Design optimisation of plasmonic enhanced waveguide integrated graphene p-n junction photodetector for telecom wavelengths

J. E. Muench[1], D. Zhang[1], J. Wang[1], H. Watson[1], S. Akhavan[1], A. Ruocco[1], V. Sorianello[2], M. Romagnoli[2], A. C. Ferrari[1], I. Goykhman[3]

[1]*Cambridge Graphene Centre, University of Cambridge, 9 JJ Thomson Avenue, Cambridge CB3 0FA, UK*
[2]*Consorzio Nazionale per le Telecomunicazioni (CNIT), Photonic Networks and Technologies National Laboratory, 56127 Pisa, Italy*
[3]*Micro- and Nanoelectronics Research Center, Technion – Israel Institute of Technology, Technion City, Haifa 320000, Israel*

jem227@cam.ac.uk

Graphene integration with silicon photonics [1-4] holds great promise for telecom and Datacom applications. For graphene-based on-chip optoelectronic links, power-efficient waveguide integrated photodetectors (PDs) are among the key components. PDs based on the photo-thermoelectric (PTE) effect [3] could directly generate a photo-voltage without dark current [4], thus removing the need of a transimpedance amplifier.
Here, we present optical and thermal simulations of plasmonic enhanced graphene p-n junction PDs coupled to silicon (Si) and silicon nitride (SiN) waveguides. Two metal gates form a p-n junction in graphene and simultaneously support plasmonic guiding in a metal-dielectric-metal structure (Fig. 1a). The light is coupled from the optical waveguide mode to a gap plasmon mode, resulting in enhanced light-graphene interaction and a "localized" hot electrons distribution that contributes to a higher PTE effect (Fig. 1b).
Using full FDTD and thermal simulations, the expected external responsivity is ~ 25V/W at 1550nm, one order of magnitude higher than currently achieved with waveguide integrated PTE-based graphene PDs [4].

References

[1] I. Goykhman et al., Nano Lett., 16 (2016) 3005
[2] V. Sorianello et al., Nat. Photonics, 12, (2018) 40
[3] F. H. L. Koppens et al., Nat. Nanotechnol., 9 (2014) 780
[4] S. Schuler et al., Nano Lett., 16 (2016) 7107

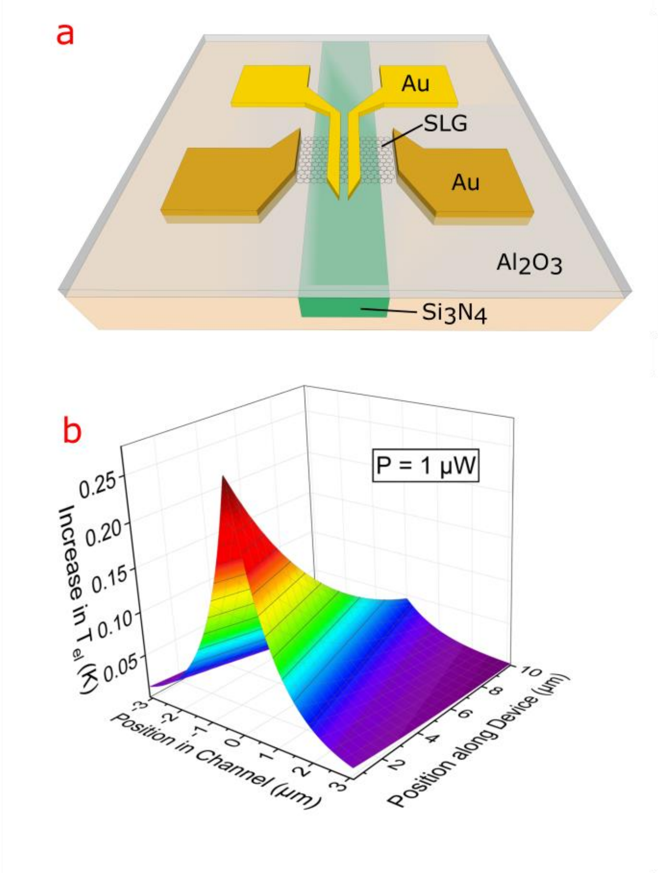

Figure 1: a) Schematic of a plasmonic enhanced waveguide-integrated graphene PD. b) Simulated increase in electronic temperature in the graphene channel.