

Heterojunction Photodetector Consisting of Metal-oxide and Colloidal Quantum-dot Thin Films

T. P. Osedach, N. Zhao, L.-Y. Chang, S. M. Geyer, A. C. Arango, J. C. Ho, M. Bawendi, V. Bulović
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We demonstrate a heterojunction photodetector consisting of a metal-oxide charge transport layer and a colloidal quantum-dot (QD) charge-generation layer. To make the device, a metal-oxide semiconductor, SnO_2 , is sputter-deposited over an array of interdigitated gold electrodes. A thin film of PbS QDs is then spin-coated over the structure (see Figure 1a). The optical and electrical characteristics of the device can be optimized independently through the modification of these two layers.

The metal-oxide and QD layers form a type-II hetero-interface (Figure 1b) suitable for dissociating photogenerated excitons. Exciton dissociation at the interface results in the generation of holes in the QD layer and electrons in the metal-oxide layer. A bias corresponding to a field of $\sim 10^4$ V/cm is applied across the electrodes to facilitate carrier collection. The increased electron density increases the metal-oxide film conductivity, which in turn manifests an increase in lateral current through the device. A plot of the spectrally resolved external quantum efficiency is shown in Figure 2, with high efficiency response matching the spectral response of quantum-dot absorption.

This work builds on previous reports from our laboratory in which an organic/organic photodetector [1] and an organic/QD photodetector [2] were described. The present device can be driven at reduced bias and extends spectral sensitivity into the infrared region. The unique ability to independently tune the optical and electrical characteristics of these structures makes them a valuable platform with which to study the physical processes at QD hetero-interfaces.

REFERENCES

- [1] J. Ho, A. Arango, and V. Bulović, "Lateral organic bilayer heterojunction photoconductors", *Applied Physics Letters*, August 2008.
- [2] T. P. Osedach, S. M. Geyer, J. C. Ho, A. C. Arango, M. G. Bawendi, V. Bulović, "Lateral heterojunction photodetector consisting of molecular organic and colloidal quantum dot thin films", *Applied Physics Letters*, January 2009.

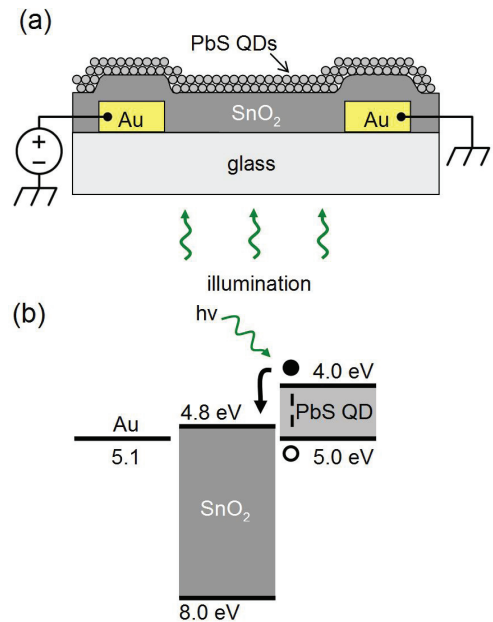


FIGURE 1: (a) Schematic of the device structure. (b) Energy band diagram. Excitons dissociate at the interface between the metal-oxide film and the quantum dots.

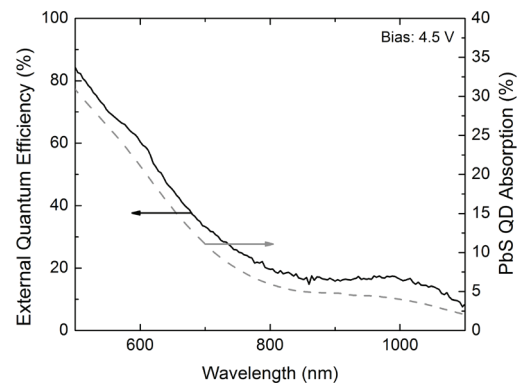


FIGURE 2: External quantum efficiency spectrum (solid) and PbS QD absorption (dashed).