Conférence à l'Ecole Nationale Polytechnique

"Nanocomposites à base de graphène pour les applications en energie "

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Amphithéâtre Ouabdesselam

Abstract: In this presentation, I will discuss our latest results on scalable synthesis strategies for the production of graphene-based nanocomposites, physical and chemical properties of these nanocomposites, as well as their potential applications in optoelectronics, thermoelectricity and on-chip- Li-ion-batteries.

Graphene has stimulated intense interest within the community for several years, because of its unique properties. Graphene sheets can be produced by many techniques. However, it is usually synthesized on a flat surface. For applications such as energy storage or sensing, the benefits of graphene are proportional to its surface area, and here there is a clear advantage in synthesizing graphene inside a volume with a high specific surface area, while preserving its 2D structure. However, there are few reports of graphene being integrated into a bulk matrix such as in porous semiconductors even though the porous semiconductor structure is an ideal host for such a goal.

The aim of this work is to develop a cost effective and scalable synthesis process of producing graphene-based composite nanomaterials, called graphene-coated porous semiconductor nanocomposite (GCPS-nC), The idea is to harness and combine the remarkable properties of graphene and porous semiconductors namely silicon (Si) and germanium (Ge) to create systems with entirely new and unexplored characteristics, and to tune these properties for use in real-world applications.

Our approach consists of two simple steps which are schematically illustrated in Figure 1, first a semiconductor crystal is electrochemically etched to produce a porous semiconductor matrix. Then the graphene coating is deposited on the inner surface of the porous surface. Scanning electron microscopy (SEM) measurements were performed to characterize the morphology of the porous layer before and after carbonization. No major changes are observed, and the intrinsic porous structure properties are preserved.
The presence of graphene-like material within the matrix has been confirmed by the confocal Raman spectroscopy observation of carbon sp2 and sp3 orbital modes. The peaks observed after carbonization are at ~1350 and ~1600 cm-1. These peaks have been observed in defective graphene materials synthesized using non-catalytic synthesis techniques [Ref], and it is worth noting that they are clearly different from the Raman signature of amorphous carbon [Ref]. It is a form of carbon that exhibits a significant amount of sp3-hybridized carbon as evidenced by the D-band (~1350 cm-1). From these results we notice that the lowest D/G ratio is for the sample that was carbonized at 650°C (D/G ~ 0.78 versus D/G ~ 1 for a sample carbonized at 800°C) attesting to better graphene quality and indicating that there is room for improvement by exploring the broader parameter space (temperature, flow ratio, porosity etc.) for the carbonization.

Biography: Dr. Boucherif is a professor of mechanical engineering at Université de Sherbrooke. He is an expert on the modification of semiconductor materials through electrochemical processes. He has developed a unique technology for the fabrication of engineered substrates that can be used for the heterointegration of lattice mismatched high quality semiconductors such as germanium or other III-V materials on silicon. His research interest includes also the synthesis of mesoporous materials and graphene-based nanocomposites for applications in micro-energy conversion and storage. He has published more than 20 papers in international peer reviewed journals and received several awards for his outstanding contributions to nanomaterials science and technology.

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