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Graphene based devices for very high resolution imaging of solutions and bio-molecules

In-situ dynamic imaging of nanometer scale objects in solution is important for many applications, particularly in biological systems, where live motion is usually associated with wet environments. However, wet environments and very high resolution imaging are often incompatible, since typical electron microscopy requires high vacuum conditions. To circumvent these limitations we developed a wet cell with an atomic graphene window which allows us to combine high dynamic resolution with liquid environments. An example of such as device is shown in the figure 1, where moving nanoparticles are imaged at sub-5nm resolution using a Scanning Electron Microscope (SEM) [1]. The nanoparticles undergo thermally driven Brownian motion and are visible under the atomic graphene membrane. The use of nanoparticles is of interest as biomarkers because of their high compatibility with many functionalization groups (antibodies, viruses) [2]. Moreover, chemical selectivity of the nanoparticles can be obtained thanks to Energy Dispersive X-ray Spectroscopy (EDX). This allows the use of different markers in the same liquid environment. The imaging window membrane (monolayer graphene) can influence the environment. Indeed, residues from the fabrication process affects the adhesion properties, particularly of the nanoparticles. Hence, controlling the quality of graphene and the subsequent processing is crucial. The use of single crystals, where defects can be better controlled, is therefore an interesting avenue in Chemical Vapor Deposited (CVD) graphene [3].

References

[1] Dynamic imaging of Au-nanoparticles via scanning electron microscopy in a graphene wet cell, W Yang, Y Zhang, M Hilke, W Reisner - Nanotechnology, 26, 315703 (2015).

[2] Au nanoparticles target cancer, PK Jain, IH El-Sayed, MA El-Sayed, Nano Today 2 (1), 18-29 (2007).

[3] Time evolution of the growth of single graphene crystals and high resolution isotope labeling, E Whiteway, W Yang, V Yu, M Hilke - arXiv:1509.01579, (2015).

Figures

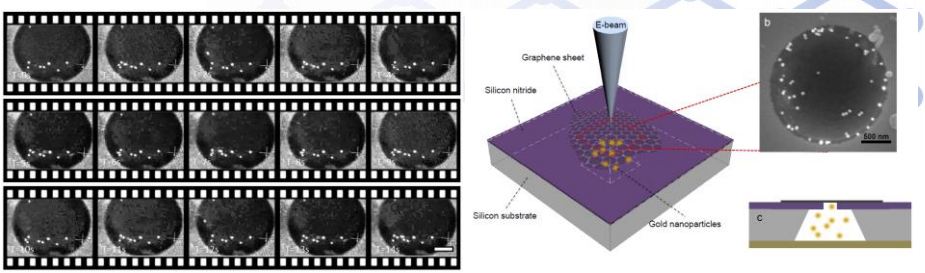

Figure 1: The left image shows a time-series of moving Au-nanoparticles in a graphene wet-cell device shown on the right. The scale bars indicate 500 nm.