Graphene/pentacene Van der Waals interfaces: from macroscopic devices to the nanoscale

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Since the discovery of the monolayer Graphene (Gr), the interest in layered heterostructures and van-der-Waals compounds is increasing. Combining OSC materials with layered materials as Gr have a lot to offer in term of interface physics and provide new behavior for electronics and optoelectronics.[1,2] We used CVD Gr transferred onto SiO_2/Si substrates on which we evaporated pentacene (P5) molecules from monolayer to thick (400 nm) films. We show (TM-AFM) the growth of flat islands (1-2 ML thick) of pentacene on 420K-annealed Gr, whereas 1D nanowire-like (ca. few µm long and ca. 10-30 nm height) islands are grown on 720 K-annealed Gr surfaces. In these nanostructures, the P5 molecules are lying flat on the Gr (Raman spectroscopy Fig. 1a).[3] We follow the electron transport properties from macroscopic P5/Gr diodes (with lithographed electrodes), P5 islands and down to single ML junctions by conductive-AFM. We observe a gradual evolution from a rectifying diode behavior (Fig. 1b) with a voltage-dependent Schottky barrier height for macroscopic devices[4,5] and the thicker islands, to an almost symmetric current-voltage behavior in the molecular-scale devices (Fig. 1b- 15 nm). The transition between these two behaviors occurs for P5 islands of about 15-20 nm thick. Voltage dependent Schottky barrier heights (thick P5), molecular orbitals (few MLs devices) are determined by fitting the appropriate analytical electron transport model (modified thermoionic emission[6], Landauer-Buttiker model[7]) on these data. Data on Au/P5/Al diodes (for different P5 thickness) were also compared with literature (Fig. 1c).[8]

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Figures

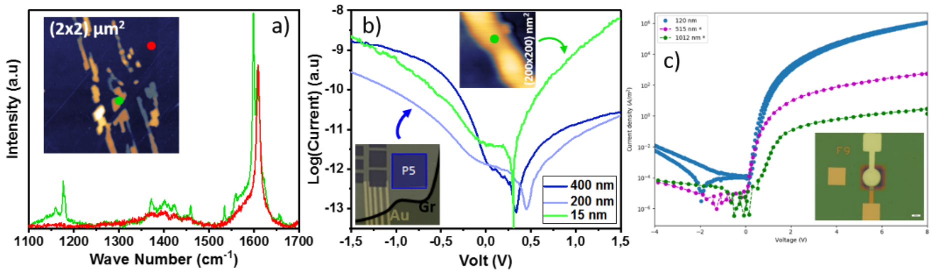

Figure 1: *Figure 1: a) Raman spectra for Gr(red line) and P5 on Gr(Green line). The inset is a TM-AFM image showing the growth of P5 on Gr. b) Log(Current)-Volt Curves of 15nm, 200nm and 400nm of Pentacene thin-films. For the same measurement conditions the evolution of the electrical behavior for different film thickness is highlighted. c) I-V characteristics of Pentacene/Al diodes of this work (blue) compared to thicker devices [8]. The inset shows the fabricated Au/Pentacene/Al structure on a SiO_2 substrate.*