Optoelectronic devices from colloidal nanocrystals: prospects and challenges

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Development of nanostructured materials has introduced revolutionary approaches for materials processing and electronic structure engineering. These materials can offer the advantages of crystalline inorganic solids combined with inexpensive solution-based device fabrication. Along these lines, semiconductor quantum dots are explored as the functional elements for printable electronics, light emitting devices, photodetectors and solar cells. All these applications require efficient coupling between individual nanostructured components. I will discuss emerging advances in the surface chemistry of semiconducting nanostructures that are poised to enable advances in additive manufacturing of semiconducting and multifunctional materials. Specifically, I will discuss inorganic linkers that permit electronic coupling between the nanocrystals and new semiconducting "solders" that transform to form high quality inorganic semiconductors. I will also introduce a general chemical approach for photoresist-free, direct optical lithography of functional inorganic nanomaterials (DOLFIN). Examples of patterned materials include metals, semiconductors, oxides, and magnetic and rare earth compositions. No organic impurities are present in the patterned layers, which helps achieve good electronic and optical properties. The conductivity, carrier mobility, dielectric, and luminescence properties of optically patterned layers are on par with the properties of state-of-the-art solution-processed materials. The ability to directly pattern all-inorganic layers using a light exposure dose comparable to that of organic photoresists opens up new opportunities for thin-film device manufacturing.