Optical and Electronic Transport Properties of Solvent Mediated Self-Assembly of Lead Sulfide Nanocrystals

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One of the most intriguing features of colloidal nanocrystals (NCs) besides their electronic quantum confinement properties is their capability to self-assembly [1] to form superstructures. Therefore, there are strong interests for both physicists and chemists to build a new material system from these quasi-atom-like NCs in form of superlattices [2] possessing emerging band structures. Nevertheless, to achieve the intended kinds of NCs, the surface conditions and interaction modes of NCs should be precisely controlled during the self-assembly process.

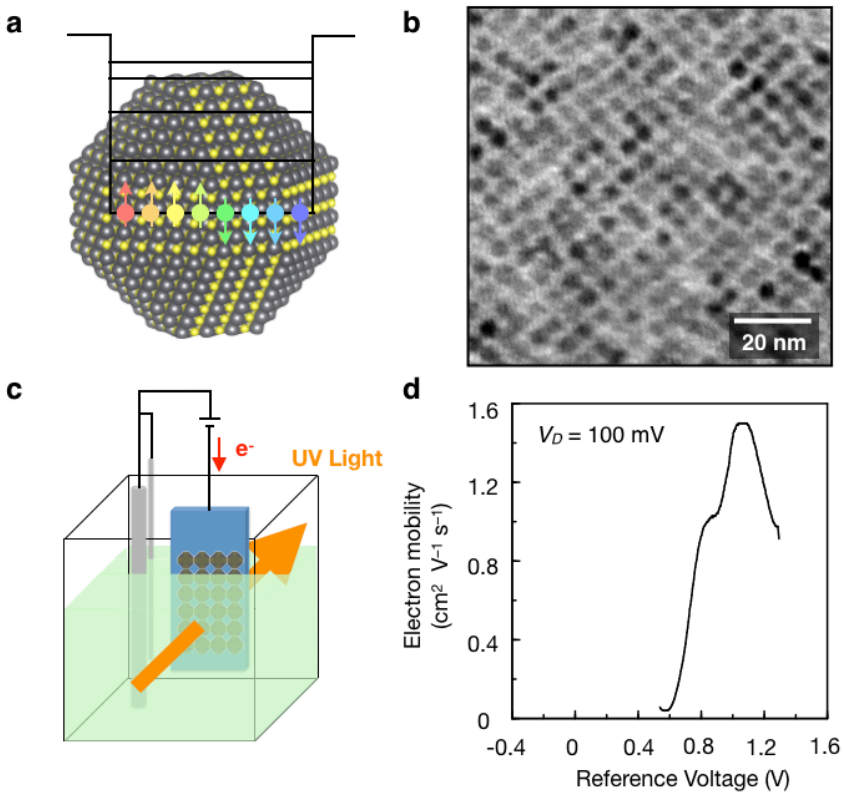

Figure 1. (a) Schematic of $1S_e$ band filling of PbS NCs. (b) TEM image of atomically connected PbS NC square lattice. (c) Schematics of the spectro-electrochemistry set-up. (d) The quantized transport of a PbS NC film, where mobility shows a peak at 1.1 V to give the half 1 S_e band filling of PbS NCs.

Here, we demonstrate a solvent mediated self-assembly of lead sulfide (PbS) NCs through the liquid–air interface assembly technique. We show that PbS NCs could assemble into different structures (random, square lattice and honeycomb lattice) by controlling ligand coverage on the usage of different bottom solvents (methanol, dimethyl sulfoxide (DMSO), acetonitrile, respectively). Furthermore, the quantized transport of atomically connected PbS NC films made by DMSO was firstly and clearly characterized by measuring the electric double layer transistor performance and by spectro-electrochemistry.

Reference

[1] Shevchenko, Elena V., et al. Nature 439.7072 (2006): 55.
[2] Boneschanscher, Mark P., et al. Science 344.6190 (2014): 1377-1380.