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Designer Nanocrystal Materials for Photovoltaics

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Advances in synthetic methods allow a wide range of semiconductor nanocrystals (NCs) to be tailored in size and shape and to be used as building blocks in the design of NC solids. However, the long, insulating ligands commonly employed in the synthesis of colloidal NCs inhibit strong interparticle coupling and charge transport once NCs are assembled into the solids state as NC arrays. We will describe the range of short, compact ligand chemistries we employ to exchange the long, insulating ligands used in synthesis and to increase interparticle coupling. These ligand exchange processes can have a dramatic influence on NC surface chemistry as well as NC organization in the solids, showing examples of short-range order. Synergistically, we use 1) thermal evaporation and diffusion and 2) wet-chemical methods to introduce extrinsic impurities and non-stoichiometry to passivate surface traps and dope NC solids. NC coupling and doping provide control over the density of states and the carrier type, concentration, mobility, and lifetime, which we characterize by a range of electronic and spectroscopic techniques. We will describe the importance of engineering device interfaces to design NC materials for solar photovoltaics.