdS shell, the reduced photoluminescence (PL) intensity of surface states and enhanced band-edge emission have been observed. The enhanced photo-chemical stability of coated CdSe/CdS nanocrystals has also been demonstrated from photo oxidation experiments. (5 References).

Kanemitsu, Y., H. Tanaka, et al. (2000). "Formation mechanism of silver nanocrystals made by ion irradiation of Na<sup>+</sup> to or from Ag<sup>+</sup> ion-exchanged sodalime silicate glass." Nuclear Instruments and Methods in Physics Research Section B Beam Interactions with Materials and Atoms **168**(2): 237-44.

Sodalime silicate glass surface layers were doped with up to 7.0 at.% Ag/sup +/- ions by ion-exchange in a AgNO<sub>3</sub>/NaNO<sub>3</sub> solution at 330-355 degrees C. Ion irradiation using either 400 and 500 keV He, 1 MeV Ne or 2 MeV Xe was then used to induce the growth of metallic nanocrystals in the ion-exchanged region. The ion fluences ranged from 1.3\*10<sup>14</sup> ions/cm<sup>2</sup> to 1.1\*10<sup>17</sup> ions/cm<sup>2</sup>. X-ray and electron diffraction show small Ag nanocrystals with a broad size distribution, up to a diameter of 10-15 nm, after irradiation. Optical transmission measurements show the characteristic surface plasmon resonance of metallic Ag around 420 nm. The absorption resonance sharpens and increases in strength with increasing ion irradiation fluence, indicating that both nanocrystal size and volume fraction increase with irradiation fluence. Depending on ion fluence, up to ~15% of the ion-exchanged Ag/sup +/- ions is incorporated in nanocrystals. From a systematic comparison of the degree of nanocrystal formation as a function of ion species, fluence and energy, it is concluded that nanocrystal formation is mainly caused by the atomic displacement energy loss component of the incoming ion beam; the electronic energy deposition component is less efficient. (12 References).

Kanemitsu, Y., K. Masuda, et al. (2000). "Near-infrared photoluminescence from Ge nanocrystals in SiO<sub>2</sub> matrices." Journal of Luminescence **87**(89): 457-9.

We have fabricated light-emitting Ge nanocrystals by means of Ge/sup +/- ion implantation into SiO<sub>2</sub> films followed by thermal annealing. Ge nanocrystals with the 5-nm average diameter are formed uniformly in SiO<sub>2</sub> films. A photoluminescence band with fine structures is observed near 0.9-1.0 eV. We will discuss the mechanism of the near-infrared luminescence from Ge nanocrystals. (16 References).

Kanemitsu, Y., H. Tanaka, et al. (2000). "Luminescence properties of GaAs nanocrystals fabricated by sequential ion implantation." Journal of Luminescence **87**(89): 432-4.

We have studied photoluminescence (PL) properties of GaAs nanocrystals in SiO<sub>2</sub> matrices formed by sequential ion implantation and thermal annealing. After thermal annealing at 900-1000 degrees C, broad PL due to GaAs nanocrystals appears in the red spectral region. The spectral shape of the red PL band depends on the hydrogen concentration in the sample. The hydrogen effect on GaAs nanocrystal luminescence will be discussed. (12 References).

Kaszur, Z. (2000). "Powder diffraction beyond the Bragg law: study of palladium nanocrystals." Journal of Applied Crystallography **33**(5): 1262-70.

An experimental method of measurement of the subtle changes of structure of metal nanocrystals occurring on chemisorption of oxygen, interaction with inert gas and hydrogen, etc., is proposed. The measured patterns and their evolution are interpreted via atomistic simulations. Described are quantitative observations of the changes in peak position, intensity and half width of the 111 diffraction peak of a palladium catalyst caused by modifying the gaseous environment. The results of the measurements are in line with an atomistic model proposed earlier and prove that the measured average lattice constant of palladium clusters evolves according to their surface relaxation. The evolution of the measured peak intensity suggests surface ordering effects and was used to propose a detailed structural model of nanocrystalline metal particles. The transition of palladium into beta -Pd-H in hydrogen under normal conditions was used as a structure probe and provided evidence for the presence of icosahedral clusters in a highly dispersed catalyst. The icosahedral phase is not significantly modified under hydrogen atmosphere and does not transform into the beta hydride. (16 References).

Katz, D., O. Millo, et al. (2000). "Size-dependent tunneling spectroscopy of InAs nanocrystals." Physica B **284**(288): 1760-1.

Scanning tunneling spectroscopy is employed in studies of single InAs nanocrystals, 2-8 nm in diameter. The I-V curves exhibit size-dependent charging and quantum size effects, from which atomic-like states having S and P symmetries are identified. Excellent agreement is found between level spacings observed by tunneling and the corresponding optical transitions. (3 References).

Kemeny, T., D. Kaptas, et al. (2000). "Size-quantization Stark effect in quasi-zero-dimensional semiconductor structures." Fizika i Tehnika Poluprovodnikov **34**(9): 1120-4.

A theory of the size-quantization Stark effect in semiconductor nanocrystals under conditions in which the polarization interaction of an electron (hole) with a nanocrystal surface plays the dominant role is developed. It is

shown that, in the region of interband absorption, the shifts of electron (hole) size-quantization levels in a nanocrystal subjected to an external homogeneous electric field are governed by the quadratic Stark effect. A new electrooptical method is proposed furnishing an opportunity to determine the critical radii of nanocrystals in which bulk excitons can appear. (20 References).

Kho, R., L. Nguyen, et al. (2000). "Zinc-histidine as nucleation centers for growth of ZnS nanocrystals." Biochemical and Biophysical Research Communications **272**(1): 29-35.

Histidine is a chelator of zinc, most notably in zinc-finger proteins (zinc coordinated by cysteine and histidine) and in hyperaccumulator plants. Sulfide incorporation into molecules containing metal-cysteine complexes has been shown to occur in vivo in certain yeasts, leading to enhanced metal tolerance. Demonstrated here for the first time is incorporation of sulfide into zinc-histidine, resulting in histidine-ZnS nanocrystals (NCs) having unique optical properties. Sulfide complexation occurred optimally at alkaline pH into zinc-(histidine)<sub>2</sub> species, and UV/Vis absorption maxima were red-shifted as increasing sulfide addition occurred. Intermediate sulfide concentrations led to multiple, thermodynamically preferred NC species within a sample. Fluorescence of histidine-ZnS NCs was greater than ZnS prepared previously with cysteine peptides. Transmission electron microscopy and selected-area electron diffraction indicated hexagonal ZnS crystals having an average size of 4.2 nm. A photocatalytic application of histidine-ZnS NCs was shown by efficient degradation of p-nitrophenol and paraquat in the presence of UV irradiation.

Kik, P. G., M. L. Brongersma, et al. (2000). "Strong exciton-erbium coupling in Si nanocrystal-doped SiO<sub>2</sub>." Applied Physics Letters **76**(17): 2325-7.

Silicon nanocrystals were formed in SiO<sub>2</sub> using Si ion implantation followed by thermal annealing. The nanocrystal-doped SiO<sub>2</sub> layer was implanted with Er to a peak concentration of 1.8 at.%. Upon 458 nm excitation the sample shows a broad nanocrystal-related luminescence spectrum centered around 750 nm and two sharp Er luminescence lines at 982 and 1536 nm. By measuring the excitation spectra of these features as well as the temperature-dependent intensities and luminescence dynamics we conclude that (a) the Er is excited by excitons recombining within Si nanocrystals through a strong coupling mechanism, (b) the Er excitation process at room temperature occurs at a submicrosecond time scale, (c) excitons excite Er with an efficiency >55%, and (d) each nanocrystal can have at most ~1 excited Er ion in its vicinity. (12 References).

Kik, P. G. and A. Polman (2000). "Transient luminescence line shapes for Mn<sup>2+</sup> ions in ZnS nanocrystals." Journal of Luminescence **90**: 1-2.

Recent time-resolved luminescence spectra reported by Yu et al. from ZnS:Mn nanocrystals embedded in a polymer matrix showed the presence of two emission bands that merge into a single band as time passed following an intense laser excitation pulse. We have calculated the bandshapes as a function of time assuming a nonequilibrium initial distribution for the excited vibrational states. Our calculated bandshapes fit quite well to those observed experimentally and support the explanation given by Yu et al. This would seem to be an ideal system in which to study the approach to thermal equilibrium in nanocrystals. (14 References).

Kim, H. B., J. H. Son, et al. (2000). "Photoluminescence from Si ion irradiated SiO<sub>2</sub>/Si/SiO<sub>2</sub> films with elevated substrate temperature." Materials Science and Engineering B Solid State Materials for Advanced Technology **70**(19): 401-5.

Photoluminescence (PL) from the Si ion irradiated SiO<sub>2</sub>/Si/SiO<sub>2</sub> layers on Si substrate at room temperature and elevated substrate temperatures has been studied to elucidate the luminescence origins. The irradiation of Si ions into SiO<sub>2</sub>/Si/SiO<sub>2</sub> layers instead of SiO<sub>2</sub> films was performed to improve the PL intensity by increasing the number of proper-sized Si nanocrystals. Before annealing at high temperature, a luminescence band around 450 nm is observed. This luminescence band was found to originate from the diamagnetic defect known as B<sub>2</sub> band generated by Si ion irradiation. The intensity of this band increases when ion irradiation is carried out at high substrate temperature. After annealing at high temperature, the PL peaks originating from the B<sub>2</sub> band disappear and a new PL peak appears around 700 nm. This luminescence band is associated with ~5-nm sized Si nanocrystals. Also it can be found that the PL peak intensity around 700 nm is significantly increased with the high substrate temperature during ion irradiation. Therefore, it is concluded that ion irradiation into SiO<sub>2</sub>/Si/SiO<sub>2</sub> layers is more effective than ion implantation into SiO<sub>2</sub> films to obtain an intensive PL peak originating from Si nanocrystals. (16 References).

Kim, B. S., L. Avila, et al. (2000). "Characterization of the optical size-dependence of pyrazolines nanocrystals." Chemical Physics Letters **322**(5): 327-32.

Nanocrystals of 1-phenyl-3-((dimethylamino)styryl)-5-((dimethylamino)phenyl)-2-pyrazoline (PYB) with different sizes were prepared by the reprecipitation method. The aggregate formation of PYB nanocrystals was found to be J-aggregate, of which the wavelength of absorption peak was observed at 445 nm. Further, we found that the PYB nanocrystals possessed a special optical size-dependent property. As the nanocrystal size decreased, the molecular absorption peak of PYB nanocrystals was observed to shift to high-energy side due to size effect and the J-aggregate absorption peak gradually vanished simultaneously. (17 References).

Kishimoto, N., Y. Takeda, et al. (2000). "The effect of ion-irradiation and annealing on the luminescence of Si nanocrystals in SiO<sub>2</sub>." Nuclear Instruments and Methods in Physics Research Section B Beam Interactions with Materials and Atoms **166**(167): 851-6.

SiO<sub>2</sub> layers containing Si nanocrystals were irradiated with either 400 keV or 3 MeV Si ions to determine the effect of nuclear and electronic energy loss processes on defect production and luminescence. Irradiation reduced the nanocrystal-related luminescence at 806 nm and produced a well-known defect emission at 640 nm. Irradiation had a similar dose dependence for both 400 keV and 3 MeV ions, despite significant differences in the magnitude and nature of their energy loss. This was reconciled by assuming that the defect production rate from electronic energy loss processes was ~10% of that for nuclear processes. The nanocrystal emission was particularly sensitive to irradiation, being quenched to 4% of its initial value following irradiation to  $5 \times 10^{12}$  Si cm<sup>-2</sup> and saturating for fluences  $> 5 \times 10^{13}$  Si cm<sup>-2</sup> (0.18 dpa). This is discussed in terms of a previously proposed model in which point defects produced by irradiation accumulate at the nanocrystal surface leading to amorphisation at low displacement rates (0.1-0.2 dpa). In this model, quenching of the nanocrystal emission and its sensitivity to dose are assumed to result from the preferential accumulation of point-defect at the nanocrystal-SiO<sub>2</sub> interface, an effect which is predicated on the assumption that such defect act as non-radiative recombination centres. The existence of such defects is shown to be supported by the annealing behaviour of the nanocrystal and defect emissions. (24 References).

Kityk, I. V., A. Kassiba, et al. (2000). "A novel technique by the citrate pyrolysis for preparation of iron oxide nanoparticles." Materials Science and Engineering B Solid State Materials for Advanced Technology(2): 207-9.

A novel technique by the citrate pyrolysis is developed to prepare metal oxide nanocrystals. In this paper details on synthesizing iron oxide nanoparticles through this method is described. The structure and morphology of nanoscale products have been characterized by powder X-ray diffraction (XRD) and scanning electron microscopy (SEM). The obtained iron oxide particles have two lattice types and a mean particle size distribution of 20 and 50 nm, respectively. (8 References).

Kityk, I. V., M. Makowska-Janusik, et al. (2000). "Nonlinear optical properties of semiconductor-doped sol-gel waveguides." Fiber and Integrated Optics **19**(1): 43-56.

Thin silica-titania films doped with CdS and PbS nanocrystals have been prepared by the sol-gel route. Their nonlinear properties have been studied using the techniques of degenerated four-wave mixing and m-lines with picosecond (ps) and nanosecond laser pulses. Depending on wavelength, doping level, and laser pulse duration, high negative nonlinearity was found for CdS-doped ( $n^2 = -2 \times 10^{-8}$  cm<sup>2</sup>/kW) and PbS-doped films ( $-10^{-10}$  to  $-2 \times 10^{-7}$  cm<sup>2</sup>/kW). The response time of the nonlinearity was below 35 ps. Saturation of the nonlinearity was observed. Straight, monomode channel waveguides have been fabricated on these films. The influence of MIE-scattering due to the nanoparticles is investigated. (32 References).

Klimov, V. I. (2000). "Optical nonlinearities and ultrafast carrier dynamics in semiconductor nanocrystals." Journal of Physical Chemistry B **104**(26): 6112-23.

Femtosecond transient absorption in the visible and infrared spectral ranges has been applied to study carrier dynamics and mechanisms for resonant optical nonlinearities in CdSe nanocrystals (NCs) with a variety of surface passivations. Sequential filling of the 1S, 1P and 1D atomic-like electron orbitals, governed by Fermi statistics, is clearly observed in the NC bleaching spectra recorded at progressively higher pump intensities. We observe that electron-hole (e-h) spatial separation strongly affects electron intraband dynamics. Such dependence indicates a nonphonon energy relaxation mechanism involving e-h interactions. A strong difference in electron and hole relaxation behavior in the stage following initial intraband relaxation is observed. In contrast to electron relaxation, which is sensitive to the quality of surface passivation (i.e., is affected by trapping at surface defects), depopulation dynamics of the initially-excited hole states are identical in NCs with different surface properties, suggesting that these dynamics are due to relaxation into intrinsic NC states. In the regime of multiparticle excitation, a quantization of relaxation rates corresponding to different multiple e-h pair states is observed. This effect is explained in terms of quantum-confined Auger recombination. (64 References).

Kodiyalam, S., R. K. Kalia, et al. (2001). "Grain boundaries in gallium arsenide nanocrystals under pressure: A parallel molecular-dynamics study." Physical Review Letters **86**(1): 55-58.

Structural transformation in gallium arsenide nanocrystals under pressure is studied using molecular-dynamics simulations on parallel computers. It is found that the transformation from fourfold to sixfold coordination is nucleated on the nanocrystal surface and proceeds inwards with increasing pressure. Inequivalent nucleation of the high-pressure phase at different sites leads to inhomogeneous deformation of the nanocrystal. This results in the transformed nanocrystal having grains of different orientations separated by grain boundaries. A new method based on microscopic transition paths is introduced to uniquely characterize grains and deformations.

Kolobov, A. V., Y. Maeda, et al. (2000). "Raman spectra of Ge nanocrystals embedded into SiO<sub>2</sub>." Journal of Applied

Physics **88**(6): 3285-9.

We start with an analysis of the Raman spectra of Ge nanocrystals obtained in previous studies and demonstrate that in many cases the observed experimental peak attributed to Ge in fact originates from the Si substrate. We further compare various experimental ways to separate the Ge signal from that of the substrate and suggest optimum conditions for such measurements. Finally, we demonstrate that upon the annealing of an amorphous Ge-Si-O film, Ge nanocrystals are formed. The nanocrystals are randomly oriented and Ge-Si mixing takes place only at the interface with the Si substrate. (25 References).

Kondo, S., H. Tanaka, et al. (2000). "Size-dependent optical edge shifts and electrical conduction behaviour of RF magnetron sputtered CdTe nanocrystals:TiO<sub>2</sub> composite thin films." Semiconductor Science and Technology **15**(11): 1011-21.

CdTe nanocrystals sequestered and passivated in an amorphous TiO<sub>2</sub>/thin film matrix have been prepared by RF sputtering from a composite TiO<sub>2</sub>/CdTe target. The CdTe nanocrystal size and volume fraction increases from 15 to 40 nm and 2 to 20% respectively as the film thickness increases, typically from 0.05 to 0.25 μm. A systematic dependence of the optical band edge on the CdTe nanocrystal size shows a strong quantum confinement effect. The optical edge shifts are significantly higher than the theoretical prediction based on single-particle confinement of decoupled electrons and holes. This is understood on the basis of nucleation-controlled growth of CdTe nanocrystals by direct vapour phase condensation, in which small nuclei are rapidly passivated by TiO<sub>2</sub> depositing at much higher rates. The nano-sized CdTe growth island thus formed comprises of several TiO<sub>2</sub> passivated nanocrystals. Electrical conduction behaviour of these films show that tunnelling between the CdTe nanocrystals is not a dominant mechanism, as a three-dimensional network is not realized due to small thickness and lower coverage. The current transport is essentially space-charge-limited. The injection of electrons from nano-sized CdTe crystals follows spherical radial space charge flow which modifies the usual power law dependence from quadratic to 3/2. The analytical description of the current conduction process in composite CdTe:TiO<sub>2</sub> is discussed. (31 References).

Korgel, B. A. and H. G. Monbouquette (2000). "Controlled synthesis of mixed core and layered (Zn,Cd)S and (Hg,Cd)S nanocrystals within phosphatidylcholine vesicles." Langmuir **16**(8): 3588-94.

Phosphatidylcholine vesicles provide reaction compartments for the synthesis of nanometer-size CdS, Zn<sub>y</sub>/Cd<sub>1-y</sub>/S, and Hg<sub>y</sub>/Cd<sub>1-y</sub>/S particles with size- and composition-tunable absorbance and luminescence features. Spectrophotometric and spectrofluorimetric measurements are consistent with crystalline, monodisperse particles with few core or surface defects and uniform core composition. Core-shell CdS-HgS and CdS-ZnS nanocrystals also are synthesized within the vesicle interiors by alternating addition of cations and sulfide to build layered particles. These materials exhibit well-defined, yet qualitatively different, absorbance and luminescence spectra and establish the versatility of vesicles for synthesis of both mixed and layered composition nanocrystals. (45 References).

Korgel, B. A. (2001). "Correlated membrane fluctuations in nanocrystal superlattices." Physical Review Letters **86**(1): 127-130.

Superlattices of organic monolayer-stabilized silver nanocrystals exhibit structural integrity at temperatures well above the melting point of the hydrocarbon capping ligands (i.e., the C (8), C (12), and C (16) alkanethiols used in this study). Temperature-dependent small angle x-ray scattering reveals that topological disordering occurs with spatially correlated domains of characteristic length  $\xi$  that grow with increasing temperature until  $\xi$  diverges at a critical temperature  $T(c)$ , as  $\xi$  approximately  $\xi(0)(1-T/T(c))^{-0.67}$ . A power law analysis of the scattering intensity with wave vector indicates that interactions between membranes due to thermal undulations control the topology below  $T(c)$ .

Korovin, S. B., B. B. Krinetskii, et al. (2000). "Optical properties of metal-coated silicon nanocrystals." Proceedings of SPIE the International Society for Optical Engineering **4070**: 465-71.

The linear and nonlinear optical properties of gold-coated nano-crystals embedded in glycerol have been investigated. The optical absorption spectra and the nonlinear absorption of these nanostructures have been determined under various excitation conditions. The peak of the plasmon resonance like curve has been observed to be blue shifted compared to the plasmon peak of colloidal gold particles. The resonance behavior exhibited by the gold coated silicon nano-crystals is interpreted in terms of the third order nonlinear susceptibility which is expressed as a saturation absorption behavior of the samples. The effect of the charged interface gold film, which covers the nanocrystals, on the electron band structure and on the linear and nonlinear optical properties are discussed. (7 References).

Korovin, S. B., V. I. Pustovoy, et al. (2000). "High nonlinear susceptibility of silicon-based nanostructures." Proceedings of SPIE the International Society for Optical Engineering **4070**: 472-8.

Presents the review of non-linear optical properties investigations of silicon based nanostructures. The non-linear optical response of the silicon nanocrystals imbedded in a glycerol matrix, as well as the silicon nanocrystals

monolayer on a silver surface and the silicon nanocrystals covered by a thin gold film were analyzed. For dressed particles the saturation absorption behavior was observed. The competition of the saturation absorption and third order non-linear optical absorption are realized for the undressed particles and nanocrystals monolayer. The huge nonlinear susceptibility  $2 \times 10^{-3} \text{ cm}^2/\text{W}$  was observed for silicon nanocrystals deposited on a silver surface. The effect of the nanoparticles interface condition to the optical properties by means of a static electric field inside the nanoparticles has been established. The internal static electric field origin and its influence on the linear and non-linear optical properties of silicon based nanocomposite structures are discussed. (10 References).

Korovin, S. B., V. I. Krasovskii, et al. (2000). "Extremely large nonlinear optical response of the silicon nanocrystal monolayer on silver surface." Proceedings of SPIE the International Society for Optical Engineering **4070**: 479-83.

The huge non-linear optical response have been observed for the silicon nanocrystals monolayer on a silver surface in the normal back scattering configuration. The competition of non-linear saturation and absorption was observed. The value of the non-linear optical absorption coefficient is coming to  $2 \times 10^{-3} \text{ cm}^2/\text{W}$ . The structure of the monolayer was tested by an atomic force microscope and the average thickness has been estimated on the basis of the surface plasma waves resonance in a Kretschmann configuration. The enhancement of the non-linear susceptibility by the effect of the surface of a noble metal is observed. (4 References).

Kovalev, D., J. Diener, et al. (2000). "Low-temperature photoluminescence upconversion in porous Si." Physical Review B Condensed Matter **61**(23): 15841-7.

We report efficient low-temperature upconverted photoluminescence (UPL) at resonant excitation of the porous Si photoluminescence band. The UPL has a linear dependence on the excitation intensity, quenches at elevated temperatures, and is absent in strongly oxidized porous Si and oxidized Si nanocrystals. These observations are explained by the resonant excitation of electron-hole pairs spatially separated in neighboring crystals. UPL results from the subsequent excitation of a second pair in the larger of the two crystals and Auger ejection of a carrier into the smaller one, with the larger gap. (31 References).

Kovalev, D., J. Diener, et al. (2000). "Diamond nucleation enhancement by direct low-energy ion-beam deposition." Physical Review B Condensed Matter **61**(8): 5579-86.

Direct ion beam deposition was successfully applied for the nucleation of nanodiamond crystallites on mirror-polished Si(001) substrates. Low-energy (80-200 eV) argon, hydrocarbon, and hydrogen ions from a Kaufman ion source were used. An amorphous carbon film was deposited on the substrate after ion bombardment. The films were characterized by high-resolution transmission electron microscopy, selected area electron diffraction, secondary electron microscopy, and micro-Raman spectroscopy. At ion doses above  $1 \times 10^{18} \text{ cm}^{-2}$ , nanocrystalline diamond particles of 50-100 Å in diameter were formed in a matrix of amorphous carbon. These diamond nanocrystals served as nucleation centers for subsequent diamond growth by conventional hot filament chemical vapor deposition. The nucleation density depended strongly on the ion dosage, and a nucleation density of  $3 \times 10^9 \text{ cm}^{-2}$  could be achieved under optimized conditions. These results were found very helpful for the evaluation of the mechanism of ion-bombardment-induced nucleation of diamond. (47 References).

Kral, K., Z. Khas, et al. (2000). "Organic ligand and solvent kinetics during the assembly of CdSe nanocrystal arrays using infrared attenuated total reflection." Applied Physics Letters **76**(25): 3715-17.

The self-assembly of amorphous three-dimensional arrays of CdSe nanocrystals is probed in real time using multiple-reflection, infrared attenuated total reflection spectroscopy by following the solvent and the organic ligands that passivate the nanocrystal surface. During the self-assembly of a 250 ML array from pyridine-capped CdSe nanocrystals in pyridine solvent, the solvent molecules evaporate in ~30-40 min and the pyridine-capping molecules leave the array very slowly, apparently limited by diffusion, with ~30±8% remaining after three days. (13 References).

Krauss, T. D. and L. E. Brus (2000). "Electronic properties of single semiconductor nanocrystals: optical and electrostatic force microscopy measurements." Materials Science and Engineering B Solid State Materials for Advanced Technology **70**(19): 289-94.

We review the room temperature optical and electronic properties of single semiconductor nanocrystals, which are made by chemical synthesis. Confocal luminescence spectroscopy of single nanocrystals reveals a blinking behavior apparently due to an intermittent photoionization. To investigate this further, the dielectric constant and electrostatic charge of single CdSe nanocrystals was measured. The static dielectric constant among single CdSe nanocrystals is uniform, and its value is consistent with the value of the dielectric constant of the bulk material. However, the electrostatic polarization among individual nanocrystals is non-uniform, with a significant fraction of the nanocrystals possessing a partial positive charge ( $Q \sim 0.5 e$ ), and/or a permanent dipole ( $P \sim 35 \text{ D}$ ). A small fraction of the nanocrystals has a positive polarization, which blinks 'on' and 'off' over time. In addition, photoexcitation with frequencies greater than the band gap of the nanocrystal results in photoionization. (32 References).

Kremar, M., W. M. Saslow, et al. (2000). "Artificially nanostructured Cu:Al<sub>2</sub>O<sub>3</sub> films produced by pulsed laser deposition." Applied Physics(5): 583-6.

The processes leading to the formation of Cu:Al/sub 2/O/sub 3/ composite films on Si (001) with a well defined nanostructure by alternate pulsed laser deposition (a-PLD) in vacuum are investigated. Alternately amorphous Al/sub 2/O/sub 3/ layers and Cu nanocrystals nucleated on the Al/sub 2/O/sub 3/ surface are formed, according to the PLD sequence. The Al/sub 2/O/sub 3/ deposited on the Cu nanocrystals fills in the space between them until they are completely buried, and subsequently, a continuous dense layer with a very flat surface (within 1 nm) is developed. The nucleation process of the nanocrystals and their resulting oblate ellipsoidal shape are discussed in terms of the role of the energetic species involved in the PLD process and the metal-oxide interface energy. (30 References).

Kurita, A., Y. Kanematsu, et al. (2000). "Wavelength- and angle-selective properties of optical memory effect by interference of multiple-scattered light in Sm-doped ZnS nanocrystals." Journal of Luminescence **87**(89): 986-8.

Our recent experiments have shown that both the wavelength and the angle of incident light are memorized in Sm-doped ZnS nanocrystals by photobleaching coupled with interference of the multiple-scattered light. We have measured the angle-selective properties by scanning the incident angle, as well as the wavelength-selective properties, and we discuss the density of data storage that can be derived from this effect. (4 References).

Kurokawa, Y., S. Nomura, et al. (2000). "Calculation of linear/nonlinear optical response functions of large quantum systems by real-time real-space higher-order finite-difference method." Institute of Physics and Chemical Research **29**: 29-32.

We report the state of progress in the application of the real-time real-space higher-order finite-difference method which is effective in computing electronic properties of large quantum systems. With the use of empirical pseudopotentials, the effectiveness of the method has been demonstrated in the calculation of absorption spectra of such realistic systems as hydrogenated silicon nanocrystallites, silicon nanocrystals embedded in amorphous silicon, and polysilane. The method has proved also effective in calculating nonlinear response functions when used in conjunction with a newly developed fast algorithm. (21 References).

Kushida, T., A. Kurita, et al. (2000). "Optical properties of Sm-doped ZnS nanocrystals." Journal of Luminescence **87**(89): 466-8.

In order to understand the spectral characteristics of ZnS:Sm nanocrystals, in which a novel optical memory effect has been observed, optical properties have been studied between 2 and 300 K for the samples prepared by a solution method. The broad fluorescence and excitation bands observed in the visible region are tentatively assigned to the transitions between the 4f/sup 6/ and 4f/sup 5/5d states of Sm/sup 2+/ and also to the transitions of excitons bound to Sm/sup 2+/. Temperature dependence of the intensity of the lowest-energy emission band and the dependence of its peak position on the excitation wavelength have been explained well by these assignments. (8 References).

Ladizhansky, V. and S. Vega (2000). "Single-electron tunneling through Si nanocrystals dispersed in phosphosilicate glass thin films." Physica A **7**: 3-4.

Electrical transport properties of extremely thin phosphosilicate glass (PSG) films containing Si nanocrystals (nc-Si) a few nanometers in diameter were studied. Samples were prepared by cosputtering Si and PSG targets, and post-annealing. Periodic Coulomb staircases were clearly observed in the DC current-voltage (I-V) characteristics along the vertical direction of films. Although the step structure was broadened with increasing temperature, it remained up to 200 K. The I-V curve could be well fitted by Monte Carlo simulation with a simple double-barrier structure model. Advantages of using PSG instead of SiO/sub 2/ as surrounding matrices of nc-Si to observe single-electron tunneling effects are discussed. (18 References).

Lazarouk, S., S. Katsouba, et al. (2000). "Optical characterization of reverse biased porous silicon light emitting diode." Materials Science and Engineering B Solid State Materials for Advanced Technology **70**(19): 114-17.

Optical characterization of porous silicon (PS) light emitting diodes (LED) formed in the transition regime and with an alumina passivating coating has been performed to understand the light emission mechanism. Fourier transform infrared reflection investigations, photoluminescence (PL), electroluminescence (EL) and Raman scattering measurements have been used. The investigated LED shows a visible emission band both for PL and EL, and a broad structured emission in the infrared for EL. The origin of visible EL and PL may be ascribed to carrier recombination in Si nanocrystals and in the defected oxide which coats them. The origin of infrared EL can be explained by band-to-band recombination in Si grains with large sizes ( $L \geq 6$  nm) and by dislocation related emissions (D1 line). Possible improvements of the presented light emitting diode structure have been discussed. (22 References).

Ledoux, G., O. Guillois, et al. (2000). "Photoluminescence properties of silicon nanocrystals as a function of their size." Physical Review B Condensed Matter **62**(23): 15942-51.

We present results on the photoluminescence (PL) properties of silicon nanocrystals as a function of their size. The nanocrystals are synthesized by laser pyrolysis of silane in a gas flow reactor and deposited at low energy on a substrate after a mechanical velocity and size selection. Both the photoluminescence spectroscopy and yield have been studied as well as the effect of aging of the samples in air. The measurements show that the PL of the silicon nanocrystallites follows the quantum confinement model very closely. The apparent PL yields are rather high (up to 18%). From evaluation of the size distribution obtained by atomic force microscopy it is concluded that the intrinsic PL yield of the nanocrystals can reach almost 100%. These results enabled us to develop a simple theoretical model to describe the PL of silicon nanocrystals. This model can also explain the changes of PL with aging of the sample, just by invoking a decrease of the size of the crystalline core as a result of oxidation. (43 References).

Lee, W. S., J. Y. Jeong, et al. (2000). "Violet and orange luminescence from Ge-implanted SiO<sub>2</sub> layers." Materials Science and Engineering B Solid State Materials for Advanced Technology **70**(19): 474-8.

Ge ions of 100 keV were implanted into a 120-nm thick SiO<sub>2</sub>/sub 2/ layer at room temperature (RT), 300, and 500 degrees C. The employed doses of Ge ion were 5\*10<sup>15</sup>/cm<sup>2</sup>, 1\*10<sup>16</sup>/cm<sup>2</sup>, 5\*10<sup>16</sup>/cm<sup>2</sup>, and 1\*10<sup>17</sup>/cm<sup>2</sup>. Maximum intensity of sharp violet photoluminescence (PL) from the sample implanted at room temperature with a dose of 1\*10<sup>16</sup>/cm<sup>2</sup> is observed after the sample has been annealed at 500 degrees C for 2 h. Broad orange luminescence is also shown in hot-implanted samples besides the violet. Both are known as defect-related luminescences. As observed by current-voltage (I-V) characteristics, the defect-related samples exhibit large leakage currents with electroluminescence (EL) at only reverse bias region while a nanocrystal-related sample obtained by an annealing at 1100 degrees C for 4 h shows the leakages at both the reverse and the forward region. The carrier-transport and EL mechanisms are explained from the PL and I-V results. (14 References).

