

Exploring the Interface between Quantum Dots and Organic Hole Transport Layers in Hybrid QD-LEDs

Matthew J. Panzer, Polina O. Anikeeva, Ian M. Rousseau, Jonathan E. Halpert, Mounqi G. Bawendi, Vladimir Bulović

Laboratory of Organic Optics and Electronics and the Department of Chemistry
Massachusetts Institute of Technology

Colloidal quantum dots (QDs) are of great interest due to a unique ability to tune their optical properties based on their size. By incorporating a monolayer of QDs into an organic light-emitting device (LED) structure, the result is a hybrid organic/inorganic QD-LED. We have investigated a variety of methods for preparing intimate bilayers of QDs and hole-transporting organic semiconductor thin films for QD-LEDs. In house-synthesized ZnCdSe QDs (9 nm in diameter) can be microcontact printed in a solvent-free manner onto thermally-evaporated or spin-coated organic thin films using an elastomeric poly(dimethylsiloxane) stamp. Alternatively, the QDs can be pre-mixed with an organic semiconductor solution; in this case, spontaneous phase separation between QDs and the organic molecules following spin-coating of the mixture forms the organic/QD bilayer in a single step. Atomic force microscopy (AFM) imaging is used to examine the average height of the QDs above the organic semiconductor layer. We find that for all of the deposition methods studied, this height is less than the QD diameter. Therefore, a significant degree of interpenetration exists between the organic hole transport and QD emissive layers in our QD-LEDs. We explore the extent to which QD location within the organic semiconductor layer may affect the operation of QD-LEDs by fabricating and characterizing devices that employ different methods of forming the QD/organic semiconductor interface. In addition, a numerical model is developed and used to explain QD-LED operation, including the dependence of QD layer placement within the device structure.