Integrating Colloidal Quantum Dot Photodiode with Graphene Phototransistor

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The realization of low-cost photodetectors with high sensitivity, high quantum efficiency and fast photoresponse in the visible and short-wave infrared remains one of the challenges in optoelectronics. Two classes of photodetectors that have been developed are photodiodes and phototransistors, each of them with specific drawbacks. Here we merge both types into a hybrid device by integrating a colloidal quantum dot photodiode atop a graphene phototransistor[1]. Graphene has extraordinary electronic properties, including ultrahigh mobility at room temperature, which enables fast response times. Colloidal quantum dots exhibit unique optical properties of spectral tunability and high absorption coefficients. Our new detector (Fig. 2) overcomes the limitations of the hybrid phototransistor in terms of speed, quantum efficiency and linear dynamic range[2]. Along with outstandingly high responsivity, we report quantum efficiencies in excess of 70% (Fig. 2), linear dynamic range of 110 dB and bandwidth of 1.5 kHz. The resulting technology is extremely promising for photodetection in visible and, more importantly, short-wave infrared (SWIR) range. Photosensing in these ranges lies at the heart of security and military surveillance, night vision applications, automotive vision systems for driver safety, food and health care inspection. We have developed various prototype devices to demonstrate the abilities of this technology.

References

[1] Konstantatos et al. Hybrid graphene–quantum dot phototransistors with ultrahigh gain. Nature Nano., 7 (2012), 363–368.

[2] Nikitskiy et al., Integrating an electrically active colloidal quantum dot photodiode with a graphene phototransistor. Nature Comm., 7 (2016), 11954

Figures

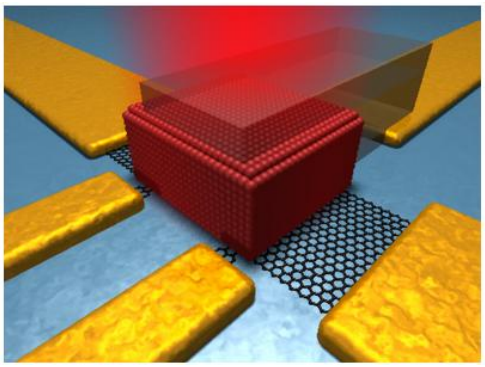

Figure 1: Integrated graphene – colloidal quantum dots photodetector design

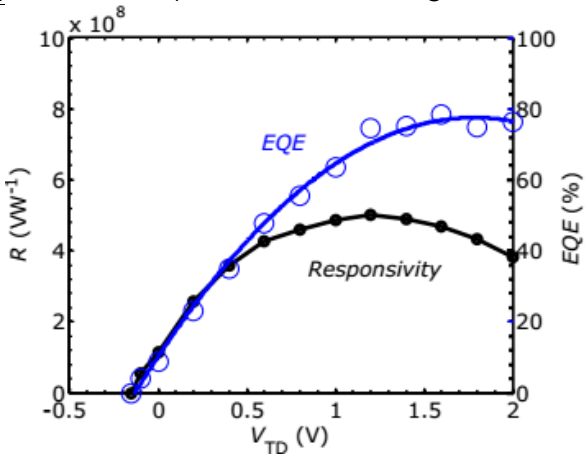

Figure 2: Responsivity and EQE of the integrated devices as a function of top-electrode voltage