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ION BEAM SYNTHESIS OF SEMICONDUCTOR NANOCRYSTALS.

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High-dose ion implantation, followed by thermal annealing, has been shown to provide a versatile technique for creating nanocrystalline precipitates embedded in the surface region of various substrate materials. Motivated by recent interest in the unique optoelectronic properties resulting from quantum spatial confinement, we have successfully formed nanocrystals composed of groups IV (Si, Ge, SiGe), III-V (GaAs, GaP, GaN, InAs, InP), or II-VI (CdS, CdSe, CdTe, ZnS, ZnSe) semiconductors. The structural and optical properties of semiconductor nanocrystals encapsulated in insulating matrices such as SiO_2, Al_2O_3 and Si have been characterized using x-ray diffraction, TEM, optical absorption and photoluminescence measurements.

The nanocrystal size distribution and other physical characteristics depend on the implantation conditions and the subsequent Ostwald ripening process. In SiO_2 substrates, the nanocrystals are nearly spherical and are randomly oriented. In Al_2O_3 (sapphire), they exhibit greater shape anisotropy, facetting, and specific crystallographic alignments. In addition, the microstructure and properties of nanocrystals formed in Al_2O_3 are strongly dependent on the degree of damage introduced into the substrate during implantation, as well as on the order of sequential implantations. Consequently, the size distribution, the crystallographic orientation and lattice structure of the quantum dots can all be controlled by varying the implantation and annealing conditions. In both SiO_2 and Al_2O_3 substrates, the optical absorption and photoluminescence of the nanostructured materials display size-dependent behavior consistent with theoretical estimates of the confinement energy as a function of nanocrystal size.

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