High visibility of graphene layers using quantitative optical phase imaging

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Graphene has recently attracted much attention as it is considered as one of the promising 2D materials for generating novel technological applications due to its interesting properties. The number of graphene layers is a very important parameter for most applications. Thus, a quick and convenient technique to identify the number of graphene layers is of great interest especially for samples prepared by micromechanical cleavage. Several methods have been proposed to count graphene layers such as Raman spectroscopy, atomic force microscopy, and optical reflectance detection. However, these methods still suffer from some limitations like time consuming, precision on the number of layers and damaging the analyzed surface.
In this work we report a direct and accurate optical method using quantitative phase imaging using a high spatial-resolution wave front sensing device to image graphene layers and any other 2D material. A commercial wavefront sensing device, based on quadriwave lateral shearing interferometer (SID4-HR) is mounted onto a lateral video port of homemade inverted microscope to recover simultaneously the phase and intensity signals. The measured phase shift gives a quantitative information about the optical thickness and then the layers number of the studied material [1].

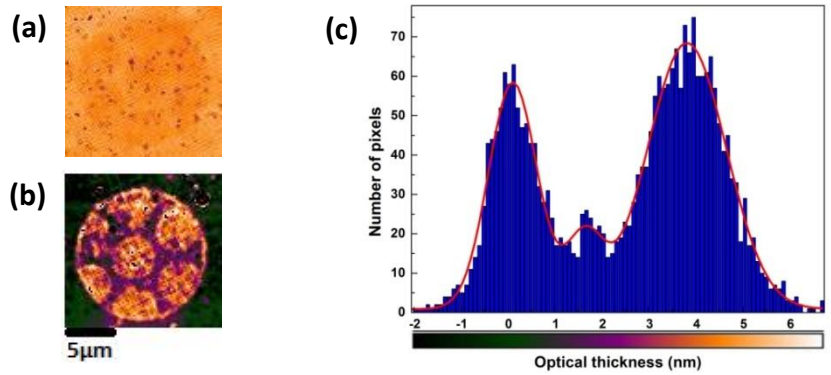

Figure 1: (a) Intensity and (b) phase shift images of structured graphene layers deposited on glass substrate. (c) Histogram plot of the phase shift image.

In order to show the accuracy of our method, we have been interested, first, in the study of structured graphene films deposited layer by layer on a glass substrate by CVD technique. As shown in figure 1.a, the contrast of the intensity image is very low and it has been greatly enhanced by the phase shift measurement (figure 1.b). One can see three different colours corresponding to the substrate, the first structured graphene layer (discs of 5 µm diameter) and the second structured graphene layer (discs of 16 µm diameter). The statistics of this image represented in figure 1.c shows three Gaussian peaks equally distant by about 2±0.3 nm. This distance corresponds to the optical thickness of a monolayer of graphene.
This method has been also applied to characterize random graphene samples fabricated by micromechanical cleavage and other 2D materials like MoS_2. Our results show the acuity and sensitivity of this method to characterize and identify any 2D material.

References:
[1] P. Bon, G. Maucort, B. Wattellier, S.Monneret,"Quadriwave lateral shearing interferometry for quantitative phase microscopy of living cells," Opt. Express 17, 13080 (2009).