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Growth of graphene by plasma-assisted chemical vapor deposition synthesis, modeling and diagnostics

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In this work, we report on some of the fundamental chemical and physical processes responsible for the deposition of graphene by plasma enhanced chemical vapor deposition (PECVD). The graphene is grown by plasma decomposition of a methane and hydrogen mixture (CH_4/H_2) at moderate pressures over polycrystalline metal catalysts. In situ optical emission spectroscopy (OES) technique was used to measure the rotational temperature of the plasma and the H-atom relative concentration under different experimental conditions obtained by varying the plasma power (300-400 W), total pressure (10-25 mbar), substrate temperature (700-1000°C), methane flow rate (1-10 sccm) and catalyst nature (Co-Cu). Then, three complementary modeling approaches (0D, 1D and 2D) were developed to analyze the plasma environment during graphene growth. The transient zero-dimensional (0D) configuration was used for evaluation of the effects of reactor conditions and permits the identification of dominant reactions and key species during graphene growth. This approach is useful for identifying the relevant set of species and reactions to consider in a higher-dimensional model. The one-dimensional and two-dimensional models were developed to predict the gas temperature and the species concentrations for different process conditions by involving gas-phase and surface reaction mechanisms. The 0D, 1D and 2D models are validated by comparison with experimental data obtained from atomic and molecular emission spectra, providing insight into graphene growth under specific plasma conditions.

Recent Publications

1. **A Mehedi, B Baudrillart, D Alloyeau, O Mouhoub, C Ricolleau, V D Pham, C Chacon, A Gicquel, J Lagoute, and S Farhat (2016) Synthesis of graphene by cobalt-catalyzed decomposition of methane in plasma-enhanced CVD: Optimization of experimental parameters with Taguchi method. Journal of Applied Physics 120:065304.**
2. **G Shivkumar, S S Tholeti, M A Alrefae, T S Fisher, and A A Alexeenko (2016) Analysis of hydrogen plasma in a microwave plasma chemical vapor deposition reactor. Journal of Applied Physics 119:113301.**
3. **D Tsyganov, N Bundaleska, E Tatarova, A Dias, J Henriques, A Rego, A Ferraria, M V Abrashev, F M Dias, C C Luhrs, and J Phillips (2016) On the plasma-based growth of 'flowing' graphene sheets at atmospheric pressure conditions. Plasma Sources Science and Technology 25:015013.**

Biography

K Pashova studied Chemical Engineering at University of Chemical Technology and Metallurgy Sofia, Bulgaria, and obtained her MSc degree in Chemical and Process Engineering from University of Chemical Technology and Metallurgy, Sofia, Bulgaria. She is currently a PhD student in the group of Dr. Samir Farhat at Laboratoire des Sciences des Procédés et des Matériaux, CNRS, LSPM – UPR 3407, Université Paris 13, France. Her research interests include the synthesis of nanomaterials by Microwave plasma chemical vapor deposition and induction; plasma diagnostics and plasma modeling.

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