Graphene-Silicon-On-Insulator (GSOI) Schottky Diode Photodetectors

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Supporting Information

I. RAMAN CHARACTERIZATION

After completion of the fabrication process, Raman spectroscopy was carried out to investigate the quality of graphene on the devices using a Renishaw InVia instrument ($\lambda = 532$nm). Fig.1a) and Fig.1b) show the Raman spectra of graphene on the oxide frame and in the silicon window of the GSOI-planar and GSOI-grating device, respectively. The sharpness of the 2D peaks and the high ratio of 2D to G peak intensities ($I_{2D/G}$) in the spectra indicate the high quality of monolayer graphene[1]. A negligible D peak observed at $\sim 1344\text{cm}^{-1}$ in Fig.1a) is indicative of the presence of a small amount of defects, presumably due to CVD-graphene transfer. Graphene in the silicon window exhibit an additional broad peak appearing around $\sim 1430\text{cm}^{-1}$ which originates from the silicon substrate[2].

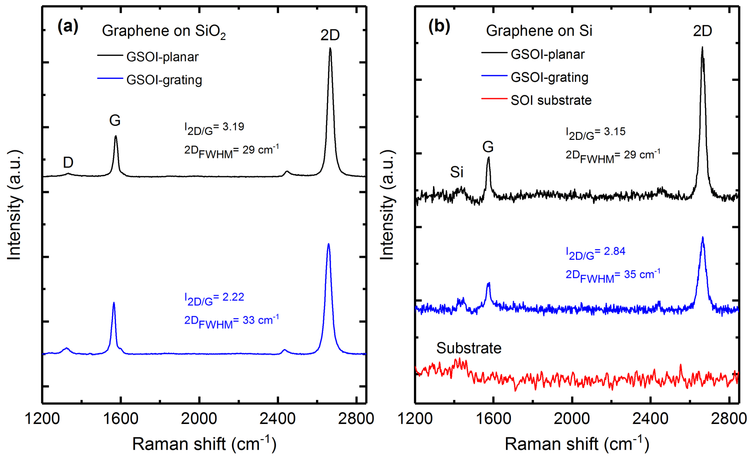

FIG. 1: Raman spectrum of graphene on the GSOI-planar and GSOI-grating devices after completion of the fabrication process. a) Raman spectrum of graphene on the SiO_2 frame. b) Raman spectrum of graphene in the silicon window together with the spectrum of the SOI substrate surface without graphene.

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II. SURFACE TOPOGRAPHY

Surface topography of the GSOI-grating device examined with surface profilometry (Dektak). Fig2 shows approximately 3μm deep and 5.5μm wide inverted pyramids with (111) facets separated by un-etched planar (100) lines of $\sim$3μm width. The asymmetry in the profile is due to tip convolution with the structured surface.

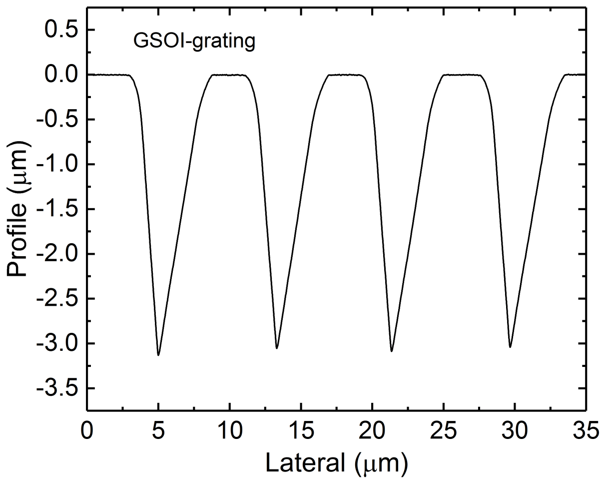

FIG. 2: Surface topography of GSOI-grating device measured with a profilometer.

III. I-V CHARACTERISATION

Experimentally observed I-V curves can be described by the Shockley equation [3].

$$\mathrm{I} = \mathrm{I_0}\left[\exp\left(\frac{\mathrm{q(V - IR_S)}}{\mathrm{nk_BT}}\right) - 1\right] \quad (1)$$

with

$$\mathrm{I_0} = \mathrm{AA^*T^2}\exp\left(\frac{-\mathrm{q}\phi_\mathrm{B}}{\mathrm{k_BT}}\right) \quad (2)$$

V is the applied bias voltage, $\mathrm{R_S}$ is the series resistance of the diode, n is the diode ideality factor, $\mathrm{k_B}$ is the Boltzmann constant, q the electron charge, and T is the temperature in Kelvin. $\mathrm{I_0}$ is the saturation current or leakage current under reverse bias, where, A is the Schottky diode contact area, $\mathrm{A^*}$ is the effective Richardson constant ($112\mathrm{A^{-2}K^{-2}}$ for n-type silicon) and ϕ_B is the Schottky barrier height (SBH) for a given voltage.

The forward bias region of the J-V curves taken in the dark were least-squares fitted with eq.1 in order to extract the ideality factor (n), series resistance (R_S) and saturation current ($\mathrm{I_0}$) of the devices.

IV. OPTICAL SIMULATIONS

Optical simulations were carried out with COMSOL employing the Wave Optics Module. A unit cell of the GSOI-grating device based on a total width of 8.5μm ($\mathrm{w_{groove}} = 5.5\ \mu$m + $\mathrm{w_{flat}} = 3\mu$m) and active silicon height $\mathrm{t_{Si}} = 10\mu$m, BOX height $\mathrm{t_{BOX}} = 1\mu$m, handle silicon height $_{\mathrm{Si-handle}} = 10\mu$m and air as incident medium was utilized as material stack into which the V-groove has been modeled. Periodic boundary conditions were enforced on the left and right hand side of the geometry respectively. The refractive index of silicon was chosen from ref.[4] and the refractive index of SiO_2 set to $n_{SiO_2} = 1.47$. The GSOI-planar device is based on the same geometry, excluding the V-groove.

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