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Professor Mauricio Terrones

Penn State Department of Chemistry

Professor of Physics, Chemistry and Materials Science and Engineering

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Two-Dimensional Materials: From Doped Graphene to WS_2 monolayers van der Waals Solids and more

This talk will discuss the synthesis of large-area, high-quality monolayers of nitrogen-, silicon- and boron-doped graphene sheets on Cu foils using ambient-pressure chemical vapor deposition (AP-CVD). Scanning tunneling microscopy (STM) and spectroscopy (STS) reveal that the defects in the doped graphene samples arrange in different geometrical configurations exhibiting different electronic and magnetic properties. Interestingly, these doped layers could be used as efficient molecular sensors and electronic devices. In addition, the synthesis of hybrid carbon materials consisting of sandwich layers of graphene layers and carbon nanotubes by a self-assembly route will be discussed. These films are energetically stable and could well find important applications as field emission sources, catalytic supports, gas adsorption materials and super capacitors. Beyond graphene, the synthesis of other 2-Dimensional materials will be described. In particular, we will discuss the synthesis of WS2 and MoS2 triangular monolayers, as well as large area films using a high temperature sulfurization of WOx clusters deposited on insulating substrates. We will show that depending on the substrate and the sizes of the oxide clusters, various morphologies of layered dichalcogenides could be obtained. In addition, photocurrent measurements on these materials will be presented. Our results indicate that the electrical response strongly depends on the laser photon energy. The excellent response observed to detect different photon wavelengths in MoS2, WS2 and WSe2 materials, suggest these materials could be used in the fabrication of novel ultrafast photo sensors.

We have found using first principles calculations, that by alternating individual layers of different metal chalcogenides (e.g. MoS_2, WS_2, WSe_2 and $MoSe_2$) with particular stackings, it is possible to generate direct band gap bi-layers ranging from 0.79 eV to 1.157 eV. Interestingly, in this direct band gap, electrons and holes are physically separated and localized in different layers. Recent experimental results will be shown along this line. It is clear that the alternation of chalcogenide layers would result in the fabrication of solids materials with unprecedented optical and physico-chemical properties.

Department Contact Information
Dr. Miguel Jose-Yacaman Miguel.yacaman@utsa.edu
Anna Belinda Tucker Anna.Tucker@utsa.edu
http://physics.utsa.edu