Interface and substrate engineering in graphene/silicon Schottky junction photodiodes

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Graphene/silicon (Gr/Si) Schottky junction photodetectors (PDs) provide an efficient hybrid platform for light detection applications [1]. High optical transmittance of graphene enables high-responsivity photodetection comparable to commercial Si photodiodes in the visible range. Also, even though limited (~2.3 %), broadband optical absorption in graphene enables extension of the spectral responsivity into fibre-optic telecommunication bands beyond the wavelength range of Si photodiodes [2].

Here we demonstrate further improvements in the figures of merit in Gr/Si PDs through substrate and interface engineering. Employment of a thin (~2 nm) native oxide layer at the Gr/Si interface as a tunneling barrier improves photovoltage responsivity as well as photon detectivities in such devices by decreasing the leakage current by an order of magnitude [3].

Response speeds of Gr-Si PDs fabricated on bulk silicon Si substrate (~0.5 mm) show strong wavelength dependence due to the depth-dependent photogeneration of charge carriers in the substrate. The response speed in Gr/Si PDs lags behind commercial Si photodiodes especially for longer wavelengths (λ > 500nm) due to dominating contribution of speed limiting diffusion currents to the overall photocurrent. We report a significant improve in the response speed approaching cut-off frequencies of f_c ~ 1 GHz in Gr/Si junctions fabricated on silicon-on-insulator (SOI) substrate with a photoactive Si thickness of 10 µm and less [4]. Furthermore, we demonstrate the control of spectral responsivity and angular dependence in Gr/Si PDs by integration of micro-optical elements through surface patterning [4].

References

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Figures

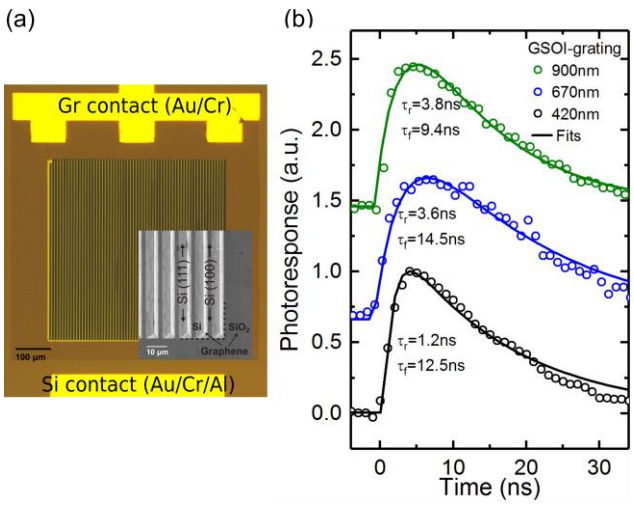

Figure 1: a) Optical image of the Gr/Si Schottky junction PD fabricated on an SOI substrate. The inset shows the scanning electron microscope (SEM) image of the grating structure formed by V-shaped grooves.
b) Time-resolved photoresponse of the device under illumination at various wavelengths.