Lee, J. M., D. H. Kim, et al. (2000). "Growth of InAs nanocrystals on GaAs(100) by droplet epitaxy." Journal of Crystal Growth **212**: 1-2.

Self-assembled InAs nanocrystals were grown by droplet epitaxy on a GaAs(100) substrate at a relatively low growth temperature of 160 degrees C. The growth mode of InAs varies as a function of the surface stabilizing conditions of the GaAs(100) substrate. Three-dimensional InAs nanocrystals with a height of 30-40 nm and a base size of 350 nm were grown on the Ga-stabilized surface. However, a two-dimensional layer of InAs with a root-mean-square roughness of 1.4-3.5 AA was formed on the As-stabilized surface. The island density was higher on the vicinal surface than that on the singular surface. The islands were preferentially aligned along the <100> direction, i.e., parallel to the step edges of the substrate. The base edges of islands on the vicinal surface were also aligned along the <100> direction. These results suggest that the conditions of substrate surface, as well as the strain energy due to the lattice misfit between InAs and GaAs play important roles in the formation of self-assembled InAs nanocrystals by droplet epitaxy. (19 References).

Leitner, D. M. and P. G. Wolynes (2000). "Heat flow through an insulating nanocrystal." Physical Review E. Statistical Physics, Plasmas, Fluids, and Related Interdisciplinary Topics **61**(3): 2902-8.

We calculate the low temperature, quantum mechanical rate of heat flow through a nanocrystal due to phonon transport by solving a many-body Schrodinger equation for oscillators in Fermi resonance. By analogy to Raman scattering through molecules, we find that normal processes due to anharmonicity of the nanocrystal give rise, over an intermediate range of lengths, to a largely length-independent thermal conductivity that resembles Fourier's law, but is in fact of a different origin. For longer crystals conductivity rises with length, as predicted for a harmonic solid. For shorter nanocrystals thermal conductivity also rises with length, followed by a turnover regime in which thermal conductivity is size specific.

Leitner, D. M. and P. G. Wolynes (2000). "Formation of luminescent spherical core-shell particles by the consecutive adsorption of polyelectrolyte and CdTe(S) nanocrystals on latex colloids." Colloids and Surfaces A Physicochemical and Engineering Aspects **163**(1): 39-44.

Functional core-shell particles were prepared by assembling a composite multilayer shell of charged polyelectrolytes and luminescent CdTe(S) nanocrystals (cadmium telluride with a certain content of sulfide) via their consecutive electrostatic adsorption from solution onto micron-sized latex particles. The formation of the composite shell has been confirmed by optical spectroscopy, confocal microscopy and high-resolution transmission electron microscopy. Variation of the size and surface chemistry of the semiconductor nanoparticles, the size and shape of the colloid templates, and the nature of the polyelectrolyte opens new avenues for the production of a variety of novel core-shell materials. (15 References).

Leman, V. I. (2000). "Energy dispersion of localized states in light-sensitive nanocrystals." Fizika Tverdogo Tela **42**(9): 1689-94.

The kinetics of the formation and thermal destruction of color centers in CuCl and AgCl nanocrystals (NCs) distributed in a glass matrix is described on the basis of the band model of an NC with colloidal color centers and

with hole traps of one species. The possibility of experimentally determining the relative depth distribution of hole states in light-sensitive NCs in glass is demonstrated. The observed energy dispersion of localized hole states and its variation in NCs are associated, in accordance with Dexter's idea, with large-scale thermal fluctuations of the crystal field. The presence of an excess charge on a colloidal particle and its influence on localized hole states are presumed. (25 References).

Lenormand, P., A. Lecomte, et al. (2000). "Reflectometry and small angle X-ray scattering studies of thin films prepared by sol-gel processing." *EDP Sciences. Journal de Physique IV* **10**(10): 255-64.

Reflectometry, diffraction and grazing incidence small angle X-ray scattering have been used to characterize zirconia (ZrO<sub>2</sub>) thin films obtained by the sol-gel route, during low temperature treatment. Different microstructural parameters of the films such as thickness, density, phase, grain size and spatial arrangement, have been determined. Thin films were formed on mirror-polished sapphire (Al<sub>2</sub>O<sub>3</sub>) wafers by a dip-coating process in a zirconia precursor sol. Before thermal treatment, the layer is amorphous and the thickness is about 140 nm. After thermal treatment at 600 degrees C during 30 minutes, the layer thickness decreases to 60 nm while the density increases. After crystallisation in the zirconia tetragonal form, the coating is made of randomly oriented nanocrystals. This structural evolution is similar to that of a conventional xerogel showing that the interface does not modify the microstructure of the layer. The nanocrystalline layer results in a relatively dense thin film. (22 References).

Leung, M. S., G. W. Stupian, et al. (2000). "International Symposium on Metastable, Mechanically Alloyed and Nanocrystalline Materials (ISMANAM-99)." *Materials Science Forum* **343**(346).

The following topics were dealt with: metastable phases, metallic systems, fullerenes, nanotubes, size effects, icosahedral alloys, quasicrystals, bulk metallic glasses, ferromagnetic alloys, thermal stability, supercooled liquids, glass forming ability, crystallisation, nanocrystals formation, plasticity, ductility, corrosion behaviour, metallic thin films, metallic multilayers, pulsed laser deposition, nanocrystalline films, mechanical alloying, ball milling, dispersion hardening, nanocomposites synthesis, structural evolution, rapid solidification, quenching, melt spinning, devitrification, mechanochemical processing, hydrogenation, combustion, short range order, electrolytic plating, ion beam effects, chemical vapour synthesis, supersonic cluster beam synthesis, plasma jet methods, cavitation, sintering, consolidation, densification, spark plasma sintering, X-ray microstructure studies, crystal microstructure, chemical structure, glass structure, mechanical properties, superplasticity, particle reinforcements, magnetic properties, coercivity, superparamagnetism, thermomagnetic studies, electrochemical properties, corrosion resistance, catalytic properties, thermoelectric materials, superconductivity, engineering applications.

Ley, L., J. Ristein, et al. (2000). "Comment on Quantum confinement effect in diamond nanocrystals studied by X-ray-absorption Spectroscopy." *Physical Review Letters* **84**(24): 5679.

Ley, L., J. Ristein, et al. (2000). "Microstructures and visible photoluminescence of TiO<sub>2</sub> nanocrystals." *Physica Status Solidi A* **179**(2): 319-27.

Nanocrystalline titanium dioxide (TiO<sub>2</sub>) of anatase structure was prepared by a hydrolysis process of tetrabutyl titanate. The microstructures were examined by X-ray diffraction and Raman spectroscopy. The TiO<sub>2</sub> nanocrystals with particle sizes from 6.8 to 27.9 nm were obtained through an annealing treatment of the as-prepared nanocrystals at various temperatures. Photoluminescence (PL) properties of TiO<sub>2</sub> nanocrystals were investigated at various annealing temperatures (particle sizes), exciting powers, and exciting photon energies, respectively. The strongest visible emission was observed in the nanocrystals annealed at 300 degrees C, with a particle size of 7.9 nm. The experimental results manifested that the visible PL arises from a radiative recombination of electrons via intrinsic surface states of TiO<sub>2</sub> nanoparticles. (23 References).

Li, X., R. D. Beck, et al. (1992). "Photon-stimulated ejection of atoms from alkali-halide nanocrystals." *Physical Review Letters* **68**(23): 3420-3423.

Li, G. H., K. Ding, et al. (2000). "Size analysis of nanocrystals in semiconductor doped silicate glasses with anomalous small-angle X-ray and Raman scattering." *Journal of Applied Physics* **88**(4): 1873-9.

Semiconductor doped glasses containing CdS<sub>x</sub>/Se<sub>1-x</sub> nanocrystallites embedded in a silicate glass matrix were investigated. The dimensions of the nanocrystallites are in the range of a few nanometers and vary as a function of a secondary heat treatment. The confinement of such quantum dots for elementary excitations depends strongly on their size. In order to obtain a mean particle size and the size distribution, anomalous small angle X-ray scattering (ASAXS) and low-frequency inelastic Raman scattering measurements were performed. The sizes and the size distributions were evaluated for samples of different mean crystallite radius and composition x. The results of Raman measurements agree well with those of ASAXS, if both the acoustic mode damping across the nanocrystallite-matrix interface and the particle size distribution are taken into account in the Raman band shape analysis. The concentration of nanocrystallites in the glass matrix was determined by using the technique of contrast variation. Scattering curves were recorded at three energies below but close to the K-

absorption edge of selenium (12.66 keV) and at 9.64 keV for comparison, which is significantly below the absorption edge. (27 References).

Li-Ping, L. and L. Guang-She (2000). "Hyperfine characterization of the crystallization of nanocrystalline NiFe<sub>2</sub>O<sub>4</sub> from the amorphous silica gel." Hyperfine Interactions **128**(4): 437-42.

Nanocrystalline NiFe<sub>2</sub>O<sub>4</sub> was in-situ prepared in amorphous silica using tetramethylorthosilicate and nickel (iron) nitrate hydrate as the starting materials in a sol-gel reaction. The magnetic nanocrystals in the amorphous silica glasses grew slowly with increasing temperature. Above 600 degrees C, nickel ferrite nanoparticles began to precipitate from the amorphous silica matrix. Mossbauer spectroscopy of the nanocomposites suggested that in the silica glasses, Fe ions were present exclusively as Fe<sup>3+</sup> in octahedral coordination, and the chemical environment of the Fe<sup>3+</sup> ions appeared to remain unchanged until the crystallization of nickel ferrite nanocrystals. The formation of NiFe<sub>2</sub>O<sub>4</sub> nanocrystals was the result of partial transformation of the FeO<sub>6</sub> octahedra to FeO<sub>4</sub> tetrahedra. The nanocrystalline NiFe<sub>2</sub>O<sub>4</sub> are characterized by superparamagnetic behaviour at room temperature. (10 References).

Lin, X. M., C. M. Sorensen, et al. (2000). "The fine structure of excitonic levels in CdSe nanocrystals." Fizika Tverdogo Tela **42**(11): 1976-84.

The fine structure of the exciton ground level in a spherical nanocrystal of a zincblende or a wurtzite structure semiconductor was calculated with the inclusion of short- and long-range (nonanalytical), exchange-interaction components. The band-parameter dependence of the long-range exchange-interaction contribution to the spin Hamiltonian describing the exciton ground-level splitting was found. A study was made of the effect exerted on the exciton-level fine structure by the difference between the background dielectric permittivities of the nanocrystal and of the dielectric host in which it was grown. (28 References).

Lin, X. M., C. M. Sorensen, et al. (2000). "Digestive ripening, nanophase segregation and superlattice formation in gold nanocrystal colloids." Journal of Nanoparticle Research **2**: 157-164.

Ling, X., H. Xinfan, et al. (2000). "Evolution of microstructure of nanocrystalline SiC under high pressures." Materials Science Forum **321**(324): 346-51.

Strain induced by external pressure in pure nanocrystalline SiC powders with different sizes beginning from 2 nm was examined with application of in situ high pressure diffraction technique in Diamond Anvil Cell., Two methods were used for elaboration of the diffraction data: (i) strain was evaluated from asymmetry of Bragg reflections fitted with use of split-Pearson functions and (ii) strain was modelled with assumption that under pressure the actual lattice parameter of a grain depends on its size where smaller grains have more compressed lattices. The diffraction profiles were simulated ab initio from Debye functions for different grain size distribution functions and compared to the experimental patterns. It was found that transfer of the external pressure to the cores of individual grains and distribution of strain in the compressed powders depend on the size of the grains. The pressure gradient across grain boundaries increases with the increase of the size of the grains. A model of microstructure of a compressed polycrystal presented earlier for nanocrystals with grains larger than 8 nm is here verified for polycrystals with the grains of smaller sizes, down to 2 nm. (9 References).

Lisiecki, I., H. Sack-Kongehl, et al. (2000). "Annealing process of anisotropic copper nanocrystals. 2. Rods." Langmuir **16**(23): 8807-8.

The annealing process of well-defined long truncated decahedral Cu rods of a diameter in the nanometer-size range and a length of the order of 1 micron was studied. For isolated rods on the grid, two melting processes that initiated a drastic change in the melting temperature were observed. These variations are explained in terms of the crystallinity of the nanorods. In the absence of defects, the nanorods are highly stable with a melting temperature close to the bulk phase. In contrast, in the presence of defects, the melting temperature drastically decreases. In this case, nanocrystals can undergo a shape transformation before melting from rod to cylinder. (14 References).

Liu, J. and J. P. Coleman (2000). "Nanostructured metal oxides for printed electrochromic displays." Materials Science and Engineering A Structural Materials Properties Microstructure and Processing(1): 144-8.

Electrochromic devices are able to change their optical properties reversibly under the action of applied voltages. The conventional method of fabricating electrochromic devices utilizes a 'sandwich' configuration of electrodes. We developed a 'side-by-side' design for fabricating electrochromic display devices without the use of conductive, transparent electrodes. A simple printing technology can be used to produce commercial scale, flexible electrochromic displays. We have also discovered that tin oxide nanocrystallites heavily doped with antimony exhibit a high level of electrochromism. The high contrast ratio of nanostructured antimony-tin oxide (ATO) electrochromic displays is attributed to an accessible antimony energy state in the band gap of the mixed oxide. The fast switching rate can be attributed to the high surface area of, and high number density of grain boundaries in, the nanophase ATO materials. The interfacial regions between ATO nanocrystallites facilitate the transport of

ions in and out of the electrochromic layer. The dynamics of the electrochromic displays is critically dependent on the nanostructure of the electrochromic layer. The design strategy for commercial production of printed, flexible electrochromic displays will be discussed. (10 References).

Liu, C. H. and C. Huang (2000). "Experimental studies on the defect states at the interface between nanocrystalline CdSe and amorphous SiO<sub>x</sub>." Journal of Physics Condensed Matter **12**(5): 751-9.

Superlattices of a-SiO/sub x//nc-CdSe and thin composite films of SiO/sub x/ doped with CdSe nanocrystals have been investigated. The CdSe nanocrystals size in both kinds of samples was determined by X-ray diffraction and HREM measurements. A significant difference has been found in the size values determined by both methods, which has been ascribed to appreciable nanocrystal lattice deformations. Subband absorption, room-temperature photoluminescence and thermally stimulated currents have been measured. It has been observed that in the superlattices the absorption in the tail region increases as sublayer thickness decreases. A new photoluminescence band has also appeared in the superlattices having thinnest (2.5 nm) CdSe sublayers. Two new maximums at about 220 K and 240 K, not existing in the CdSe single layers studied, have been found in thermally stimulated current spectra of the composite films. Both maximums are less expressed in the superlattices. The described results have been connected with a size-induced increase in the concentration of interface defect states in CdSe nanocrystals. It has been estimated that these defects are disposed at about 0.35 eV above the highest occupied molecular orbit in CdSe. (27 References).

Liu, S. M., F. Q. Liu, et al. (2000). "Excitonic and quasiparticle gaps in Si nanocrystals." Physical Review Letters **84**(11): 2457-60.

We present calculations of the one- and two-particle excitations in silicon nanocrystals. The one-particle properties are handled in the GW approximation, and the excitonic gap is obtained from the Bethe-Salpeter equation. We develop a tight binding version of these methods to treat clusters up to 275 atoms. The self-energy and Coulomb corrections almost exactly cancel each other for crystallites with radius larger than 0.6 nm. The result of this cancellation is that one-particle calculations give quite accurate values for the excitonic gap of crystallites in the most studied range of sizes. (22 References).

Liu, J. M., Q. Huang, et al. (2000). "Ultrafast interfacial charge separation processes from the singlet and triplet MLCT states of Ru(bpy)<sub>2</sub>(dcbpy) adsorbed on nanocrystalline SnO<sub>2</sub> under negative applied bias." Journal of Chemical Physics **113**(8): 3366-73.

We have observed the stimulated emission from the <sup>1</sup>/MLCT state of Ru(bpy)<sub>2</sub>(dcbpy) adsorbed on SnO/sub 2/ nanocrystal by femtosecond pump-probe spectroscopy under applied bias (V/sub ex/) for the first time. The luminescence from the <sup>3</sup>/MLCT state has been also observed by picosecond time-resolved measurement. Observed lifetimes of the stimulated emission and the luminescence are 70 fs and 130 ps, respectively, at zero applied voltage. Both these lifetimes continuously increase with increasing negative bias and reach 320 fs (stimulated emission) and 6 ns (luminescence) at V/sub ex/=-0.7 V. The change in the lifetime of luminescence and of stimulated emission under negative applied bias is considered to be due to the change in the interfacial CS rate, although the possibility of the bias dependent desorption of the dye cannot be completely excluded. We analyzed the result by assuming that the changes in the lifetimes of the stimulated emission and the luminescence are due to the change in the interfacial CS rate constant. This analysis shows that interfacial CS occurs from both the <sup>1</sup>/MLCT and <sup>3</sup>/MLCT states. The competition between CS and intersystem crossing (ISC) from <sup>1</sup>/MLCT occurs in ~100 fs time region. Assuming there is no nonradiative relaxation pathways from <sup>1</sup>/MLCT except for CS and for ISC, the rate constant of ISC was estimated to be 1/(320 fs). The ratio of the numbers of electrons injected from the <sup>1</sup>/MLCT and the <sup>3</sup>/MLCT states was 0.76:0.22. This means that unnegligible number of electrons are injected to SnO/sub 2/ from the <sup>1</sup>/MLCT state. (20 References).

Liu, J.-B., Z.-M. Wang, et al. (2000). "Point defect thermodynamics: macro- vs. nanocrystals." Electrochemistry **68**(6): 395-402.

Point defect thermodynamics is considered for macro- and nanocrystals. The first part reviews-for the equilibrium case-the way in which ionic and electronic carrier concentrations can be calculated in bulk and boundaries of macroscopic crystals as a function of the decisive control parameters. This includes pure and impure materials, complete and partial equilibria as well as different levels of concentrations (dilute case, interactions). In the second part trivial and non-trivial effects are discussed, occurring if the crystal size is continuously decreased towards and below the nano-range. Not only do core disorder and space charge effects become increasingly important, but also there will be two characteristic scales defining mesoscopic effects. One is the Debye-length, the other the scale that characterises the transition from crystal chemistry to cluster chemistry. The situation is more complicated if pronounced elastic effects of long range are important. Simple estimates are given for a variety of simplified cases. The phenomena are discussed in terms of transport properties. The treatment includes boundary phase transitions and the effect of ionic heterostructures. Experimental examples are discussed which underline the conclusions. (49 References).

Liu, C., J. Liu, et al. (2000). "The g factor-shift in ZnS:Mn<sup>2+</sup> nanocrystals/pyrex glasses composites." Materials Science and Engineering B Solid State Materials for Advanced Technology(1): 78-81.

The increase in g factors with decreasing diameters of the nanocrystals were observed by electron paramagnetic resonance (EPR) experiments in ZnS:Mn/sup 2+/ nanocrystals embedded in pyrex glass matrix. These increases are due to the hybridization between s and p states of ZnS and d states of the Mn ions by quantum confinement effects. The experimental results can be well described according to Cardona model using k.p perturbation analysis. (11 References).

Liu, F. M., J. H. Jia, et al. (2000). "Optical diffuse reflectance spectra of GaSb nanocrystals embedded in SiO<sub>2</sub> matrix by radio-frequency magnetron co-sputtering." Applied Physics(4): 457-9.

Nanocrystalline GaSb embedded in SiO/sub 2/ films was grown by radio-frequency magnetron co-sputtering. X-ray diffraction pattern and transmission electron microscopy (TEM) confirm the existence of GaSb nanocrystals in the SiO/sub 2/ matrix. The average size of GaSb nanoparticles is in the range of 3 to 11 nm. Diffuse reflectance spectra were used to characterize the small change of the band gap of the semiconductor. The diffuse reflectance spectra shows that the absorption peaks have a large blueshift of about 4.0 eV of the absorption relative to that of bulk GaSb. It has been explained by quantum confinement effects. Room temperature optical transmission spectra show that the absorption edge exhibits a very large blueshift of about 2.1 eV with respect to that of bulk GaSb in agreement with quantum confinement. (11 References).

Liu, J. M., J. Li, et al. (2000). "Partially crystallized La<sub>0.5</sub>Sr<sub>0.5</sub>MnO<sub>3</sub> thin films by laser ablation and their enhanced low-field magnetoresistance." Applied Physics Letters **76**(16): 2286-8.

Amorphous, partial-crystallized, and epitaxial La/sub 0.5/Sr/sub 0.5/MnO/sub 3/ thin films have been deposited at various temperatures of 200-650 degrees C on (001) SrTiO/sub 3/ substrates using pulsed-laser deposition. The X-ray diffraction and high-resolution transmission electron microscopy indicate complete (001) orientation of the crystalline structures in these films. Enhanced low-field magnetoresistance effect has been observed for the partial-crystallized thin films where the nanosized ferromagnetic crystals are embedded in nonferromagnetic amorphous matrix. It is argued that the amorphous layer separating the neighboring nanocrystals behaves as the barrier for the spin-polarized tunneling and/or spin-dependent scattering, resulting in enhanced magnetoresistance at low magnetic field. (18 References).

Liu, Y., C. Liu, et al. (2001). "The surface enhanced Raman scattering effects of composite nanocrystals of Ag-TiO<sub>2</sub>." Spectrochimica Acta A Molecular Biomolecule Spectroscopy **57**(1): 35-9.

The composite particles of Ag-TiO<sub>2</sub> both in a nanocrystal form was prepared by photoreduction of AgNO<sub>3</sub> in the rutile colloidal solution. The surface plasmon absorption (SPA) band of the silver clusters supported on the TiO<sub>2</sub> nanocrystal was red shift, and a strong surface enhanced Raman scattering (SERS) effect for the composite particles of Ag-nanocrystalline TiO<sub>2</sub> was observed. The SERS effect is relating to the red shift phenomenon of SPA band, which could be explained by induced-resonance effect.

Lloyd, J. R., V. A. Sole, et al. (2000). "Direct and Fe(II)-mediated reduction of technetium by Fe(III)-reducing bacteria." Applied Environmental Microbiology **66**(9): 3743-9.

The dissimilatory Fe(III)-reducing bacterium *Geobacter sulfurreducens* reduced and precipitated Tc(VII) by two mechanisms. Washed cell suspensions coupled the oxidation of hydrogen to enzymatic reduction of Tc(VII) to Tc(IV), leading to the precipitation of TcO(2) at the periphery of the cell. An indirect, Fe(II)-mediated mechanism was also identified. Acetate, although not utilized efficiently as an electron donor for direct cell-mediated reduction of technetium, supported the reduction of Fe(III), and the Fe(II) formed was able to transfer electrons abiotically to Tc(VII). Tc(VII) reduction was comparatively inefficient via this indirect mechanism when soluble Fe(III) citrate was supplied to the cultures but was enhanced in the presence of solid Fe(III) oxide. The rate of Tc(VII) reduction was optimal, however, when Fe(III) oxide reduction was stimulated by the addition of the humic analog and electron shuttle anthraquinone-2,6-disulfonate, leading to the rapid formation of the Fe(II)-bearing mineral magnetite. Under these conditions, Tc(VII) was reduced and precipitated abiotically on the nanocrystals of biogenic magnetite as TcO(2) and was removed from solution to concentrations below the limit of detection by scintillation counting. Cultures of Fe(III)-reducing bacteria enriched from radionuclide-contaminated sediment using Fe(III) oxide as an electron acceptor in the presence of 25 microM Tc(VII) contained a single *Geobacter* sp. detected by 16S ribosomal DNA analysis and were also able to reduce and precipitate the radionuclide via biogenic magnetite. Fe(III) reduction was stimulated in aquifer material, resulting in the formation of Fe(II)-containing minerals that were able to reduce and precipitate Tc(VII). These results suggest that Fe(III)-reducing bacteria may play an important role in immobilizing technetium in sediments via direct and indirect mechanisms.

Loffler, J. F., W. L. Johnson, et al. (2000). "Formation of nanocrystals in Zr-Al-Cu-Ni alloys." Materials Science Forum **343**(346): 185-90.

Metastable nanocrystalline phases were prepared by crystallization of amorphous (Zr/sub 65/Al/sub 7.5/Cu/sub

17.5/Ni/sub 10)/sub 100-x/Fe/sub x/ alloys ( $0 \leq x \leq 20$ ). For iron contents  $\geq 1$  at.% the formation of a NiTi/sub 2/-type phase (S.G. Fd 3 m,  $a/\text{sub } 0 = 1.22$  nm) is observed as the first step of crystallization. The existence region of the metastable fcc phase becomes extended in temperature with increasing iron content. Depending on the iron content  $x$  the mean crystallite size is decreased from 12 nm for  $x=1$  to 4 nm for  $x=20$ . The number of fcc crystallites is found to be proportional to the iron content suggesting that iron acts as nucleation centre for the metastable fcc phase. Site disorder within the NiTi/sub 2/-type unit cell can be concluded from the X-ray diffraction patterns for low annealing temperatures. Annealing at higher temperature ( $T/\text{sub } A$  approximately = 750 K) or longer time leads to the growth of only slightly larger fcc crystallites and to site ordering of the atoms within the unit cell. At higher temperatures the fcc phase transforms eutectically into different stable Zr-phases depending on the composition of the alloy. (13 References).

Loffler, J. F. and W. L. Johnson (2000). "Model for decomposition and nanocrystallization of deeply undercooled  $\text{Zr}_{41.2}\text{Ti}_{13.8}\text{Cu}_{12.5}\text{Ni}_{10}\text{Be}_{22.5}$ ." Applied Physics Letters **76**(23): 3394-6.

From in situ small-angle neutron scattering performed at temperatures in the undercooled liquid regime, we derive a model for the crystallization pathway of Zr/sub 41.2/Ti/sub 13.8/Cu/sub 12.5/Ni/sub 10/Be/sub 22.5/ (Vit1). Vit1 first decomposes on the nanometer scale, increasing drastically the nucleation probability. In the later stages nanocrystallization occurs in one of the decomposed amorphous phases. The growth kinetics of the nanocrystals corresponds to a chemical relaxation process in which they equilibrate with the remaining amorphous matrix. Based on our model, a chemical diffusion constant is derived whose temperature dependence follows an Arrhenius law and is comparable with the expected self-diffusion constant of Ti in Vit1, as determined in independent studies of diffusion. (23 References).

Lopez, M., B. Garrido, et al. (2000). "Effect of implantation and annealing conditions on the photoluminescence emission of Si nanocrystals ion beam synthesised in  $\text{SiO}_2$ ." Microelectronics and Reliability **40**: 4-5.

In this article, we present a systematic study of the evolution of photoluminescence (PL) emission of Si nanocrystals with elaboration conditions. Si nanocrystals synthesised in  $\text{SiO}_2$  by ion implantation and annealing at 1100 degrees C show a wide (0.3 eV) and a very intense PL emission centred at 1.5-1.7 eV, linked to the presence of the nanocrystals. The intensity of this emission shows a typical behaviour with the annealing time, with a fast transitory increase to reach an asymptotical saturation. There is a linear increase of the PL intensity at saturation with the dose. Two regimes are clearly observed for the evolution of the PL energy position as a function of the annealing time for different peak supersaturations (s): (i) for  $s < 5\%$ , there is a decrease transient followed by a saturation state of the maximum peak energy, and (ii) for  $s \geq 5\%$  the PL energy presents an increase transient followed by a saturation state. (12 References).

Lu, S. W., B. I. Lee, et al. (2000). "A simple method for preparing uniform amorphous films of mixed metal halides by means of two-source evaporation." Journal of Physics D Applied Physics **33**(22): 2973-6.

Two-source evaporation of metal halides onto cooled substrates provides a simple method for achieving uniform amorphous networks of solid solution with any composition ratio, yielding film samples. We exemplify its novel use for in situ monitoring of cluster or nanocrystal formation in the films. The method may be applicable to exploring new films heavily doped with clusters or nanocrystals in a controlled manner. (13 References).

Luterova, K., I. Pelant, et al. (2000). "Size effect of microstructures of anatase-type nanocrystalline titanium dioxides." Zhenkong Kexue Yu Jishu Xuebao/Vacuum Science and Technology **20**(5): 361-2.

Samples of anatase-type titanium dioxide nanocrystals (n-A-TiO/sub 2/), grown under similar conditions but with different grain sizes, were systematically studied with X-ray diffraction. Various microstructural parameters, such as grain size, interplane spacing, lattice constant, axial ratios and cell volume were measured. A significant monotonous, anisotropic size effect on the microstructures of nanocrystalline anatase phase TiO/sub 2/ was observed. (7 References).

Maier, J. (2000). "Preparation of Si nanocrystals using anodic porous alumina template formed on silicon substrate." Chinese Physics Letters **17**(6): 451-3.

A novel technique to extend template application of anodic porous alumina to Si has been reported. First, porous alumina template about 400 nm thick was prepared on silicon substrate by anodizing a thin aluminum film with high purity of 99.99% in 15 wt.% sulfuric acid under a constant voltage of 20 V and at an electrolyte temperature of 5 degrees C. Then, an amorphous Si layer approximately 50 nm in thickness was deposited onto the surface of template by using electron beam evaporation technique followed by an Xe ion beam bombardment upon which the as-coated Si layer at the pore mouth could be removed into pores smoothly. Three runs were performed by repeating above process of deposition and post bombardment. Finally, samples were annealed at 800 degrees C for 30 min in nitrogen. Transmission electron microscopy and x-ray analysis reveal Si nanocrystals with a size of 15-20 nm being formed in the pores of the template. (15 References).

Maillard, M., L. Motte, et al. (2000). "Rings and hexagons made of nanocrystals: a Marangoni effect." Journal of Physical

Chemistry B **104**(50): 11871-7.

By controlling solvent evaporation rates, it has been possible to form micrometer rings and hexagonal arrays made of nanocrystals of different sizes, shapes and materials. Such patterns are driven by surface tension gradients that induce Benard-Marangoni instabilities in the liquid films. The resulting self-assembled structures are consistent with theoretical prediction of hydrodynamic instabilities. (32 References).

Maly, P., J. Kudrna, et al. (2000). "Dominant role of surface states in photoexcited carrier dynamics in CdSe nanocrystalline films prepared by chemical deposition." Applied Physics Letters **77**(15): 2352-4.

We report on ultrafast carrier dynamics in nanocrystalline CdSe thin films prepared by chemical solution deposition. The photoluminescence and transient absorption dynamics have spectrally dependent decay faster at shorter wavelengths. The spectral behavior of the decay rates in samples with different nanocrystal sizes and the sensitivity of the dynamics on the surface modification indicate the dominant role of the surface states in the photoluminescence. (8 References).

Maly, P. and T. Miyoshi (2000). "Optical properties of spark-processed Ge." Materials Science and Engineering B Solid State Materials for Advanced Technology(3): 237-40.

We report the photoluminescence (PL) and decay times of spark-processed Ge (sp-Ge) at various temperatures. Further Fourier transform infrareds (FTIR) have been measured. The luminescence peak of sp-Ge is observed around 520 nm with two new shoulder peaks at 410 and 610 nm at room temperature. At low temperature, however, two shoulder peaks become dominant while the green luminescence peak vanishes. Moreover, the PL peak wavelength remains constant during cooling. The decay times are characterized as a fast decay time of a few tens of ns and slow decaying tails in  $\mu$ s range and independent of measured wavelengths. Further, low temperature luminescence measurements for three luminescence bands of sp-Ge reveal a considerable degree of local disorder. Vibrational modes obtained from FTIR are mainly composed of Ge--O modes with some OH vibration. These results suggest that the origin of PL from sp-Ge is associated with Ge--O related defects rather than the radiative recombination of excitons confined in nanocrystals. (19 References).

Mano, T., K. Watanabe, et al. (2000). "Electron transport in nanocrystalline Si based single electron transistors." Japanese Journal of Applied Physics **39**(7B): 4647-50.

