Organization of nanocrystals on a mesoscopic scale: Collective Properties

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Nanocrystal organizations are produced by evaporation of a solution in which nanocrystals are dispersed or through a supercritical regime. The nanocrystals involved in such organizations are either metal (magnetic or not) or oxide. In 2D superlattices they are organized either in a compact hexagonal network, rings or linearly. In 3D superlattices a large variety of organizations are obtained with formations of stripes, dots, labyrinths and hexagons. In this presentation we will describe the various parameters involved in controlling the nanocrystal organizations. Particle-particle and particle-substrate interactions, Marangoni instabilities, surface tension, etc. play a major role in these organizations. The formation of FCC "supra" crystals made of cobalt nanocrystals is demonstrated for the first time. The ordering of such "supra" crystals can be controlled by the experimental conditions.

The physical properties of this nanocrystal assembly differ from either those of isolated particles or the bulk material. Collective properties appear. Anisotropic optical properties are observed when nanocrystals are organized on various substrates. This process wasobserved by reflectivity and is confirmed by polarized electron photoemission spectroscopy with a two-photon mechanism and an enhancement due to the surface plasmon resonance of the nanocrystal film. One SPR peak, at low energy, is attributed to isolated silver nanocrystals whereas that at high energy is due to dipolar interactions induced by the self-organization of silver nanocrystals. Collective properties are also observed with metallic magnetic nanocrystals such as those of cobalt.. They are organized either linearly or form a monolayer. Magnetic properties governed by dipolar interactions markedly differ with the structural order. When monolayers of nanocrystals are deposited on a substrate, the magnetic properties do not depend on the local ordering of the nanocrystals and the latter behave as a well-ordered, square lattice. Conversely, when nanocrystals are arranged linearly, the magnetic properties are similar to those of nanowires.