Hybrid graphene-graphene quantum dots photodetectors

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Solution processing of graphene and related materials (GRMs) is a scalable approach for devices fabrication. However, photodetectors (PDs) prepared from solution processed GRMs have limited responsivity~mA/W, mainly due to the presence of defects and trap states[1,2]. Here we show that larger responsivities can be realized by integrating graphene quantum dots (GQDs) via inkjet printing on CVD graphene channels. Our PDs show higher responsivity than those based only on graphene, where graphene absorbs only 2.3%[3], limits PD responsivity[4], or only GQDs[5]. Our PDs exploit photogating[6], whereby the photogenerated electrons are injected from the GQDs to the graphene channel, leaving behind uncompensated holes. These induce additional electrostatic gating on graphene, resulting in a higher build-in potential between graphene and GQDs, Fig.1, leading to larger charge transfer to the graphene channel. GQDs are prepared by the microwave-assisted hydrothermal method[5]. Glucose is dissolved in deionized water, followed by aqueous ammonia. The solution is then heated in a microwave oven for 5 min to make GQDs. An ink is then formulated by mixing GQDs with Ethylene glycol. The PDs operate in the 350-650nm range with external (internal) responsivity~740A/W (~10^4 A/W) at 488nm, Fig.2. The photoconductive gain, i.e. the ratio of trapped carrier's life time (measured from the PD response time) in GQDs to the transit time in the graphene channel, is up to 10^7. The specific detectivity $(R_{ext}A_{PD}{}^{1/2}/(2eI_{dark})^{1/2})$ where R_{ext} is external responsivity, A_{PD} the PD area and I_{dark} the dark current is~10^{10} Jones. The responsivity is six orders of magnitude higher than inkjet printed devices made with liquid-phase-exfoliated MoS_2 [7,8].

References

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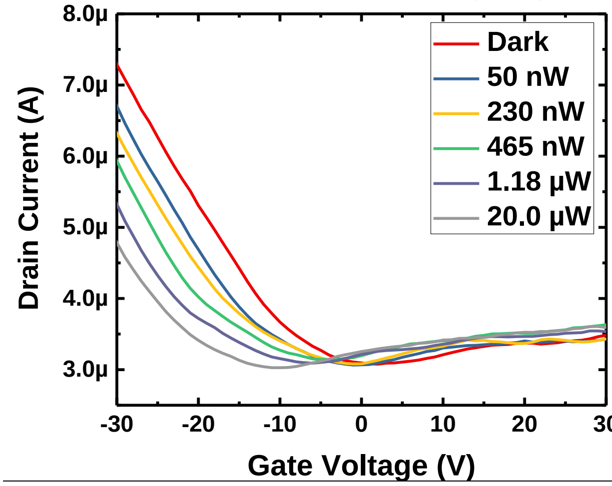

Figure 1: Transconductance at different illumination powers at 488nm.

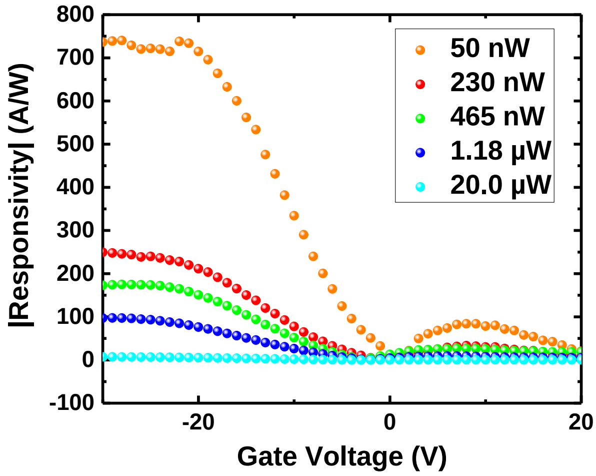

Figure 2: External responsivity as a function of back gate at 488 nm for different intensities.