High Efficiency Room Temperature HgTe Colloidal Quantum Dot Photodiodes

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Colloidal quantum dots offer an inexpensive, solution-processed alternative to conventional, crystalline material devices for mid-infrared photodetection. Photodiodes of size 1 mm by 1 mm made using HgTe quantum dots previously reached the background limit at cryogenic temperatures but suffered from a 30-fold decrease in signal near room temperature. This was attributed to a decreased carrier diffusion length at higher temperatures, where the thermal carrier concentration is high. An alternative explanation based on a simple circuit model suggests that it is instead due to the effects of a finite series resistance, coming mainly from the semitransparent indium tin oxide electrode.
Using microfabrication, devices were prepared which use an insulating polymer to restrict the active device area to 50 by 50 microns. This decrease in size increases the shunt resistance to be greater than the series resistance even at room temperature. It was also found to be important to employ a guard ring in the final design to only collect carriers within this restricted area, which limits crosstalk between nearby devices and allows one to measure the true resistance of the devices. As a result of these alterations, greater signal is collected, leading to 15% EQE and a four-fold improvement in the detectivity in excess of 10^9 Jones near room temperature for photodiodes with a cutoff at 4 microns.

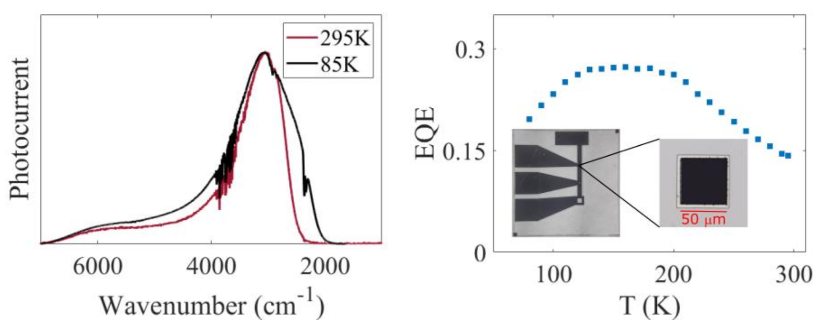

Figure 1: Photocurrent spectrum of HgTe pn photodiode (left) and associated external quantum efficiency (right). Inset is a picture of the device substrate. [1]

[1] J. C. Peterson, P. Guyot-Sionnest, Room-Temperature 15% Efficient Mid-Infrared HgTe Colloidal Quantum Dot Photodiodes. ACS Applied Materials & Interfaces. Article ASAP, (2023).

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