Electrical Polarization Induced Ultra-high Responsivity Photodetectors Based on Graphene and Graphene Quantum Dots

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Abstract

Hybrid quantum dot-graphene photodetectors have recently attracted substantial interest owing to their remarkable performance and low power consumption. However, the performance of the device greatly depends on the interfacial states and photogenerated screening field. As a consequence, the sensitivity is limited and the response time is relatively slow. In order to circumvent these challenges, herein, we have designed a composite graphene and graphene quantum dot (GQD) photodetector on Lead Zirconate Titanate ($Pb(Zr_{0.2}Ti_{0.8})O_3$) (PZT) substrates to form a ultra-sensitive photodetector over a wide range of illumination power. Under 325 nm UV light illumination, the device shows sensitivity as high as 4.06×10^9 AW^{-1}, which is 120 times higher than reported sensitivity of the same class of devices. Plant derived GQD has a broad range of absorptivity and is an excellent candidate for harvesting photons generating electron-hole pairs. Intrinsic electric field from PZT substrate separates photogenerated electron-hole pairs as well as provides the built-in electric field that causes the holes to transfer to the underlying graphene channel. The composite structure of graphene and GQD on PZT substrate therefore produces a simple, stable, and highly sensitive photodetector over a wide range of power with short response time, which shows a way to obtain high performance optoelectronic devices.

References

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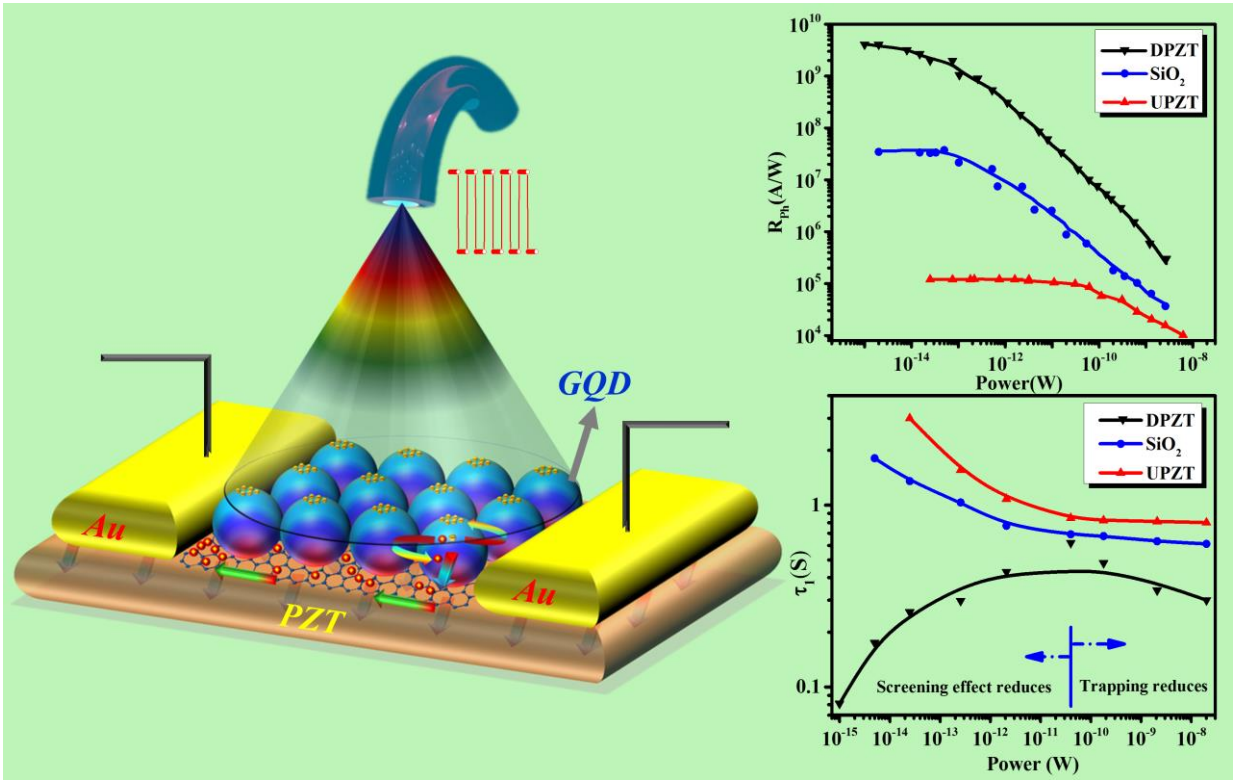

The permanent polarization of piezoelectric substrate (PZT) parallel to the built-in electric field (DPZT) in the composite graphene and graphene quantum dot photodetector device assists efficient transfer of photogenerated holes to the graphene channel thus enhancing the photoresponsivity more than 100 times with ten times faster response compared to the device on SiO_2 substrate. In contrast, opposite PZT polarization in UPZT devices abates the photoresponsivity with slower response time.