Work function of metal-doped CVD graphene by Kelvin Probe Force Microscopy

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Abstract
In graphene-based electronic devices, graphene employed as a channel material or as an electrode material always contacts a metal, and the charge transfer between graphene and metal is a critical parameter because it strongly affects the performance of the devices.
The optimization of the metal-graphene contact resistance depends on the metal, on the conduction mode of graphene on metal, and on graphene work function. Specifically, a high work function of graphene (p-doping) leads to better injection efficiency from metal to graphene while for FET applications the decrease of the graphene work function (n-doping) is highly desirable because it leads to an increase of the field emission current by over two orders of magnitude [1-2].
Therefore, a better understand and study of the work function of graphene under metal, W_{G-M}, is essential for the realization of graphene-based electronic devices.
Despite the significance of the work function, mainly theoretical calculations have been reported and a few direct observations on how the work function of graphene is affected by different metals.
Here, we report on the measurement of the work function of graphene deposited by Chemical Vapor Deposition (CVD) in contact with different metals using the Kelvin probe force microscopy (KPFM).
We use an Autoprobe CP (Thermomicroscope) to record the sample topography and the amplitude-modulated Kelvin probe force microscopy (KP-EFM) signal in a single-pass mode. [3-4]. We used a conductive tip, Au-coated Si, with a frequency of $\sim$ 80kHz to scan in non-contact mode [5-6] the sample surface, following its topography. The oscillating potential, Vac, applied to the tip is 5V at a frequency ω of 13kHz. The samples were electrically connected to the ground of the microscope (the sample stage). All measurements were collected in air at room temperature. Prior the imaging, all samples are cleaned and measured soon after the deposition, in order to improve the reproducibility and accuracy of the SP measurements that are affected by the surface of the sample (contaminations, uniformity or charging) [7]. All measurements are repeated in different points, using samples and in time in order to set the baseline for the sensitivity of our KPEFM measurements.
Specifically, we present results on metal-on-graphene (figure 1a) and graphene-on-metal (figure 1b).
We discuss the effect of the metal thickness, patterning and nanostructure on the graphene work function variation. We consider metals (Au, Ag, Al, Ga) able to induce p-type and n-type doping of graphene.

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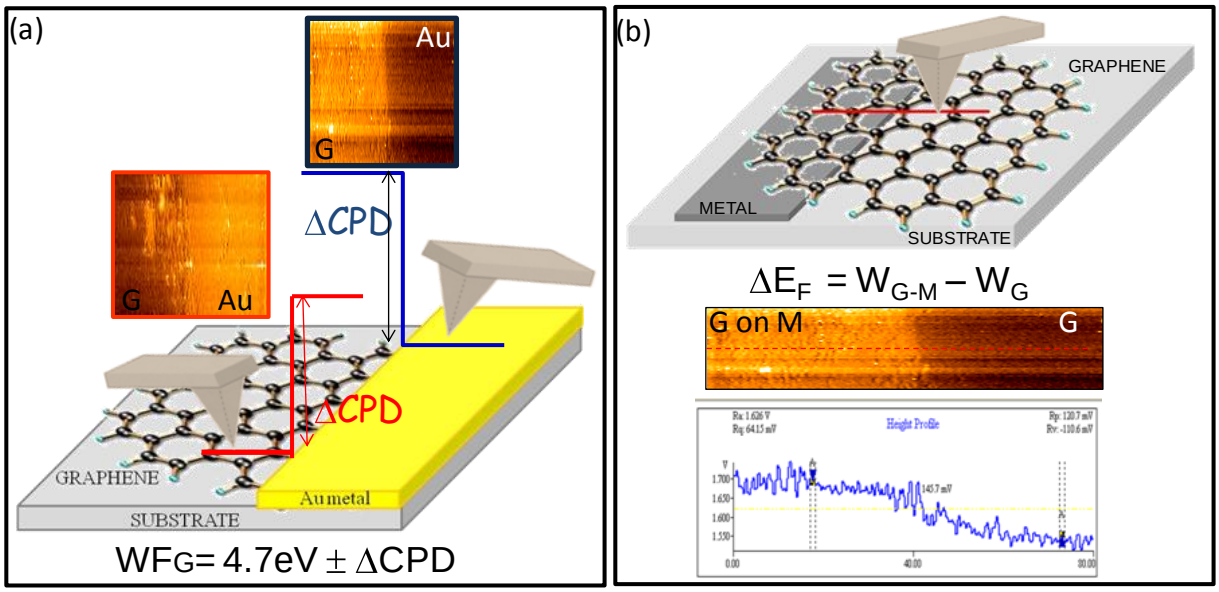

Figure 1: Configurations used during the KPFM measurements for (a) metal-on-graphene and (b) graphene-on-metal.