PECVD of Graphene on sapphire substrates: A Design of Experiments (DoE) approach

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The use of graphene in the semiconductor industry is not yet widespread because controlling the properties of material and reproducibility of the process is still challenging. In addition, the catalyst-free growth of graphene directly on technologically relevant substrates (such as sapphire) at low temperatures is highly desirable for back end of line integration [1]. By using the plasma enhanced chemical vapour deposition (PECVD) technique, the temperature of the synthesis of graphene on sapphire can be reduced significantly, since the plasma provides the energy to break the molecules from the precursor [2]. Thus, providing a controllable synthesis procedure of catalyst-free graphene on such dielectric substrate will boost the use of graphene in the industry [3].
In this work, the optimization of the PECVD growth of graphene on c-plane sapphire is carried out by means of the statistical Design of Experiments (DoE) method. The quality and defects of the synthesized graphene layers are characterized by means of Raman spectroscopy. Factorial DoE with one central point is performed to evaluate the effect of the growth parameters and the extent of their interactions on the quality of the graphene layers. We found that the main factors affecting the ratio I_{2D}/I_G are the flow of methane and pressure. In addition, we found that a transition from graphene to amorphous carbon can be controlled by tunning the flow of methane, the pressure, and plasma power. Finally, the graphene layers were functionalized using 1-pyrenebutyric acid N-hydroxysuccinimide ester (PBASE), as a molecule that binds to both graphene and to antibodies, demonstrating its potential for future applications in biosensing.

References

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[2] Wie, D., Peng, L., Li, M., et al. *ACS Nano*, (2015), 164.
[3] Shan, J., Sun, J., and Liu, Z. *ChemNanoMat*, 5 (2021), 515–525.

Figures

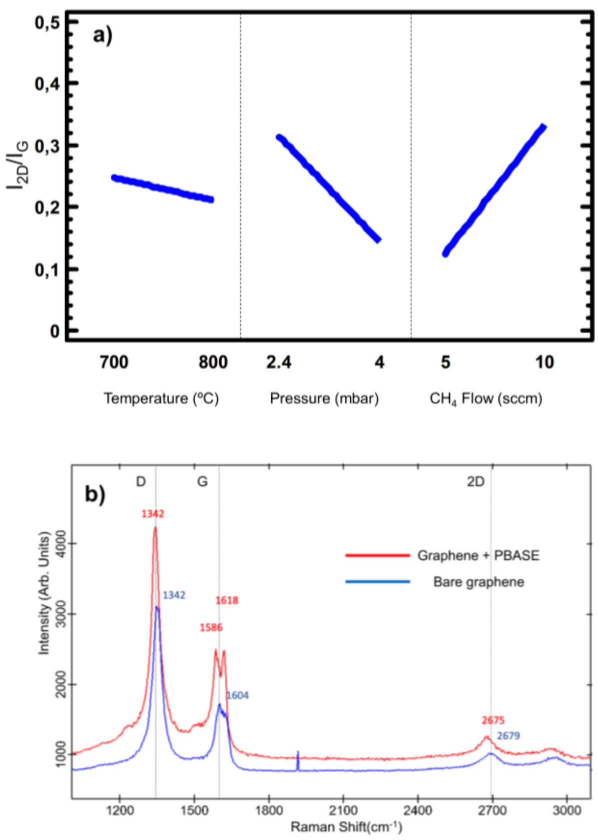

Figure 1: a) Main effect plots of the factors temperature, pressure and CH_4 flow for the response I_{2D}/I_G; b) Raman spectra of graphene before and after functionalization with PBASE molecule.