Structure, transport and photoconductance of PbS quantum dot monolayers functionalized with a copper phthalocyanine derivative

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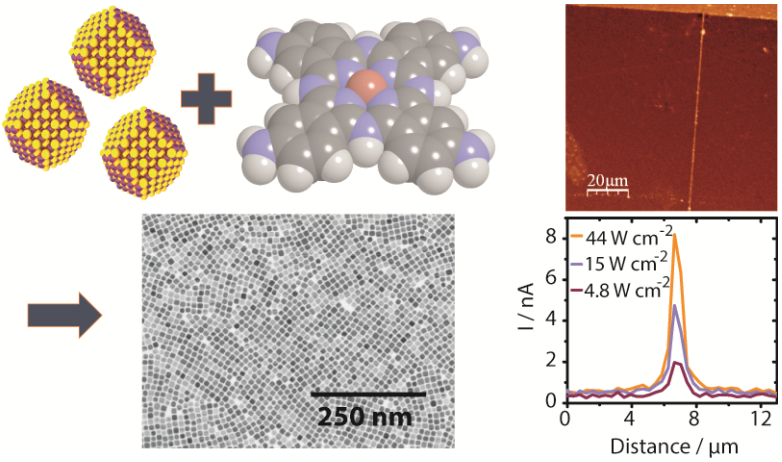
Combining semiconductor nanocrystals (NC) and organic semiconductor molecules into coupled organic–inorganic nanostructures (COIN) gives access to hybrid materials with entirely new properties.[1–5] To name only a few, some key questions in COIN materials involve the nature of the exciton (Frenkel or Wannier-Mott type), the speed of charge transfer across the organic/ inorganic interface, the tunability of electronic coupling via the quantum size effect as well as the efficiency of singlet fission.[6–9] In particular, COINs based on PbS nanocrystals have demonstrated excellent potential for applications as photodetectors.[9–11] Thus, we see great potential for a hybrid material comprising of well-dispersed PbS NCs and phthalocyanines with many frequent interfaces for optoelectronic applications. In addition, the energies of the first excited hole state in PbS NCs and the highest occupied molecular orbital in Phthalocyanines are rather similar which bears the prospect of resonant coupling for holes in this hybrid material.[12,13]

In this work, we simultaneously surface-functionalize PbS nanocrystals with Cu-4APc and assemble this hybrid material into macroscopic monolayers. Electron microscopy and X-ray scattering reveal a granular mesocrystalline structure with strong coherence between the atomic lattice and the superlattice of nanocrystals within each domain. Terahertz spectroscopy and field-effect transistor measurements indicate efficient coupling of holes throughout the hybrid thin film, in conjunction with a pronounced photoresponse. We demonstrate the potential of this material for optoelectronic applications by fabricating a light-effect transistor.



SEM micrograph of a typical prepared thin film and line scan measurement of the confocal photocurrent of such a film.

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