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Plasma enhanced chemical vapor deposition of graphene

Plasma-enhanced CVD (PECVD) has emerged as a versatile method to produce different carbon materials such as diamond, carbon nanotubes and graphene. High energy electrons generated by the plasma are accelerated by the electric field and enhance ionization, excitation and dissociation processes leading to a rich chemical environment and a relatively low gas temperature. In the case of graphene, growth rate is reduced but the film quality can be controlled better. In this direction, we propose a quantitative understanding of the gas phase chemistry as well as the growth mechanism in the specific conditions of PECVD. We will discuss the significant roles of process parameters in the deposition of graphene films via catalyzed decomposition of methane diluted in hydrogen. Different conditions obtained by varying plasma power, total pressure, substrate temperature, methane flow rate and catalyst nature will be experimentally analyzed via ex situ Raman spectroscopy and correlated to in situ optical emission spectroscopy measurements (OES) in order to access the rotational and excitation temperatures of the plasma as well as the relative H-atom concentration. Different modeling approaches at (0D), (1D) and (2D) will be presented to analyze the plasma environment during graphene growth. The (0D) model extends classical chemistry formulation to non-equilibrium plasma reactors that include gas, electron and vibrational temperatures while (1D) and (2D) uses more sophisticated geometries and surface chemistry. In addition, self-consistent two-dimensional model (2D) is used in order to determine auto coherently the electromagnetic field, gas and electron temperatures, heavy species, electron and ions densities distribution in the reactor. Models are validated by comparison with experimental data obtained from atomic and molecular emission providing insight regarding graphene growth under specific plasma conditions.

Biography

Samir Farhat has completed his PhD from Institut National Polytechnique of Toulouse in France where he was awarded Léopold Escand Price and his Habilitation from Université Paris 13. He is actually Associate Professor at University Paris 13 where he developed arc discharge reactors for the synthesis of carbon nanotubes and PECVD reactors for the growth of nanotubes and graphene. He collaborated with Johnson Space Center and ONERA to develop a global understanding of the growth mechanism of nanotubes and is currently involved in parallel projects for graphene. He has published more than 65 papers and 5 book chapters.

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