Electron transport has been studied by measurement and simulation of single electron transistors based on nanocrystalline silicon (nc-Si). Nanocrystalline silicon is formed in the gas phase of the SiH<sub>4</sub>/sub 4/ plasma cell by the coalescence of radicals. Digital chemical vapor deposition CVD technique using pulsed gas in the plasma is effective to obtain highly uniform Si quantum dots with an average size of 8 nm and dispersion of 1 nm. Single electron transistors have been successfully fabricated by deposition of nc-Si on top of heavily doped silicon nanoelectrodes with a gap of 15 nm which allows the study of electron transport through two or three nanocrystals. Coulomb blockade and Coulomb oscillations are observed in these devices at various temperatures, including room temperature. The observed Coulomb diamond structure is not as simple as in the case of metallic islands. With increasing gate voltage, the spacing between oscillation peaks decreases and the Coulomb diamonds reduce in size. These observations are explained on the basis of electron transport through a quantum dot with an energy gap between the highest occupied and the lowest unoccupied electron states. Modeling of such a system can reproduce measured electrical characteristics. The unequal spacing of gate oscillations and the reduced size of Coulomb diamonds are due to the interplay of Coulomb charging energy and the energy separation between the quantized energy levels. (20 References).

Mary, C., P. Lenormand, et al. (2000). "X-ray diffraction of polycrystalline or epitaxial films. Utilisation of asymmetric reflection apparatus with curved position sensitive detector." EDP Sciences. Journal de Physique IV **10**(10): 377-86.

We have realised an X-ray diffraction apparatus with a four-axis sample holder working under controlled incidence in the reflection mode. The incident beam, supplied by a rotating anode associated with a Bartels monochromator, is strictly parallel and monochromatic. The diffracted beams were simultaneously measured using a curved position sensitive detector. The use of this diffractometer in powder diffraction experiments has been presented elsewhere. In this paper we would illustrate the possibility of such an apparatus in the field of thin film characterization. Thin films of zirconia precursor were formed on mirror-polished sapphire wafers by a sol gel dip coating process. Thermal treatment of the sample at moderated temperature induced the crystallisation of zirconia under the tetragonal form. The coating is made of randomly oriented nanocrystals. Higher temperature thermal treatment resulted in the formation of micrometer sized islands epitaxied onto the single crystalline substrate. The relative disorientation of those islands was estimated through rocking-curves measurements. Sometimes the diffracted intensity distributions of the different island families were partially superimposed on each others. The measurement of all the intensity distributions obtained by the use of the curved detector allowed us to separate the rocking curves of each islands family. (28 References).

Mastai, Y., D. Gal, et al. (2000). "Nanocrystal-size control of electrodeposited nanocrystalline semiconductor films by surface capping." Journal of the Electrochemical Society **147**(4): 1435-9.

The crystal size of nanocrystalline CdS and CdSe films, electrodeposited from dimethyl sulfoxide solutions containing a Cd salt and elemental S or Se, is shown to depend on the nature of the anion of the Cd salt. Relatively strongly adsorbing anions, such as chloride, result in a smaller nanocrystal size than relatively nonadsorbing anions such as perchlorate. This difference in nanocrystal size is explained by blocking (or capping) of the growing crystals by the adsorbed ions. Very strongly adsorbing species, such as alkyl phosphines, result in even smaller crystal size (3.5 nm average diameter). (22 References).

Matsuda, A., Y. Kotani, et al. (2000). "Transparent anatase nanocomposite films by the sol-gel process at low temperatures." *Journal of the American Ceramic Society* **83**(1): 229-31.

We have successfully prepared transparent anatase nanocomposite films on various types of substrates, including organic polymers, using the sol-gel method at temperatures <100 degrees C under ambient pressure. This novel process is based on the findings that (i) anatase nanocrystals are uniquely formed in sol-gel-derived SiO<sub>2</sub>/TiO<sub>2</sub> films that have been subjected to a hot-water treatment, and (ii) the addition of an organic polymer such as poly(ethylene glycol) in the films accelerates the formation of anatase nanocrystals. The film coating on the substrates is a promising candidate for use as a photocatalyst to decompose environmental pollutants and harmful microorganisms. (22 References).

Matsuda, A., Y. Kotani, et al. (2000). "Digestive ripening, nanophase segregation and superlattice formation in gold nanocrystal colloids." *Journal of Nanoparticle Research* **2**(2): 157-64.

A novel digestive ripening process is shown to narrow the particle size distribution from a highly polydisperse dodecanethiol ligated gold colloid. Unlike the Ostwald ripening process, the digestion occurs through transferring materials from large particles to small particles. Temperature-induced size segregation can further select the particle sizes. By using these two methods, highly ordered superlattices using nanocrystals as building blocks can be synthesized directly from a polydisperse colloid. (31 References).

Matsumoto, Y., M. T. Oo, et al. (2000). "Optical and structural properties of pure and Ce-doped nanocrystals of barium titanate." *Progress in Crystal Growth and Characterization of Materials* **40**: 1-4.

Nanocrystals barium titanate (nc-BT) and Ce-doped barium titanate were synthesized by an unusual hydrothermal process. X-ray diffraction and Raman spectroscopy were used to investigate their microstructures, as well as their lattice vibration and photoluminescence (PL) spectra. Particle sizes as small as 20 nm were measured by X-ray diffraction pattern via Scherer equation. The critical size relative to the cubic-tetragonal transition is about 48 nm in nc-BT below which ferroelectricity vanishes. The lattice parameter ratio  $c/a$  of is equal to 1.003, much smaller than 1.01 for that of the bulk crystal, leading to a weakening of ferroelectricity. Hydroxyl defects are observed in the Ce-doped nc-BT samples which show a vibrational band at 3300 cm<sup>-1</sup>. Good crystallization character and the lattice perfection were characterized by Raman spectra in the nanophase barium titanate. Strong PL spectra centered at 696 and 585 nm were observed in the pure and Ce-doped nc-BT, respectively. PL dependence on temperature and annealing time was examined. A molecule-like recombination and the charge transfer between Ce<sup>4+</sup> and Ce<sup>3+</sup> are proposed to elucidate the luminescence process in the nc-BT and Ce-doped nc-BT system. (27 References).

Matsuura, D., Y. Kanemitsu, et al. (2000). "Optical characterization of CdS nanocrystals in Al<sub>2</sub>O<sub>3</sub> matrices fabricated by ion-beam synthesis." *Applied Physics Letters* **77**(15): 2289-91.

We have studied optical properties of CdS nanocrystals formed by sequential Cd<sup>+</sup> and S<sup>+</sup> ion implantation into Al<sub>2</sub>O<sub>3</sub> matrices. Two bands related to free excitons in the wurtzite CdS are clearly observed in the absorption spectrum at low temperatures. Efficient photoluminescence (PL) appears near the absorption edge. At high temperatures, the band edge PL band consists of two components. One is the free-exciton emission with a short lifetime (several hundreds of picoseconds), while the other is the bound exciton emission at shallow localized states with a long lifetime (several nanoseconds). The temperature dependence of the band gap energy has been determined for wurtzite CdS nanocrystals. Spectroscopic analysis shows that high-quality compound semiconductor nanocrystals are fabricated by the ion-beam synthesis technique. (15 References).

Mattern, N., U. Kuhn, et al. (2000). "Formation of ultrafine nanostructure by crystallization of Zr<sub>52</sub>Al<sub>6</sub>Cu<sub>14</sub>Ni<sub>8</sub>Fe<sub>20</sub> metallic glass." *Applied Physics Letters* **77**(8): 1153-4.

The short-range order and the crystallization behavior of amorphous Zr<sub>52</sub>Al<sub>6</sub>Cu<sub>14</sub>Ni<sub>8</sub>Fe<sub>20</sub> alloys have been investigated by means of calorimetry and X-ray diffraction. The amorphous structure transforms upon annealing without formation of long-range order. An ultrafine microstructure consisting of about 60 vol% cubic NiZr<sub>2</sub> crystal-like clusters with a size of  $\langle D \rangle$  approximately=2 nm embedded in a residual amorphous matrix phase forms as a first step of crystallization resulting from high nucleation rate combined with low growth velocity. In a second step growth of the clusters to crystals up to a mean diameter of  $\langle D \rangle$  approximately=4-5 nm takes place as a distinct process. (11 References).

Mattern, N. and M. Muller (2000). "Formation of nanocrystals by crystallization of amorphous Fe-Si-B based alloys." Materials Science Forum **321**(324): 694-9.

The crystallization of amorphous Fe-Si-B based alloys was investigated by means of X-ray diffraction, DSC, and transmission electron microscopy. Crystallization temperatures, phase sequences, and the microstructures of the phases formed are strongly influenced by the chemical composition. In the case of amorphous Fe/<sub>76.5</sub>-x/Si/<sub>15.5</sub>/B/<sub>7</sub>/Cu/<sub>1</sub>/Nb/<sub>x</sub> a reduction of the crystallite size down to 15 nm is found to depend on the Nb content. XRD values of the mean crystallite size calculated from the analysis of line broadening agree well with the TEM results. From in situ XRD observations at high temperature kinetic parameters of the crystallization process could be estimated. The amorphous phase changes its composition due to the primary crystallization and acts, enriched with Nb and B, acts as a diffusion barrier leading to a nanostructured state. (8 References).

Mattern, N., H. D. Bauer, et al. (2000). "Grain boundaries and mechanical properties of nanocrystalline diamond films." Materials Science Forum **343**(346): 255-60.

Phase-pure nanocrystalline diamond thin films grown from plasmas of a hydrogen-poor carbon argon gas mixture have been analyzed regarding their hardness and elastic moduli by means of a micro indenter and a scanning acoustic microscope. The films are fully elastic, superhard and the moduli rival single crystalline diamond. In addition, Raman spectroscopy with an excitation wavelength of 1064 nm shows a peak at 1438 l/cm and no peak above 1500 l/cm, and X-ray photoelectron spectroscopy a shake-up loss at 4,2 eV. This gives strong evidence for the existence of solitary double bonds in the films. The hardness and elasticity of the films are then explained by the assumption that the solitary double bonds interconnect the nanocrystals in the films, leading to an intergrain boundary adhesion of similar strength as the intragrain diamond cohesion. The results are in good agreement with recent simulations of high-energy grain boundaries. (27 References).

Medeiros-Ribeiro, G., A. M. Bratkovski, et al. (1998). "Shape transition of germanium nanocrystals on a silicon (001) surface from pyramids to domes." Science **279**(5349): 353-5.

Chemical vapor deposition of germanium onto the silicon (001) surface at atmospheric pressure and 600 degrees Celsius has previously been shown to produce distinct families of smaller (up to 6 nanometers high) and larger (all approximately 15 nanometers high) nanocrystals. Under ultrahigh-vacuum conditions, physical vapor deposition at approximately the same substrate temperature and growth rate produced a similar bimodal size distribution. In situ scanning tunneling microscopy revealed that the smaller square-based pyramids transform abruptly during growth to significantly larger multifaceted domes, and that few structures with intermediate size and shape remain. Both nanocrystal shapes have size-dependent energy minima that result from the interplay between strain relaxation at the facets and stress concentration at the edges. A thermodynamic model similar to a phase transition accounts for this abrupt morphology change.

Meldrum, A., L. A. Boatner, et al. (2000). "Ion irradiation effects in nonmetals: formation of nanocrystals and novel microstructures." Materials Research Innovations **3**(4): 190-204.

Ion implantation is a versatile and powerful technique for producing nanocrystal precipitates embedded in the near-surface region of materials. Radiation effects that occur during the implantation process can lead to complex microstructures and particle size distributions, and in the present work, we focus on the application of these effects to produce novel microstructural properties for insulating or semiconducting nanocrystals formed in optical host materials. Nanocrystal precipitates can be produced in two ways: by irradiation of pure (i.e., non-implanted) crystalline or amorphous materials, or by ion implantation followed by either thermal annealing or subsequent additional irradiation. Different methods for the formation of novel structural relationships between embedded nanocrystals and their hosts have been developed, and the results presented here demonstrate the general flexibility of ion implantation and irradiation techniques for producing unique near-surface nanocomposite microstructures in irradiated host materials. (89 References).

Melnik, N. N., T. N. Zavaritskaja, et al. (2000). "Investigation of semiconductor nanocrystals by Raman scattering." Proceedings of SPIE the International Society for Optical Engineering **4069**: 212-16.

The spectra of Raman scattering and photoluminescence of porous Si, Ge, GaP and carbon nanocrystals are investigated at room temperature. The deduction that porous structures consist of isotropic nanoparticles which have a crystalline kernel is made. Using GaP as an example, it can be shown that nanocrystals obtained by an electrochemical etching have more perfect crystalline structure than the initial monocrystal. The interaction of phonon modes for nanocrystals created by an electrochemical etching of Si/Ge/<sub>x</sub>/Si/<sub>1-x</sub> superlattices was observed. The intensive photoluminescence of graphite particles was observed. (6 References).

Mentese, S., J. B. Suck, et al. (2000). "3-D atom probe studies of some nanostructured materials." Materials Science Forum **343**(346): 701-8.

This paper reports recent results of our 3-dimensional atom probe (3DAP) investigations of two different examples of nanostructured materials; electrodeposited nanocrystalline Ni and Ni-P alloys and melt-spun amorphous nanocrystalline Fe-Si-Cu-Nb-B-Al alloys. 3DAP analysis of as-deposited nanocrystalline Ni showed a uniform

distribution of about 0.1at.% of impurity atoms, most of which were sulphur. Such low impurity levels and lack of grain boundary pinning enables grain growth to occur during heating at only 200 degrees C. In the Ni-P alloys, however, 3DAP showed clear evidence of P segregation and formation of Ni/sub 3/P particles during heat treatment at 425 degrees C. As a result, nanocrystalline Ni-P alloys are found to be significantly stabilized relative to nanocrystalline pure Ni alloys. 3DAP analysis of nanocrystalline Fe/sub 71.5/Si/sub 13.6/Cu/sub 1/Nb/sub 3/B/sub 9/Al/sub 2/ showed that the Al strongly partitions away from the amorphous matrix into the nanocrystals, also there was strong partitioning of the Al into the Cu-rich particles and corresponding depletion of Al in the amorphous matrix. The partitioning of the Al to the Fe-Si nanocrystals is thought to be the cause of the reduced coercivity and magnetostriction and magnetic anisotropy in this alloy. (16 References).

Menzel, E. R., S. M. Savoy, et al. (2000). "Photoluminescent semiconductor nanocrystals for fingerprint detection." Journal of Forensic Science **45**(3): 545-51.

The concept of utilizing photoluminescent semiconductor nanocrystals for latent fingerprint detection, especially in concert with phase-resolved imaging for background fluorescence suppression, is reduced to practice with CdS nanocrystals that are capped with dioctyl sulfosuccinate. The nanocrystals are dissolved in heptane or hexane and are applied in much the same way as staining with fluorescent dye, on articles that have been pre-fumed with cyanoacrylate ester and also on the sticky side of electrical tape without pre-fuming. Since CdS can form a photoluminescent nanocomposite with dendrimers, a feasibility examination of dendrimer tagging of fingerprints has also been conducted.

Merrins, A., X. Marguerettaz, et al. (2001). "Elimination of cross-talk and modulation of function in an organized heterosupramolecular assembly." Chemistry **7**(6): 1309-21.

A close-packed monolayer of TiO<sub>2</sub> nanocrystals was deposited on a conducting glass support using Langmuir-Blodgett (LB) techniques and fired. A close-packed mixed monolayer of eicosyl phosphonic acid (I) and the viologen. 1,1'-dieicosyl-4,4'-bipyridinium dichloride (II) was then deposited on the TiO<sub>2</sub> substrate, also using LB techniques. At sufficiently high dilutions of II in I a single viologen molecule is adsorbed with a known orientation at the surface of each nanocrystal. The resulting assembly was incorporated as the working electrode in an electrochemical cell. Under open circuit conditions, bandgap excitation of a TiO<sub>2</sub> nanocrystal results in electron transfer to a viologen molecule. No electron transfer between the viologen molecules adsorbed at different nanocrystals is observed. At a positive applied potential, electron transfer following bandgap excitation is largely suppressed. Considered are the implications of these findings for the development of practical devices based on modulatable function addressable on the nanometer scale.

Meshcheryakov, V. V. (2000). "Deformation states in nanocrystals." Fizika Tverdogo Tela **42**(9): 1700-6.

The limitations of the classical description of static deformations in crystals in nanometric regions are demonstrated. The problem is formulated on the basis of the phonon Hamiltonian supplemented with point force sources of the monopole and dipole types. It is found that the quantization of Fourier amplitudes of the total energy for steady deformation states leads to an energy spectrum with the Fermi-type energy level distribution and that the stationary response of nanocrystals to the force action is determined by the discreteness of variation in the number of displaced ions in the region of the force nonuniformity. The conditions for the generation of ionic displacement waves are determined, and the possibility of creating new solid-state elements for information storage and transmission by controlling the collective properties of deformation-induced excitations is envisaged. (18 References).

Mikrajuddin, F. G. Shi, et al. (2000). "Metal-to-semiconductor transition in nanocrystals: size and temperature dependence." Microelectronics Journal **31**(5): 343-51.

The electrical conductivity of nanocrystals is investigated by using a hybrid approach that treats the electronic structure of a nanocrystal quantum mechanically, and the transport of electrons semiclassically. The simplicity and its analytical nature of the present approach allow one to gain unique insights into the size dependent metal-to-semiconductor transition in nanocrystals. The analytical expression for the electrical conductivity of nanocrystals as a function of size and temperature demonstrates that for a given temperature, there is a critical size at which the metal-to-semiconductor transition occurs which decreases with increasing temperature. For a given sized nanocrystal, a critical temperature for the occurrence of the metal-to-semiconductor transition is also demonstrated. The critical transition temperature is found to decrease with the increasing nanocrystal size. Although the predicted size and the temperature dependence of electrical conductivity for nanocrystals is shown to be remarkably consistent with the recent experimental observations, the effect of the size distribution of nanocrystals must be further investigated. (26 References).

Mikrajuddin, F. G. Shi, et al. (2000). "On the condensation and preferred orientation of TiC nanocrystals - effects of electric field, substrate temperature and second phase." Materials Science and Engineering A Structural Materials Properties Microstructure and Processing: 1-2.

The condensates formed by reacting Ti plasma with C/sub 2/H/sub 2/ gas (75 sccm) under relatively low vacuum

( $1 \times 10^{-3}$  Torr) and collected on carbon-coated collodion film were characterized by transmission electron microscopy to be TiC nanocrystals in random crystallographic orientation. The TiC condensates showed preferred orientation (200) when assembled on polycrystalline and amorphous substrates at ca. 150 degrees C, and changed further into (111) when the substrate was subject to voltage bias (-120 V) with or without preheating to 450 degrees C. The alpha-Ti co-deposited, with the TiC at a relatively low flow rate of C/sub 2/H/sub 2/ (25 sccm), followed the crystallographic relationship: (0001)/sub alpha-Ti///(111)/sub TiC/; 1120/sub alpha-Ti///110/sub TiC/, in accordance with the TiC (111) preferred orientation. On the other hand, the amorphous carbon formed at a high flow rate of C/sub 2/H/sub 2/ (250 sccm) hindered the preferred orientation (111) of TiC. The effects of applied electric field, substrate temperature and second phase on the accumulation and reorientation of the TiC condensates in the coating can be rationalized by surface charge of the TiC crystallites, Brownian rotation-coalescence of the crystallites, and atom configuration specification at the interphase interface, respectively. (40 References).

Mikulec, F. V. and M. G. Bawendi (2000). "Synthesis and characterization of strongly fluorescent CdTe nanocrystal colloids." Nanophase and Nanocomposite Materials III. Symposium **581**: 139-44.

We present a synthesis of colloidal CdTe nanocrystals whose absolute room temperature quantum yields are routinely above 60%. The preparation is based on the trioctylphosphine oxide (TORO) method reported by Murray, with a more stable tellurium precursor now used as the chalcogenide source. The photoluminescence is continuously tunable over the range 590-760 nm and is as narrow as 135 meV (45 nm) FWHM. No deep trap luminescence is detected for the diameter range 4-11 nm. CdTe nanocrystals are characterized by UV/vis absorption, photoluminescence emission, transmission electron microscopy, and powder X-ray diffraction. (11 References).

Mikulskas, I., E. Bernstein, et al. (2000). "Properties of CdS nanocrystallites embedded in to thin ZrO<sub>2</sub> waveguides." Materials Science and Engineering B Solid State Materials for Advanced Technology **70**(19): 418-23.

In this paper we present results on CdS nanocrystal (NC) formation in ZrO/sub 2/ thin film grown by sol-gel process. Raman and waveguiding Raman scattering spectroscopies were applied to determine CdS nanocrystal precipitation in our films. RBS (Rutherford back scattering) and optical absorption spectroscopy were applied to determine CdS distribution homogeneity through the layer depth, NC size and dispersion. Thus we obtained low size dispersed CdS nanocrystals with preparation temperature controlled size. Moreover, Raman and high-resolution transmission electron microscopy (HRTEM) evidenced simultaneous correlated crystallisation of hexagonal CdS and tetragonal/monoclinic ZrO/sub 2/ phases. We applied also light induced dynamic grating technique under high excitation conditions in order to analyse dynamic properties of nonequilibrium charge carriers in thin films. (17 References).

Millo, O., D. Katz, et al. (2001). "Imaging and spectroscopy of artificial-atom states in core/shell nanocrystal quantum dots." Physical Review Letters **86**(25): 5751-4.

Current imaging scanning tunneling microscopy is used to observe the electronic wave functions in InAs/ZnSe core/shell nanocrystals. Images taken at a bias corresponding to the s conduction band state show that it is localized in the central core region, while images at higher bias probing the p state reveal that it extends to the shell. This is supported by optical and tunneling spectroscopy data demonstrating that the s-p gap closes upon shell growth. Shapes of the current images resemble atomlike envelope wave functions of the quantum dot calculated within a particle in a box model.

Mimura, A., M. Fujii, et al. (2000). "Photoluminescence from Si nanocrystals dispersed in phosphosilicate glass thin films." Journal of Luminescence **87**(89): 429-31.

Photoluminescence (PL) spectra of Si nanocrystals (nc-Si) in phosphosilicate glass matrices, and the PL decay dynamics were studied. The 1.4 eV peak corresponding to the recombination of electron-hole pairs confined in nc-Si (band-edge PL) became intense with increasing the P concentration in the matrix region, while the 0.9 eV peak related to the defects at the interfaces between nc-Si and matrices became weaker. The lifetime of the band-edge PL increased with the P concentration. These results indicate that the improvement of the band-edge PL efficiency is achieved by decreasing the interface defect density by P doping. (6 References).

Mimura, A., M. Fujii, et al. (2000). "Method for nanostructuring of Ag atoms on Ni(111) surfaces." Physical Review B Condensed Matter **62**(19): 13136-41.

The nanostructuring process of Ag atoms on the Ni(111) surface was investigated in two different ways: (1) the use of a morphological change caused by Pb deposition onto the Ag-covered Ni(111) surface and (2) the use of Volmer-Weber growth mode by Ag depositions onto the Pb-covered Ni(111) surface. In case (1), the preexisting Ag layer was transformed into three-dimensional islands (nanocrystals) during Pb deposition at room temperature: The nanocrystals were directly on the Ni(111) surface and surrounded by a monoatomic Pb layer. In case (2), the Ag nanoparticles were formed not on the bare Ni(111) surface, but on the preexisting Pb layer: The particles were found to be mobile under the interaction with scanning tunneling microscopy tip. The results were

discussed in terms of simple thermodynamic considerations and growth kinetics. (12 References).

Ming-Sheng, Z., Y. Jian, et al. (2000). "The stability and surface reactivity of gallium phosphide nanocrystals." Progress in Crystal Growth and Characterization of Materials **40**: 1-4.

The stability and surface reactivity of GaP nanocrystals were characterized by TG-DTA, XRD and XPS measurements. The samples were heated in O<sub>2</sub> and N<sub>2</sub> atmospheres respectively. The experimental curve which describes the mass change as a function of temperature shows that the mass decreases under 330 degrees C but increases in two stages between 330 degrees C and 550 degrees C. The curves obtained in O<sub>2</sub> and N<sub>2</sub> are obviously different. The results of XPS indicate that the density of oxygen atoms bonded chemically to the gallium atoms on the surface increases when the sample is heated in O<sub>2</sub> up to 200 degrees C, whereas the density of nitrogen atoms increased when heated to 330 degrees C in N<sub>2</sub>. It can be concluded that the N<sub>2</sub> could be activated on the surface of GaP nanocrystals at a rather low temperature, and highly reactive nitrogen atoms formed. Our result obtained makes it possible to synthesize a series of nitrogen-containing compounds in N<sub>2</sub> gas under moderate conditions. (12 References).

Mingyuan, G., C. Lesser, et al. (2000). "High spatial density nanocrystal formation using thin layer of amorphous Si<sub>0.7</sub>Ge<sub>0.3</sub> deposited on SiO<sub>2</sub>." Journal of Applied Physics **87**(5): 2449-53.

The process to make nanocrystals with an average size <5 nm and a spatial density >10<sup>12</sup>/cm<sup>2</sup> was proposed using agglomeration and partial oxidation of thin amorphous Si<sub>0.7</sub>Ge<sub>0.3</sub> layer deposited in between the SiO<sub>2</sub> layers by low pressure chemical vapor deposition. The reason to use an amorphous layer is to make it possible to deposit a thin continuous layer with a thickness of less than 5 nm. Si<sub>0.7</sub>Ge<sub>0.3</sub> alloy layer was used to control the spatial density of the nanocrystals by using selective oxidation of Si in Si<sub>0.7</sub>Ge<sub>0.3</sub> alloy layer. The single electron memory, similar to a flash type memory device was fabricated using these Si<sub>0.7</sub>Ge<sub>0.3</sub> nanocrystals. The Coulomb blockade effect could be clearly observed at room temperature with a threshold voltage shift of about 2.4 V, which demonstrated the formation of nanocrystals with a high spatial density. (15 References).

Mishra, P. and K. P. Jain (2000). "Temperature-dependent Raman scattering studies in nanocrystalline silicon and finite-size effects." Physical Review B Condensed Matter **62**(22): 14790-5.

A comparative study of the temperature-dependent Raman scattering of nanocrystalline and bulk silicon is presented. The nanocrystalline silicon samples were made by a cw laser annealing process, and the characteristic dimensions were determined with a phenomenological phonon confinement model. Experimental results indicate a higher degree of anharmonicity in nanocrystals compared to that in the bulk. The anharmonic constants are found to be highly size dependent and increase greatly with decreasing dimensions. The phonon lifetimes have two contributions, one temperature dependent and the other temperature independent, both decreasing rapidly with decreasing nanocrystal size. The temperature-dependent term  $\tau_0$  is important for larger nanocrystals, while the temperature-independent term  $\tau_1$  becomes dominant for nanocrystals of sizes less than 4 nm. (24 References).

Mitsuishi, K., M. Kawasaki, et al. (2001). "High-angle annular dark-field STEM observation of Xe nanocrystals embedded in Al." Ultramicroscopy **88**(1): 25-31.

High-angle annular dark-field scanning transmission electron microscope (HAADF-STEM) observation of Xe precipitates embedded in crystalline membranes has been made using electron probes of atomic dimensions and HAADF-STEM images of Xe precipitates qualitatively different from conventional TEM observation results have been obtained. Multislice-based HAADF-STEM simulation has been made and it has been revealed that the intensity of images of Xe atoms at positions displaced from Al matrix columns decreases rapidly as the thickness increases. Even in a thin specimen, the off-site Xe atoms of the precipitate at deep locations, were not observable. Therefore, different images are expected for specimens of different thicknesses or depths of these precipitates. These results indicate that the observation of precipitates in crystalline membranes requires some care.

Miyoshi, T., A. Hirano, et al. (2000). "Size dependence of phonon Raman spectra in Mn<sub>2</sub>O<sub>3</sub> nanocrystals." Japanese Journal of Applied Physics **39**(11): 6293-5.

Nanometer manganese oxide (Mn<sub>2</sub>O<sub>3</sub>) has been prepared by the chemical liquid homogeneous precipitation (CLHP) method. The size dependence of phonon Raman spectra in Mn<sub>2</sub>O<sub>3</sub> nanocrystals has been investigated. Transmission electron micrographs and X-ray powder diffraction patterns show that the average particle sizes are in the range of 9 to 50 nm. From the Raman spectra patterns of the nanometer Mn<sub>2</sub>O<sub>3</sub> particle, we determined the broadening of the Raman peak in the lower frequency region. This phenomenon was explained by a spatial correlation model. We also found that the intensities of the main Raman peak decrease with the decrease in the grain size of Mn<sub>2</sub>O<sub>3</sub> nanocrystals. (19 References).

Morel, Y., P. Najchalski, et al. (2000). "Optical power limiting properties of organic crystals and nanocrystals in an f/5

optical system." Synthetic Metals **109**: 1-3.

We have evaluated the optical limiting properties of transparent organic crystals and nanocrystals in an f/5 optical system. We have studied three organic or organic-inorganic crystals and a sol-gel glass which contains organic nanocrystals of stilbene3. The spectral dependence of the optical limiting curves have shown that broadband limitation can be achieved in the visible range with the 2-amino-5-nitropyridinium-dihydrogenphosphate (2A5NPDP) crystal as the transmitted energy is less than 10  $\mu$  J over a wide spectral range (450-600 nm). Results on nanocrystals have indicated that these new materials are a suitable alternative to crystals due to their isotropic response with polarization. (14 References).

Motte, L., E. Lacaze, et al. (2000). "Influence of the substrate on the self-assemblies of silver sulfide nanocrystals." Applied Surface Science **162**(163): 604-12.

The influence of the substrate on the morphology of 2D and 3D superlattices made of 5.8 nm silver sulfide nanocrystals coated with dodecanethiol is reported. Two substrates, highly oriented pyrolytic graphite (HOPG) and molybdenum disulfide (MoS/sub 2/), are used. Self-assemblies of nanocrystals are characterized with scanning electron microscopy (SEM), transmission electron microscopy (TEM) and atomic force microscopy (AFM) techniques, It is proposed that the different behaviors observed on the two substrates are related to van der Waals interactions between particles and between particle-substrate as well as to capillary forces. (46 References).

Motte, L. and M. P. Pileni (2000). "Self-assemblies of silver sulfide nanocrystals: influence of length of thio-alkyl chains used as coating agent." Applied Surface Science **164**(1): 60-7.

We report on the influence of the length of thiol alkyl chains used to coat silver sulfide particles on the self-organization of nanoparticles in monolayers. The variation of the average distance between particles with the length of the thio derivative alkyl chain is derived from direct measurements of TEM patterns. (35 References).

Motte, L., E. Lacaze, et al. (2000). "Self-assemblies of silver sulfide nanocrystals on various substrates." Langmuir **16**(8): 3803-12.

The influence of the substrate on the morphology of 2D and 3D superlattices made of 5.8 nm silver sulfide nanocrystals coated with dodecanethiol is reported. The two substrates used are highly oriented pyrolytic graphite (HOPG) and molybdenum disulfide (MoS/sub 2/). The self-assemblies of nanocrystals were characterized with scanning electron microscopy and atomic force microscopy techniques, and it was found that the self-organization in 2D and 3D superlattices markedly differs with the substrate used. These changes in behavior are explained in terms of particle-particle and particle-substrate van der Waals interactions and capillary forces. (35 References).

Muller, P. and R. Kern (2000). "Equilibrium shape changes of nanocrystals induced by strain." Applied Surface Science **162**(163): 133-8.

In this paper we establish a generalized Wulf-Kaisheff theorem giving the equilibrium shape of a 3D crystal. A deposited coherently onto a lattice mismatched planar substrate B. Our main results are: (1) The epitaxial strain acts against wetting so that globally it leads to a thickening of the equilibrium shape. (2) Owing to the coherent strain the equilibrium shape changes with size. More precisely the various facet extensions change during the growth, some facets decreasing, some others increasing. (3) Each dislocation entrance, necessary for relaxing too large crystals having thus stored a prohibitive elastic energy, modifies abruptly the equilibrium shape and thus the different facet extension. Some experimental evidences are discussed. (16 References).

Murase, N., R. Jagannathan, et al. (2000). "Preparation and fluorescence properties of Eu<sup>3+</sup>-doped strontium chloroapatite nanocrystals." Journal of Luminescence **87**(89): 488-90.

Strontium chloroapatite nanocrystals doped with trivalent europium ions were prepared by an aqueous colloidal method. The mean diameter of the crystal was found to be ~3 nm by transmission electron microscopy, although, for the most part, they were agglomerated. The X-ray diffraction patterns show that the lattice constants of nanocrystals are contracted by ~2% compared to the corresponding bulk counterpart, and also that they further decrease by annealing at 200-300 degrees C. The fluorescence spectrum of nanocrystals exhibited blue shifts of both the  $^5D_0/5D_1$  transition and the charge transfer excitation band, and an apparent enhancement in the strength of the hypersensitive  $^5D_0/5D_1$  transition. (9 References).

