# Graphene-black phosphorus photodetectors

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Heterostructures can be assembled from liquid phase exfoliated (LPE) layered materials (LMs) [1] via inkjet printing with tens μm [1] resolution and controllable thickness [2] to make photodetectors (PDs) [2]. However, LPE materials are unfavourable compared to chemical vapor deposited and mechanically exfoliated LMs, due to the presence of traps [1], which results in low responsivities ~mA/W [1,2]. Here, we fabricate printable PDs based on graphene and black phosphorus (BP) inks (Fig. 1) showing high responsivity (>300A/W) and broadband (0.4-2.8 μm) detection (Fig. 2). LPE BP is used due to its broadband optical absorption (400-3500nm) [3] and its tuneable layer dependent direct bandgap [3]. Photoexcited holes from BP are injected into graphene, leaving behind uncompensated electrons, resulting in photogating. We achieve a photoconductive gain (ratio of carrier life time measured from the device response time to transit time [4])~$10^7$ ,broadband (400-2800nm), and fast (~50ms) response time. The dark current shows a 1/f component, with a noise equivalent power~1.88x$10^{-10}$W/√Hz, and a detectivity~$10^7$ Jones. The responsivity is at least three orders of magnitude higher than previously reported ink-jet printed BP PDs operating at the same spectral range [5], and the operating wavelength range (up to 2.8 μm) is ~0.5 μm longer compared to state of the art hybrid LMs-colloidal quantum dots PDs [6,7].

References

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Figures

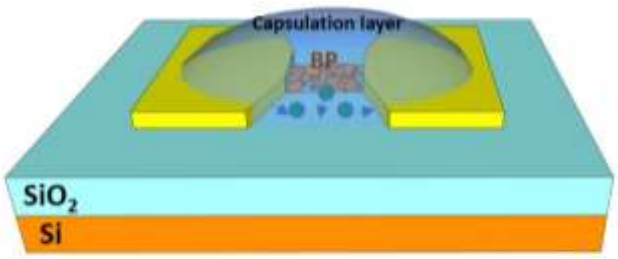


**Figure 1:** Schematic of hybrid graphene-BP PDs.

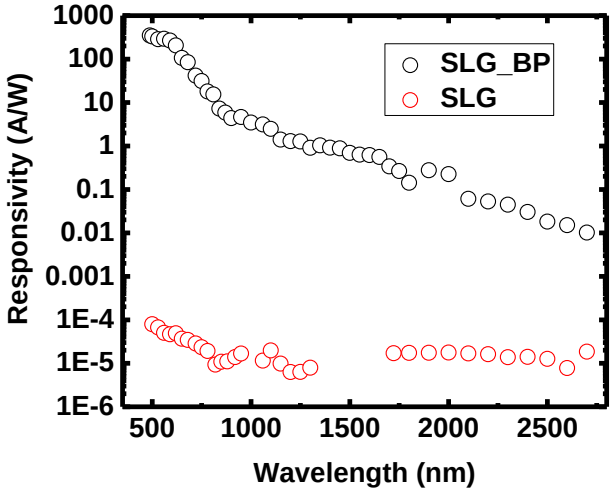


**Figure 2:** Responsivity of hybrid graphene-BP as function of excitation wavelength.