SAND2019-11591C

The Deeply Depleted Graphene-Insulator-Semiconductor Junction: A Versatile Approach Towards Light Sensing Across the Electromagnetic Spectrum

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The deeply depleted graphene-insulator-semiconductor (D^2GOS) junction has been shown to be a promising device structure for photon detection, due to its high responsivity, signal to noise ratio and ability for direct readout of individual pixels. One of the unique advantages of this architecture is its ease of exchangeability to other semiconductor absorber material, with the major caveat of realizing a functional device is to be able to deplete the semiconductor in the graphene-insulator-semiconductor (GOS) stack. This allows the opportunity to design GOS junctions to selective absorption cutoffs by choosing bulk semiconductors with the appropriate bandgaps. In this work, recent progress in demonstrating the D^2GOS detectors across the mid-Infrared to gamma ray spectrum is discussed, using a variety of semiconductor absorbers (InSb, InAs, InGaAs, Si, and CdZnTe), along with the challenges associated with working with each absorber type. It is shown that the semiconductor/insulator interface defect density and graphene mobility are the two critical determinants in improving the D^2GOS junction's integration lifetime, responsivity and signal to noise ratio. Reduction of defects the semiconductor/insulator interface are demonstrated by employing surface passivation of the semiconductor through the deposition of a thin high-quality oxide, specific to each semiconductor. This is shown to dramatically reduce the dark charge generation in the device, resulting in improvements in integration lifetime, responsivity and signal to noise ratio. Finally, the device performance between 77 K and 300 K are compared, demonstrating an increase in performance at lower temperatures, due to further reduction of dark charge generation.

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