SELECTIVE GROWTH OF PbSe ON ONE OR BOTH TIPS OF COLLOIDAL SEMICONDUCTOR NANORODS

Synthesis and characterisation

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Synthesis and properties of dumbbell-like structures consisting of two different semiconductor materials, CdS or CdSe nanorods as backbones with PbSe spheres on the ends, are discussed. The synthesis reveals tiny distinctions between different facets of the CdS nanorods, as can be seen by the selective formation of dumbbell or matchstick structures.

The interest in nanocrystals is mainly motivated by the diversity of properties they provide. This diversity can be seen in the most drastic way on the semiconductor nanocrystals. By simply changing their size, their optical properties, i.e. their bandgap emission wavelength, can be tuned over a wide range [1]. If additionally one can control their shape [2,3], they become interesting structural elements, and also their optical properties can be tuned.

An additional approach to extend the properties of the particles is to build hybrid structures. The resulting particles will unite the qualities of the single constituents in one object. When fluorescent particles carry a magnetic part [4], an externally applied magnetic field can direct the particles in three dimensions, while they are still fluorescening.

Ultimate control of the hybrid material is achieved when also the position and the orientation of one material with respect the other can be controlled. Colloidal nanoparticles provide an interesting system for this purpose. While they are synthesized, the growth of the particles is tuned by controlling the passivation of the surface. Surfactant molecules are dynamically bond to the nanocrystal surface, allowing the addition and the removal of atoms. The efficiency of the binding is strongly dependent on the crystallographic facet. For instance on one facet the anions can have three unsaturated bonds, on another facet only one, so that these facets are chemically different.

We could demonstrate the selective growth of PbSe on CdSe and CdS nanorods [5]. First the CdX nanorods are grown and purified. Then the PbSe is prepared in the presence of the nanorods, and the nanorods provide a substrate for the nucleation of PbSe. By carefully adjusting the conditions, one can selectively grow the PbSe on the ends of the rods to form dumbbells structures. In the case of the more polar CdS, one can even decide to add the dots only to one end of the rods (see figure).

These particles possess an interesting electronic structure, in which a high bandgap material (CdSe, CdS, $E_g \cong 2eV$) separates two regions of a material with a lower bandgap (PbSe, $E_g \cong 0.5eV$).

References:

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[2] Peng, X., L. Manna, et al. (2000). "Shape control of CdSe nanocrystals." nature **404**(1): 59-61.
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[5] Kudera, S., L. Carbone, et al. (2005). "Selective Growth of PbSe on One or Both Tips of Colloidal Semiconductor Nanorods." Nanoletters **5**(3): 445-449.

Figures:

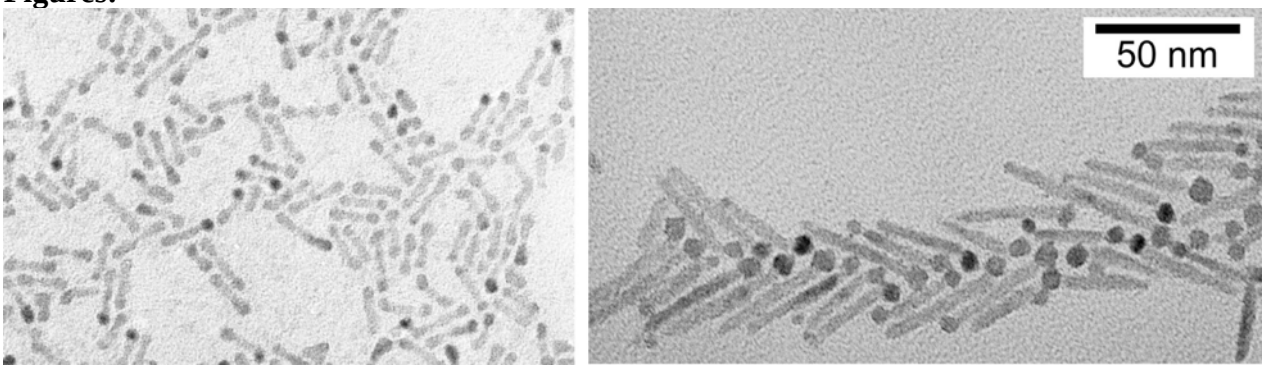

Figure 1: TEM pictures of CdSe rods with PbSe dots on both ends (left) and of CdS rods with only one dot (right)