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Making Graphene and Graphene Layers Visible on ITO

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Abstract - We developed a method for making graphene on Indium tin oxide (ITO) visible to optical microscopy. We produce graphene samples using mechanical exfoliation of natural graphite and deposit the graphene on ITO/SiO_2/Si substrate. We can identify mono- and bilayer graphenes using an optical microscope and the number of layers is confirmed with micro-Raman spectroscopy and atomic force microscopy.

Single layer graphene (SLG) and few layer graphene (FLG) are currently obtained through two main processes: epitaxial growth and mechanical exfoliation [1]. With mechanical exfoliation of graphite, SLG and FLG can be visualized by using an optical microscope if prepared on top of Si wafers with a SiO_2 film of certain thickness [2]. In addition, with Raman spectroscopy it is possible to unambiguously determine the number of graphene layers [3]. Graphene films are alternatives to replace ITO electrodes in organic light emitting diode [4]. We develop a method for making SLG and FLG on Indium tin oxide (ITO) visible for optical microscopy and the number of layers determined by Raman spectroscopy.

First we have a SiO_2 film with thickness of 300 nm on top of a Si wafer. ITO is then grown on this substrate by RF-Sputtering during 5 min and 40 W, resulting a final ITO thickness of about 30 nm. Afterwards we use mechanical exfoliation of natural graphite to produce graphene samples and deposit them on ITO. In Fig. 1 we show that identification of SLG (red arrow) and bilayer graphene (blue arrow) was possible with an optical reflection microscope using white light illumination and without narrow band filters and a 100x objective. The number of layers is then attested with micro-Raman spectroscopy (Fig. 2) ratifying the attendance of SLG and FLG on ITO. The Raman spectrum is obtained with a Horiba Jobin-Yvon T64000 spectrometer in backscattering configuration and a 100x objective. Excitation laser energy is 2.41 eV (514 nm) and the laser beam spot is ~1 μm^2 on the sample. Atomic force microscopy analysis is carried out on a JPK instrument using the tapping mode at ambient temperature to help on the identification of the SLG and FLG. The arrows in Fig. 1 also indicate the position of the laser spot during the spectrum acquisition. In Fig. 2.a) we see a typical SLG spectrum where the intensity ratio G/G' ~0.5 and the G' peak at ~2677 cm^{-1}. Fig. 2 b) shows the bilayer graphene spectrum, with intensity ratio G/G' ~1.17 and the G' peak at ~2703 cm^{-1}.

SLG and FLG visibility can be explained by Fresnel theory based on the universal optical conductance of graphene layer. This theory reveals a dependence of optical contrast with the thickness and index of refraction of substrate, so that not only SiO_2 substrates can be used to make graphene visible [2, 5]. In this study, for instance, we show the possibility of making SLG and FLG visible on ITO.

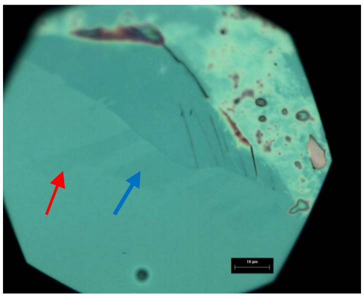
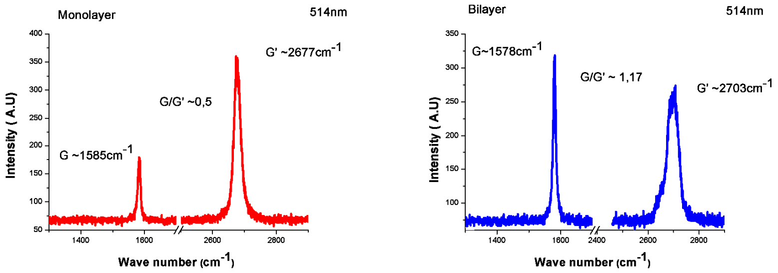


Figure 1: Optical microscopy image of a monolayer and bilayer graphene (red and blue arrows respectively).



(a) (b)

Figure 2: Raman spectra showing the first-order G peak and second-order G′ peak of **a)** monolayer and **b)** bilayer graphenes using a 514 nm excitation laser. Note the typical strong G’ peak of a monolayer in contrast to the one of a bilayer.

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