Preparation and Properties of Nanocrystals and Nanocrystal Superlattices: Building with Artificial Atoms.

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Synthetic chemistry allows to production nanometer scale structures which are uniform size to + or - one lattice constant while controlling crystal shape, structure and surface passivation. We combine a high temperature solution phase synthesis with size selective processing techniques to produce organically passivated magnetic and nanocrystals with size distributions less than 5%. These nanocrystals then form the basis for a combined structural and magnetic study of the evolution nanocrystal properties with size. These monodisperse nanocrystals self-organize during controlled evaporation to produce 2D and 3D superlattices (colloidal crystals, opals). The nanocrystals resemble ”artificial atoms” sitting on regular close-packed superlattice sites, each separated by a selected organic spacer. The inter-particle spacing can be varied from intimate contact up to 40Åseparation. The superlattices retain and enhance many of the desirable mesoscopic properties of individual nanocrystals and permit the first systematic investigation of new collective phenomena. Our goal is to study the properties of both the dispersed nanocrystals and assemblies as all major structural parameters are varied (composition, size, and spacing). Procedures have been developed for Co, Ni, and FePt magnetic nanocrystals ans well as for CdSe and PbSe semiconductor quantum dots. Recent explorations of magnetic recording the transport phenomena in magnetic nanocrystal superlattices will be discussed as well as optical studies of the semiconductor nanostructures. Progress in the development of techniques to pattern nanocrystal superlattices, which will be essential to the fabrication of devices incorporating these molecular- scale building blocks, will also be highlighted.