Na, G. C., H. J. Stevens, et al. (1999). "Physical stability of ethyl diatrizoate nanocrystalline suspension in steam sterilization." Pharmaceutical Research **16**(4): 569-74.

PURPOSE: To study the effects of formulation variables on the physical stability of a submicron crystal (nanocrystal) suspension under steam sterilization conditions. METHODS: Suspensions of ethyl diatrizoate nanocrystals were prepared by wet milling in the presence of the surfactant poloxamine 908. Particle size distribution and zeta potential were measured by photon correlation spectroscopy. RESULTS: On heating, the mean particle size of the nanocrystal suspension remained essentially unchanged up to 110 degrees C, the cloud point of the stabilizing surfactant, but increased significantly above that temperature. The increase in particle size

was a result of particle aggregation rather than crystal growth. Adding a cloud point booster to the suspension significantly minimized the particle aggregation at high temperatures. The purity of poloxamine 908 and the tonicity agent and buffer salt used also affected the heat stability of the suspension, the latter agents apparently through altering the surfactant cloud point. CONCLUSIONS: The aggregation of the ethyl diatrizoate nanocrystalline suspension under steam sterilization conditions was a result of phase separation of the stabilizing surfactant at its cloud point. When formulated with a cloud point booster to prevent the phase-separation, the suspension maintained its physical stability under steam sterilization without any significant change in particle size distribution.

Nakanishi, S., K. Umezawa, et al. (2000). "Quantum confinement of quasi-two-dimensional  $E_1$  excitons in Ge nanocrystals studied by resonant Raman scattering." Physical Review B Condensed Matter **62**(3): 1584-7.

Ge nanocrystals of diameters ranging from 4 to 10 nm were synthesized by ion implantation of Ge/sup +/ ions into SiO/sub 2/ films followed by annealing. Confinement of its optical phonon and of the quasi-two-dimensional E/sub 1/ exciton have been observed at room temperature by resonant Raman scattering. The observed size-dependent blueshifts of the E/sub 1/ excitons energy (which can be larger than 0.7 eV) are found to be in good agreement with a theoretical calculation based on the effective mass approximation. (28 References).

Narayan, J. (2000). "Breakdown of the k-conservation rule in Si<sub>1-x</sub>Ge<sub>x</sub> alloy nanocrystals: Resonant photoluminescence study." Journal of Applied Physics **88**(10): 5772-6.

Resonant photoluminescence from Si/sub 1-x/Ge/sub x/ alloy nanocrystals as small as 4 nm in diameter embedded in SiO/sub 2/ thin film matrices was studied. In pure Si nanocrystals, phonon structures were clearly observed, indicating that optical transitions are assisted by momentum-conserving phonons. These structures are quenched by adding a small amount of Ge atoms in Si nanocrystals, i.e., due to the formation of Si/sub 1-x/Ge/sub x/ alloy. Furthermore, the lifetime of the radiative recombination became much faster in doped nanocrystals. These results suggest that Si/sub 1-x/Ge/sub x/ alloy formation leads to a disorder in the translation invariance of the crystalline lattice, thus resulting in the breakdown of the k-conservation rule. (16 References).

Narayan, J. (2000). "Size and interface control of novel nanocrystalline materials using pulsed laser deposition." Journal of Nanoparticle Research **2**: 91-96.

Narazaki, A., T. Hirano, et al. (2000). "Second-harmonic generation in oriented CdSe-nanocrystal-doped indium tin oxide film and its application to an infrared detector." Infrared Applications of Semiconductors III. Symposium **607**: 421-6.

Second-harmonic generation in CdSe nanocrystals doped in indium tin oxide (ITO) films has been examined. The thin film samples were prepared by r.f. magnetron sputtering with ITO target on which CdSe chips were placed. The X-ray diffraction patterns of as-deposited films indicate that CdSe crystallites are precipitated in an amorphous ITO matrix, and they are preferentially oriented in the direction of (111) plane of zinc blende structure or (002) plane of wurtzite structure. The mean diameter of CdSe crystallite was estimated to be 3-5 nm using Scherrer's equation. Moreover, the CdSe crystallites grew with keeping its initial orientation when a dc voltage of 50 V/cm was applied in the direction parallel to the film surface. The application of the electric field effectively enhanced the second-harmonic intensity by two orders of magnitude compared to that of the as-deposited films. The second-order nonlinear coefficient d/sup (2)/ for the electrically-treated specimen calculated on a basis of a modified Maker fringe theory is d/sub 31/=3.0\*10 pm/V at the wavelength of 1064 nm, which is comparable to d values reported for CdSe single crystal, d/sub 31/=25 pm/V at 1054 nm and d/sub 33/=76 pm/V at 1064 nm. (6 References).

Nemec, P., P. Maly, et al. (2000). "Auger recombination as a probe of the Mott transition in semiconductor nanocrystals." Applied Physics Letters **76**(20): 2850-2.

We report on picosecond dynamics of photoexcited carriers in CsPbCl/sub 3/ nanocrystals in a CsCl host. For low carrier densities, photoexcited carriers form excitons, which decay with a characteristic time constant of 170 ps at 300 K. Under strong photoexcitation, we have observed the Auger recombination with the Auger coefficient C approximately=10/sup -29/ cm/sup 6/ s/sup -1/. We have identified the onset of the Auger recombination at the carrier densities of approximately=10/sup 20/ cm/sup -3/ as the Mott-like transition from excitons to electron-hole plasma in nanocrystals. (15 References).

Nemec, P., D. Mikes, et al. (2000). "Light-controlled growth of CdSe nanocrystalline films prepared by chemical deposition." Materials Science and Engineering B Solid State Materials for Advanced Technology **70**(19): 500-4.

We report on preparation of high quality thin films of CdSe nanocrystals by chemical solution deposition technique. The samples characterized by optical spectroscopy have the nanocrystal radii 1.9-10 nm. We demonstrated that the sizes of nanocrystals could be controlled by changing the intensity and/or the spectrum of light illumination of growing film. (8 References).

Nemec, P. and P. Maly (2000). "Preferential deuterium bonding at the ice surface: A probe of surface water molecule

mobility." Journal of Chemical Physics **112**(13): 5527-9.

Infrared spectra have been used to determine the temperature dependence of the preferential D-bonding of HDO at the single-donor (dangling O-H) sites on the ice surface. Data for ice nanocrystals containing H/sub 2/O, D/sub 2/O, and HDO were in the form of the relative peak intensities of the O-D stretch mode bands of three-coordinated single-donor surface molecules of HDO and D/sub 2/O. The magnitude of the enhanced stability of the D-bonded HDO molecules at these surface sites is estimated as  $52 \pm 8 \text{ cm}^{-1}$ . This value matches, within experimental error, the literature value for the D-bonded dimer of HDO Engdahl and Nelander, J. Chem. Phys. 86, 1819 (1987). The thermal equilibrium between the H-bonded and D-bonded configurations of HDO at these sites is lost upon cooling below 60 K. This identifies the temperature of onset of molecular rotation of the single-donor surface molecules as 60 K, on a time scale of  $10^5 \text{ s}$ . The possibility exists for determination of the onset temperatures of more complex molecular motions on the surface of ice from related data. In that respect, the constant intensity of the O-D stretch mode band of single-donor D/sub 2/O molecules suggests that more complex surface motions, necessary for interchange with neighboring H-bonded HDO/H/sub 2/O molecules, are frozen at temperatures below 130 K. (8 References).

Nesheva, D., Z. Levi, et al. (2000). "Early crystallisation stages in a heavy metal fluoride glass prepared under normal and weightless conditions." Physics and Chemistry of Glasses **41**(1): 32-7.

Scanning electron and atomic force microscopies were used to study homogeneity and crystallisation of glasses of the system ZrF/sub 4/-BaF/sub 2/-LaF/sub 3/-AlF/sub 3/-NaF after various thermal treatments. Some of the glasses were doped with a trace of silver. Classical investigations yielded results similar to those obtained earlier, e.g. beta -BaZrF/sub 6/ as the main phase, preferred surface crystallisation for the undoped and bulk crystallisation for the doped samples. High resolution atomic force microscopy of the glass fracture surfaces showed the typical ripple pattern in the case of as melted glasses. After heating at the maximum nucleation temperature the ripples of this pattern grew to nanoscale dimensions with widths of 60 to 70 nm and length 145-155 nm. In the doped glasses these nanocrystals were even larger. Heating to maximum crystal growth temperature led to an even coarser nanotopography. One Ag doped glass was remelted during a microgravity experiment in space. The nanostructure of this glass was homogeneous and after annealing the fracture surface of the bulk glass was much smoother than that of the glass near the crucible wall. The suppression of convective transport processes under weightless conditions may cause this difference. (25 References).

Nesheva, D., Z. Levi, et al. (2000). "Charge transport in CdSe nanocrystalline sublayers of SiO<sub>x</sub>/CdSe multilayers and composite SiO<sub>x</sub>-CdSe thin films." Journal of Physics Condensed Matter **12**(17): 3967-74.

Dark-current measurements have been carried out on SiO/sub x//CdSe multilayers and composite SiO/sub x/-CdSe thin films having varying CdSe sublayer thicknesses and average nanocrystal sizes and, for comparison, on SiO/sub x/ and CdSe single layers. Size-induced changes in room temperature conductivity and dark-current activation energy at temperatures  $T > 320 \text{ K}$  have been observed in both multilayers and composite films. The high-resolution electron microscopy studies performed have shown that: (i) the CdSe sublayers in the multilayers are nanocrystalline with nanocrystallite size equal to the sublayer thickness; and (ii) the CdSe nanocrystals in the composite films are disposed in SiO/sub x/-CdSe 'sublayers' having high CdSe volume fractions. The conclusion has been reached that in both multilayers and composite films charge transport, in the layer plane, involves networks of CdSe nanocrystals contacting each other. It has been found that in the SiO/sub x//CdSe multilayers charge transport is controlled by potential barriers for electrons existing at the CdSe nanocrystal interface and that the barrier height does not exceed 0.25 eV. In the SiO/sub x/-CdSe composite films the potential barriers at the CdSe-CdSe interface do not appreciably affect the charge transport, due to the great conductivity increase, induced by the SiO/sub x/ matrix. The observed size-induced changes in the dark conductivity and dark-current activation energy in these films have been attributed to an upward quantum-size shift of the conduction band bottom in CdSe nanocrystals. (22 References).

Neuhauser, R. G., K. T. Shimizu, et al. (2000). "Multiphonon resonant Raman scattering in nanocrystals." Physical Review B Condensed Matter **62**(16): 11006-16.

We have studied the multiphonon resonant Raman scattering from confined and interface polar optical phonons in spherical nanocrystallites. The intermediate virtual states in the scattering process are taken into account as Wannier-Mott confined excitons in a spherical dot. Frohlich interaction between excitons and optical phonons has been considered and general selection rules for the exciton-phonon matrix elements and multiphonon scattering processes in the case of spherical quantum dots have been derived. It is shown that for a second-order process, two phonons are created with the same angular momentum ( $l_1 = l_2$ ) while, in a third-order process, the second emitted (or absorbed) phonon with angular momentum  $l_2$  must fulfill the triangular property  $|l_1 - l_3| \leq l_2 \leq l_1 + l_3$ . In the general case, the sum of phonon momentum projections on the z axis  $m_1 + m_2 + \dots = 0$ . We have performed multiphonon Raman cross-section calculations of CdSe quantum dots of various sizes up to third order and present detailed comparison with available experimental data. The effect of size distribution is studied; we show that a broad dispersion of nanocrystal sizes has important consequences on the multiphonon Raman spectra. The experimental relative

intensities between phonon overtones are correctly described in the framework of the present model. Also, an analysis of the applicability of the Huang-Rhys factor for quantum dot systems is presented and several contradictions found in the literature concerning this parameter have been explored. (42 References).

Ng, V., S. P. Ng, et al. (2000). "Comment on "Quantum confinement effect in diamond nanocrystals studied by X-ray-absorption spectroscopy" and reply." Physical Review Letters **84**(24): 5679-80.

For original paper see Chang et al., *ibid*, vol.82, p.5377 (1999). Ley et al. question the foundations of the calculations used by Chang et al. in their study of an increase in the binding energy of the C1s core exciton in diamond nanopowders, ascribed to quantum confinement. Chang et al reply to the comments, defending their methods. (12 References).

Nicklaw, C. J., M. P. Pagey, et al. (2000). "Defects and nanocrystals generated by Si implantation into a-SiO<sub>2</sub>." IEEE Transactions on Nuclear Science **47**(6): 2269-75.

Electrical charge-trapping characteristics have been studied in thermal oxides that were implanted with Si, experimentally using electron spin resonance (ESR), capacitance versus voltage (CV) measurements, transmission electron microscopy (TEM), atomic force microscopy (AFM), and theoretically with Density Functional Theory (DFT) using plane waves. Our study examines possible defect structures associated with excess Si in thermal oxides. (22 References).

Niquet, Y. M., G. A. Allan, et al. (2000). "Dilution effect on magnetic properties of Co<sub>3</sub>O<sub>4</sub> nanocrystals." Journal of Applied Physics **88**(5): 2771-4.

We have prepared diluted systems of Co/sub 3/O/sub 4/ nanocrystals dispersed in an amorphous silicate by calcination of molecular sieve soaked in precursor solutions with concentrations of 0.01 and 0.1 mol/l. For both systems we have observed the disappearance of the antiferromagnetic phase transition at 33 K of bulk Co/sub 3/O/sub 4/, a difference in the dc susceptibility between field cooling and zero field cooling, and the frequency dependence of the ac susceptibility. Nonlinear susceptibility measurements demonstrated that the systems from the solution of 0.01 and 0.1 mol/l were in superparamagnetic and spin glass phases, respectively. The 0.01 mol/l solution system showed no peaks at any temperature, although the peak temperature for the 0.1 mol/l solution system was 18-22 K. The interparticle interactions were independent and collective for the systems from 0.01 and 0.1 mol/l solutions, respectively. (6 References).

Nishida, M. (2000). "STM studies of passivated Au nanocrystals immobilised on a passivated Au (111) surface: ordered arrays and single electron tunnelling." Chemical Physics Letters **330**: 1-2.

We have employed scanning tunnelling microscopy (STM) in ultra-high vacuum (UHV) to explore the assembly and electron transport properties of an ordered layer of passivated gold clusters adsorbed onto an alkanethiol passivated Au(111) surface. The passivation of the Au(111) surface stabilises the cluster layer. STM images show ordered hexagonal arrays of the nanoparticles extending over distances >100 nm with a mean nearest neighbour spacing of 6.5 nm. I-V measurements show a strong non-linear I-V relationship, as well as equidistant steps of width ~0.15 V above a bias voltage of ~2 V, attributed to a Coulomb staircase, i.e., single electron charging, in this structure. (27 References).

Oda, M., M. Y. Shen, et al. (2000). "Photobrightening of CuBr nanocrystals in PMMA." Journal of Luminescence **87**(89): 469-71.

The photoluminescence (PL) intensity and its decay time of CuBr nanocrystals (NCs) embedded in poly methyl methacrylate increase with increasing the exposure time of the excitation light at 77 K. The PL intensity becomes smaller with increasing applied electric field, and returns to the initial one as soon as the electric field is cut. From these results, we propose a mechanism that an electron and a hole are generated inside the NC by light, and then, either of them goes out of the NC to neutralize a charged center outside the NC. On the other hand, the photodarkening effect by an applied electric field may be caused by the neutralization of the ionized centers inside the NC. (9 References).

Ohba, R., N. Sugiyama, et al. (2000). "Influence of channel depletion on the carrier charging characteristics in Si nanocrystal floating gate memory." Japanese Journal of Applied Physics Part **39**(3A): 989-93.

The carrier charging/discharging characteristics in a multidot Si nanocrystal floating gate memory are investigated by measuring the gate current directly. To detect a small gate current, we use a large device-size memory. In the gate current characteristics, double peak structures, with one of the peaks at the threshold voltage and the other at the flat-band voltage, are found. The separation into two peaks is shown to be due to the change of the charging/discharging carrier sources between the source/drain and the substrate in the channel depletion region. These show that the carrier charging/discharging characteristics change critically at each of the threshold voltage and the flat-band voltage. Charging/discharging rate reduction due to the surface potential flexibility and the carrier number shortage in the channel depletion region is proposed to explain the critical changes. (8 References).

Osman, H., J. Schmidt, et al. (2000). "Optical properties of SnO<sub>2</sub> nanocrystals with surface modification." *Acta Optica Sinica* **20**(11): 1575-9.

The experimental results of absorption, luminescence and excitation spectra in both bare and coated SnO<sub>2</sub>/nanocrystals are presented. It is found that the absorption edge shifts to the longer wavelength as the particle size decreases when the SnO<sub>2</sub>/nanocrystals are coated by a layer of organic molecules, which is inconsistent with that of the bare SnO<sub>2</sub>/nanocrystals. It is demonstrated that the size and surface situations of nanocrystals greatly affect their spectroscopic properties. The experimental data are discussed in terms of the quantum confinement effects and dielectric confinement effects. (16 References).

Osterbacka, R., C. P. An, et al. (2000). "Two-dimensional electronic excitations in self-assembled conjugated polymer nanocrystals." *Science* **287**(5454): 839-42.

Several spectroscopic methods were applied to study the characteristic properties of the electronic excitations in thin films of regioregular and regiorandom polythiophene polymers. In the regioregular polymers, which form two-dimensional lamellar structures, increased interchain coupling strongly influences the traditional one-dimensional electronic properties of the polymer chains. The photogenerated charge excitations (polarons) show two-dimensional delocalization that results in a relatively small polaronic energy, multiple absorption bands in the gap where the Lowest energy band becomes dominant, and associated infrared active vibrations with reverse absorption bands caused by electron-vibration interferences. The relatively weak absorption bands of the delocalized polaron in the visible and near-infrared spectral ranges may help to achieve laser action in nanocrystalline polymer devices using current injection. (31 References).

Pauchard, M., A. Devaux, et al. (2000). "Dye-loaded zeolite L sandwiches as artificial antenna systems for light transport." *Chemistry* **6**(18): 3456-70.

The synthesis and characterization of dye loaded zeolite L sandwiches acting as artificial antenna systems for light harvesting and transport is reported. A set of experimental tools for the preparation of neutral dye-zeolite L materials ranging from low to maximum packing densities has been developed. The role of co-adsorbed water and the distribution of molecules between the inner and the outer surface were found to be the determining parameters. p-Terphenyl (pTP) turned out to be very suitable for studying these and other relevant parameters of neutral dye-zeolite L materials. We observed that pTP located in the channels of zeolite L can reversibly be displaced by water. This can be used when synthesizing such materials. We also observed that all-trans-1,6-diphenyl-1,3,5-hexatriene (DPH) which is very photolabile in solution is stable after insertion into zeolite L. By combining our extensive knowledge of these systems with ion-exchange procedures developed in an earlier study, we have realized the first bi-directional three-dye antenna. In this material the near UV absorbing compounds DPH or 1,2-bis-(5-methyl-benzoxazol-2-yl)-ethene (MBOXE) are located in the middle part of zeolite L nanocrystals followed on both sides by pyronine (Py) and then by oxonine (Ox) as acceptors. Fluorescence of the oxonine located at both ends of the cylindrical zeolite L crystals was observed upon excitation of the near UV absorber in the middle section at 353 nm, where neither oxonine nor pyronine absorb a significant amount of the excitation light.

Pavesi, L., L. D. Negro, et al. (2000). "Optical gain in silicon nanocrystals." *Nature* **408**(6811): 440-4.

Adding optical functionality to a silicon microelectronic chip is one of the most challenging problems of materials research. Silicon is an indirect-bandgap semiconductor and so is an inefficient emitter of light. For this reason, integration of optically functional elements with silicon microelectronic circuitry has largely been achieved through the use of direct-bandgap compound semiconductors. For optoelectronic applications, the key device is the light source—a laser. Compound semiconductor lasers exploit low-dimensional electronic systems, such as quantum wells and quantum dots, as the active optical amplifying medium. Here we demonstrate that light amplification is possible using silicon itself, in the form of quantum dots dispersed in a silicon dioxide matrix. Net optical gain is seen in both waveguide and transmission configurations, with the material gain being of the same order as that of direct-bandgap quantum dots. We explain the observations using a model based on population inversion of radiative states associated with the Si/SiO<sub>2</sub> interface. These findings open a route to the fabrication of a silicon laser. (31 References).

Peng, X., L. Manna, et al. (2000). "Shape control of CdSe nanocrystals." *Nature* **404**(6773): 59-61.

Nanometre-size inorganic dots, tubes and wires exhibit a wide range of electrical and optical properties that depend sensitively on both size and shape, and are of both fundamental and technological interest. In contrast to the syntheses of zero-dimensional systems, existing preparations of one-dimensional systems often yield networks of tubes or rods which are difficult to separate. And, in the case of optically active II-VI and III-V semiconductors, the resulting rod diameters are too large to exhibit quantum confinement effects. Thus, except for some metal nanocrystals, there are no methods of preparation that yield soluble and monodisperse particles that are quantum-confined in two of their dimensions. For semiconductors, a benchmark preparation is the growth of nearly spherical II-VI and III-V nanocrystals by injection of precursor molecules into a hot surfactant. Here we

demonstrate that control of the growth kinetics of the II-VI semiconductor cadmium selenide can be used to vary the shapes of the resulting particles from a nearly spherical morphology to a rod-like one, with aspect ratios as large as ten to one. This method should be useful, not only for testing theories of quantum confinement, but also for obtaining particles with spectroscopic properties that could prove advantageous in biological labelling experiments and as chromophores in light-emitting diodes.

Peng, Z. A. and X. Peng (2001). "Formation of high-quality CdTe, CdSe, and CdS nanocrystals using CdO as precursor." Journal of the American Chemical Society **123**(1): 183-4.

Penn, R. L. and J. F. Banfield (1998). "Imperfect oriented attachment: dislocation generation in defect-free nanocrystals." Science **281**(5379): 969-71.

Dislocations are common defects in solids, yet all crystals begin as dislocation-free nuclei. The mechanisms by which dislocations form during early growth are poorly understood. When nanocrystalline materials grow by oriented attachment at crystallographically specific surfaces and there is a small misorientation at the interface, dislocations result. Spiral growth at two or more closely spaced screw dislocations provides a mechanism for generating complex polytypic and polymorphic structures. These results are of fundamental importance to understanding crystal growth.

Peperzak, L., E. G. Vrieling, et al. (2000). "Immuno flow cytometry in marine phytoplankton research." Scientia Marina **64**(2): 165-181.

The developments in the combination of flow cytometry and immunology as a tool to identify, count and examine marine phytoplankton cells are reviewed. The concepts of immunology and flow cytometry are described. A distinction is made between quantitative and qualitative immunofluorescence. Quantitative immunofluorescence, the identification and enumeration of phytoplankton cells, is the research area that has advanced rapidly in the past decade, and is reviewed extensively. Key steps of quantitative immunofluorescence, fixation and immunolabel intensity, are discussed in more detail. Qualitative immunofluorescence is a new, hardly explored but highly interesting development in which qualitative -physiological- variables related to e.g. nutrient limitation or primary production are measured in individual cells instead of phytoplankton populations as a whole. Several combinations of immunological probes, both for species identification and for physiological measurements, are proposed. A special case of qualitative immunofluorescence is the measurement of phytoplankton toxins in single cells from natural populations. It is anticipated that the future use of semiconductor nanocrystals or "quantum dots" as fluorophores will greatly enhance signal detection in flow cytometry, and hence in both quantitative and qualitative immunofluorescence applications.

Perlin, E. and D. I. Stasel'ko (2000). "Nonlinear excitation of AgBr nanocrystals in the field of short light pulses." Optika i Spektroskopiya **88**(1): 57-61.

Processes of the electron-hole pair generation and excited-state relaxation at earlier stages of the latent image formation in the AgBr nanocrystals are studied theoretically. The experimental dependence of the photographic blackening  $D$  in the field of the intense laser light on the light pulse energy  $I$  is analyzed in the range of pulse durations  $\tau$  from  $10^{-13}$  to  $10^{-8}$  s. The values of  $I$  needed to obtain a fixed blackening  $D$  at  $\tau$  exceeded those at  $\tau$  by three orders of magnitude. However, as  $\tau$  further decreased to hundreds of fs, these values decreased by two orders of magnitude. It is shown that experimental nonmonotonic dependences can be explained by saturation of the one-photon interband generation of electron-hole pairs accompanied by the development of the two-photon generation. For shortest pulses and, correspondingly, greatest light intensities, the pair generation rate varies more strongly than upon usual two-photon absorption, which is caused by the resonance optical Stark effect. (16 References).

Peters, D. P., C. Strohhofner, et al. (2000). "Synthesis of CdS nanocrystal within copolymer." Journal of Luminescence **87**(89): 538-41.

In this paper, polystyrene-maleic anhydride (PSM) was used to fabricate CdS nanocrystals in dimethylsulfoxide (DMSO) aqueous solution. The concentration of Cd<sup>2+</sup> ions loaded on polymer was determined by inductively coupled plasma atomic emission spectroscopy (ICP-AES). Various techniques, including Fourier transform infrared (FTIR), transmission electron microscopy (TEM), UV-Vis spectrophotometry and fluorescence spectrophotometry, were used to describe the characteristics of CdS nanocrystals. (10 References).

Pielaszek, R., S. Stel'makh, et al. (2000). "Temperature study of trap-related photoluminescence decay in CdS<sub>x</sub>Se<sub>1-x</sub> nanocrystals in glass." Journal of Applied Physics **87**(7): 3342-8.

The trap-related photoluminescence dynamics in CdS<sub>x</sub>/Se<sub>1-x</sub> nanocrystals (for  $x=0.24$  and  $x=0.74$ ) in glass were studied in the temperature interval 10-300 K. A close link between the temperature behavior of the photoluminescence decay rate and that of the photoluminescence efficiency was found, which indicates a dominant role of nonradiative recombination. The trap-related photoluminescence was interpreted as the recombination of a shallowly trapped electron with a hole in a deep trap. An exponential decrease (with a constant

in the range 0.2-0.4 eV) in the density of the deep traps with increasing energy above the valence band was found. Apart from the Arrhenius type of temperature behavior of decay rate with the activation energy approximately=50 meV, the Berthelot type (characteristic temperature approximately=160 K) was also observed. The latter was modeled by carrier tunneling between localized sites and the energetic distribution of the tunneling distances was obtained. (73 References).

Pokutnii, S. I. (2000). "Ordering and self-organization in nanocrystalline silicon." Nature **407**(6802): 358-61.

The spontaneous formation of organized nanocrystals in semiconductors has been observed during heteroepitaxial growth and chemical synthesis. The ability to fabricate size-controlled silicon nanocrystals encapsulated by insulating SiO<sub>2</sub> would be of significant interest to the microelectronics industry. But reproducible manufacture of such crystals is hampered by the amorphous nature of SiO<sub>2</sub> and the differing thermal expansion coefficients of the two materials. Previous attempts to fabricate Si nanocrystals failed to achieve control over their shape and crystallographic orientation, the latter property being important in systems such as Si quantum dots. Here we report the self-organization of Si nanocrystals larger than 80 Å into brick-shaped crystallites oriented along the (111) crystallographic direction. The nanocrystals are formed by the solid-phase crystallization of nanometre-thick layers of amorphous Si confined between SiO<sub>2</sub> layers. (20 References).

Praver, S., J. L. Peng, et al. (2000). "Size dependence of structural stability in nanocrystalline diamond." Physical Review B Condensed Matter **62**(24).

We describe experiments which demonstrate that carbon atoms introduced into a fused-silica substrate by means of MeV ion implantation can, after suitable annealing, form nanocrystalline diamond. Unlike other methods of creating diamond, the coalescence of the carbon into diamond nanocrystals occurs when the samples are heated in a conventional furnace and does not require the application of high external pressures, or any pre-existing diamond template. Following a dose of  $5 \times 10^{16}$  C/cm<sup>2</sup> into fused quartz and after annealing in forming gas (4% hydrogen in argon), perfect cubic diamond crystallites of 5-7 nm diameter are formed. For higher doses, the same annealing treatments produce larger crystallites which are comprised of other varieties of solid carbon phases. We conclude that diamond is the stable form of carbon provided that the crystallite size is sufficiently small (less than 7 nm) and that the nanocrystallites are appropriately surface passivated. (12 References).

Principi, G., A. Maddalena, et al. (2000). "Furnace and current annealing of the amorphous Fe<sub>72</sub>Cu<sub>1</sub>Nb<sub>4.5</sub>Si<sub>13.5</sub>B<sub>9</sub> alloy." Journal of Applied Physics **87**(9): 1-3.

Specimens of the amorphous Fe<sub>72</sub>Cu<sub>1</sub>Nb<sub>4.5</sub>Si<sub>13.5</sub>B<sub>9</sub> alloy have been nanocrystallized by furnace (FA) and current (CA) annealing and analyzed by simultaneous small-angle (SAXS) and wide-angle (WAXS) X-ray scattering using the beam-line 5.2L at Elettra Synchrotron Source, Trieste. The analysis has been carried out also dynamically on untreated samples current heated in situ. Significant differences in the SAXS regime have been observed between the FA and CA samples having the same amount of nanocrystallization as determined from previous WAXS and Mossbauer measurements. These differences can be attributed to a lower contrast of the nanocrystallites in the CA samples as compared to FA samples. The Mossbauer spectra show that in FA and CA samples the nanocrystalline grains consist of a nonstoichiometric partially disordered Fe<sub>3</sub>Si phase, and indicate the presence of boron atoms in the nanocrystals of CA samples. This is in agreement with the lower contrast found by SAXS and implies a lower segregation of boron atoms and/or of borides at the boundaries of nanocrystallites of CA samples, accounting for their lower brittleness. (12 References).

Puntes, V. F., K. M. Krishnan, et al. (2001). "Colloidal nanocrystal shape and size control: the case of cobalt." Science **291**(5511): 2115-7.

We show that a relatively simple approach for controlling the colloidal synthesis of anisotropic cadmium selenide semiconductor nanorods can be extended to the size-controlled preparation of magnetic cobalt nanorods as well as spherically shaped nanocrystals. This approach helps define a minimum feature set needed to separately control the sizes and shapes of nanocrystals. The resulting cobalt nanocrystals produce interesting two- and three-dimensional superstructures, including ribbons of nanorods.

Qian, X., X. Zhang, et al. (2000). "Photoelectrochemical characteristics of  $\alpha$ -Fe<sub>2</sub>O<sub>3</sub> nanocrystalline semiconductor thin film." Journal of Nanoparticle Research **2**: 191-198.

Rakovich Yu, P., A. A. Gladyschuk, et al. (2000). "Effect of deformation of a polymer matrix on the optical properties of CdS nanocrystals incorporated into it." Zhurnal Prikladnoi Spektroskopii **67**(1): 101-4.

A study is made of the photodegradation kinetics of luminescence and absorption of cadmium sulfide nanocrystals incorporated into a plastic polymer matrix. The reversibility effect of photodegradation under mechanical deformation (stretching) of a polymer films is revealed. It is suggested that the photodegradation reversibility is related to the extraction of electrons, photoexcited in nanocrystals, from deep-lying traps in the

surrounding polymer matrix during its deformation. (10 References).

Ramesh, R. and R. Jagannathan (2000). "On determination of volume fraction of crystalline phase in partially crystallized amorphous and nanocrystalline materials." Journal of Materials Science **35**(18): 4495-500.

The method for determination of volume fraction of crystalline phase in amorphous-crystalline materials is proposed. The method is based on the analysis of X-ray patterns obtained under study of structure-phase changes in nanocrystalline Finemet-type alloys. Verification of the method was carried out with the use of X-ray diffraction data (including small-angle X-ray scattering) of specimens in as-quenched amorphous state as well as after annealing at various temperatures, which provided formation and growth of crystals in amorphous matrix with sizes in a range from 2 to 15 nm. The method is the most effective under nanocrystals' size exceeding 5-6 nm, when their further increase does not affect the height and width of diffraction reflexes. (13 References).

Rastogi, A. C., S. N. Sharma, et al. (2000). "Analysis of the noble metal catalytic additives introduced by impregnation of as obtained SnO<sub>2</sub> sol-gel nanocrystals for gas sensors." Sensors and Actuators B Chemical **B70**: 87-100.

