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# Asymmetric Dual Grating Gate Graphene-FETs for Direct Detection of THz Radiation

Over the last years, graphene has been of great interest for the development of THz (or far-infrared) detectors due to its unique optical and electronic properties such us high carrier mobility [1]. Plasmonic graphene based field effect transistors (GFET) have become as promising devices for an efficient detection of terahertz (THz) radiation [2] allowing different THz applications such as security and inspection screening, medical imaging and high-speed wireless communication [3]. Moreover, vertically stacked heterostructures of encapsulated graphene with hexagonal-boron nitride (h-BN) have opened a new realm for ultra-high electron mobility devices[4].

Here we report the fabrication and characterization of graphene-based FETs (GFETs) as THz detectors. The devices were fabricated with exfoliated graphene and h-BN and by a dry-transfer method based on PPC polycarbonate being employed to fabricate the h-BN/Graphene/h-BN heterostructures on a $SiO_2$/Doped-Si substrates. The obtained heterostructures were characterized by Raman spectroscopy to test and ensure a high crystallographic quality. Raman spectrum of the h-BN/Graphene/h-BN heterostructures revealed a consistent I(2D)/I(G) intensity peak value ratio higher than 6. Drain and source contacts were defined as 1D edge contacts. The 1D edge contact resistances on the graphene-based FETs were found to be in the order of 2 kΩ. Two metal grating footnote patterns were laterally shifted in respect to each other to introduce an asymmetry into the design of the asymmetric dual grating gates graphene FETs (ADGG-GFETs) structure. Figure 1(a) shows the false color SEM image of one of the ADGG-GFET fabricated and characterized. The geometrical parameters shown in Figure 1 (b) of the grating are the following: $L_{G1}$ = 750 nm, $L_{G2}$ = 1.5 µm, $d_1$ = 500 nm, $d_2$ = 1µm, $s_1$ = 500 nm and $s_2$ = 1 µm. The ADGG-GFET was placed into an optical cryostat and characterized at temperatures from 300K down to 4K. The doped-Si substrate was used as a back gate. Electron and hole mobility values above 100,000 $cm^2V^{-1}s^{-1}$ and 40,000 $cm^2V^{-1}s^{-1}$ where found at 4K and room temperature respectively. The device was excited with an electronic source at two different frequencies of 0.15 THz and 0.3 THz at temperatures from 4K up to 300K. The modulated THz beam was collimated and focused onto the ADGG-GFET placed in the optical cryostat by a parabolic mirror and an optical lens. The induced photocurrent generated by the THz radiation was measured on the drain contact by using the lock-in technique while the source contact was grounded. No DC current or voltage bias was applied to the drain contact. A direct detection of THz radiation by using the ADGG GFETs was found with biasing either back or top gates. Figure 2 shows the obtained photocurrent signal when the ADGG-GFET was excited with 0.3 THz radiation. The device exhibits a clear photocurrent under the THz excitation. A maximum of photocurrent around 2.5 nA was measured for $V_{TOP\text{-}GATE}$ = -0.2V, close to the Charge Neutrality Point.

## References


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## Figures

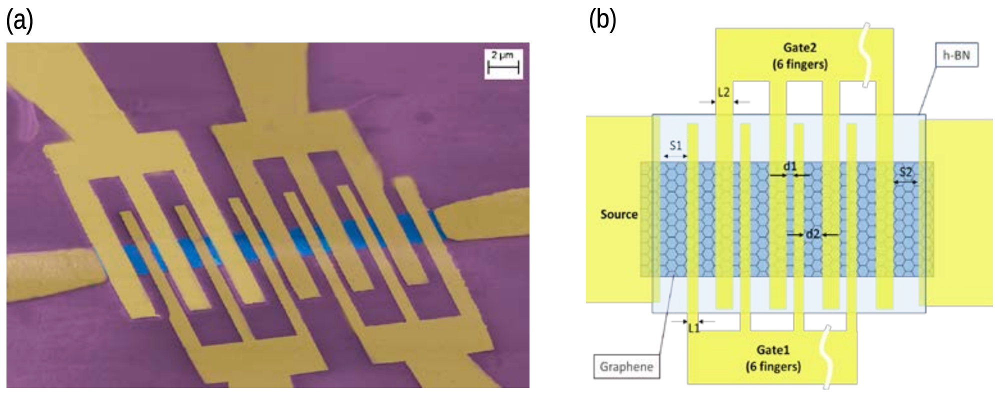


**Figure 1:** False color tilted SEM image of an ADGG-GFET device (a) and schematic top view of the AGDD-GFET (b).

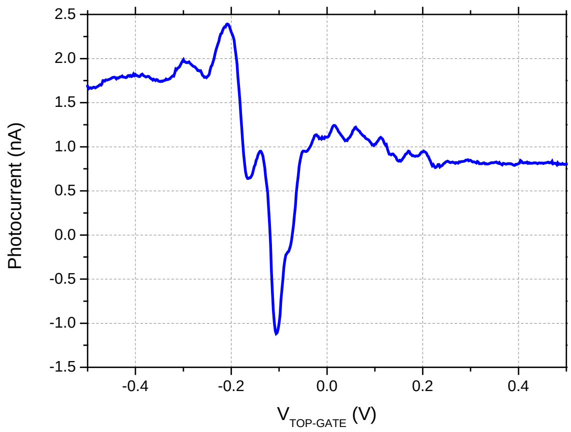


**Figure 2:** Measured photocurrent obtained as a function of the top-gate voltage at 4.2 K when the device was illuminated at 0.3 THz.