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Plasma design of 2D nanostructures and beyond graphene

Uros Cvelbar
Jožef Stefan Institute, Ljubljana, Slovenia, EU

Abstract - Plasma design of nanomaterials found its way into applications of various fields of materials science, including the building of 2D carbon nanostructures like graphene nanowalls (GNW). As such, it became an emerging field of material synthesis with some challenges related to its processing. Synthesis of GNW in a controlled manner with plasma-enhanced techniques opened future pathways for the large-scale, rapid functionalization of graphene for advanced applications. Plasma-supported methods enhance the possibility of processing (synthesis and functionalization) during the surface interactions between substrate and GNW offer the possibility for surface post-treatment. Among the important plasma-assisted methods for GNW synthesis, the most frequently used method is plasma-enhanced chemical vapour deposition (microwave-assisted, inductively coupled, capacitively coupled PECVD), which can enable the grow GNW on the substrate even in the absence of the metal catalyst. This talk addresses the most important challenges associated with plasma-assisted mechanisms of GNWs dealing with the growth and doping of GNWs or further materials beyond graphene. From this point of view, it's clear the importance of gas mixtures and plasma's properties. In these systems, plasma parameters, including the densities of ions and radicals, are regulated by the discharge parameters, including power, gas mixture ratio, gas flow, and pressure. However, the main challenge is connected to understanding the role of plasma species in growth and their efficient control for improving the quality and selectively modifying properties of the synthesized GNW. Another challenge is material doping and understanding the mechanism of plasma doping. Nitrogen functionalization and doping are one of the potential directions on how to alter the electronic properties. Furthermore, the oxygen plasma treatment, for example, helps to enhance surface morphological properties and band gaps widening, etc. In this perspective, the talk will highlight the recent progress in the field of plasma design of graphene and N-graphene, including the processing, functionalization, and future challenges that we have to address in the synthesis. Here the top-end simulations with our developed full-scale models will be used for plasma design of 2D nanostructures growth, and the simulated predictions supported by experimental evidence.

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Short Bio

Uroš Cvelbar is professor of nanotechnology and head of Department for Gaseous Electronics (F6) at Jožef Stefan Institute, Slovenia. His research is in the area of low-temperature plasmas, plasma physics and chemistry, plasma nanoscience and applications. He graduated in 2000 from The School of Physics at the Faculty of Mathematics and Physics, University of Ljubljana. In 2001, he became the Young Researcher on the MSZS grant. Dr Cvelbar's PhD was awarded in 2005 in the area of Materials Science at the University of Ljubljana. As a researcher, Dr Cvelbar also worked at former CPAT Laboratories at the University Paul Sabatier in Toulouse (France), University of Louisville (USA), CSIRO and University of Sydney (Australia). Currently, he is a vice-chair of Division for Dielectric Science and Technology at ECS, and chair of Plasma Nanoscience. He is an ERUDITE professor in India, visiting professor at Shanghai Jiao Tong University and a fellow of WAAS. He serves as guest editor of *Journal of Physics D*, *ECS Transactions*, *Plasma Sources Science and Technology*, is an associated editor of *Frontiers in Materials* and *Frontiers in Energy Research* for Nanoenergy technology and materials section, Nature *Scientific Data*, MDPI *Nanomaterials*, Elsevier *Microelectronic Engineering* and *Micro and Nano Engineering* journals.