In order to clarify the role of the noble metal additives in the gas sensing mechanisms, three of the most common catalytic additives, such as Pd, Pt and Au, have been introduced in a sol-gel obtained tin oxide base material. The additives nominal weight concentrations used were 0.2% and 2%, and they were introduced in the precipitated tin oxide. A posterior calcination treatment was carried out, during 8 h, at the temperatures of 250 degrees C, 400 degrees C, 450 degrees C, 600 degrees C, 800 degrees C and 1000 degrees C. Structural and surface analysis of these nanopowders have been performed. Identification and localisation of metallic, 2+ and 4+ oxidised states of the used noble metals are discussed, and experimental evidence about their effects on the sensor performance is presented. Likewise, effects of their presence on the nanoparticle characteristics, and also on the material sensitivity to CO and CH<sub>4</sub>, are analysed and discussed. (40 References).

Ridley, B. A., B. Nivi, et al. (1999). "All-Inorganic Field Effect Transistors Fabricated by Printing." Science **286**(5440): 746-749.

A solution of cadmium selenide nanocrystals was used to print inorganic thin-film transistors with field effect mobilities up to 1 square centimeter per volt second. This mobility is an order of magnitude larger than those reported for printed organic transistors. A field effect was achieved by developing a synthesis that yielded discretely sized nanocrystals less than 2 nanometers in size, which were free of intimately bound organic capping groups. The resulting nanocrystal solution exhibited low-temperature grain growth, which formed single crystal areas encompassing hundreds of nanocrystals. This process suggests a route to inexpensive, all-printed, high-quality inorganic logic on plastic substrates.

Riwotzki, K., H. Meysamy, et al. (2001). "Liquid-phase synthesis of colloids and redispersible powders of strongly luminescing LaP<sub>4</sub>:Ce,Tb nanocrystals." Angewandte Chemistry International Edition English **40**(3): 573-576.

Rockenberger, J., U. zum Felde, et al. (2000). "The morphology and formation mechanism of aluminum nitride nanocrystals synthesized by chemical vapor deposition." Journal of Crystal Growth **208**: 1-4.

Nanocrystal aluminum nitride (AlN) powders were obtained by the chemical vapor deposition (CVD) process via the AlCl<sub>3</sub>/NH<sub>3</sub>/N<sub>2</sub> system at 1323 K with various total flow rates. The morphology and formation mechanism of the synthesized AlN powders were characterized by X-ray diffraction (XRD) and transmission electron microscopy (TEM). It has been shown that all of the obtained powders exclusively belong to the single-phase AlN and do not depend on the variation of the total flow rate of the 1:1 molar ratio of the gas mixture of NH<sub>3</sub>/N<sub>2</sub>. On the other hand, the crystal shapes were affected by the position of the entry/mixing of the reacting gases of AlCl<sub>3</sub> and NH<sub>3</sub>. The average crystal size of the AlN powders was decreased from 35.0 to 12.5 nm as the gas-mixture flow rates were increased from 200 to 800 cm<sup>3</sup>/min. A crystal growth model of the AlN powders has been proposed for the stages of the adsorption/desorption rates in the inlet zone of the reacting gases to AlN formation to crystal growth to crystal agglomeration. (26 References).

Rodriguez-Suarez, R., E. Menendez-Proupin, et al. (2000). "Long-lived quantum-confined infrared transitions in CdSe nanocrystals." Applied Physics Letters **77**(18): 2816-18.

We present quasi-steady-state photoinduced absorption measurements on thin films of CdSe nanocrystals dispersed in a polystyrene matrix. For nanocrystals treated with pyridine we observe an intense, size-dependent absorption peaking in the mid-infrared when the samples are irradiated with visible light. This infrared absorption is associated with a size-dependent bleach in the visible, near the peak of the first excitonic absorption. We attribute the infrared absorption to an intraband electron transition in the quantum dots and measure the lifetime of the absorbing state to be 1.0 ms at 295 K. (20 References).

Rolo, A. G., M. I. Vasilevskiy, et al. (2000). "Optical phonons in CdS nanocrystals: effects of size, shape and packing density." Semiconductor Quantum Dots. Symposium. **571**: 217-22.

Optical vibrations confined in CdS nanocrystals (embedded in a glass film or forming a close-packed film with

some organic-molecule links between them) have been studied experimentally, by means of FIR and Raman spectroscopies, and theoretically. The asymmetric Raman lineshape can be modelled considering resonant and nonresonant scattering on spherical modes with  $l=0$  (those with  $n>1$  are responsible for the low-frequency wing). A phonon-related dielectric response of the nanocrystal composites has been studied by measuring FIR reflectivity and transmission spectra. The theoretical consideration consists of (i) calculation of the single-particle polarisability due to the confined  $l=1$  modes and (ii) including the dipole-dipole interaction between the particles. We show that, for the smallest particles, the FIR response has a bimodal structure, which disappears as the nanocrystal size increases. However, the experimentally observed bulk-CdS-like reflection band at 230-300  $\text{cm}^{-1}$  is too broad and can not be explained by the model. Only making further assumptions, namely, of a fractal structure of the nanocrystal composites, enables us to fit well the experimental FIR spectra. (12 References).

Romero, J. and L. F. Fonseca (2000). "Monte Carlo analysis of the surface and size effects in ferroelectric nanocrystals." Integrated Ferroelectrics **28**: 1-4.

Computer Monte Carlo simulations have been carried out to study the ferroelectric phase transition in nanocrystals. The microscopic description of the system includes up to four pseudospin interactions describing first order phase transitions in bulk systems. Of main importance is the analysis of the critical temperature ( $T_c$ ) shifts due to size effects in the nanostructure. The average polarization for temperatures ranging from below to above  $T_c$  have been obtained for particles of different sizes. The results show that  $T_c$  shifts down as the size of the particle is reduced. This shift is followed by the modification of the transition from first order to second order type. However, the simulations show that surface effects can drive up  $T_c$ , and if the magnitude of the interaction parameters at the surface differ significantly from those at the inside, the particle can spontaneously polarize its surface and its interior at different temperatures. (13 References).

Rosenthal, S. J. (2001). "Bar-coding biomolecules with fluorescent nanocrystals." Nature Biotechnology **19**(7): 621-2.

Rossi, F., G. Pucker, et al. (2000). "SiC nanocrystals embedded in oligoetheracrylate photopolymer matrices; new promising nonlinear optical materials." Optical Materials **13**(4): 449-53.

Photoinduced optical phenomena in SiC nanocrystallites embedded within the photo-polymer oligoetheracrylate matrices have been studied using experimental nonlinear optics, particularly photoinduced optical second harmonic generation (SHG). The YAG-Nd-laser ( $\lambda = 1.06 \mu\text{m}$ ;  $W=30 \text{ MW}$ ; pulse duration within the 30-50 ps) was used as a source of pumping light and the nitrogen laser ( $\lambda = 337 \text{ nm}$ ) has been applied as a source of the photoinducing light. With increasing intensity of the photoinducing beam, the SHG ( $\lambda = 0.53 \mu\text{m}$ ) signal increased and achieved a maximum ( $\chi^{(2)} = 10.1 \pm 0.13 \text{ pm/V}$ ) at a photon flux of about 1.61  $\text{GW/cm}^2$ . With decreasing temperature, the SHG signal strongly increases within the temperature range 25-30 K. Time-dependent probe-pump measurements indicate an existence of the SHG maximum for a pump-probe time delay of about 20 ps. The SiC hexagonal structural components play a key role in the observed photoinduced nonlinear optical effects. Large values of the nonlinear optical constants as well the good technological parameters open a possibility to enhance the nonlinear optical susceptibilities. (21 References).

Rossi, M. C., S. Salvatori, et al. (2000). "Laser-induced nanocrystalline silicon formation in a-SiO<sub>2</sub> matrices." Materials Science and Engineering B Solid State Materials for Advanced Technology **70**(19): 299-302.

Nanocrystalline silicon formation by CW laser-irradiation of amorphous silicon-oxygen alloys of variable composition has been investigated as a function of both laser power density and alloy composition. Structural changes during the annealing treatment were monitored 'in situ' by micro Raman spectroscopy. Careful Raman lineshape analysis in the 450-550  $\text{cm}^{-1}$  range allowed the evaluation of Si nanocrystal size distribution. It is shown that depending on the size of the nanocrystallites, irradiation can yield to a strong photoluminescence (PL) enhancement or quenching. (13 References).

Russier, V., C. Petit, et al. (2000). "Structural and luminescence properties of nanostructured ZnS:Mn." Applied Physics Letters **77**(9): 1301-3.

We have studied structural and luminescence properties of nanostructured (NS-) ZnS:Mn which has potential applications in thin-film electroluminescence (TFEL) devices. As a NS-ZnS:Mn system, a ZnS:Mn/Si<sub>3</sub>N<sub>4</sub>/multilayer having thicknesses of 2.5 nm for ZnS and 0.6 nm for Si<sub>3</sub>N<sub>4</sub> was prepared by a conventional rf-magnetron sputtering method. Grazing incidence X-ray reflectometry and X-ray diffractometry show that ZnS:Mn nanocrystals were formed between the amorphous Si<sub>3</sub>N<sub>4</sub> layers. Photoluminescence intensity associated with the Mn<sup>2+</sup> transitions per total thickness of the ZnS:Mn layers is increased in NS-ZnS:Mn in comparison with that of the ZnS:Mn thin film, indicating the effects due to quantum confinement. The TFEL device with NS-ZnS:Mn as an emission layer exhibits a reddish-orange broad band emission with the maximum luminance of 2.8  $\text{cd/m}^2$  under the 1-kHz sinusoidal wave operation at a voltage of 20.5 V<sub>0-p</sub>. (17 References).

Sasaki, Y. C., Y. Suzuki, et al. (2000). "Tracking of individual nanocrystals using diffracted X-rays." Physical Review E. Statistical Physics, Plasmas, Fluids, and Related Interdisciplinary Topics **62**(3): 3843-7.

We demonstrated dynamical observation of an individual nanocrystal in supercooled liquid water with the guidance of X-ray diffracted spots from the nanocrystal itself. This new system, which we call diffracted X-ray tracking, monitored small Brownian motions ( $D=0.68$  mrad/sup 2//s at 233 K) of a single nanoparticle in real time and real space. (19 References).

Sato, M., S. Kohiki, et al. (2000). "Low-field magnetoresistive property of partially crystallized  $\text{La}_{0.5}\text{Sr}_{0.5}\text{MnO}_3$  thin films by pulsed laser deposition." Journal of Applied Physics **88**(5): 2791-8.

$\text{La}/\text{sub } 0.5/\text{Sr}/\text{sub } 0.5/\text{MnO}/\text{sub } 3/$  thin films deposited on (001)  $\text{SrTiO}/\text{sub } 3/$  substrates at different temperatures are prepared using pulsed laser deposition, and their electro- and magnetotransport properties are experimentally evaluated. The structure analysis reveals that the thin films show amorphous, mixed amorphous/nanocrystalline as well as epitaxial microstructures, respectively, depending on the deposition temperature. While the amorphous thin film exhibits variable range hopping conduction, the epitaxial sample is metal like and ferromagnetic. Enhanced low-field magnetoresistance at low temperature for the microstructure in which the nanocrystalline phase and amorphous phase coexist is demonstrated. It is argued that the amorphous layer separating the neighboring nanocrystals behaves as barrier for the spin-dependent tunneling, resulting in enhanced magnetoresistance at low magnetic field. The modified two-channel model where the insulating conduction channel and the spin-ordered and metallic conduction channel coexist in parallel is employed to explain the magnetotransport phenomena. (21 References).

Schaaff, T. G. and R. L. Whetten (2000). "Giant gold-glutathione cluster compounds: intense optical activity in metal-based transitions." Journal of Physical Chemistry B **104**(12): 2630-41.

A series of giant metal-cluster compounds, each composed of a gold core and a glutathione (GSH) adsorbate layer, have been prepared from Au(I)SG polymers and separated by gel electrophoresis, using methods reported in a recent Letter J. Phys. Chem. B 1998, 102, 10643-6. Identification of the separated compounds by core mass is accomplished through laser desorption mass spectrometry of matrix-diluted films. Three principal compounds have core masses of ca. 4.3, 5.6, and 8.2 kDa (in the range of ~20-40 Au atoms), and show structured optical absorption spectra with clear optical absorption onsets near 1.7, 1.3, and 1.0 eV, respectively. Each of these shows unusually strong chiroptical activity in the metal-based electronic transitions across the near-infrared, visible, and near-ultraviolet regions, whereas neither the crude (unseparated) mixture nor its higher molecular weight components possess such strong optical activity. The location and strength of the optical activity suggest a metal electronic structure that is highly sensitive to the chiral environment imposed by the glutathione adsorbate groups, if indeed the gold core is not inherently chiral. Mechanisms that could account for the observed optical activity are discussed, but the mere presence of strong chiroptical effects in this metallic-cluster system places these novel compounds in a special class of molecular substances. Previously known giant metal-cluster compounds (and nanocrystals) have not been reported to exhibit significant optical activity. With these results, there emerges a rather complete picture of the evolution of optical and electronic properties of thiol-based gold cluster compounds (or self-assembled monolayer passivated gold nanocrystals) from 20 to 1000 Au atoms (0.7-3.2 nm core diameter). (41 References).

Schief, W. R., S. R. Dennis, et al. (2000). "GaAs nanocrystals fabricated by sequential ion implantation: structural and luminescence properties." Physica A **7**: 3-4.

We have fabricated GaAs nanocrystals in  $\text{SiO}/\text{sub } 2/$  matrices by sequential ion implantation and thermal annealing and studied their photoluminescence (PL) properties. After thermal annealing, GaAs nanocrystals are formed in  $\text{SiO}/\text{sub } 2/$  films and some PL bands appear in the red and infrared spectral region. After low-energy deuterium implantation, defect- and impurity-related PL bands disappear and the band-edge emission of GaAs nanocrystals is clearly observed. The luminescence mechanism of GaAs/ $\text{SiO}/\text{sub } 2/$  nanocomposites will be discussed. (15 References).

Schmidt, U., C. Eisenschmidt, et al. (2000). "Sol-gel preparation and characterization of transparent  $\text{KTiOPO}_4\text{SiO}_2$  nanocomposite glass for second harmonic generation." Journal of Non Crystalline Solids **271**: 1-2.

A nanocomposite glass consisting of sol-gel derived nanocrystalline  $\text{KTiOPO}/\text{sub } 4/$  (KTP) and  $\text{SiO}/\text{sub } 2/$ -based glass has been developed. The multicomponent glass in the  $\text{K}/\text{sub } 2/\text{O}-\text{TiO}/\text{sub } 2/-\text{P}/\text{sub } 2/\text{O}/\text{sub } 5/-\text{SiO}/\text{sub } 2/$  system has been prepared by the sol-gel method. After heat treatment at temperatures higher than 650 degrees C, the glass transformed into a dense nanocomposite glass containing KTP nanocrystals. The transparent nanocomposite glasses, 10 mm in diameter and 2-3 mm thick, call be obtained by the heat treatment. (41 References).

Schoenlein, R. W., D. M. Mittleman, et al. (1993). "Investigation of femtosecond electronic dephasing in CdSe nanocrystals using quantum-beat-suppressed photon echoes." Physical Review Letters **70**(7): 1014-1017.

Schreder, B., T. Schmidt, et al. (2000). "Quantum-confined atoms": novel luminescent centers for future II-VI devices." Journal of Crystal Growth **214**(215): 926-30.

We report for the first time how the optical transitions associated with a localized impurity can be modulated by quantum confinement. The effect of quantum confinement on an impurity critically depends on the size of the host nanocrystal. The luminescent properties of  $\text{Y}_2\text{O}_3:\text{Tb}^{3+}$  and  $\text{ZnS}:\text{Mn}^{2+}$  are discussed within the framework of the quantum-confined atoms. (8 References).

Schreder, B., T. Schmidt, et al. (2000). "CdTe/CdS clusters with "core-shell" structure in colloids and films: the path of formation and thermal breakup." Journal of Physical Chemistry B **104**(8): 1677-85.

A new organometallic "cold-slow" route to strongly fluorescing CdTe/CdS (core-shell) colloids and transparent films is presented. Based on the optical absorption, fluorescence, FTIR, micro-Raman, XPS, and XRD data collected on these nanostructures before and after thermal annealing, a mechanistic path of the core-shell formation and thermal break up is proposed and discussed. The processing of the CdTe/CdS nanostructures starts with 0.5 M tributylphosphine (TBP) stabilized CdS colloid in dichloromethane as a solvent. This yellow colloidal oil composed of 3-4 nm CdS clusters is reacted with liquid Bis(trimethylsilyl)telluride ( $\text{TMS}_2\text{Te}$ ) in the presence of excess insoluble  $\text{CdCl}_2$  salt. During this reaction, a rapid chalcogen atom exchange occurs within a few seconds which produces a new CdTe "core". The expelled sulfide reacts slowly with the  $\text{CdCl}_2$  salt to form new CdS clusters after several hours. Furthermore, this "CdS-formation-driven  $\text{CdCl}_2$  salt dissolution" activates a strong green-yellow fluorescence indicating a possible evolution of a "core-shell"-like CdTe/CdS structure. Thermal sintering of the subsequently prepared CdTe/CdS films between 100 and 200 degrees C completely suppresses the fluorescence and initiates CdTe cluster growth, reflecting a high thermal sensitivity of the "core-shell" interfaces. By further raising the sintering temperature to 300-400 degrees C, the TBP ligands are released and, consequently, bare CdS and CdTe nanocrystals, as well as ternary nanocrystalline CdTe/ $\text{S}_{1-x}$  phases, start forming. Above 400 degrees C, the CdTe part of the nanostructures sublimates, yielding (111)-oriented CdTe films. (32 References).

Serna, R., C. N. Afonso, et al. (2000). "Electrochromism of highly doped nanocrystalline  $\text{SnO}_2:\text{Sb}$ ." Journal of Physical Chemistry B **104**(40): 9388-95.

The electrochromic effect of layers of nanocrystalline tin dioxide highly doped with antimony has been investigated in detail, using chronoamperometry, cyclic voltammetry, potential-dependent IR spectroscopy and UV-vis spectroscopy. It is shown that two different mechanisms are responsible for the color changes observed upon negative polarization of porous  $\text{SnO}_2:\text{Sb}$  nanocrystal layers. Injection of electrons via the back contact increases the plasma absorption of the material, which has its maximum intensity in the near-infrared region. This increase is accompanied by a strong increase of the electrical conductivity of the layer, indicating that the grain boundary potentials of the nanoparticle layer decrease at negative potentials applied. In the presence of small ions such as  $\text{Li}^+$  or in protic electrolytes such as water, insertion of  $\text{Li}^+$  and  $\text{H}^+$  takes place, resulting in an additional color change mainly in the visible. The rate of the color changes is mainly determined by the conductivity of the substrate. Very fast coloration and decoloration is observed ( $t_{1/2} < 10$  ms) if the particle layer is deposited onto highly conductive substrates such as platinum. (37 References).

Serna, R., C. N. Afonso, et al. (2000). "Artificially nanostructured  $\text{Cu}:\text{Al}_2\text{O}_3$  films produced by pulsed laser deposition." Applied Physics a(5): 583-6.

The processes leading to the formation of  $\text{Cu}:\text{Al}_2\text{O}_3$  composite films on Si (001) with a well defined nanostructure by alternate pulsed laser deposition (a-PLD) in vacuum are investigated. Alternately amorphous  $\text{Al}_2\text{O}_3$  layers and Cu nanocrystals nucleated on the  $\text{Al}_2\text{O}_3$  surface are formed, according to the PLD sequence. The  $\text{Al}_2\text{O}_3$  deposited on the Cu nanocrystals fills in the space between them until they are completely buried, and subsequently, a continuous dense layer with a very flat surface (within 1 nm) is developed. The nucleation process of the nanocrystals and their resulting oblate ellipsoidal shape are discussed in terms of the role of the energetic species involved in the PLD process and the metal-oxide interface energy. (30 References).

Serna, R., J. Gonzalo, et al. (2001). "Structural studies of pulsed-laser deposited nanocomposite metal-oxide films." Journal of Microscopy **201**(2): 250-255.

Pulsed laser deposition in vacuum has been used to develop metal-oxide nanocomposite films with well controlled structural quality. Results for the copper-aluminium oxide ( $\text{Cu}:\text{Al}_2\text{O}_3$ ) system are used to illustrate the main morphological and structural features of these films. High resolution transmission electron microscopy (TEM) analysis shows that the films consist of Cu nanocrystals with average dimensions that can be controlled between 2 nm and 10 nm embedded in an amorphous  $\text{Al}_2\text{O}_3$  matrix. It is observed that the in-plane shape of the nanocrystals evolves from circular to elongated, and the number of nanocrystals per unit area decreases as their size increases. This evolution is explained in terms of nucleation at the substrate surface and coalescence during the later stages of growth. The thermal stability of the films has been studied by in situ TEM annealing and no transformation could be observed up to about 800 degrees C when partial crystallization of the  $\text{Al}_2\text{O}_3$  starts.

Sheehan, P. E. and C. M. Lieber (1996). "Nanotribology and nanofabrication of MoO<sub>3</sub> structures by atomic force microscopy." Science **272**(5265): 1158-61.

Atomic force microscopy was used to characterize the sliding of molybdenum oxide (MoO<sub>3</sub>) nanocrystals on single-crystal molybdenum disulfide (MoS<sub>2</sub>) surfaces. Highly anisotropic friction was observed whereby MoO<sub>3</sub> nanocrystals moved only along specific directions of the MoS<sub>2</sub> surface lattice. The energy per unit area to move the MoO<sub>3</sub> nanocrystals along their preferred sliding direction was an order of magnitude less than required to slide macroscopic MoS<sub>2</sub>-bearing contacts. This extreme friction anisotropy was exploited to fabricate multicomponent MoO<sub>3</sub> nanostructures. These reversibly interlocking structures could serve as the basis for devices such as mechanical logic gates.

Shen, Q., K. Abe, et al. (2000). "Photoluminescence and photoacoustic investigations of the photodarkening effect in CdS<sub>x</sub>Se<sub>1-x</sub> nanocrystal-doped glasses." Journal of Luminescence **87**(89): 444-6.

Photoluminescence (PL) and Photoacoustic (PA) techniques were applied to study photodarkening phenomena in CdS/sub  $x$ /Se/sub  $1-x$ / ( $x=0.26$ ) nanocrystal-doped glasses. We found that the PL intensities decreased greatly after undergoing darkening and the PA signal intensities became higher (~3-6%). The PA signal intensities exponentially decay below the fundamental absorption edges, of which the logarithmic slope decreases after undergoing photodarkening. This implies an increase of the effective number of the surface states of the CdS/sub  $x$ /Se/sub  $1-x$ / nanocrystals due to darkening. These results can be explained well by a model according to which nonradiative recombination centers were activated at the semiconductor nanocrystal and glass interfaces by the darkening. (14 References).

Shibata, M., Y. Nitta, et al. (2000). "Facets formation of pyramidal Si nanocrystals selectively grown on Si(001) windows in ultrathin SiO<sub>2</sub> films." Journal of Crystal Growth **220**(4): 449-56.

We have used in situ scanning tunneling microscopy (STM) to study the facet formation in the selective growth of pyramidal Si nanocrystals on Si(001) windows in ultrathin 0.3-nm-thick SiO<sub>2</sub>/sub  $2$ / films. Broad (001) surfaces developed as the top of the crystals, and {1, 1, (2n+1)} ( $n=1-6$ ) facets formed the sidewalls. As growth continued, the slope angle of sidewall facets increased, and {1, 1, 9} and {1, 1, (2m+1)} ( $0 < m < 4$ ) facets often came to coexist on the sidewalls. On well-oriented Si(001) surfaces, layer-by-layer growth in the 001 direction was dominant. On vicinal Si(001) surfaces, lateral step growth took place in the initial stage, and the layer-by-layer growth was suppressed until after a large (001) surface had formed as the top of the crystal. (17 References).

Shim, M. and P. Guyot-Sionnest (2000). "n-type colloidal semiconductor nanocrystals." Nature **407**(6807): 981-3.

Colloidal semiconductor nanocrystals combine the physical and chemical properties of molecules with the optoelectronic properties of semiconductors. Their colour is highly controllable, a direct consequence of quantum confinement on the electronic states. Such nanocrystals are a form of 'artificial atoms' (ref. 4) that may find applications in optoelectronic systems such as light-emitting diodes and photovoltaic cells, or as components of future nanoelectronic devices. The ability to control the electron occupation (especially in n-type or p-type nanocrystals) is important for tailoring the electrical and optical properties, and should lead to a wider range of practical devices. But conventional doping by introducing impurity atoms has been unsuccessful so far: impurities tend to be expelled from the small crystalline cores (as observed for magnetic impurities), and thermal ionization of the impurities (which provides free carriers) is hindered by strong confinement. Here we report the fabrication of n-type nanocrystals using an electron transfer approach commonly employed in the field of conducting organic polymers. We find that semiconductor nanocrystals prepared as colloids can be made n-type, with electrons in quantum confined states.

Shim, M. and P. Guyot-Sionnest (2000). "Electronic states and optical properties of silicon nanocrystals terminated by dimers." Solid State Communications **116**(12): 655-9.

An electronic state calculation for Si nanocrystals terminated by Si-Si dimers is reported by using the extended Huckel-type nonorthogonal tight-binding method. It is shown that dimer-related surface states appear in the range up to 1 eV below the conduction band edge in all the Si nanocrystals studied, in good agreement with experimentally observed electron trap states in porous Si, and that these surface states in the dimer configuration have stronger optical coupling with the valence band edge in Si nanocrystals than the conduction band edge in the dihydride-terminated configuration, explaining a significant part of the mechanisms governing the luminescence properties of porous Si. (33 References).

Singh, D., R. Houriet, et al. (2000). "Influence of LiMn<sub>2</sub>O<sub>4</sub> film and particle morphology on electrochemical properties of Li ion rechargeable batteries." Lithium Batteries. Proceedings of the International Symposium **99**(25): 371-8.

The pulsed laser deposition (PLD) and the laser spark atomization (LSA) techniques were used to deposit LiMn/sub  $2$ /O/sub  $4$ / films. The films grown by PLD were thin (<0.2  $\mu$ m), highly crystalline and textured along either (111) or (001) direction depending on the substrate type. Films grown by LSA were much thicker (>1  $\mu$ m) and exhibited a porous structure consisting of a mixture of randomly oriented LiMn/sub  $2$ /O/sub  $4$ / nanocrystals

embedded in an amorphous matrix. Electrochemical measurements obtained in a half-cell configuration with lithium metal as anode and reference electrode and the grown  $\text{LiMn}_2\text{O}_4$  films as cathode indicated that differences in film structure and particle morphology have a significant impact upon electrochemical kinetics of Li intercalation acid de-intercalation. The films grown by PLD exhibited good electrochemical characteristics such as high rate capability, good Coulombic efficiency and rechargeability up to 400 cycles. However, the LSA deposited films exhibited rather poor electrochemical kinetics. (15 References).

Suhua, W., Y. Shihe, et al. (2000). "Poly(N-vinylcarbazole) (PVK) photoconductivity enhancement induced by doping with CdS nanocrystals through chemical hybridization." Journal of Physical Chemistry B **104**(50): 11853-8.

We have functionalized poly(N-vinyl carbazole) (PVK) by controlled sulfonation. CdS nanocrystals of 3-20 nm across were synthesized in the sulfonated PVK matrix with the CdS molar fraction of ~1-18%. The CdS nanoparticle size increased with the molar fraction of CdS. At high CdS molar fractions, the CdS nanocrystals exist in both cubic and hexagonal phases. Photoluminescence efficiency of PVK decreases when the molar fraction of CdS increases due to quenching through interfacial charge transfer. Photoluminescence attributable to the CdS nanocrystals can be observed only at low molar fractions of CdS. Significant enhancement in photoconductivity induced by the chemical doping of CdS in PVK has also been demonstrated. (20 References).

Suk-Ho, C. (2000). "Bias- and photo-induced charging effects in  $\text{SiO}_2$  films containing Si nanocrystals." Journal of the Korean Physical Society **37**(4): 461-5.

Bias- and photo-induced charging effects are reported for metal-insulator-semiconductor (MIS) structures containing nanocrystals produced by ion-implantation and annealing. UV illumination or constant voltage stress is shown to induce reversible shifts in the current-voltage (I-V) characteristics in a similar manner, and the shape of the shifted I-V curves almost does not change with time. The phenomenon of negative photoconductivity observed under forward bias persists even after a 60 min illumination. The current-voltage (C-V) curves, as well as the I-V curves, are reversibly shifted by a short-time illumination under a positive or a negative bias. No such behavior is observed in structures that have not been ion-implanted. These and other effects are explained by nanocrystal charging and charge movement in the insulator layer of the MIS structures. (22 References).

Sun, P., Y. Wang, et al. (2000). "Optical properties of  $\text{Ce}^{3+}$  in self-assembled strontium chloro(hydroxy)apatite nanocrystals." Journal of Physical Chemistry B **104**(35): 8351-60.

Strontium chloroapatite nanocrystals (nc) of size in the range 10-100 nms have been prepared by an aqueous colloidal method. In this preparation, hydroxyl ( $\text{OH}^-$ ) ion contamination having profound dependence on the preparative conditions (in particular pH) could not be avoided. The hydroxyapatite phase (at pH=8) resulting from this contamination seems to exhibit some self-assembly properties that may be electrostatic in nature. Optical data (based on UV-visible and fluorescence studies) show that the ground state of  $\text{Ce}^{3+}$  as a dopant in these nanocrystalline apatites undergoes considerable modification arising from cross-relaxation between the  $\text{Ce}^{3+}$  ground state and hole states of the host matrix created near valence band edge. (25 References).

Sun, L., X. Fu, et al. (2000). "Paramagnetism and conductivity in nanostructured Bi-Sr-Ca-Cu-O." Superconductor Science and Technology **13**(7): 964-7.

On nanocrystalline materials, which were grown by an appropriate annealing of quasi-amorphous  $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_{8+\delta}$  / the static magnetic susceptibility  $\chi$  and electrical conductivity  $\sigma$  have been measured between 1.8 and 300 K. Up to grain sizes of  $d_c=50$  nm, the crystalline phase displays the  $\text{Bi}_2\text{Sr}_2\text{CuO}_{6+\delta}$  / ( $\text{Bi}2201$ ) structure. Upon increasing the size of the  $\text{Bi}2201$  nanocrystals, an onset of a variable-range-hopping type  $\sigma(T)$  is observed along with a rapid reduction of  $\chi$  which comprises contributions from both the Curie term and the temperature-independent background. We propose to associate these novel features with the depletion of the intergranular phase, containing rather large amounts of paramagnetic centres and of antiferromagnetically coupled pairs, at the expense of the formation of metallic  $2201$ -nanocrystals. (19 References).

Sun, L., J. Yao, et al. (2000). "Rare earth activated nanosized oxide phosphors: synthesis and optical properties." Journal of Luminescence **87**(89): 447-50.

$\text{Gd}_2\text{O}_3:\text{Eu}$  and  $(\text{Gd},\text{Y})_2\text{O}_3:\text{Eu}$  nanocrystals were prepared by the glycine assist combustion method. The as-prepared products are porous networks from the HTEM and isolated nanoparticles can be observed after further annealing. From the luminescence spectra and XRD patterns, the prepared  $\text{Gd}_2\text{O}_3:\text{Eu}$  nanocrystals were found to be monoclinic. While  $\text{Y}^{3+}$  doped into the  $\text{Gd}_2\text{O}_3$  to form the complex host, the structure changed from monoclinic to cubic when  $\text{Y}^{3+}/\text{Gd}^{3+}$  is 0.3. More interesting, the luminescent intensity of the  $(\text{Gd},\text{Y})_2\text{O}_3:\text{Eu}$  nanocrystals is higher than that of pure  $\text{Y}_2\text{O}_3:\text{Eu}$  or  $\text{Gd}_2\text{O}_3:\text{Eu}$  system. Besides XRD pattern, the luminescence spectra, another powerful evidence in deducing the crystal structure, are used for analysis. (10 References).

Sun, P., Y. Wang, et al. (2000). "Quantum-size effect of semiconductor nanocrystals CdS<sub>0.1</sub>Se<sub>0.9</sub>." Journal of Beijing Normal University **36**(2): 184-7.

Semiconductor nanocrystals CdS/sub x/Se/sub 1-x/ embedded in silicate glass matrix are obtained with a two-step annealing method. The average size of CdS/sub x/Se/sub 1-x/ nanocrystals increases with increased heating time. From room-temperature optical absorption spectrum, a 0.089 eV high-energy shift of absorption edge of CdS/sub 0.1/Se/sub 0.9/ has been measured as the mean diameter decreases from 5.61 nm to 4.69 nm. The absorption edge shift of CdS/sub 0.1/Se/sub 0.9/ nanocrystals, compared with that of bulk, is calculated by means of the effective-mass approximation model. The calculation and experimental results are compared. (10 References).

