Near-Infrared Resonant Cavity Enhanced Graphene/Silicon Photodetectors

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Abstract

Due to recent breakthroughs, silicon (Si) photonics is now the most active discipline within the field of integrated optics and, at the same time, a present reality [1]. Silicon photodiodes are excellent detectors at visible wavelengths, but the development of Si photodetectors (PDs) operating at near-infrared wavelengths is not straightforward as Si is transparent at wavelengths larger than 1.1 µm. Many Si-based photodetectors (PDs) for 1550 nm have been proposed for telecom and datacom applications, these typically rely on a waveguide configuration [2], in which optical confinement contribute to enhanced light absorption. On the contrary, for many applications as free-space optical communications (FSO), coherence optical tomography (OCT), and light-radars (LIDAR), vertically-illuminated PDs are required.
We report on vertically-illuminated Si-graphene Schottky photodetectors operating at both 1550nm and 2000nm and integrated with a 200 nm-thick Si optical microcavity obtained starting by a silicon on insulator (SOI) substrate. The photocurrent generation is based on the internal photoemission effect, where photoexcited carriers from graphene are emitted to Si over the Schottky barrier that exists at the graphene-Si interface [3]. This device is able to enhance the graphene absorption thanks to the effect of optical microcavity obtained by depositing a metal mirror on the back of the Si substrate. The rectifying Schottky diode behaviour is shown from the IV curve, where both series resistance and Schottky barrier, are extrapolated. Thanks to the presence of the optical microcavity, we demonstrate an external responsivity higher than 20mA/W; this value is more than 4 times higher than state-of-the-art of vertically-illuminated Si-based PDs [3]. Finally, our device shows the potentialities to work also at wavelengths longer than 1550 nm, indeed an experimental maximum internal responsivity (photogenerated current-absorbed optical power ratio) of 24 mA/W at 2000nm, has been achieved for a similar device (Fig. 1).
Our devices pave the way for developing high responsivity hybrid graphene/Si free-space illuminated PDs for FSO, OCT and LIDAR

References

[1] M. Paniccia, Nature Photonics, 4 (2010) 498–499
[2] I. Goykhman et al.,Nanoletters, 16 (2016), 3005-3013, (2016)
[3] M. Casalino et al., Laser & Photonics Review, 10 (2016), 895-921

Figures

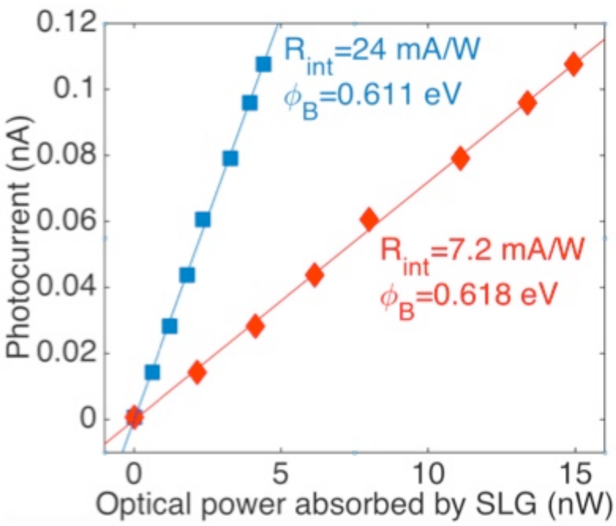

Figure 1: Measured photocurrent vs absorbed optical power at 2000nm