RAMAN OPTICAL TRAPPING OF GRAPHENE

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Dimensionality plays a special role in nature. From phase transitions to transport phenomena, two-dimensional (2d) systems often exhibit a strikingly different behavior from those with higher or lower dimensionality. Graphene [1] is the prototype 2d material and, as such, has unique mechanical, thermal, electronic, and optical properties, already proven outstanding for both fundamental research and applications [2,3]. Here we demonstrate optical trapping of individual graphene flakes in aqueous dispersion [4]. This enables the investigation of their Raman spectra in the optical trap. The modification of the Raman spectra due to colloidal metallic nanoparticles [7] of different shapes [8] added to the dispersion are investigated both by micro-Raman and Raman tweezers analysis.
Graphite is exfoliated by ultrasonication in a water-surfactant solution, followed by ultracentrifugation. (Fig. 1). We do not use any functionalization nor oxidation, in order to retain the electronic structure of pristine graphene in the exfoliated layers [9]. We use dihydroxy sodium deoxycholate (SDC) as surfactant. We then place 75 microlitres of dispersion in a chamber attached to a piezo-stage with 1nm resolution. Optical trapping (Fig. 2a) is obtained by focusing a helium-neon (633 nm) laser through a 100X oil immersion objective (NA=1.3). The latter is coupled to a spectrometer through an edge filter. This allows us to use the same laser light both for optical trapping and for Raman scattering, realizing a Raman optical tweezers to directly probe the structure of the trapped flake. A typical Raman spectrum of trapped flakes measured at 633 nm is plotted in Fig. 2b. Besides the G and 2D peaks, this has significant D and D' intensities, and the combination mode D+D'$\sim$2950 cm^{-1}. The large intensity of the D peak in Fig. 2b is assigned to the edges of our submicrometer flakes [10]. We note that the 2D band, although broader than in pristine graphene [5], is well fitted by a single Lorentzian lineshape. Thus, even if the flakes are multilayers, they are electronically almost decoupled.

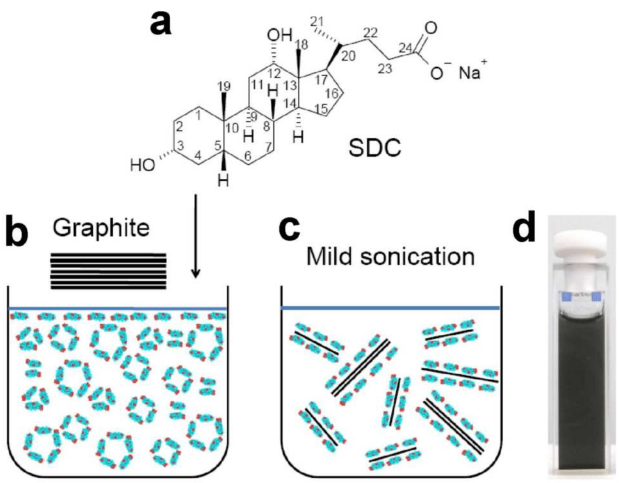

Figure 1: Graphite exfoliation. (a) Molecular structure of SDC. (b) Schematic illustration of the graphite exfoliation process. (c) A mild ultrasonication produces exfoliated mono- and few-layer graphene encapsulated by SDC. (d) Photograph of the as-prepared dispersion.

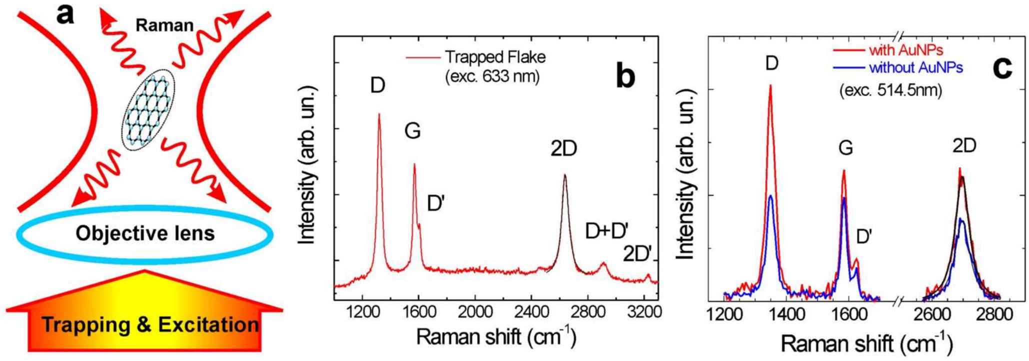

Figure 2: (a) Experimental setup. The same optics is used to trap graphene in dispersion and collect the Raman signal that is sent to a spectrometer. (b) Raman spectrum of an optically trapped flake for 633 nm trapping and excitation wavelength. (c) Micro-Raman spectra of graphene dispersions with and without gold nanoparticles for 514.5nm excitation.

References

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