Szucs, A., F. Berger, et al. (2000). "Elongated prolate ellipsoid CoPt nanocrystals embedded in graphite-like C magnetic thin films." Journal of Magnetism and Magnetic Materials **219**(3): 325-30.

In nanogranular CoPtC thin films, the CoPt nanocrystals embedded in graphite-like C were found to have an elongated prolate ellipsoid-like shape. The long axes of the ellipsoids were perpendicular to the film plane, that is, in the film-growth direction. The shape magnetic anisotropy resulting from the shape of the CoPt ellipsoids gave rise to a magnetization component out of the film plane. The easy axis of the magnetization remained as that of the film plane. (8 References).

Tae-Sik, Y., K. Jang-Yeon, et al. (2000). "Near edge X-ray absorption fine structure measurements (XANES) and extended X-ray absorption fine structure measurements (EXAFS) of the valence state and coordination of antimony in doped nanocrystalline SnO<sub>2</sub>." Journal of Chemical Physics **112**(9): 4296-304.

Colloids of nanocrystalline tin dioxide containing 9.1 at.% and 16.7 at.% antimony have been prepared by the coprecipitation method. High-resolution transmission electron microscopy (TEM) images show crystalline particles in the 2-6 nm size regime. X-ray powder diffraction patterns of nanocrystalline powders obtained by drying the colloids and heating to 100 degrees C indicate the same rutile lattice structure known from bulk SnO/sub 2/. On heating to 500 degrees C in air, the nanocrystalline powder shows a slight increase in particle size but especially a change in color from yellowish to bluish which is accompanied by the development of n-type conductivity. The coordination of antimony in the SnO/sub 2/ nanocrystallites has been investigated by extended X-ray absorption fine structure measurements (EXAFS) at the Sb K-edge at 5 K while its valence state was determined by near edge X-ray absorption fine structure measurements (XANES) at the Sb L/sub 1/ edge. The Sb higher neighbor shell distances in the doped material differ from the corresponding distances in Sb/sub 2/O/sub 3/ or Sb/sub 2/O/sub 5/ but are identical to those in tin dioxide, indicating that antimony is almost completely incorporated into the tin dioxide lattice despite the high doping level. XANES measurements reveal that a large fraction of Sb/sup III/ employed during the synthesis is already oxidized to Sb/sup V/ at low temperatures. On the basis of these observations, a two-step model for the formation of n-conductive Sb-doped SnO/sub 2/ nanocrystals is given and quantitatively discussed with respect to the data. (64 References).

Takagahara, T. (1993). "Electron-phonon interactions and excitonic dephasing in semiconductor nanocrystals." Physical Review Letters **71**(21): 3577-3580.

Takahashi, N., H. Ishikuro, et al. (2000). "Surface modification on time-resolved fluorescences of Fe<sub>2</sub>O<sub>3</sub> nanocrystals." Journal of Physics and Chemistry of Solids **61**(5): 757-64.

The time-resolved studies on the fluorescence properties of Fe/sub 2/O/sub 3/ nanoparticles prepared by forcing hydrolysis and microemulsion techniques were carried out for the first time. Two different systems of different sized nanocrystals were characterized. Specifically Fe/sub 2/O/sub 3/ 5, 10 and 20 nm particles in water and Fe/sub 2/O/sub 3/ 5, 10 nm particles in toluene demonstrated different fluorescence behavior. We discussed the observed phenomena in terms of surface related effects, attributing the crucial role in optical time response to the surface polarization in these systems. At the same time we clarify some controversial conclusions made in other related studies. (22 References).

Takeoka, S., M. Fujii, et al. (2000). "Size-dependent photoluminescence from surface-oxidized Si nanocrystals in a weak confinement regime." Physical Review B Condensed Matter **62**(24): 16820-5.

Photoluminescence (PL) from surface-oxidized Si nanocrystals (nc-Si) was studied as a function of the size. The size of nc-Si was comparable with or larger than the Bohr radius of free excitons in bulk Si crystal (5 nm). In contrast to smaller surface-oxidized nc-Si (typically as small as a few nanometers in diameter), these relatively large nc-Si exhibited PL properties with strong size dependence. A high-energy shift of the PL peak from the vicinity of the bulk band gap to the visible region was observed. This PL shift was accompanied by a shortening of the PL lifetime and an increase in the exchange splitting energy of excitons. These size dependences indicate that the PL originates from the recombination of excitons confined in nc-Si. The differences in the PL properties between H-terminated and surface-oxidized nc-Si are also discussed. (30 References).

Takeoka, S., K. Toshiyuki, et al. (2000). "Control of photoluminescence energy of Si nanocrystals by Ge doping." Journal

of Luminescence **87**(89): 350-2.

SiGe alloy nanocrystals (nc-Si/sub 1-x/Ge/sub x/) as small as 4-5 nm in diameter were prepared and their photoluminescence (PL) properties were studied as a function of the Ge content. The growth of nc-Si/sub 1-x/Ge/sub x/ in SiO/sub 2/ matrices was confirmed by high-resolution transmission electron microscopy, electron diffraction and Raman spectroscopy. The PL spectra of nc-Si/sub 1-x/Ge/sub x/ were found to be sensitive to the Ge content. For the sample without Ge doping, a PL peak was observed at around 1.45 eV; the peak was assigned to the radiative recombination of electron-hole pairs confined in Si nanocrystals. As the Ge content increased, the PL peak shifted to lower energies although the average diameter of nc-Si/sub 1-x/Ge/sub x/ was almost the same for all the samples. This result indicates that the Ge doping is an effective method to control the band gap energy of Si nanocrystals. (12 References).

Takeoka, S., K. Toshiakiyo, et al. (2000). "Photoluminescence from Si<sub>1-x</sub>Ge<sub>x</sub> alloy nanocrystals." Physical Review B Condensed Matter **61**(23): 15988-92.

Photoluminescence (PL) from Si/sub 1-x/Ge/sub x/ alloy nanocrystals (nc-Si/sub 1-x/Ge/sub x/) as small as 4-5 nm in diameter was studied as a function of the Ge content. The nc-Si/sub 1-x/Ge/sub x/ samples were fabricated by the cosputtering of Si, Ge, and SiO/sub 2/ and postannealing at 1100 degrees C. High-resolution transmission electron microscopy, electron diffraction, and Raman spectroscopy clearly showed the growth of spherical Si/sub 1-x/Ge/sub x/ nanocrystals in SiO/sub 2/ matrices. The PL spectra of nc-Si/sub 1-x/Ge/sub x/ were found to be very sensitive to the Ge content. A low-energy shift of the PL peak from the widened band gap of Si nanocrystals to that of Ge nanocrystals with increasing Ge content was clearly observed. (29 References).

Taketomi, S., C. M. Sorensen, et al. (2000). "Preparation of yttrium-iron-garnet nanocrystals dispersed in nanosize-pore glass." Journal of Magnetism and Magnetic Materials **222**: 1-2.

Amorphous yttrium-iron-garnet (YIG) nanoparticles were dispersed in kerosene solvent and these colloids were introduced into the nanosize pores of controlled pore glass (CPG). After heat treatment, a YIG nanocrystal-dispersed glass was obtained and observed by electron microscopy. The compounds prepared with different pore size CPG under different heat treatment conditions were identified by X-ray diffraction. For samples with a 292-nm-pore-size CPG matrix which were calcined for 2h, only YIG was observed up to a 800 degrees C calcination temperature. However, at a heat treatment of 2h at 900 degrees C, the YIG particles decomposed and many kinds of iron and yttrium silicate compounds were formed. (33 References).

Taketomi, S., Z. R. Dai, et al. (2000). "Correlated structural and optical investigation of terbium-doped zinc oxide nanocrystals." Physics Letters A **271**: 1-2.

Tb<sup>3+</sup>-doped zinc oxide nanocrystals with a hexagonal wurzite structure were successfully prepared by reaction between Zn-O-Tb precursors and LiOH in ethanol. Good incorporation of Tb<sup>3+</sup> in ZnO nanocrystals is proved by XRD, FTIR, PL and PLE measurements. The presence of acetate complexes to zinc atoms on particle surfaces is disclosed by FTIR results. Emission from both Tb<sup>3+</sup> ions and surface states in ZnO matrix, as well as their correlation were observed. The luminescence mechanism is discussed. (19 References).

Taleb, A., F. Silly, et al. (2000). "S-layer proteins as basic building blocks in a biomolecular construction kit. Electron transport properties of nanocrystals. Isolated and supra-crystalline phases." Nanotechnology **11**(2): 100-7.

Crystalline bacterial cell surface layer (S-layer) proteins have been optimized during billions of years of biological evolution as constituent elements of one of the simplest self-assembly systems. Isolated S-layer proteins possess the intrinsic property of being able to recrystallize into two-dimensional arrays at a broad spectrum of surfaces (e.g. Silicon) and interfaces (e.g. Air-water interface or planar lipid films). The well-defined arrangement of functional groups on S-layer lattices allows the binding of molecules and particles in defined regular arrays. S-layers recrystallized on solid supports can be patterned in the submicrometre range using standard optical lithography. S-layers also represent templates for the formation of inorganic nanocrystal superlattices (e.g. CdS, Au, Ni, Pt, or Pd) as required for molecular electronics and nonlinear optics. (56 References).

Silver nanocrystals (NCs) deposited on an Au (111) substrate have been investigated using scanning tunneling microscopy. The electron transport properties are presented for the particles as isolated NCs, in self-assembled 2D and 3D superlattices. The electronic behavior is found to vary markedly, the monolayer showing both metallic and Coulomb blockade contributions, while NCs in fcc superlattices show ohmic behavior. (29 References).

Tamulaitis, G., V. Gulbinas, et al. (2000). "Optical nonlinearities of glass doped with PbS nanocrystals." Journal of Applied Physics **88**(1): 178-82.

Nonlinear absorption of glass doped with PbS nanocrystals is studied and application of this composite material as a saturable absorber for mode locking in lasers is discussed. By using time resolved absorption pump-probe investigation, bleaching due to filling of discrete states caused by quantum confinement in the nanocrystals as well as induced absorption are revealed and characterized. The origin of the induced absorption is discussed. Kinetics of the transient absorption is studied. Two components observed in the decay of the nonlinearities are observed and interpreted in terms of the carrier trapping. (25 References).

Tanaka, M., J. Qi, et al. (2000). "Comparison of energy levels of  $Mn^{2+}$  in nanosized- and bulk-ZnS crystals." Journal of Luminescence **87**(89): 472-4.

The 3d/sup 5/ multiplet level structure of the manganese ion is determined for two ZnS:Mn/sup 2+/ nanoparticle samples, whose average crystallite sizes are different, by measuring the photoluminescence excitation spectra in the ultraviolet- and visible-regions. The peak positions of the spectra of both samples are found to be almost the same as those observed for the bulk crystal, showing that the multiplet energies of Mn/sup 2+/ are almost independent of the ZnS host crystal size. This result suggests that the degree of the mixing between the s-p state of ZnS and the 3d orbitals of Mn/sup 2+/ does not change significantly with the reduction in the host crystallite diameter down to a few nanometers. (10 References).

Tanaka, M., J. Qi, et al. (2000). "Optical properties of undoped and  $Mn^{2+}$ -doped CdS nanocrystals in polymer." Journal of Crystal Growth **214**(215): 410-14.

We prepare a polyvinyl alcohol film containing undoped and Mn/sup 2+/doped CdS nanocrystals by a chemical method, and investigate the photoluminescence properties. The luminescence of Mn/sup 2+/ of this sample shows long decay times of about 1.1 and 0.2 ms, unlike the previous report on ZnS:Mn/sup 2+/ nanocrystals. Under the interband excitation, the temperature quenching of the Mn/sup 2+/ luminescence is found to be remarkably weak in comparison with the bulk crystals of CdS:Mn/sup 2+/. Probable causes of this difference are discussed in terms of the electron-hole pair (or exciton)-phonon interaction and the thermally induced dissociation of the electron-hole pair. Further, we measure site-selective luminescence spectra and discuss the origin of the green luminescence of the undoped CdS nanocrystals. (13 References).

Tanaka, M. and Y. Masumoto (2000). "XPS and HRTEM characterization of cobalt-nickel silicide thin films." Applied Surface Science **161**: 1-2.

We studied by X-ray photoelectron spectroscopy (XPS) and high-resolution transmission electron microscopy (HRTEM) films of Co-Ni/p-Si deposited by PLD on Si(100) substrates. They were thermally treated in vacuum to promote silicide formation. By means of XPS in-depth profiles, it was observed that the deposited metal film contains more Co than Ni. The Co and Ni2p transitions present shifts characteristic of silicide at respective ranges of 778.3-778.6 and 853.2-853.6 eV, while the Si2p transition appears at 99.2-99.5 eV, as determined by XPS. By means of HRTEM, nanocrystalline regions belonging to CoSi/sub 2/, Ni/sub 2/Si and NiSi/sub 2/ structures were identified. Some grains of CoSi/sub 2/, are large in size, more than 20 nm in diameter, while Ni/sub 2/Si and NiSi/sub 2/ nanocrystals are of the order of 10 nm, There are several regions where no crystalline ordering seems to be apparent. The SiO/sub 2/ layer acted as an effective diffusion barrier suppressing mobility of metal into the Si(100) substrate. The observed tendencies of the Co and Ni concentrations as a function of depth agree with a model of CoSi and NiSi structure separation and subsequent formation of CoSi/sub 2/ and NiSi/sub 2/. (53 References).

Tanaka, M., S. Sawai, et al. (2000). "Luminescence properties of ZnS phosphor nanocrystals prepared by the laser-induced gas-evaporation method." Journal of Applied Physics **87**(12): 8535-40.

Nanocrystalline particles of ZnS:(Ag, Al) semiconductor phosphor, whose sizes are mostly 3-5 nm in diameter, are prepared by the gas-evaporation method with cw CO/sub 2/ laser heating. The Raman scattering spectrum as well as the transmission electron microscope observation demonstrates that the crystallization of the nanoparticles was caused successfully through the gas-phase condensation. Under irradiation of ultraviolet light, the nanoparticles exhibit blue luminescence, as in the case of the starting material of ZnS:(Ag, Al) bulk powder. The peak of the luminescence spectrum of the nanoparticles shifts to lower energy with increasing delay time and also with decreasing excitation intensity, showing that the luminescence originates from the donor-acceptor pair recombination. However, it is concluded that the luminescence of the nanoparticles is not ascribed to the blue Ag luminescence mechanism responsible for the luminescence of the bulk powder, by taking into account the spatial confinement of an electron trapped at the donor and a hole at the acceptor. It is argued that the luminescence mechanism of the nanoparticles is the so called self-activated luminescence, which involves zinc vacancies. (27 References).

Tang, X., X. Baie, et al. (2000). "Self-aligned silicon-on-insulator nano flash memory device." Solid State Electronics **44**(12): 2259-64.

This paper reports on the fabrication of a silicon-on-insulator nano flash memory device based on the differential oxidation rate of silicon resulting from gradients in the arsenic doping concentration. The key processes involved are the formation of the desired arsenic doping profile, electron beam lithography and wet oxidation. The resulting device is a triangular-channel MOSFET with a nanocrystal floating gate embedded in the gate oxide. The length, width and height of the nanocrystal are 10, 10 and 20 nm, respectively. As long as the control gate voltage does not exceed +or-2 V, the device behaves like a thin and narrow P-channel MOSFET. When a voltage of -5 or +5 V is applied to the control gate at room temperature, holes are injected into the floating gate or removed from it, respectively. This effect induces a persistent shift of the threshold voltage of the device, which acts as a miniature

EEPROM. (8 References).

Thomas, P. J., G. U. Kulkarni, et al. (2000). "Effect of size on the Coulomb staircase phenomenon in metal nanocrystals." Chemical Physics Letters **321**: 1-2.

The Coulomb staircase in polymer-covered Pd and Au nanocrystals of varying diameters in the 1.7-6.4 nm has been investigated by employing tunneling conductance measurements. Charging up to several electrons is observed at room temperature in the I-V data. Small nanocrystals show charging steps exceeding 200 mV while the larger ones exhibit smaller steps. Significantly, the charging energies follow a scaling law of the form,  $U=A+B/d$ , where  $d$  is the diameter of the nanocrystal. Furthermore, the line widths in the derivative spectra also vary inversely with the diameter. (20 References).

Tolbert, S. H., A. B. Herhold, et al. (1994). "Comparison of quantum confinement effects on the electronic absorption spectra of direct and indirect gap semiconductor nanocrystals." Physical Review Letters **73**(24): 3266-3269.

Tolbert, S. H., A. B. Herhold, et al. (1996). "Pressure-induced structural transformations in Si nanocrystals: Surface and shape effects." Physical Review Letters **76**(23): 4384-4387.

Tong, W., Z. Yang, et al. (1998). "Studies on diffusion maximum in x-ray diffraction patterns of plasma-sprayed hydroxyapatite coatings." Journal of Biomedical Materials Research **40**(3): 407-13.

Study of an amorphous phase in plasma-sprayed hydroxyapatite (HA) coatings is important owing to its unique characteristics and nonnegligible amount of the amorphous phase compared to crystalline HA. However, little is known about the component parts of an amorphous phase. It is known that amorphous phase usually appears as the diffusion maximum (Dmax) in X-ray diffraction (XRD) patterns. Analyzing Dmax, including the position (Pmax) and area of Dmax, we can indicate the component parts of an amorphous phase and their transitions. In this study, the variation of Dmax in XRD patterns of the coatings during plasma spraying, in postheating, and in dissolving in vitro was studied with the aid of XRD. It was found that component parts of the amorphous phase in the coating varied with increasing thickness, consisting of two part represented by Dmax1, located between 29.4 and 29.8 degrees (2 theta), and Dmax2, located between 31.0 and 31.4 degrees (2 theta). It was concluded that Dmax3, located between 32.0 and 32.4 degrees (2 theta), should be referred to as nanocrystals of HA. In addition, the particle size of the starting powder may affect the component parts of the amorphous phase in the coating in addition to thickness. With vacuum heating (650 degrees C) and water vapor treatment at a low temperature (125 degrees C) in a saturated vaporic atmosphere, transition of the amorphous components was not as efficient as that at 490 degrees C with water vapor. The reason might be that the amorphous-to-crystalline HA conversion is dependent on both temperature and water vapor pressure. It was found that amorphous components were transformed completely into crystalline HA after heating at 490 degrees C with a partial water vapor pressure of 0.01 MPa for 2 h. It was concluded that the unstable amorphous components (Dmax1, Dmax2) converted into more stable nanocrystals of HA (Dmax3). Degradation in vitro showed that Dmax3 was more stable than Dmax1 and Dmax2. It was concluded that nucleation of apatite in vitro should be attributed to nanocrystals of HA (Dmax3) except for the amorphous components. It is recommended that the optimal phasic contents of the plasma-sprayed HA coating be mainly composed of crystalline HA and nanocrystals of HA (Dmax3) in terms of the stability and biocompatibility of the coating.

Trindade, T., M. C. Neves, et al. (2000). "Visible up-conversion luminescence in  $\text{Er}^{3+}:\text{BaTiO}_3$  nanocrystals." Optical Materials **15**(1): 47-50.

Visible emissions at 548, 528 and 660 nm have been observed from the sol-gel derived nanocrystalline  $\text{Er}^{3+}:\text{BaTiO}_3$  powders under infrared excitations at both 980 and 810 nm. Combined with the energy level structure of  $\text{Er}^{3+}$  and the decay kinetics of the green emissions, the up-conversion mechanism has been analyzed and explained. The bright green emission at 548 nm has been attributed to the ground state-directed transition from  $^4\text{S}_{3/2}$ , which is populated through excited state absorption (ESA) for 810 nm excitation, and through both ESA and energy transfer (ET) processes for 980 nm excitation. (14 References).

Trojanek, F., R. Cingolani, et al. (2000). "Tailoring of nanocrystal sizes in CdSe films prepared by chemical deposition." Journal of Crystal Growth **209**(4): 695-700.

We report on the control of nanocrystal sizes in nanocrystalline films of CdSe prepared by chemical solution deposition. We studied the effect of growth duration, of the light illumination during the growth, and of subsequent heat treatment of the films. Nanocrystals with radii from 1.9 to 10 nm were prepared and characterized by transmission electron microscopy, X-ray diffraction, and optical photoluminescence and absorption spectroscopy. We have observed the cubic and hexagonal structure for small and large nanocrystals, respectively. We interpret the trap-related photoluminescence in nanocrystals in terms of recombination of a deeply trapped hole with an electron in an interior state or in a shallow trap. (13 References).

Tsuruta, K., H. Totsuji, et al. (2000). "Tight-binding molecular dynamics of ceramic nanocrystals using PC-based parallel

machines." Nanophase and Nanocomposite Materials III. Symposium **581**: 673-8.

The evolution of atomic and electronic structures of silicon-carbide (SiC) nanocrystals during sintering is investigated by a tight-binding molecular dynamics (TBMD) method. An O(N) algorithm (the Fermi-operator expansion method) is employed for calculating electronic contributions in the energy and forces. Simulations are performed on our eight-node parallel PC cluster. In a sintering simulation of aligned (no tilt or twist) SiC nanocrystals at T=1000 K, we find that a neck is formed promptly without formation of defects. Analyses of local electronic density-of-states (DOS) and effective charges reveal that unsaturated bonds exist only in grain surfaces accompanying the gap states. In the case of tilted (<122>) nanocrystals, surface structures formed before sintering affect significantly the grain-boundary formation. (8 References).

Tsybeskov, L. and D. J. Lockwood (2000). "Quantum confinement in nanocrystalline silicon superlattices." Asian Journal of Physics **9**(3): 745-57.

The effect of quantum confinement in nanocrystalline silicon superlattices composed of Si nanocrystals nearly monodispersed in size vertically separated by SiO<sub>2</sub>/ layers is discussed. A comprehensive structural, optical, and electrical characterization of this system indicates flat and atomically abrupt Si/SiO<sub>2</sub>/ interfaces and a low defect density. We present a convincing demonstration of quantization in dispersion of acoustic phonons and of electron-hole pairs. This novel fabrication technique, with angstrom accuracy, is very promising for nanoscale electronic and optoelectronic device manufacturing. (26 References).

Tsybeskov, L., G. F. Grom, et al. (2000). "Optical and microstructural characterization of nanocrystalline silicon superlattices." Optical Microstructural Characterization of Semiconductors. Symposium **588**: 173-85.

We present optical and microstructural characterization of nanocrystalline silicon superlattices (nc-Si SLs). Our samples have better than 5% Si nanocrystal size distribution and a long range order along the direction of growth provided by periodically alternating layers of Si nanocrystals and SiO<sub>2</sub>/ . Flat and chemically abrupt nc-Si/SiO<sub>2</sub>/ interfaces with a roughness of <4 Å are confirmed by transmission electron microscopy (TEM), Auger elemental microanalysis, X-ray small angle reflection, and low frequency Raman scattering. Photoluminescence (PL) in our structures has been studied in details including time-resolved and steady-state PL spectroscopy in a wide range of temperature, excitation wavelength and power. Resonantly excited PL spectra show phonon steps proving that the PL originates in Si nanocrystals. Electrical measurements show the signature of phonon-assisted tunneling proving the low defect density nc-Si/SiO<sub>2</sub>/ interface. (12 References).

Tsybeskov, L., G. F. Grom, et al. (2000). "Nanocrystalline silicon superlattices: building blocks for quantum devices." Materials Science and Engineering B Solid State Materials for Advanced Technology **70**(19): 303-8.

A nanocrystalline silicon superlattice (nc-Si SLs) is a structure consisting of Si nanocrystal layers separated by nanometer-thick SiO<sub>2</sub>/ . A long range order in the nc-Si SL is obtained along the direction of growth by periodically alternating layers of Si nanocrystals and SiO<sub>2</sub>/ . A number of characterization techniques such as transmission electron microscopy (TEM) and atomic force microscopy (AFM), Auger elemental microanalysis. X-ray diffraction and X-ray small angle reflection have proved that the nc-Si SL exhibits a very narrow nanocrystal size distribution (less than 5% in average) and very abrupt and flat nc-Si/SiO<sub>2</sub>/ interfaces with a roughness of <4 Å. Conductance tunnel spectroscopy and capacitance-voltage (C-V) measurements showed that the nc-Si SL is a nearly defect free structure. The results hold promise for nc-Si SL quantum device applications. (11 References).

Vacha, M., S. Takei, et al. (2001). "Sub-wavelength region spectroscopy and local morphology of individual mesoscopic quantum systems." Journal of Microscopy **202**(Pt 2): 391-4.

Results of reflection microscopy and local reflection spectroscopy of J-aggregates of two pseudoisocyanine dyes in a thin film polymer matrix are reported. The individual J-aggregates assemble into fibre-like shapes of large structural heterogeneity. Reflectance spectra obtained at different samples, different locations on one sample and even at different positions of the same aggregate fibre reveal a wide distribution of optical properties. The shapes and absolute reflectivities of the spectra are suggested to originate from varying strengths of exciton-photon interaction and from the effect of finite thickness of the aggregate fibres. Polarization dependence measurements of local reflectivities provide orientations of the exciton transition dipole moments at 572 nm and 540 nm with respect to the orientation of the aggregate fibres. Furthermore, modified synthesis of capped semiconductor nanocrystals of CdSe is presented. The method yields high quality quantum dots suitable for microscopic imaging and spectroscopy.

Valenta, J., J. Dian, et al. (2000). "Temperature behaviour of optical properties of Si<sup>+</sup>-implanted SiO<sub>2</sub>." European Physical Journal D **8**(3): 395-8.

Silicon nanocrystals were prepared by Si<sup>+</sup>-ion implantation and subsequent annealing of SiO<sub>2</sub>/ films thermally grown on a c-Si wafer. Different implantation energies (20-150 keV) and doses (7\*10<sup>15</sup>/cm<sup>2</sup> - 2\*10<sup>17</sup>/cm<sup>2</sup>) were used in order to achieve flat implantation profiles (through the thickness of about 100 nm) with a peak concentration of Si atoms of 5, 7, 10 and 15 atomic%. The presence of Si nanocrystals was verified

by transmission electron microscopy. The samples exhibit strong visible/IR photoluminescence (PL) with decay time of the order of tens of  $\mu$ s at room temperature. The changes of PL in the range 70-300 K can be well explained by the exciton singlet-triplet splitting model. We show that all PL characteristics (efficiency, dynamics, temperature dependence, excitation spectra) of our Si/sup +/-implanted SiO/sub 2/ films bear close resemblance to those of a light-emitting porous Si and therefore we suppose similar PL origin in both materials. (9 References).

Vallat-Sauvain, E., U. Kroll, et al. (2000). "Formation and characteristics of silicon nanocrystals in plasma-enhanced chemical-vapor-deposited silicon-rich oxide." Journal of Applied Physics **87**(6): 2808-15.

The formation of nanosized Si crystals in dual-frequency plasma-enhanced chemical-vapor-deposited silicon oxides is identified in this study. As a higher SiH/sub 4/N/sub 2/O gas flow rate ratio is employed during the deposition process, the silicon-to-oxygen atomic ratio and the dangling bond density both increase. The resulting oxide films contain more Si-H bonds and less Si-O and Si-O-H bonds, as determined from the Fourier-transform infrared spectra. The main type of charge defects in these oxides change from .Si identical to O/sub 3/ bonds (E' centers) to .Si identical to Si/sub 3/ bonds, which eventually cluster together and precipitate out from the oxide network to form the Si nanocrystals. The size of these Si nanocrystals falls within the range of 30-50 nm, as observed by high-resolution transmission electron microscopy. The formation of these nanocrystals inside the silicon-rich oxides results in a lower film density, a tensile stress component, and a higher wet etching rate, even under the ion bombardment provided by the rf bias power during deposition. The underlying mechanisms for the formation of these Si nanocrystals from the silicon oxide will be proposed. (13 References).

Van Swygenhoven, H., D. Farkas, et al. (2000). "Grain-boundary structures in polycrystalline metals at the nanoscale." Physical Review B Condensed Matter **62**(2): 831-8.

We present a detailed analysis of grain-boundary structures in computer-generated Cu and Ni three-dimensional nanocrystalline samples. The study includes both totally random and textured microstructures with grain sizes in the range of 5-12 nm. A detailed direct visualization technique is used at the atomic scale for studying the grain-boundary structural features. The study focuses on determining the presence of regions in the boundary exhibiting order and structural units normally expected for high-angle boundaries. For low-angle boundaries we investigate the presence of dislocation networks accommodating the misfit between the grains. A significant degree of crystalline order is found for all the boundaries studied. The highest degree of structural order was identified for boundaries with misfits within about 10 degrees deviation from the perfect twin. These grain boundaries contain a repeated building structure consisting of structural units typical of a Sigma =3 symmetrical tilt twin boundary and highly disordered steps between those structural units. For all other types of misfit, we also observe some degree of structural coherence, and misfit accommodation occurs in a regular pattern. The cases studied include grain boundaries with a high-index common axis and show structural coherency that is independent of the grain size. Similar results are obtained for textured samples containing only low-angle grain boundaries, where regular dislocation arrays that are typical of larger grain materials are observed. These results provide evidence against the view of grain boundaries in nanocrystals as highly disordered, amorphous, or liquidlike interfaces. The results suggest that the grain-boundary structure in nanocrystalline materials is actually similar to that found in larger grain polycrystals. (43 References).

Vijayalakshmi, S., H. Grebel, et al. (2000). "Nonlinear optical response of Si nanostructures in a silica matrix." Journal of Applied Physics **88**(11): 6418-22.

We provide a systematic study on the nonlinear optical properties of silicon nanocrystals within a fused silica matrix. Nonlinear measurements at various wavelengths exhibited the role of three bands in the visible spectrum. Measurements at various laser pulse durations showed several time constants, which exhibited the role of quantum confined and surface states. (9 References).

Vinciguerra, V., G. Franzo, et al. (2000). "Quantum confinement and recombination dynamics in silicon nanocrystals embedded in Si/SiO<sub>2</sub> superlattices." Journal of Applied Physics **87**(11): 8165-73.

In this study the structural and optical properties of nanocrystalline Si/SiO/sub 2/ superlattices have been investigated and discussed. Ordered planar arrays of silicon nanocrystals (Si-nc) have been formed by thermal annealing of ten period amorphous Si/SiO/sub 2/ superlattices prepared by plasma enhanced chemical vapor deposition. Thermal processing of the superlattices results in well separated (by about 5 nm of SiO/sub 2/) nanocrystalline Si layers, when the annealing temperature does not exceed 1200 degrees C. The photoluminescence (PL) properties of these layers have been studied in details. The PL peaks wavelength has been found to depend on the laser pump power; this intriguing dependence, consisting in a marked blueshift for increasing power, has been explained in terms of the longer lifetime characterizing larger Si-nc. It is also observed that these decay lifetimes exhibit a single exponential behavior over more than two orders of magnitude, in clear contrast with the typical, nonsingle exponential trends observed for Si-nc uniformly dispersed inside an insulating matrix. We attributed this peculiar behavior to the lack of interaction among nanocrystals, due to their large reciprocal distance. In agreement with the carrier quantum confinement theory, we have found that the wavelength of the PL peak can be properly tuned by changing the annealing temperature and/or the thickness of

the Si layers of the superlattices, and, in turn, the Si-nc mean size. Moreover, the observed lifetimes remain very long (about 0.3 ms) even at room temperature, revealing the absence of relevant nonradiative decay processes in these samples. Furthermore, we have used the experimental PL intensities and decay times to evaluate the radiative rate as a function of the temperature; the obtained data are in good agreement with a model proposed by Calcott in the case of porous silicon. All of these data are presented, discussed, and explained within a consistent picture. (25 References).

Vogelsang, H., O. Husberg, et al. (2000). "Optical properties of gamma -AgI nanocrystals synthesized in reverse micelles." Journal of Luminescence **86**(2): 87-94.

AgI nanocrystals were synthesized in reverse micelles. From X-ray diffraction patterns the nanocrystals were found to exhibit predominantly a zincblende structure. The exciton absorption was blueshifted and inhomogeneously broadened due to spatial confinement and the particle size distribution. "Free" exciton luminescence was weak. Instead, in addition to donor-acceptor recombination, a strong LO multiphonon Raman scattering was observed under resonant excitation in the exciton absorption. An LO phonon energy of 15.4 meV was derived and the incoming and outgoing resonances with the exciton were investigated. All results were consistent with the case of weak exciton confinement. (94 References).

von Helden, G., A. G. Tielens, et al. (2000). "Titanium carbide nanocrystals in circumstellar environments." Science **288**(5464): 313-6.

