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# Backside Anti-Reflecting Absorbing Layer Microscopy for in situ Graphene Imaging and Modification

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Two-dimensional nanomaterials and their association into 2-D heterostructures have been extensively studied for the last couple of years. Thus, the development of new, versatile, high-resolution visualization and placement techniques is highly desirable. It is well known that a single layer of graphene can be observed under optical microscopy on Si/SiO<sub>2</sub> substrates because of interference effects when the thickness of silicon oxide is optimized.<sup>1,2</sup> However, differentiating monolayers from bilayers remains a challenge and advanced techniques like Raman mapping, Atomic Force or Scanning Electron Microscopy (AFM, SEM) are more suitable to observe monolayers of graphene. Raman mapping and AFM are relatively slow and SEM is operated in vacuum so that in all cases real-time experiments including chemical modifications are not accessible. Therefore, the development of techniques that combine the large scale and speed of SEM, the topological information of AFM and the simplicity optical microscopy may greatly facilitate the study of nanomaterials.

In our group, we are interested in particular forms of graphene derivatives which are graphene oxide (GO) and reduced graphene oxide (r-GO). While a single layer of graphene absorbs 2.3% of the incident light,<sup>3</sup> graphene oxide monolayer exhibits a weaker light absorption that makes it almost impossible to distinguish on Si/SiO<sub>2</sub> surface. In 2007, Ruoff and co-workers were able to observe directly GO flakes using confocal microscopy; they even obtained higher contrast for GO than for graphene on Si/SiO<sub>2</sub>. For that they optimized a substrate by depositing silicon nitride layers from 60 to 70 nm on silicon.<sup>4</sup> Here we introduce a novel optical microscopy technique based on the use of Anti-Reflecting and Absorbing (ARA) layers yielding to ultra-high contrast reflection imaging of graphene monolayers in air or in water. We name this technique “Backside Absorbing Layer Microscopy” (BALM) and we illustrate its efficiency by in-situ imaging graphene oxide (see Figure) and its chemical modification.



**Figure.** Wide field optical images of graphene oxide flake.

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