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Graphene-silicon Schottky heterojunctions for optoelectronic applications

Antonio Di Bartolomeo[1], Giuseppe Luongo[1], Laura Iemmo[1], Francesca Urban[1] and **Filippo Giubileo[2]**
[1]Università di Salerno, Italy
[2]CNR-SPIN, Italy

The graphene/silicon (Gr/Si) junction has been the subject of an intense research activity both for the easy fabrication and for the variety of phenomena that it allows studying. It offers the opportunity to investigate new fundamental physics at the interface between a 2D semimetal and a 3D semiconductor, and holds promises for a new generation of graphene-based devices such as photodetectors, solar cells and chemical-biological sensors. A Gr/Si junction with defect-free interface exhibits rectifying current-voltage (I-V) characteristics, which are the result of the formation of a Schottky barrier, as in traditional metal-semiconductor (M/S) Schottky diodes. The vanishing density of states at the graphene Dirac point enables Fermi level tuning and hence Schottky barrier height modulation by a single anode-cathode bias. When the Gr/Si junction is used as a photodiode, graphene acts not only as anti-reflecting and transparent conductive layer for charge transport to the external circuit, but it functions also as active material for light absorption and electron-hole generation and separation. Although most of the incident light is converted to photocharge into Si, the absorbance in graphene enables detection of photons with Si sub-bandgap energy through internal photoemission over the Schottky barrier. Photo charges injected over the Schottky barrier, under high reverse bias, can be accelerated by the electric field in the depletion region of the diode and cause avalanche multiplication by scattering with the Si lattice, thus enabling internal gain. The Gr/Si junction forms the ultimate ultra-shallow junction, which is ideal to detect light absorbed very close to the Si surface, such as near- and mid-ultraviolet. In this talk, we present the electrical characterization and the photoresponse of two types of Gr/Si devices, shown in figures 1 (b) and (c). Although due to different mechanisms, on both devices we demonstrate photo-responsivity exceeding 2.5 A/W that is competitive with present solid-state devices. We attribute it to the contribution of charges photogenerated in the surrounding region of the flat junction or to the internal gain by impact ionization caused by the enhanced field on the nano tips.

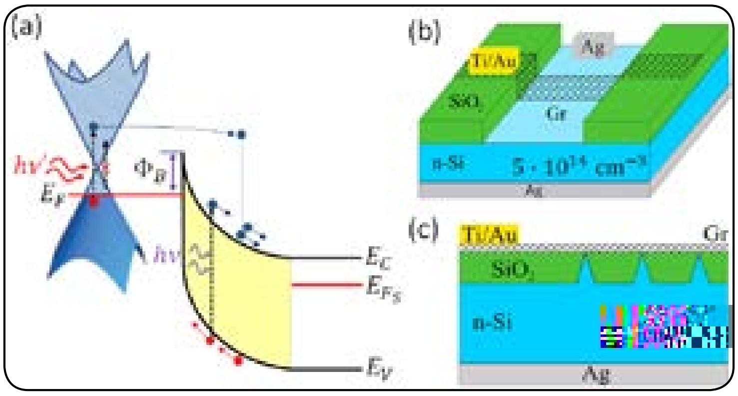

Figure 1: (a) Photodetection in a Gr/Si junction. Photons with energy lower than the Si bandgap, $E_G = E_C – E_V$ but higher than the Schottky barrier Φ_E (Φ_B < hv < E_G) can be absorbed in graphene. Emitted over the Schottky barrier, such electrons can originate avalanche multiplication through impact ionization. (b) Graphene on flat Si substrate ("flat Gr/Si" junction) and (c) graphene on patterned Si (Gr/Si-tips junction)

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Biography

Antonio Di Bartolomeo received MS and PhD degree in Physics from Salerno University, Italy. He worked as System Engineer for Creative Electronic Systems (CH) and as Device Engineer for ST Microelectronics (AZ) and Intel Corporation (IE). He started his career in experimental high-energy physics in the CHORUS and ALICE experiments at the CERN (Geneva, CH). Currently, he works as Associate Professor of Experimental Condensed Matter Physics at the Salerno University, Italy. He has been Visiting Scientist at IHP Microelectronics, Frankfurt Oder, Germany, 6 (CoAsss.et thGeorgetown (University)73.6 (,)0.7W)3718.3ashitiAnt, DC. (He haco-a

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