2D-SbGe: Preparation and characterization of antimonene and germanium nanolayers

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Abstract

Two-dimensional (2D) materials (from one up to few atomic layers in thickness) present a huge potential for technological applications. Over the past 12 years we have witnessed 3 major activity waves in this area: Graphene, 2D transition-metal dichalcogenides, and phosphorene. We anticipate the next waves to be related to two elemental materials: Antimony and Germanium. Consequently, the main goal of 2D-Sb&Ge is to provide the research community with the understanding of the properties and the basics to fabricate and make use of novel 2D materials based on these two elements. This also includes the study of their physical and chemical properties including supramolecular and/or covalent functionalization to produce a series of band gap tunable devices.Graphene is a semimetal with zero gap which precludes it for many applications in electronics. A number of theoretical works predicted antimony as a promising material for optoelectronic applications due to the band gap opening when thinned to one atomic layer. In addition, it has also been predicted to exhibit topological character and conducting surface states in its few-layer form. Members of this consortium have demonstrated, for the first time that antimony can be exfoliated by micromechanical and liquid phase techniques and have characterized the resulting 2D flakes from a structural morphological point of view. In particular, we have shown that unlike black phosphorus, single layers of antimonene are stable in atmospheric conditions. Electrical characterization and theoretical work in this regard are currently under way.The second 2D material, recently produced in our labs and which also features very promising optoelectronic properties, is a 2D form of alpha-germanium (2D-a-Ge), not to be mistaken with germanene, the hexagonal form that only grows on metallic surfaces. Theoretical calculations carried out from a member of this consortium predict exciting electrical properties such as band gap tuning as a function of the thickness. The 2D-Sb&Ge project is structured in three different interconnected lines:i) Materials production including their chemical functionalization and structural/morphological characterization.ii) Experimental studies of their physical properties.iii) Theoretical modelling for design and rationalization of experimental results.We plan to evaluate the experimental conditions to produce few-layer (FL) germanium and antimonene at a large scale and the possibility of chemical functionalization of the latter. We foresee applications in the context of energy (supercapacitor, water splitting, oxygen reduction, etc.) as well as in prototypes of optoelectronic devices. Theoretical calculations will be used to rationalize their physical and chemical properties and will aid in future materials design.

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