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BACKSIDE ABSORBING LAYER MICROSCOPY: WATCHING GRAPHENE CHEMISTRY

S. Campidelli,¹ R. Abou Khachfe,² K. Jaouen,¹ R. Cornut,¹ B. Joussetme,¹ D. Ausserré³ and V. Derycke¹

¹ LICSEN, NIMBE, CEA, CNRS, Université Paris-Saclay, CEA Saclay 91191 Gif-sur-Yvette Cedex, FRANCE.

² Institut Universitaire de Technologie de Saida, Université Libanaise, Saida, LEBANON.

³ Institut des Molécules et Matériaux du Mans (UMR 6283), Université du Maine, Avenue Olivier Messiaen, 72000 Le Mans, FRANCE.

The rapid rise of 2-dimensional nanomaterials implies the development of new versatile, high-resolution visualization and placement techniques. For example a single graphene layer becomes observable on Si/SiO₂ substrates by reflected light under optical microscopy because of interference effects when the thickness of silicon oxide is optimized.^{1,2} However, differentiating monolayers from bilayers remains challenging and advanced techniques like Raman mapping, atomic force microscopy (AFM) or scanning electron microscopy (SEM) are more suitable to observe graphene monolayers. The two first are slow and the third one is operated in vacuum so that in all cases real-time experiments including notably chemical modifications are not accessible.

Here, we introduce a new wide-field optical microscopy technique: Backside Absorbing Layer Microscopy (BALM), which uses Anti-Reflection and Absorbing (ARA) layers to achieve extreme contrast at an interface.³ It combines the vertical *sub*-nm sensitivity of an AFM with the versatility and real-time imaging capabilities of an optical microscope. We demonstrate that this technique allows imaging very easily 2D materials like graphene oxide and MoS₂, both in air and in water, with extremely high resolution (see Figure). In addition, it also provides chemical contrast: we are notably able to clearly differentiate GO flakes from reduced graphene oxide flakes (r-GO) even though they only differ by the density of oxygen functions. BALM also permits to monitor surface reactions *in situ*. As examples, we followed the deposition of nanoparticles on GO and we took advantage of the high-resolution and real-time imaging of BALM to study the dynamics of the adsorption of small molecules on GO. Finally we show that, thanks to its favorable geometry, the BALM technique can be naturally combined with other techniques, notably electrochemistry and that its use is not limited to 2D materials.

References

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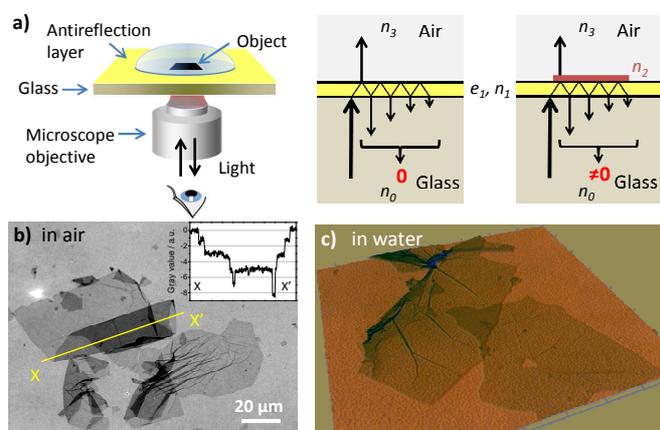


Figure: a) Representation of the BALM geometry: the image is obtained in reflected light microscopy; the contrast is enhanced for the part of the sample which is very close to the surface and the half-space on the top remains accessible. b) BALM image of GO imaged in air; inset: light intensity as a function of the number of layers. c) BALM image of GO obtained in water (RGB, with topographical representation of the total reflected intensity).

corresponding author : stephane.campidelli@cea.fr