Doped Graphene: Advantages for sensing individual molecules

Mauricio Terrones

Department of Physics, Center for 2-Dimensional & Layered Materials. The Pennsylvania State University, University Park, Pennsylvania 16802, USA, IMDEA Materials Institute, Eric Kandel 2, Getafe, Madrid 28005, Spain and Department of Materials Science and Engineering & Chemical Engineering, Carlos III University of Madrid, Avenida Universidad 30, 28911 Leganés, Madrid, Spain

mut11@psu.edu

This talk will discuss the synthesis of large-area, high-quality monolayers of nitrogen-, silicon- and boron-doped graphene graphene sheets on Cu foils using ambient-pressure chemical vapor deposition (AP-CVD) [1-3]. Scanning tunneling microscopy (STM) and spectroscopy (STS) reveal that the defects in the doped graphene samples arrange in different geometrical configurations exhibiting different electronic and magnetic properties. Different substitutional nitrogen sites could be controlled by controlling the CVD temperature, flowrate and the dureation of the doping precursor insider the reactor. Interestingly, these doped layers could be used as efficient molecular sensors.

We will show that B-doped graphene (BG) exhibits unique sensing when detecting toxic gases such as NO_2 and NH_3 [3]. The detection limit for BG can reach as low as 95 ppt for NO_2 gas and 60 ppb for NH_3 gas. BG has enhanced sensitivity values of 27 and 105 times better than graphene for NO_2 and NH_3 detection [3]. This is attributed to the presence of B atoms within the graphene lattice that results in a high affinity to both donor and acceptor molecules, leading to stronger interactions between the molecules and graphene.
Finally we will discuss the use of graphene for enhancing Raman signals for specific molecules, also known as graphene enhanced Raman scattering (GERS). NG and Si-doped graphene (SiG) could significantly enhance the Raman signal of fluorescent molecules: Rhodamine B (RhB), crystal violet (CRV) and methylamine blue (MB) [1]. SiG exhibits an enhancement factor 10-40 times higher than that of PG (see Fig. 1) [1]. We will also show that by using NG as a substrate, Raman signals of dye molecules can be detected at a record low concentration of 10^{-11} M [4]. This is very close to single molecular detection. However, this enhanced Raman sensing requires the Fermi energy of the substrate to match the LUMO level of the probe molecule, which allows an effective charge-transfer excitation [4].

References

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Figures

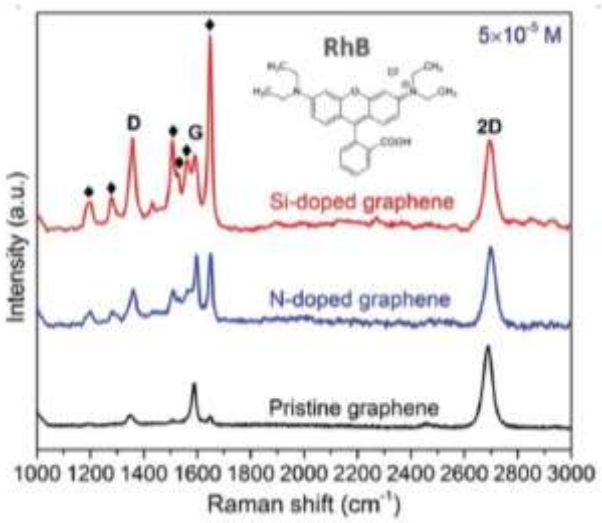

Figure 1: Comparison of Raman enhancement effect when RhB molecules are applied on top of pristine, N-doped and Si-doped graphene respectively.