Meteorites contain micrometer-sized graphite grains with embedded titanium carbide grains. Although isotopic analysis identifies asymptotic giant branch stars as the birth sites of these grains, there is no direct observational identification of these grains in astronomical sources. We report that infrared wavelength spectra of gas-phase titanium carbide nanocrystals derived in the laboratory show a prominent feature at a wavelength of 20.1 micrometers, which compares well to a similar feature in observed spectra of postasymptotic giant branch stars. It is concluded that titanium carbide forms during a short (approximately 100 years) phase of catastrophic mass loss (>0.001 solar masses per year) in dying, low-mass stars.

Wang, Z. L. (2000). "Transmission electron microscopy of shape-controlled nanocrystals and their assemblies." Journal of Physical Chemistry B **104**(6): 1153-75.

The physical and chemical properties of nanophase materials rely on their crystal and surface structures. Transmission electron microscopy (TEM) is a powerful and unique technique for structure characterization. The most important application of TEM is the atomic-resolution real space imaging of nanoparticles. This article introduces the fundamentals of TEM and its applications in structural determination of shape-controlled nanocrystals and their assemblies. By forming a nanometer size electron probe, TEM is unique in identifying and quantifying the chemical and electronic structure of individual nanocrystals. Electron energy-loss spectroscopy analysis of the solid-state effects and mapping the valence states are even more attractive. In situ TEM is demonstrated for characterizing and measuring the thermodynamic, electric, and mechanical properties of individual nanostructures, from which the structure-property relationship can be registered with a specific nanoparticle/structure. (79 References).

Wang, H., S. P. Wong, et al. (2000). "Magnetic properties and structure evolution of amorphous Co-C nanocomposite films prepared by pulsed filtered vacuum arc deposition." Journal of Applied Physics **88**(8): 4919-21.

The magnetic properties and structure evolution of Co/<sub>x</sub>C/<sub>1-x</sub> (x=44, 65, 71 at.%) nanocomposite films prepared by pulsed filtered vacuum arc deposition were studied. The as-deposited films consist of amorphous Co clusters in a-C and are soft ferromagnets. The low coercivity in the amorphous films is due to the very low anisotropy of the amorphous Co clusters. After annealing in vacuum at 350 degrees C for 1 h, the Co clusters crystallize and these films become magnetically harder. The magnetic hardening is attributed to the enhanced magnetic anisotropy of the nanocrystals. Their saturation magnetization reduces slightly. This is attributed to the reduction of the density of states at the Fermi level caused by the crystallization of the amorphous Co clusters. (15 References).

Wang, L. M., S. X. Wang, et al. (2000). "Thermal stability of low dimensional crystals." Materials Science and Engineering A Structural Materials Properties Microstructure and Processing(1): 139-43.

A model, free of any adjustable parameter, has been developed for the size-dependent melting temperature and melting entropy of nanocrystals. The model can be utilized to predict the thermal stability both for metallic and organic low dimensional materials. The results show that their melting thermodynamic functions are dependent on their size, dimension, and environment. The theoretical predictions in terms of the above model are fully consistent with experimental evidences and the results of molecular dynamics simulation. (27 References).

Wang, Z. L. and J. S. Yin (2000). "Irradiation-induced nanostructures." Materials Science and Engineering A Structural Materials Properties Microstructure and Processing(1): 72-80.

This paper summarizes the results of our studies on the irradiation-induced formation of nanostructures, where

the injected interstitials from the source of irradiation are not major components of the nanophase. This phenomena has been observed by in situ transmission electron microscopy (TEM) in a number of intermetallic compounds and ceramics during high-energy electron or ion irradiations when the ions completely penetrate through the specimen. Beginning with single crystals, electron or ion irradiation in a certain temperature range may result in nanostructures composed of amorphous domains and nanocrystals with either the original composition and crystal structure or new nanophases formed by decomposition of the target material. The phenomenon has also been observed in natural materials that have suffered irradiation from the decay of constituent radioactive elements and in nuclear reactor fuels that have been irradiated by fission neutrons and other fission products. The mechanisms involved in the process of this nanophase formation are discussed in terms of the evolution of displacement cascades, radiation-induced defect accumulation, radiation-induced segregation and phase decomposition, as well as the competition between irradiation-induced amorphization and recrystallization. (36 References).

Wang, H., S. P. Wong, et al. (2000). "Exciton-erbium interactions in Si nanocrystal-doped SiO<sub>2</sub>." Journal of Applied Physics **88**(4): 1992-8.

The presence of silicon nanocrystals in Er doped SiO<sub>2</sub> can enhance the effective Er optical absorption cross section by several orders of magnitude due to a strong coupling between quantum confined excitons and Er. This article studies the fundamental processes that determine the potential of Si nanocrystals as sensitizers for use in Er doped waveguide amplifiers or lasers. Silicon nanocrystals were formed in SiO<sub>2</sub> using Si ion implantation and thermal annealing. The nanocrystal-doped SiO<sub>2</sub> layer was implanted with different doses of Er, resulting in Er peak concentrations in the range 0.015-1.8 at.%. All samples show a broad nanocrystal-related luminescence spectrum centered around 800 nm and a sharp Er luminescence line at 1536 nm. By varying the Er concentration and measuring the nanocrystal and Er photoluminescence intensity, the nanocrystal excitation rate, the Er excitation and decay rate, and the Er saturation with pump power, we conclude that: (a) the maximum amount of Er that can be excited via exciton recombination in Si nanocrystals is 1-2 Er ions per nanocrystal, (b) the Er concentration limit can be explained by two different mechanisms occurring at high pump power, namely Auger de-excitation and pair-induced quenching, (c) the excitable Er ions are most likely located in an SiO<sub>2</sub>-like environment, and have a luminescence efficiency <18%, and (d) at a typical nanocrystal concentration of 10<sup>19</sup> cm<sup>-3</sup>, the maximum optical gain at 1.54 μm of an Er-doped waveguide amplifier based on Si nanocrystal-doped SiO<sub>2</sub> is ~0.6 dB/cm. (22 References).

Wang, Y. S., R. Z. Wang, et al. (2000). "Photoluminescence and Raman scattering of silicon nanocrystals prepared by silicon ion implantation into SiO<sub>2</sub> films." Journal of Applied Physics **88**(3): 1439-42.

Photoluminescence (PL) and Raman spectra of silicon nanocrystals prepared by Si ion implantation into SiO<sub>2</sub> layers on Si substrate have been measured at room temperature. Their dependence on annealing temperature was investigated in detail. The PL peaks observed in the as-implanted sample originate from the defects in SiO<sub>2</sub> layers caused by ion implantation. They actually disappear after thermal annealing at 800 degrees C. The PL peak from silicon nanocrystals was observed when thermal annealing temperatures are higher than 900 degrees C. The PL peak is redshifted to 1.7 eV and the intensity reaches maximum at the thermal annealing temperature of 1100 degrees C. The characterized Raman scattering peak of silicon nanocrystals was observed by using a right angle scattering configuration. The Raman signal related to the silicon nanocrystals appears only in the samples annealed at temperature above 900 degrees C. It further proves the formation of silicon nanocrystals in these samples. (17 References).

Wang, H., H. Yang, et al. (2000). "Crystallization of amorphous AlDy- and AlDyCo-alloys." Journal of Non Crystalline Solids **271**: 1-2.

Partially or fully amorphous Al<sub>89</sub>Dy<sub>11</sub>, Al<sub>84</sub>Dy<sub>11</sub>Co<sub>5</sub> and Al<sub>84</sub>Dy<sub>6</sub>Co<sub>10</sub> alloys were prepared by melt spinning. The amorphous to crystalline and subsequent transitions were studied with X-ray diffraction, electrical resistivity, thermal and microhardness measurements. The transformation kinetics were analysed in terms of the classical and the generalized Johnson-Mehl-Avrami-Kolmogorov models for nucleation and growth processes. In amorphous Al<sub>89</sub>Dy<sub>11</sub>, crystallization begins with alpha (fcc Al) formation closely followed by gamma (Al<sub>3</sub>Dy), which transforms to alpha (Al<sub>3</sub>Dy). Addition of Co increases the stability of the amorphous states. The first crystallization process in the ternary alloys is eutectic-like; nanocrystals are present in Al<sub>84</sub>Dy<sub>6</sub>Co<sub>10</sub>. Annealing in the region of structural relaxation retards subsequent crystallization. (16 References).

Wang, W., H. Isshiki, et al. (2000). "Site of the Er<sup>3+</sup> optical centers of the 1.54 μm room-temperature emission in Er-doped porous silicon and the excitation mechanism." Journal of Luminescence **87**(89): 319-22.

Sites of the Er<sup>3+</sup> luminescent centers in Er-doped porous silicon (PS:Er) formed by immersion are studied in order to make clear the cause of the strong room temperature luminescence at 1.54 μm due to the 4f intra-transition of Er<sup>3+</sup> ions. The luminescence spectra and the temperature quenching of the intensity and the fluorescence lifetime are compared between PS:Er samples formed by immersion in an ErCl<sub>3</sub>/alcohol

solution and Er-implanted PS, using the same PS hosts. PS:Er samples formed by immersion show a small temperature quenching in the intensity and the fluorescence lifetime, resulting in a strong luminescence at RT. On the other hand, PS:Er samples formed by Er ion implantation into PS shows almost the same strong temperature quenching as the Er-implanted crystalline Si. These results indicate that the sites of Er ions responsible for the strong RT 1.54  $\mu\text{m}$  luminescence in PS:Er formed by immersion is not inside Si nanocrystals but on the surface of Si nanocrystals. (12 References).

Wang, Z. L. and J. S. Yin (2000). "Self-assembly of shape-controlled nanocrystals and their in-situ thermodynamic properties." Materials Science and Engineering A Structural Materials Properties Microstructure and Processing **A286**(1): 39-47.

Size and shape selected nanocrystals behave like molecular matter that can be used as fundamental building blocks for constructing nanocrystal assembled superlattices. The nanocrystals form a new class of materials that have orders in both atomic and nanocrystal length-scales. The nanocrystals are passivated with organic molecules (called thiolates) that not only protect them from coalescence but act as the molecular bonds for forming the superlattice structure. The interparticle distance is adjustable, possibly resulting in tunable electric, optical and transport properties. This paper reviews our current progress in nanocrystal self-assembled materials and their thermodynamic properties probed by in-situ transmission electron microscopy (TEM). The studies mainly focused on size and shape-controlled nanocrystals to understand the role played by particle shape in determining their physical and chemical properties. Recent studies on photonic crystals and mesoporous materials such as silica and titania are also presented. (37 References).

Wang, C., M. Shim, et al. (2001). "Electrochromic nanocrystal quantum dots." Science **291**(5512): 2390-2. Incorporating nanocrystals into future electronic or optoelectronic devices will require a means of controlling charge-injection processes and an understanding of how the injected charges affect the properties of nanocrystals. We show that the optical properties of colloidal semiconductor nanocrystal quantum dots can be tuned by an electrochemical potential. The injection of electrons into the quantum-confined states of the nanocrystal leads to an electrochromic response, including a strong, size-tunable, midinfrared absorption corresponding to an intraband transition, a bleach of the visible interband exciton transitions, and a quench of the narrow band-edge photoluminescence.

Warren, P. J., M. Thuvander, et al. (2000). "Hole levels and exciton states in CdS nanocrystals." Physical Review B Condensed Matter **62**(19): 12613-16.

We have studied the hole levels and exciton states in CdS nanocrystals by using the hole effective-mass Hamiltonian for wurtzite structure. It is found that the optically passive P/sub x/ state will become the ground hole state for small CdS quantum dots of radius less than 69 AA. It suggests that the "dark exciton" would be more easily observed in the CdS quantum dots than that in CdSe quantum dots. The size dependence of the resonant Stokes shift is predicted for CdS quantum dots. Including the Coulomb interaction, exciton energies as functions of the dot radius are calculated and compared with experimental data. (20 References).

Watanabe, Y. and F. Maeda (2000). "Effect of strain on the chemical bonds in InAs nanocrystals self-organized on GaAs and Se-terminated GaAs surfaces." Applied Surface Science **162**(163): 625-9.

We employed surface sensitive photoelectron spectroscopy (PES) using synchrotron radiation to investigate the strain of both deposited InAs and GaAs substrates with and without Se-termination. The two distinct chemical components comprising Ga-As bonding and In-As bonding states in the As 3d spectrum are clearly observed for the first time, which indicates that the strain in both the deposited InAs and GaAs substrates can be separately evaluated using the core-level energy difference between the respective core-level chemical components. This difference between the chemical components of Ga 3d and As 3d levels for both two kinds of samples is found to be independent of InAs deposition time, and to be almost the same as that of a bulk GaAs, implying that no strain is generated in both types of GaAs substrates. On the other hand, in the case of the deposited InAs, this value increases with an increase in the layer thickness of InAs for the InAs/GaAs system and approaches to a bulk InAs value, whereas, there exists only a slight change for the InAs/Se/GaAs system at the very early stages of InAs growth and is almost the same as a bulk InAs value. These results suggest that the driving force for the formation of InAs nanocrystals in the InAs/GaAs system is the elastic strain, whereas, in the InAs/Se/GaAs system, a passivation-induced self-organizing mechanism is crucial. (14 References).

Watanabe, K., S. Takeoka, et al. (2000). "Photoluminescence decay dynamics of SiO<sub>2</sub> films containing Si nanocrystals and Er." Journal of Luminescence **87**(89): 426-8.

Photoluminescence decay dynamics of SiO<sub>2</sub> films containing Si nanocrystals (nc-Si) and Er was studied. On increasing the Er concentration, the 1.54  $\mu\text{m}$  PL due to the intra-4f shell transition of Er/sup 3+/ increased drastically, while the PL peak at 0.8  $\mu\text{m}$  due to the recombination of electron-hole pairs in nc-Si decreased and the lifetime became shorter. For the 1.54  $\mu\text{m}$  PL, PL delay was observed after the pulsed excitation of nc-Si host. The results clearly indicated that Er/sup 3+/ is excited by the energy transfer from nc-Si. From the observed

PL delay, the energy transfer rate from nc-Si to Er/sup 3+/ was estimated to be  $5 \times 10^5$  s/sup -1/. (7 References).

Watanabe, M., Y. Maeda, et al. (2000). "Epitaxial growth and ultraviolet photoluminescence of CaF<sub>2</sub>ZnO/CaF<sub>2</sub> heterostructures on Si(111)." Japanese Journal of Applied Physics **39**(6A).

The epitaxial growth of zinc oxide (ZnO) nanocrystals embedded in a single-crystalline CaF/sub 2/ layer on a Si(111) substrate has been demonstrated. Highly c-axis-oriented ZnO 4-10 nm thick was grown on a CaF/sub 2/(111) layer using radiofrequency (RF) sputtering followed by annealing in ultrahigh vacuum, resulting in the formation of epitaxial self-organized ZnO nanocrystals on CaF/sub 2//Si(111). It was found that CaF/sub 2/ can be grown epitaxially over ZnO/CaF/sub 3/ by molecular beam epitaxy (MBE), thus the CaF/sub 2//ZnO/CaF/sub 2/ heterostructure has been formed on a Si(111) substrate. Abrupt heterointerfaces between CaF/sub 2/ and ZnO were confirmed on a transmission electron microscope (TEM) cross section, and ultraviolet (UV) photoluminescence (PL) corresponding to the band-gap energy of ZnO was dominant in PL spectra observed at room temperature. (15 References).

Wei-Feng, Z., X. Qian, et al. (2000). "Microstructures and optical properties of strontium titanate nanocrystals prepared by a stearic-acid gel process." Modern Physics Letters B **14**(19): 709-16.

SrTiO/sub 3/ nanocrystals with grain sizes from 26 to 86 nm were prepared by stearic-acid gel method. The microstructures, lattice vibration and luminescence spectra were examined by X-ray diffraction, infrared, Raman and photoluminescence (PL) spectroscopies. Hydroxyl defects were clearly found by infrared spectroscopy in the SrTiO/sub 3/ nanocrystals. Raman measurement results showed that internal stress exists in the SrTiO/sub 3/ nanocrystals, which induces first-order Raman scattering processes. Strong visible PL near 2.62 eV was observed under 3.54 eV light excitation in small SrTiO/sub 3/ nanocrystals. Grain-size dependence of the PL spectrum is investigated and the origin for the PL is attributed to a charge transfer via intrinsic defects inside an oxygen octahedron. (29 References).

Wellner, A., P. D. Nellist, et al. (2000). "Fluorescence line narrowing study of Cr<sup>3+</sup> ions in cordierite glass nucleating MgAl<sub>2</sub>O<sub>4</sub> nanocrystals." Optical Materials **13**(4): 373-9.

The luminescence of Cr/sup 3+/ ions in cordierite glass nucleating MgAl/sub 2/O/sub 4/ nanocrystallites has been investigated. The time resolved fluorescence line narrowing measurements and the temperature dependence of the homogeneous line width show that most Cr/sup 3+/ ions are inside the nanocrystallites. Cr/sup 3+/ ions occupy non-equivalent crystal sites, due to the Mg/sup 2+/-Al/sup 3+/ inversion effect. The values of the homogeneous line width compare well with those of previous studies in crystals. No surface effect has been observed due to the large size of the crystals. (36 References).

Wen, Z., M. Zhao, et al. (2000). "The optical size-dependent properties of pyrazoline nanocrystals." Colloids and Surfaces A Physicochemical and Engineering Aspects **174**(3): 367-73.

Nanocrystals of 1-phenyl-3-(p-oxymethyl-styryl)-5-(p-oxymethyl-phenyl)-2-pyrazoline (PYB) with different sizes were prepared by the reprecipitation method. The aggregate formation of PYB nanocrystals was found to be J-aggregate, of which the wavelength of absorption peak was observed at about 430 nm. Further, we found that the PYB nanocrystals possess a special optical size-dependent property. As the nanocrystal size decreased, the molecular absorption peak of PYB nanocrystals was observed to shift to the high-energy side due to the size effect and at the same time, the J-aggregate absorption peak gradually vanished. (18 References).

Whaley, S. R., D. S. English, et al. (2000). "Selection of peptides with semiconductor binding specificity for directed nanocrystal assembly." Nature **405**(6787): 665-8.

In biological systems, organic molecules exert a remarkable level of control over the nucleation and mineral phase of inorganic materials such as calcium carbonate and silica, and over the assembly of crystallites and other nanoscale building blocks into complex structures required for biological function. This ability to direct the assembly of nanoscale components into controlled and sophisticated structures has motivated intense efforts to develop assembly methods that mimic or exploit the recognition capabilities and interactions found in biological systems. Of particular value would be methods that could be applied to materials with interesting electronic or optical properties, but natural evolution has not selected for interactions between biomolecules and such materials. However, peptides with limited selectivity for binding to metal surfaces and metal oxide surfaces have been successfully selected. Here we extend this approach and show that combinatorial phage-display libraries can be used to evolve peptides that bind to a range of semiconductor surfaces with high specificity, depending on the crystallographic orientation and composition of the structurally similar materials we have used. As electronic devices contain structurally related materials in close proximity, such peptides may find use for the controlled placement and assembly of a variety of practically important materials, thus broadening the scope for 'bottom-up' fabrication approaches.

Wickham, J. N., A. B. Herhold, et al. (2000). "Shape change as an indicator of mechanism in the high-pressure structural

transformations of CdSe nanocrystals." *Physical Review Letters* **84**(5): 923-6.

X-ray diffraction was used to monitor the structure of 45 Å diameter CdSe nanocrystals as they transformed repeatedly between fourfold and sixfold coordinated crystal structures. Simulations of the diffraction patterns reveal that a shape change occurs as the crystals transform. They also show that stacking faults are generated in the transition from the high- to the low-pressure phase. The shape change and stacking fault generation place significant constraints on the possible microscopic mechanism of the phase transition.

Wickham, J. N., A. B. Herhold, et al. (2000). "Deformation behavior of Zr-based bulk nanocrystalline amorphous alloys." *Physical Review B Condensed Matter* **61**(6).

Mechanical properties of bulk Zr<sub>55</sub>Ni<sub>5</sub>Cu<sub>30</sub>Al<sub>10</sub> metallic glass alloy and Zr<sub>53</sub>Ti<sub>5</sub>Ni<sub>10</sub>Cu<sub>20</sub>Al<sub>12</sub> nanocrystalline-amorphous alloy were measured by compression tests at room temperature. Although no distinct plastic deformation is recognized in the Zr<sub>55</sub>Ni<sub>5</sub>Cu<sub>30</sub>Al<sub>10</sub> metallic glass, the Zr<sub>53</sub>Ti<sub>5</sub>Ni<sub>10</sub>Cu<sub>20</sub>Al<sub>12</sub> as-quenched alloy exhibits significant plastic strain. Moreover, we found that both the strength and plastic strain increased significantly with increasing volume fraction of nanocrystals, and the plastic strain achieved a maximum in the early stage of nanocrystallization. High-resolution electron microscopy showed that nanocrystals with average grain sizes of about 2.0 and 2.5 nm were embedded in the amorphous matrix of the as-quenched bulk Zr<sub>53</sub>Ti<sub>5</sub>Ni<sub>10</sub>Cu<sub>20</sub>Al<sub>12</sub> alloy and the specimen with the maximum plastic strain, respectively. (9 References).

Wiedenmann, A. (2000). "Small-angle neutron scattering investigations of magnetic nanostructures using polarized neutrons." *Journal of Applied Crystallography* **33**(1): 428-32.

Crystalline and magnetic nanostructures have been studied by means of small angle neutron scattering. Using polarised neutrons, the relative contrasts are strongly modified which allowed magnetisation, density and composition profiles at surfaces and interfaces to be evaluated. In nanocrystalline Fe<sub>3</sub>O<sub>4</sub> embedded in a glass ceramics matrix the magnetic order is strongly disturbed at the surface of the particles, leading to a magnetically inactive layer. In partially crystallised metallic Fe-Si-B-(Nb,Cu) alloys the presence of a non-magnetic interface between Fe<sub>3</sub>Si nanocrystals and the amorphous matrix has been demonstrated which breaks the direct ferromagnetic exchange interactions. In Co-ferrofluids the superparamagnetic core is encapsulated by a shell of surfactant molecules which was found to be impenetrable for the solvent. (14 References).

Wiedmann, T. S., L. DeCastro, et al. (1997). "Nebulization of nanocrystals: production of a respirable solid-in-liquid-in-air colloidal dispersion." *Pharmaceutical Research* **14**(1): 112-6.

Williams, R. S., G. Medeiros-Ribeiro, et al. (2000). "Thermodynamics of the size and shape of nanocrystals: epitaxial Ge on Si(001)." *Annu Rev Phys Chem* **51**(18): 527-51.

The growth and evolution of strained epitaxial Ge on a Si(001) surface provides a rich system for exploring the behavior of strongly interacting nanocrystals. In the temperature regime above 500 degrees C, there are two different (metastable) shapes of defect-free nanocrystals, termed pyramids and domes, that dominate the system depending on the temperature of the substrate during growth and the amount of Ge deposited. In contrast to the usual case considered in nucleation theory, the relaxation of the strain energy at the surface of the nanocrystals makes those surfaces stabilizing, i.e. the surface contribution to the free energy of the Ge nanocrystals is negative. Given that the edges of the nanocrystals are destabilizing (positive free energy), the interaction of the surfaces and edges of the nanocrystals in an ensemble renders an internal free energy for the system that has a local minimum with respect to the size (volume) of the nanocrystal. At finite temperatures, this free energy yields a size distribution with a characteristic centroid, width, and skewness for each nanocrystal shape. The smaller pyramids transform into domes when they grow to the point where they can surmount a kinetic energy barrier between the two structures. However, the Ge nanocrystals also effectively repel one another strongly via the strain fields that are produced in the Si substrate. This repulsive interaction makes the ensemble of Ge nanocrystals a highly nonideal thermodynamic system and, in turn, makes the free energies of the nanocrystals a function of their number density, or equivalently a function of the amount of Ge deposited. The interplay of the stabilizing effect of the nanocrystal surfaces and the destabilizing influence of their repulsive interactions yields a complex behavior for the nanocrystal-size distributions that can nonetheless be modeled using simple thermodynamic expressions.

Wittorf, D., W. Jager, et al. (2000). "Electron microscopy of interfaces in chemical vapour deposition diamond films on silicon." *Diamond and Related Materials* **9**: 9-10.

The structure of interfaces in diamond films grown on Si(100) has been investigated by transmission electron microscopy for the early stages of microwave-assisted chemical vapour deposition. Using conditions optimized for achieving so-called highly-oriented diamond films the depositions were performed in two steps, a bias-enhanced nucleation step and a subsequent growth step. Characteristic for the early deposition stages is the self-organized formation of regular arrays of predominantly {111}-faceted Si substrate surface grooves and islands elongated along 110 and  $\bar{1}\bar{1}0$  directions. Subsequently, an interlayer of nanocrystalline beta -silicon carbide islands forms,

followed by the formation of epitaxially oriented diamond nanocrystals with high fractions of {111} interfaces. High-resolution electron microscopy of the interface regions depicts arrays of terminating {111} diamond planes at an average ratio of five diamond to four SiC lattice planes which corresponds to a remaining lattice mismatch of 2.3%. The orientation relationships between the lattices may be described by a coincidence site lattice model if the elastic lattice distortions are taken into account. Only small fractions of amorphous inclusions are present near interfaces, essentially consisting of amorphous carbon as could be deduced from analyses of the C K edge fine structure in electron energy loss spectra. The observations are compared with cases for which diamond nucleation directly on silicon has been obtained. (14 References).

Wu, R. I., G. Wilde, et al. (2000). "Glass formation and nanostructure development in Al-based alloys." Nanophase and Nanocomposite Materials III. Symposium **581**: 101-6.

Al-Sm and Al-Y-Fe alloys with a high number density of nanocrystalline fcc-Al homogeneously dispersed within the amorphous matrix have been synthesized by devitrifying the precursor metallic glasses produced by rapid solidification. The kinetics of metallic glass formation and the development of the nanostructure during devitrification are discussed in terms of the rate limiting mechanism. The glass transition temperature of the two metallic glasses has been successfully assessed with the application of the modulated-temperature differential scanning calorimetry (DDSC). In addition, the formation of quenched-in nuclei was investigated by a comparison study on the cold-rolled and melt-spun Al/sub 92/Sm/sub 8/ amorphous samples. Furthermore, the enhancement of the particle density of the fcc-Al nanocrystals in the amorphous matrix after devitrification has been demonstrated by the incorporation of nanosize Pb particles. (16 References).

Wu, Y.-C. and X.-H. Zhang (2000). "Voltage-controlled electroluminescence from SiO<sub>2</sub> films containing Ge nanocrystals and its mechanism." Applied Physics(3): 299-303.

Luminescent SiO/sub 2/ films containing Ge nanocrystals are fabricated by using Ge ion implantation, and metal-oxide-semiconductor structures employing these films as the active layers show yellow electroluminescence (EL) under both forward and reverse biases. The EL spectra are strongly dependent on the applied voltage, but slightly on the mean size of Ge nanocrystals. When the forward bias increases towards 30 V, the EL spectral peak shifts from 590 nm to 485 nm. It is assumed that the EL originates from the recombination of injected electrons and holes in Ge nanocrystals near the Si/SiO/sub 2/ interface, or through luminescent centers in the SiO/sub 2/ matrix near the SiO/sub 2//metal interface. The mismatch of the injection amounts between holes and electrons results in the low EL efficiency. (33 References).

Wu, J.-H., L. Pu, et al. (2000). "Observation of pressure-induced direct-to-indirect band gap transition in InP nanocrystals." Journal of Chemical Physics **113**(5): 2016-20.

We investigate the quantum size effects in the pressure-induced direct-to-indirect band gap transition in InP nanocrystals. Hydrostatic pressures of up to 13 GPa are applied to two different sizes of InP nanocrystal samples in a diamond anvil cell. The band gap pressure dependence and the nature of the emitting states are studied by photoluminescence (PL) and fluorescence line narrowing (FLN) techniques at 10 K. Pressure-dependent FLN spectra show that the nature of the emitting states at pressures up to 9 GPa is similar to that at ambient pressure, suggesting that no direct-to-indirect transition happens below 9 GPa. For both sizes, the PL peak energy exhibits a strong blueshift with rising pressure until approximately 9 to 10 GPa. Above this pressure, the PL peak position slightly shifts red. Beyond 12 GPa, the band gap emission intensity becomes extremely weak and trap emission dominates the PL spectra. As the pressure is released, both the luminescence intensity and the peak position recover in a fully reversible manner. The change in the sign of the band gap energy pressure dependence and the disappearance of the band edge luminescence indicate the pressure-induced direct-to-indirect band gap transition. Contrary to theoretical calculations, no substantial reduction of the transition pressure is observed in the nanocrystal cases compared to the bulk transition pressure. (35 References).

Wu, N. C., M. S. Tsai, et al. (2000). "Formation of photoluminescence centers during annealing of SiO<sub>2</sub> layers implanted with Ge ions." Fizika i Tehnika Poluprovodnikov **34**(1): 23-7.

Photoluminescence (PL), Raman scattering, and the Rutherford backscattering of alpha -particles were used to study the formation of the centers of radiative-recombination emission in the visible region of the spectrum on annealing of the SiO/sub 2/ layers implanted with Ge ions. It was found that the Ge-containing centers were formed in the as-implanted layers, whereas the stages of increase and decrease in the intensities of PL bands were observed following an increase in the annealing temperature to 800 degrees C. The diffusion-related redistribution of Ge atoms was observed only when the annealing temperatures were as high as 1000 degrees C and was accompanied by formation of Ge nanocrystals. However, this did not give rise to intense PL as distinct from the case of Si-enriched SiO/sub 2/ layers subjected to the same treatment. It is assumed that, prior to the onset of Ge diffusion, the formation of PL centers occurs via completion of direct bonds between the neighboring excess atoms, which gives rise to the dominant violet PL band (similar to the PL of O vacancies in SiO/sub 2/) and a low-intensity long-wavelength emission from various Ge-containing complexes. The subsequent formation of centers of PL with lambda /sub m/ ~570 nm as a result of anneals at temperatures below 800 degrees C is

explained by agglomeration of bonded Ge atoms with formation of compact nanocrystalline precipitates. The absence of intense PL following the high-temperature anneals is believed to be caused by irregularities in the interfaces between the formed Ge nanocrystals and the SiO<sub>2</sub>/Si matrix. (28 References).

Xiaogang, P., L. Manna, et al. (2000). "Pyramidal Si nanocrystals with a quasiequilibrium shape selectively grown on Si(001) windows in ultrathin SiO<sub>2</sub> films." Physical Review B Condensed Matter **61**(11): 7499-504.

Pyramidal Si nanocrystals selectively grown on Si(001) windows in ultrathin 0.3-nm-thick SiO<sub>2</sub> films were studied using in situ scanning tunneling microscopy. In the initial growth stage, {1, 1, 13} facets were formed on the four equivalent sidewalls of the crystal due to the repulsion force between neighboring steps. The crystals were stable with a quasiequilibrium shape when they were surrounded by the SiO<sub>2</sub> film, but rapidly decayed once the boundary to the SiO<sub>2</sub> film was removed. This indicates that Si adatoms were confined within the Si window area by the surrounding ultrathin SiO<sub>2</sub> film and the Si adatom density became stationary. The confinement was enabled by a difference in the adsorption energy of Si adatoms on SiO<sub>2</sub> and those on Si(001). (26 References).

Xiong, G., W. Pengfei, et al. (2000). "Deuterium diffusion through hexagonal boron nitride thin films." Journal of Applied Physics **87**(1): 110-16.

We evaluated the deuterium diffusion coefficient in hexagonal boron nitride (h-BN) thin films deposited by radio frequency magnetron sputtering on metallic substrate. The measurements were carried out by studying the transient of the deuterium permeation flux through substrates coated with h-BN thin films 400 nm thick, for temperatures ranging from 535 to 752 K. The deuterium diffusion coefficient was in the range between  $1.4 \times 10^{-13}$  and  $5.3 \times 10^{-12}$  cm<sup>2</sup>/s and was characterized by an activation energy of 0.52±0.04 eV and pre-exponential factor of the order of  $10^{-8}$  cm<sup>2</sup>/s. In steady-state transport conditions the deuterium concentration in the h-BN layers was close to  $3 \times 10^{21}$  at./cm<sup>3</sup>. Starting from the earlier data we suggest a model in which the deuterium migration process is controlled by diffusion of D atoms in the volume fraction of the h-BN films relative to grain boundaries, just in connection with the structure of the deposited samples which consists of nanocrystals with 2 nm average diameter. (50 References).

