ELECTRONIC STRUCTURE AND SELF-ASSEMBLY OF SEMICONDUCTOR NANOCRYSTALS ARRAYS

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The electronic level structure of colloidal InAs quantum dots (QDs) in two-dimensional arrays, forming a QD-solid system, was probed using scanning tunneling spectroscopy. The band gap is found to reduce compared to that of the corresponding isolated QDs. Typically, the electron ('conduction-band') ground state red shifts more than the hole ('valence-band') ground state. This is assigned to the much smaller effective mass of the electrons, resulting in stronger electron delocalization and larger coupling between electron states of neighboring QDs compared to the holes. This is corroborated by comparing these results with those for InAs and CdSe nanorod assemblies, manifesting the effects of the electron effective mass and arrangement of nearest neighbors on the band gap reduction. In addition, in InAs QD arrays, the levels are broadened, and in some cases their discrete level structure was nearly washed out completely and the tunneling spectra exhibited a signature of two-dimensional density of states.

In an attempt to achieve long-range order and alignment in CdSe nanorod arrays, various techniques were used. Arrays of close-packed standing rods were formed by applying electric field of ~10^6V/m perpendicular to the substrate during solution evaporation. For the alignment of laying rods, very slow evaporation of nanorods solution (~20 nm/sec) perpendicular to the substrate was found most effective for achieving long-range ordered 2D arrays.