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(U*) Making graphene visible - On leaves

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The experimental discovery of graphene has largely relied on making it visible by optical microscopes when deposited on silicon wafers coated by a 300-nm SiO2 layer, leading to constructive optical interference in the visible photon energy range [1]. While such a discovery has enabled exciting new areas of research, so many of them do not use graphene on 300-nm SiO2/Si. Thus, methods to image graphene on complex surfaces are of paramount importance. Here, we are targeting biophysics applications in which graphene flakes need to be deposited and imaged on leaves. This is complicated by the structure of the leaves, in which a layer of variable thickness (epidermis) overlaps to random globular objects (chloroplasts) leading to incoherent light scattering. We have devised a method to characterize graphene flakes on the surface of plant leaves via laser scanning confocal optical microscopy (SCOM) in the visible wavelength range (532 nm). Multilayer graphene flakes suspended in water with the aid of a surfactant (ribonucleic acid from Torula Utilis) were deposited on the surface of leaves of Ceratophyllum Demersum, which were imaged cross-sectionally using SCOM. Three-dimensional SCOM images were compared with computer simulations of the same (performed with an ad hoc designed routine running under Python) to model multiple reflections of light from chloroplasts, the leaves' epidermis, and graphene as a function of the number of layers. These simulations indicate that, depending on the number of layers, graphene does affect the multiple reflections form underlying chloroplasts at different in-depth levels within a leave, from a few tens nm up to several hundred nm, thus providing a method to determine the thickness of the graphene flake. These results are essential to visualize and characterize graphene layers on leaves, further enabling the possible investigation of graphene as an assisting element in the process of photosynthesis.

[1] P. Blake et al. "Making Graphene Visible". Appl. Phys. Lett. 91, 063124 (2007)

Keyword-1

Graphene

Keyword-2

Plants

Keyword-3

Confocal Microscopy

Primary author: BURAGINA, Teresa

Co-authors: VIDISH, Denys; FANCHINI, Giovanni; IDRIS, Munirat; WONG, Victor

Presenter: BURAGINA, Teresa

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