Xiong, G., W. Pengfei, et al. (2000). "Effect of gamma -ray irradiation on structures and luminescent properties of nanocrystalline MSO<sub>4</sub>:xEu<sup>3+</sup> (M=Ca, Sr, Ba; x=0.001-0.005)." Journal of Physics and Chemistry of Solids **61**(1): 115-21.

A series of nanocrystalline rare earth doped alkaline earth sulphates, MSO<sub>4</sub>:Eu<sup>3+</sup> (M=Ca, Sr, Ba; x=0.001-0.005), have been prepared by co-precipitation method. Their crystal structures and luminescent properties with and without gamma -ray irradiation are compared. It was found that their crystal structures have not changed, but their lattice parameters with irradiation become smaller than those without irradiation. On the other hand, the characteristic emissions of both Eu<sup>3+</sup> and Eu<sup>2+</sup> are observed in the same nanocrystals with gamma -irradiation. The differences in their crystal structures and luminescent properties are also discussed. (28 References).

Xu, L., X. F. Huang, et al. (2000). "The formation of close-packed two-dimensional, CdSe colloidal films by electric-field-induced deposition." Semiconductor Quantum Dots. Symposium, **571**: 81-6.

Monodispersed CdSe nanocrystals with an average diameter of ~5 nm were synthesized from SeSO<sub>3</sub> and rich Cd<sup>2+</sup> ionic reagents in aqueous solution. Two-dimensional (2D) close-packed colloidal CdSe films were formed on the electrode surface by an electric-field induced deposition method. Transmission electron microscopy (TEM) images show that colloidal CdSe films exhibit different states, named "gas", "liquid" and "solid" states, which can be transformed by adjusting the applied field (E) or deposition time (T). The experimental results demonstrate that the average nearest-neighbor distance of clusters on the electrode surface is inversely proportional to the ET product. (8 References).

Xu, X. L., J. D. Guo, et al. (2000). "The melting temperature of molecular nanocrystals at the lower bound of the mesoscopic size range." Journal of Physics Condensed Matter **12**(41): 8819-24.

Our simple thermodynamic model, free of any adjustable parameters, has predicted the size-dependent and dimension-dependent melting temperatures of molecular nanocrystals whose diameters are at the lower bound of the mesoscopic size range, of 2 to 10 nm. In this size range, the depression of the melting temperature is no longer proportional to the reciprocal of the diameter of the nanocrystals. The model predictions are supported by experimental and molecular dynamics simulation results for cyclohexane, benzene, n-decane, methyl chloride, oxygen, neon, argon and krypton nanocrystals. (27 References).

Xudong, F., W. Hailin, et al. (2000). "Probing radiative recombination in semiconductor nanocrystals with cavity QED." Quantum Electronics and Laser Science Conference **40**(IEEE Cat. No.00CH37089).

Summary form only given. The physical nature of photoluminescence (PL) from semiconductor nanocrystals has been a subject of considerable debate. Earlier studies using organically-capped nanocrystals have shown that the PL arises primarily from dark excitonic states with a radiative lifetime of order microseconds. Recent advances in

developing inorganically-capped nanocrystals have led to much improved quantum efficiency and thus prompted the need to reexamine radiative processes in these core/shell nanocrystals. Time-resolved PL of typical core/shell nanocrystals, however, is characterized by complex multi-exponential decays. It has been difficult to extract information on radiative processes from these measurements. We report studies of radiative recombination in core/shell nanocrystals using an experimental approach based on cavity QED and the fact that only radiative processes are affected by modifications in vacuum fluctuations. We single out radiative processes from the complex decay dynamics in time resolved PL by embedding nanocrystals in an optical microresonator and by comparing time-resolved PL obtained at energies resonant or off-resonant with relevant resonator modes. An estimated radiative lifetime of order 10 ns is obtained, indicating that a significant part of the PL arises from dipole-allowed radiative recombination in nanocrystals. Core/shell CdSe/ZnS nanocrystals with a diameter near 5 nm are fabricated by using high temperature organometallic synthesis. (2 References).

Xudong, F., P. Palinginis, et al. (2000). "Correlation between structural and optical properties of Si nanocrystals embedded in SiO<sub>2</sub>: The mechanism of visible light emission." Applied Physics Letters **77**(20): 3143-5.

The size distribution, band gap energy, and photoluminescence of silicon nanocrystals embedded in SiO<sub>2</sub> have been measured by direct and independent methods. The size distribution is measured by coupling high-resolution and conventional electron microscopy in special imaging conditions. The band gap is calculated from photoluminescence excitation measurements and agrees with theoretical predictions. Their correlation allows us to report the experimental Stokes shift between absorption and emission, which is 0.26±0.03 eV, independent of average size. This is almost exactly twice the energy of the Si-O vibration (0.134 eV). These results suggest that the dominant emission is a fundamental transition spatially located at the Si-SiO<sub>2</sub> interface with the assistance of a local Si-O vibration. (20 References).

Yamamoto, M., T. Koshikawa, et al. (2000). "Quantum confinement in germanium nanocrystals." Applied Physics Letters **77**(8): 1182-4.

The electronic structure of Ge nanocrystals is studied using a sp<sup>3</sup>/tight binding description. Analytical laws for the confinement energies, valid over the whole range of sizes, are derived. We validate our results with ab initio calculations in the local density approximation for smaller clusters. Comparing to experimental data, we conclude that, similar to the case of silicon: (a) the blue-green photoluminescence (PL) of Ge nanocrystals comes from defects in the oxide and (b) the size dependent PL in the near infrared probably involves a deep trap in the gap of the nanocrystals. We predict that the radiative lifetimes remain long in spite of the small difference (0.14 eV) between direct and indirect gaps of bulk Ge. (30 References).

Yamanaka, T., T. Morie, et al. (2000). "Impurity doping into Si nanocrystals." Oyo Buturi **69**(7): 820-4.

We have studied the roles of impurity atoms in the zero-dimensional structures of indirect-bandgap semiconductors. In this article, the luminescence properties of Si nanocrystals (nc-Si) embedded in SiO<sub>2</sub>/thin films are first discussed. Then, the effects of three kinds of impurities, i.e., (i) group IV elements, (ii) group III and V elements, and (iii) rare-earth ions, on the photoluminescence properties of nc-Si are examined. (15 References).

Yamanaka, T., T. Morie, et al. (2000). "A single-electron stochastic associative processing circuit robust to random background-charge effects and its structure using nanocrystal floating-gate transistors." Nanotechnology **11**(3): 154-60.

A new single-electron circuit using the unique features of single-electron devices is proposed, based on a basic strategy and circuit architecture for achieving large-scale integration. A unit circuit consisting of a single-electron transistor and a capacitor operates as an exclusive-NOR gate by the Coulomb blockade effect, and its transient behaviour is stochastic due to electron-tunnelling events. Using this unit circuit, a stochastic associative processing circuit is proposed, based on a new information-processing principle where the association probability depends on the similarity between the input and reference data. This circuit can be constructed by using a silicon nanocrystal floating-gate structure in which dots are regularly arranged on a gate electrode of a MOSFET. The simulation results of a simple digit pattern association demonstrate the successful stochastic operation. The background-charge effects on the proposed circuit are analysed and simulated, and it is shown that the circuit is much more robust to such effects than the conventional single-electron logic circuits. (18 References).

Yang, G. W. and J. B. Wang (2000). "Synthesis and photoluminescence characteristics of AlN nanocrystalline solids." Applied Physics a(3): 351-2.

A new condensed form of AlN nanocrystalline solids was obtained directly from reactions of metal Al and (NH<sub>4</sub>Cl/NH<sub>4</sub>l) in liquid ammonia at 550 degrees C, without the subsequent consolidation process as in the conventional method. The synthesized product is a transparent bulk solid, while the constituted nanocrystals have an average size of about 18 nm and possess the same wurtzite structure as bulk AlN. (NH<sub>4</sub>Cl/NH<sub>4</sub>l), which plays a role of a catalyst in the present synthetic route, is indispensable. The photoluminescence spectrum of the AlN nanocrystalline solids shows a broad blue band centered at 400 nm. (9 References).

Yao, K. F. and H. W. Kui (2000). "Evidence of a two-dimensional nucleation and growth mechanism for metastable nanocrystals embedded in Pd<sub>40.5</sub>Ni<sub>40.5</sub>P<sub>19</sub> glass." Applied Physics Letters **77**(15): 2313-15.

Nanocrystals, with a body-centered-cubic crystal structure of lattice parameter 18.2525 Å, were found in amorphous Pd/sub 40.5/Ni/sub 40.5/P/sub 19/ specimens that had been annealed at 628 K for 30 min. The crystal surfaces are smooth and dislocations are absent, suggesting that the growth of these nanocrystals is through a two-dimensional nucleation and growth mechanism (formation of surface nuclei of critical size and their subsequent growth). (13 References).

Yastrebov, S. G., R. Smith, et al. (2000). "Absorption of infrared radiation by a giant enhancement of two-phonon lattice modes at a dielectric-conductor interface." Philosophical Magazine B Physics of Condensed Matter Structural Electronic Optical and Magnetic Properties **80**(6): 1219-28.

Recent experimental work has shown that, at certain frequencies of infrared radiation, there is a giant absorption at the interface between a nanosize graphite substrate doped with copper and diamond nanocrystals grown on the substrate. We propose a model for this absorption based on the Born approach which uses a set of dynamic surface dipoles induced in a conducting medium at its interface with a dielectric and where the frequency of radiation corresponds to a combination of two-lattice vibrations. The wavenumber at which the enhancement occurs can be determined from the fundamental frequency of the vibrations and the functional dependence of the extinction coefficient as a function of wavenumber can be determined from the relaxation times and the plasma frequencies. An analytical expression for the enhancement absorption factor is derived and it is shown how the cut-off of the absorption band can be used to ascertain the size and shape of conductive nanocrystals. (15 References).

Yi, X., L. Jun, et al. (2000). "IR spectra of nano- and macro-crystals: the overriding importance of optical path." Astronomical Society of the Pacific Conference Series **196**: 291-9.

To clarify the effect of optical path, infrared (IR) absorption spectra were collected from nanocrystals of SiC and structurally related AlN and TiB/sub 2/, and from commercial bulk samples using thin film, powder dispersion and single crystal methods. Crystals of 5-10 nm that were individually encapsulated in salt and subsequently pressed into thin films give identical features to those from thin films of the bulk sample (grain size >1 μm), which removes all possibility of a matrix effect, and negates the importance of grain size below a micron. Shifts in peak position for SiC samples are shown to relate to optical path, and are such that the beta - and alpha - polymorphs can be distinguished. The shifts arise because peaks have finite widths and hence small frequency increments can have a widely different absorption coefficient for the intense Si-C stretch. The high absorption coefficient serves as a filter for particulate dimensions perpendicular to the propagation of light. (11 References).

Yi, Y., C. Tran, et al. (2000). "From Ga(NO<sub>3</sub>)<sub>3</sub> to nanocrystalline GaN: confined nanocrystal synthesis in silica xerogels." Materials Letters **43**: 5-6.

A simple chemical reaction of gallium nitrate, incorporated into a silica gel precursor, to form gallium oxide and then the nitride, leads to a composite material with nanocrystals of hexagonal phase GaN (approximately 5 nm average diameter) embedded in a silica matrix. (18 References).

Young-Nam, H., K. Cheon Min, et al. (2000). "Optical absorption cross sections of Si nanocrystals." Physical Review B Condensed Matter **61**(7): 4485-7.

Using the photoluminescence Auger saturation phenomenon, we deduce the values of the absorption cross section of silicon nanocrystals in a wide range of energies. The very large variation of their values versus energy of the absorbed light is attributed to the enhanced optical transition oscillator strength but reduced density of electronic states towards higher confinement energies. The overall spectral behavior of the absorption cross section reflects the indirect-gap nature of silicon nanocrystals. (15 References).

Yu, B., Y. Gu, et al. (2000). "Melting thermodynamics of nanocrystals embedded in a matrix." Acta Materialia **48**(20): 4791-5.

A simple model, free of any adjustable parameter, is established for the melting temperature and melting entropy of nanocrystals embedded in a matrix where the interface between the nanocrystals and the matrix is coherent. The model is based on Lindemann's criterion for the melting, Mott's equation for the melting entropy of bulk crystals and our model for the size-dependent melting temperature. It is shown that the melting temperature and the melting entropy of nanocrystals embedded in a matrix increase as the size of the nanocrystals decreases. The above predictions are supported by available experimental results on Pb and In nanocrystals embedded in an Al matrix. On the basis of the model, the melting mechanism of superheating is discussed. (47 References).

Yuan, W., M. Takeguchi, et al. (2000). "Study of crystallization and spectral properties of PbS nanocrystals doped in SiO<sub>2</sub> aerogel matrix." Journal of Crystal Growth **216**: 1-4.

PbS nanocrystallites with a diameter smaller than 15 nm doped in silica aerogel matrix have been prepared by sol-gel route preceding supercritical drying technique and colloidal chemistry method. These PbS-nanocrystals-

doped aerogels were characterized by optical absorption, X-ray diffraction (XRD) and transmission electron microscopy (TEM). Blue shifts in optical absorption threshold indicate that the PbS crystallite sizes range from 5 to 15 nm with an increase of annealing temperature from 298 to 1023 K. It has been speculated that three mechanisms exist during the growth of the PbS nanocrystallites, and various apparent growth excitation energies were calculated using an Arrhenius relation. (18 References).

Zacharias, M. and P. Streitenberger (2000). "Crystallization of amorphous superlattices in the limit of ultrathin films with oxide interfaces." Physical Review B Condensed Matter **62**(12): 8391-6.

Annealing of amorphous Si/SiO<sub>2</sub> or Ge/SiO<sub>2</sub> multilayers produces nanocrystals embedded between oxide interfaces. It is found that the crystallization temperature is strongly enhanced by the presence of the oxide interfaces and follows an exponential law. The crystallization temperature increases rapidly with decreasing Si layer thickness, and a nonstoichiometric interface decreases the crystallization temperature compared to a stoichiometric interface of the same thickness. A model is presented that takes into account the interface energies, the thickness of the layer, the melting point of the system, and the crystallization temperature of the thick amorphous layer. The evidence for a critical crystallization radius and the influence of deviations from a perfect stoichiometric interface are discussed. (13 References).

Zacharias, M., S. Richter, et al. (2000). "Room temperature luminescence of Er doped nc-Si/SiO<sub>2</sub> superlattices." Journal of Non Crystalline Solids **266**(269): 608-13.

Amorphous Si/SiO<sub>2</sub> superlattices with a 80 nm top oxide are implanted with various erbium doses ( $1.2 \times 10^{15}$  to  $5.2 \times 10^{16}$  cm<sup>-2</sup>). The effect of Si nanocrystals in the vicinity of the Er ions is investigated. We found that the luminescence intensity is increased compared to an a-SiO<sub>2</sub> film implanted with the same erbium dose. The Si layers are completely crystallized with an average crystal size of 5.7 nm after annealing at 800 degrees C. Room temperature luminescence is found at 1.54 μm, and the intensity scales with the annealing time. Increasing the implantation dose decreases the room temperature luminescence intensity. Over the whole range of 7-300 K the luminescence quenches below one order of magnitude. Luminescence at 2, 2.55 and 3.0 eV is assigned to interface defects at the nanocrystal surface and to implantation damage in the SiO<sub>2</sub>. (16 References).

Zengtao, L., K. Myongseob, et al. (2000). "Process and device characteristics of self-assembled metal nano-crystal EEPROM." Superlattices and Microstructures **28**: 5-6.

Metal nanocrystals self-assembled on gate tunneling oxide can be used to replace the conventional Si/Ge nanocrystals as the floating gate in EEPROM cells. We have demonstrated the successful use of Au and W with their respective process dependence and self-assembly characteristics. The new material options can potentially enhance the applicability and functionality of the nanocrystal EEPROM device. Implications on process integration, in particular the control oxide growth and overall thermal budget, are examined by microscopy, gate current injection and channel mobility monitoring. Charging by hot-carrier injection and control gate tunneling have both been observed by shifts in I-V characteristics. The electrostatic behavior of metal nanocrystals is similar to that of Si nanocrystals in terms of the asymmetrical threshold voltage on source-drain reversal after hot-carrier injection and the Coulomb blockade effects. The electrodynamic behavior is expected to be quite different due to the density of states, but further study is required for quantitative analysis. (11 References).

Zhang, Y. W., S. Jin, et al. (2000). "Charge storage and interface states effects in Si-nanocrystal memory obtained using low-energy Si<sup>+</sup> implantation and annealing." Applied Physics Letters **77**(21): 3450-2.

Thin SiO<sub>2</sub> oxides implanted by very-low-energy (1 keV) Si ions and subsequently annealed are explored with regards to their potential as active elements of memory devices. Charge storage effects as a function of Si fluence are investigated through capacitance and channel current measurements. Capacitance-voltage and source-drain current versus gate voltage characteristics of devices implanted with a dose of  $1 \times 10^{16}$  cm<sup>-2</sup> or lower exhibit clear hysteresis characteristics at low electric field. The observed fluence dependence of the device electrical properties is interpreted in terms of the implanted oxide structure. (9 References).

Zhang, Z., J. C. Li, et al. (2000). "(FeCoNi)-ZrBCu base alloys, the influence of transition metal composition and heat treatment on structure and magnetic properties." Journal of Magnetism and Magnetic Materials **215**(216): 437-9.

Magnetic properties of amorphous and partially crystallized (Fe:Co:Ni)<sub>86</sub>Zr<sub>7</sub>B<sub>6</sub>Cu<sub>1</sub> alloys were investigated. Primary formation of BCC as well as FCC nanocrystals takes place at the first stage of crystallization. Low coercivities ( $H_c < 10$  A/m) and low magnetostrictions are observed only in the Fe-rich corner. Maximum value of saturation polarization  $J_s = 1.63-1.67$  T are obtained in the partially crystallized (Fe:Co)<sub>86</sub>Zr<sub>7</sub>B<sub>6</sub>Cu<sub>1</sub> alloys with 30-35 Co-parts. (4 References).

Zhang, H. X., C. H. Kam, et al. (2000). "Influence on the gas sensor performances of the metal chemical states introduced by impregnation of calcinated SnO<sub>2</sub> sol-gel nanocrystals." Sensors and Actuators B Chemical: 1-3.

The effects of the introduction of Pt and Pd by impregnation in sol-gel fabricated SnO<sub>2</sub> nanoparticles after

calcination are reported in this paper. The differences in base resistance and sensitivity of sensors prepared using these powders are presented and explained-taking into account the chemical states of the metal additives and the generated surface states in the band gap of the SnO<sub>2</sub>. (9 References).

Zhang, J. Y., Y. H. Ye, et al. (2000). "Carbon nitride nanocrystals having cubic structure using pulsed laser induced liquid-solid interfacial reaction." Applied Physics a(3): 343-4.

Carbon nitride nanocrystals were prepared using a pulsed laser induced liquid-solid interfacial reaction and transmission electron microscopy, while high resolution electron microscopy characterized their morphology and structure. It is important that the cubic-C<sub>3</sub>N<sub>4</sub> phase was observed. The formation mechanism of the carbon nitride nanocrystals is also discussed. (16 References).

Zhang, W. F., Y. L. He, et al. (2000). "Raman scattering study on anatase TiO<sub>2</sub> nanocrystals." Journal of Physics D Applied Physics **33**(8): 912-16.

Titanium dioxide (TiO<sub>2</sub>) nanocrystals are prepared by a hydrolysis process of tetrabutyl titanate. Nanocrystal samples with various sizes of 6.8-27.9 nm are obtained after annealing from 100 to 650 degrees C. The crystal structures and the average particle sizes are examined using X-ray diffraction. Raman scattering was employed to investigate the evolution of the anatase phase in the nanocrystals during annealing. Phonon confinement and nonstoichiometry effects are responsible for the blueshift and broadening of the lowest-frequency E<sub>g</sub> Raman mode. The influence of interfacial vibrations on the Raman linewidth is also discussed. (19 References).

Zhang, W. J., X. S. Sun, et al. (2000). "Characterization and size-dependent magnetic properties of Ba<sub>3</sub>Co<sub>2</sub>Fe<sub>24</sub>O<sub>41</sub> nanocrystals synthesized through a sol-gel method." Journal of Materials Science **35**(4): 931-6.

Ba<sub>3</sub>Co<sub>2</sub>Fe<sub>24</sub>O<sub>41</sub> nanocrystals are synthesized through a stearic acid sol-gel method. The reaction temperatures are dramatically lower than that of the conventional ceramic method. The nanocrystalline powders obtained at 750 degrees C were spherical in shape with grain sizes in the range 15-25 nm and become a plate-like form when the heat-treatment temperature increased. The magnetic properties of these samples are different from those of the bulk Z-type hexagonal ferrite with a lower specific saturation magnetization. This phenomenon can be attributed to the existing of a nonmagnetic layer existing on the surface of the particles. The higher value of the coercivity force is obtained when the particle sizes approximately are equal to 90 nm and assume a single-domain character. The surface composition of the nanocrystalline Co<sub>2</sub>-Z hexagonal ferrite is different from that of the bulk counterpart material with a higher content of the Ba element and Co element. (24 References).

Zhang, W. F., M. S. Zhang, et al. (2000). "Deposition of tellurium films by decomposition of electrochemically-generated H<sub>2</sub>Te: application to radiative cooling devices." Thin Solid Films **370**: 1-2.

The preparation of homogenous, large area thin layers of tellurium on thin polyethylene foils is described. The tellurium was formed by room temperature decomposition of electrochemically generated H<sub>2</sub>Te. Pre-treatment of the polyethylene substrates with KMnO<sub>4</sub> to give a Mn-oxide layer was found to improve the Te adhesion and homogeneity. Optical characterization of the layers was performed using UV/VIS/NIR spectroscopy. Such coatings have favorable characteristics for use as solar radiation shields in radiative cooling devices. The simplicity of generation of the very unstable H<sub>2</sub>Te was also exploited to demonstrate formation of size-quantized CdTe nanocrystals. (12 References).

Zhang, W. F., M. S. Zhang, et al. (2000). "Photoluminescence in anatase titanium dioxide nanocrystals." Applied Physics B Lasers and Optics(2): 261-5.

Titanium dioxide (TiO<sub>2</sub>) nanocrystals were prepared by a hydrolysis process of tetrabutyl titanate. X-ray diffraction and Raman scattering showed that the as-prepared TiO<sub>2</sub> nanocrystals have anatase structure of TiO<sub>2</sub>, and that the monophasic anatase nanocrystals can be achieved through a series of annealing treatments below 650 degrees C. We measured photoluminescence (PL) spectra of the TiO<sub>2</sub> nanocrystals. Under 2.41-2.71 eV laser irradiation, the TiO<sub>2</sub> nanocrystals displayed strong visible light emission with maxima of 2.15-2.29 eV even at excitation power as low as 0.06 W/cm<sup>2</sup>. To identify the PL mechanism in the TiO<sub>2</sub> nanocrystals, the dependences of the PL intensity on excitation power and irradiation time were investigated. The experimental results indicated that the radiative recombination is mediated by localized levels related to surface defects residing in TiO<sub>2</sub> nanocrystallites. (28 References).

Zhao, J., M. Ikezawa, et al. (2000). "Shape-dependent confined excitons and acoustic phonons of CuCl nanocrystals embedded in NaCl crystals." Journal of Luminescence **87**(89): 525-7.

The confined excitons and acoustic phonons of CuCl nanocrystals embedded in NaCl crystals were studied by the persistent spectral-hole-burning (PSHB) spectroscopy. A resonant hole and many low-energy satellite holes as well as longitudinal, transverse optical, and acoustic phonon sidebands were observed in the PSHB spectra. The satellite holes come from the hole burning of the ground-state excitons under the site-selective excitation of the corresponding excited states in the nanocrystals of nearly cubic shapes. The confined acoustic phonons in

CuCl nanocrystals were explained as the low-frequency vibrational modes of nearly cubic quantum boxes. (9 References).

Zhao, J., L. Guo, et al. (2000). "High bulk modulus of nanocrystal gamma -Fe<sub>2</sub>O<sub>3</sub> with chemical dodecyl benzene sulfonic decoration under high pressure." Chinese Physics Letters **17**(2): 126-8.

Structural transformation in gamma -Fe<sub>2</sub>O<sub>3</sub> nanocrystals (about 10 nm) with dodecyl benzene sulfonic (DBS) coating is studied by using high-pressure energy dispersive X-ray diffraction of synchrotron radiation and high-resolution transmission electron microscopy (HRTEM). Relative to the bulk crystal, the transition pressure showed a decrease while the compressibility increases significantly up to 375 (+or-9 GPa). HRTEM confirmed that there is surface cladding surrounding nanocrystals due to DBS, which formed new special boundaries between nanocrystals and should be different from the ordinary grain boundaries. The experimental results imply that the surface layers of gamma -Fe<sub>2</sub>O<sub>3</sub> nanocrystals have a strong effect on the compressibility. (12 References).

Zhiwen, C., T. Shun, et al. (2000). "Solvothermal coordination-reduction route to gamma -NiSb nanocrystals at low temperature." Journal of Solid State Chemistry **155**(1): 42-5.

A very mild synthesis of nanocrystalline gamma -NiSb via a novel solvothermal coordination-reduction process is reported here. The reaction of the mixture of NiCl<sub>2</sub>, antimony, and KBH<sub>4</sub> was carried out in ethylenediamine (en) at 140 degrees C for 24 h. X-ray powder diffraction and transmission electron microscope images show that the products are hexagonal gamma -NiSb phase and well crystallized with an average size of about 15 nm. The reaction proceeds through a metallic nickel intermediate. The morphology of the products was influenced markedly by the solvents, and a dendritic crystal of NiSb was obtained in diethylamine. The products were also investigated by UV/vis absorption, photoluminescence, X-ray photoelectron spectra, and Fourier transform IR. (19 References).

Zhu, Y., H. Wang, et al. (2000). "Coupling semiconductor nanocrystals to a fused-silica microsphere: a quantum-dot microcavity with extremely high Q factors." Optics Letters **25**(21): 1600-2.

We demonstrate a quantum-dot microcavity by coupling core-shell semiconductor nanocrystals to a fused-silica microsphere. We show that the composite microcavity can feature and factors of the order of 10<sup>8</sup>, providing a model system for investigating cavity QED and microlasers at the level of single quantum dots. (12 References).

Zhuang, Y. and X. Ye (2000). "Electro-optic effect of CdS<sub>0.1</sub>Se<sub>0.9</sub> nanocrystals in resonance regime." Guangzi Xuebao/Acta Photonica Sinica **29**(9): 843-7.

The changes of optical properties of CdS<sub>0.1</sub>Se<sub>0.9</sub> nanocrystals in presence of external field are investigated using electro-absorption (EA) spectra. The effect of the electric field is discussed. This electric field induces absorption spectrum of nanocrystals to broaden and red shift. The first excited state is very sensitive to the external field. The signal magnitude of EA scales is proportional to the square of applied field. It indicates that the electro-optic effect of CdS<sub>0.1</sub>Se<sub>0.9</sub> nanocrystals is due to the Kerr effect and that nanocrystals have third order nonlinear optical polarizability  $\chi^{(3)}$ . (14 References).

Zhuravlev, K. S. and A. Kobitsky (2000). "Highly photoconductive nanocomposites of metallophthalocyanines and conjugated polymers." Advanced Materials **12**(17): 1274-8.

Highly photoconductive devices with very broad absorbance spectra are presented here. These double-layer devices consist of nanocrystals of titanium phthalocyanine dispersed in thin films of a conjugated ladder polymer (BBL). The presence of the BBL increases the spectral range for commercial TiOPc by several hundred nanometers, opening a new spectral range for photosensitive devices. (28 References).

Zimmerman, R. L., D. Ila, et al. (2000). "Effects of modulated electric field form and frequency on the electro-optical properties of CdS<sub>0.1</sub>Se<sub>0.9</sub> nanocrystals." Journal of Applied Physics **88**(3): 1473-5.

The electroabsorption (EA) of CdS<sub>0.1</sub>Se<sub>0.9</sub> nanocrystals was measured under pulse-like modulated fields and recovered both with similar frequency ( $1f$ ) and with double frequency ( $2f$ ) of the applied field. The EA properties and the effects of applied field form and recovered frequency on the EA properties were studied. Electric field induced strong change of absorption ( $10^{-3}$ ) was observed in resonant and nonresonant regions. The EA signal in the resonant region was due to the quantum confined Stark effects and the signal in the nonresonant region was due to the change of local field that resulted in the change of refractive index, the change of absorption. The quadratic dependence of EA signal intensity on the electric fields indicated that the nanocrystals had third nonlinear optical susceptibility. The EA signal intensity measured with  $1f$  mode was about ten times of that measured with  $2f$  mode. Perhaps the lower response measured with  $2f$  mode was due to the measured mode and the different response coefficient in different frequency regions. (11 References).

Zou, B. S. and V. Volkov (2000). "Addition energies and quasiparticle gap of CdSe nanocrystals." Applied Physics Letters **76**(13): 1731-3.

Using atomistic pseudopotential wave functions we calculate the quasiparticle gap, the optical gap and the electron and hole addition energies of CdSe nanocrystals. We find that the quasiparticle gap and the addition energies depend strongly on the dielectric constant of the surrounding material, while the optical gap is rather insensitive to the environment. We provide scaling laws for these quantities as a function of the quantum dot size, and compare our results with recent scanning tunneling spectroscopy experiments. (11 References).

Zsebok, O., J. V. Thordson, et al. (2000). "The composition dependence of the structural and magnetic properties in  $\text{Fe}_{92-x}\text{B}_x\text{Zr}_7\text{Cu}_1$  nanocrystals." Journal of Magnetism and Magnetic Materials **215**(216): 268-71.

Melt-quenched amorphous  $\text{Fe}_{92-x}\text{B}_x\text{Zr}_7\text{Cu}_1$  ribbons were heat treated to the end of the first crystallization stage. The size of the BCC grains decreases from 20 to 6 nm with increasing B content, while the average thickness of the residual amorphous phase stays approximately constant at about 4 nm. The nanocrystalline BCC phase contains 2-4 at% of dissolved B and Zr, which is also reflected in its modified Curie temperature. The average composition of the residual amorphous regions in the nanocrystalline composite was established as  $\text{Fe}_{2/(B_{1-y}\text{Zr}_y)}$ , which makes possible a direct comparison of macro- and nanophases of close composition. (17 References).

Zuk, J., H. Krzyzanowska, et al. (2000). "Defects and their movement in Pb and Ge nanocrystals characterized by ultra-high vacuum high resolution transmission electron microscope." Applied Surface Science **159**(160): 486-91.

Defects in Pb and Ge nanocrystals deposited on thinned Si(110) substrates have been studied by a 200 kV ultrahigh vacuum field emission transmission electron microscope (UHV-FE-TEM). The nanocrystals ranged from 2 to 10 nm in size and contained several types of defects that are observable in the 110 direction. High-resolution transmission electron microscopy (HRTEM) indicated that the most frequently observed defects in these particles are stacking faults, twins and Frank partial dislocations. The possibility of defect formation in Pb nanocrystals is much higher than that in Ge nanocrystals. Frank partial dislocations are detected both near the surface and at the central part of Ge nanoparticles. The structural fluctuation of Pb nanocrystals has been recorded at a video rate of 1/60 s, showing the movement and annihilation of the defects. In Pb nanocrystals, Frank partial dislocations and twin boundaries (TBs) moved within 1 s, while the defects in Ge nanocrystals were stationary. (14 References).

zum Felde, U., M. Haase, et al. (2000). "Hydrothermal synthesis and structural characterization of  $\text{BaTiO}_3$  nanocrystals." Journal of Crystal Growth **219**(3): 269-76.

Barium titanate ( $\text{BaTiO}_3$ ) nanocrystals were tailored by hydrothermal method in the presence of polyoxyethylene (20) sorbitan monooleate (Tween-20) as a polymeric surface modifier at 230 degrees C for 0.5-2 h. The mean particle size was 77.8±23.5 nm by transmission electron microscopy (TEM), and 83±19 nm by laser-scattering particle size analyzer. The narrow particle size distribution of the nanocrystals suggested that further growth and agglomeration of crystals have been hindered by the surface modifier. These nanocrystals were identified as metastable cubic phase BT by X-ray diffractometry (XRD) and differential scanning calorimetry (DSC). However, Raman-active modes of tetragonal phase BT were detected from Raman spectra of as-prepared nanocrystals. Large strains have been observed in TEM dark field image, indicative of a structural deformation from metastable cubic phase to tetragonal phase. The results suggest that the hydrothermally synthesized BT nanocrystals are metastable cubic phase with some tetragonality. (45 References).