Sensitivity Enhancement by Graphene as Receptor Layer in Surface Plasmon Resonance Biosensors

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Graphene and related materials advanced from fundamental research to a variety of applications, e.g. in biosensing. The local plasmon enhancement and the ability to interact with molecules via π-stacking makes graphene attractive as receptor layer in surface plasmon resonance (SPR). The most commonly used methods to fabricate graphene are CVD and chemical exfoliation. Graphene prepared by CVD results in higher sensitivity compared to reduced graphene oxide prepared by chemical exfoliation in detection of small molecules by SPR [1, 2]. A possible reason might be found in the lower number of defects and the larger extension of the sp^2 hybridized Carbon lattice in CVD-graphene. Alternatively, graphene can be fabricated by shear-exfoliation of graphite. This yields in graphene flakes with low number of defects and controlled flake size from 300 to 800 nm [2]. The almost defect free nature of the flakes was validated by Raman spectroscopy [3].

When applied as receptor layer in SPR, shear exfoliated graphene was compared to CVD graphene and rGO in terms of surface sensitivity upon adenine binding. The sensitivity of shear exfoliated graphene was similar or higher than CVD graphene, depending on sheet size. The bigger the flakes, the higher the corresponding sensitivity. Due to its sheet structure, the shear exfoliated graphene hasn't as many adenine binding sites than CVD graphene and hence has a lower binding capability. But it outperforms rGO, where the defects present limit the available binding sites. In essence shear exfoliation is a cost effective and easy to perform fabrication alternative for affinity based sensing applications.

References

[1] Genslein C., Hausler P., Kirchner E-M., Bierl R., Baeumner A. J., Hirsch T., Beilstein J. Nanotechnol., 7 (2016) 1564

[2] Genslein C., Hausler P., Kirchner E-M., Bierl R., Baeumner A. J., Hirsch T., Proc. SPIE 10080, Plasmonics in Biology and Medicing XIV (2017) 100800F

[3] Eckmann A., Felten A., Mishchenko A., Britnell L., Krupke R., Novoselov KS., Casiraghi C, Nano Lett., 12 (2012) 3925

Figures

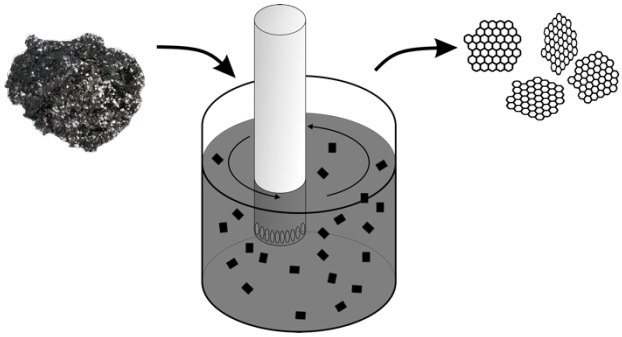

Figure 1: Scheme of shear exfoliation procedure. Graphite is processed using a dispersing instrument and is exfoliated to graphene sheets.

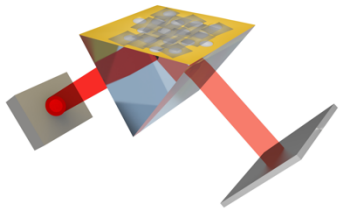

Figure 2: Scheme of the SPR setup, which measures a refractive index, sensitive to changes at the sensor surface. A laser with λ = 650 nm is used for excitation. Shear exfoliated graphene is used as receptor layer.