2D Materials Technical Group
Room Ballroom A - Session 2D-ThP
2D Materials: Poster Session

2D-ThP-1 MoS_2 on Sapphire for Aligned Growth Using Liquid Precursor, ***Anindita Chakravarty***, University at Buffalo

Aligned growth of MoS2 has been a hot topic for research due to the high quality of two dimensional (2D) films obtained by Chemical Vapor Deposition (CVD). This research paper demonstrates aligned growth of MoS2 on sapphire using liquid precursors. Importance of parameters like oxygen plasma etching, amount of precursor used and low temperature annealing has been experimented with in this research. It has been determined that the sapphire used should be c-type , and needs to have a relatively smooth surface for growth of aligned MoS2 on it. The bond between the substrate and the flakes plays a significant role on the properties of the material grown. To test the quality of the flakes, ionic liquid has been used as a side gate. Electronic properties were measured after directly performing electron beam lithography and metal deposition onto the sapphire substrate containing the flakes.

2D-ThP-2 Growing and Analyzing Ultra-Thin Polyaniline Films, ***Anthony Annerino***, *P. Gouma,* The Ohio State University

Presented here are investigations on the growth and analysis of ultra-thin polyaniline films. Polyaniline is a highly studied intrinsically conducting polymer that has shown promise in a wide variety of applications but still proves relatively difficult to process on account of its negligible solubility in all but the most toxic organic solvents. This work aims at highlighting an uncommon avenue of polyaniline processing with great promise for many applications. Polyaniline films described here are grown via oxidative polymerization on the surface of an aqueous solution, and growth parameters including growth time, available growth area, and starting material concentrations are evaluated for their effects on various properties of the resultant films. Properties investigated include electrical properties, thermal properties, and film thickness.

2D-ThP-3 Modification of Bilayer VSe_2 by Intercalating Transition Metals, ***Vimukthi Pathirage***, *K. Lasek, J. Li, I. Ponomareva, M. Batzill ,* University of South Florida

Transition metal dichalcogenides (TMDs) are prototypical van der Waals materials that can be grown as ultrathin films and/or van der Waals heterostructures. While TMDs exhibit a variety of properties, they are usually non-magnetic.[1] Metal intercalation in between TMDs may be a process to introduce magnetism and thus design magnetic van der Waals materials.

Here we explore the possibility of controlling the intercalation of transition metals into ultrathin VSe_2 films in an attempt to modify their magnetic properties and to design magnetic van der Waals heterostructures. VSe_2 mono- to few-layer films are grown by van der Waals epitaxy on HOPG or MoS_2. These films are subsequently modified by post-growth deposition of transition metals, such as Cr. Our scanning tunneling microscopy (STM) studies indicate that the deposited Cr reacts with monolayer VSe_2 and forms complex ad-atom structures. In contrast, for bi- and multilayer VSe_2 the Cr-deposition maintains an atomic corrugation of the VSe_2 layer, however, the periodicity changes to a 2x1 structure with respect to VSe_2 lattice. This additional superstructure is interpreted as caused by the intercalation of Cr in between two VSe_2 layers and the superstructure at the surface is related to the periodicity of the intercalated Cr layer. The experimental results are supported by DFT calculations that suggest that Cr-intercalation is favored over Cr adatoms in bilayer structures.

Our study presents successful incorporation of dissimilar metal atoms into the van der Waals gap of TMDs by post growth intercalation. This opens new opportunities for engineering of layered materials. This intercalation process may be combined with van der Waals epitaxy and thus creates a new direction for modifications of van der Waals heterostructures.

[1] K. Lasek, J. Li, S. Kolekar, P. M. Coelho, L. a. Guo, M. Zhang, Z. Wang and M. Batzill, *Surface Science Reports***76** (2) (2021).

2D-ThP-7 Quantum Confinement in Topological Semimetal Nano-Platelets, ***Margaret Brown***, *R. Laing, T. Muratore,* University of Dayton*; K. Burzynski, J. Brown,* Wright Patterson Air Force Base*; J. Corbett,* Miami University*; K. Eyink,* Wright Patterson Air Force Base*; S. Elhamri,* University of Dayton*; A. Reed,* Wright Patterson Air Force Base

Topological insulators (TI) have shown widespread excitement in the development of spintronic devices and quantum computers. Despite their revolutionary properties, the small band gaps of many TIs severely limit their potential applications. Investigations which involve increasing the bandgap are vital in supporting the implementation of this material class. One route to do so uses nano-sized grains of the material to employ quantum confinement. Quantum confinement in TIs increases in bandgap and quantizes the Dirac cone as a function of nano-particle size. Inspired by such, this presentation consists of two parts: nano-platelet growth and resulting bandgap characterization. A study of the topological semimetal, Bi_4Se_3, grown via direct current magnetron sputtering revealed the nucleation process across a variety of growth pressures using atomic force microscopy. All films began as island-type nucleation and transitioned to layered growths at varying transition thicknesses which depend on pressure. During the initial nucleation period, prior to the layering transition, the morphology is composed of many nano-platelets dispersed with nearest neighbor ordering. The sizes of the nano-platelets are controlled by deposition time and growth pressure. Ultra-violet to visible light spectroscopy was used to investigate the dependence of the optical bandgap on the dimensionality of these nano-platelets. Variation of the optical bandgap was observed over a range from 1.55 eV to 2.21 eV with decreasing average platelet volume of 200,000 nm^3 to 30,000 nm^3. Using these data, fine tuning of the nano-platelet bandgaps to meet a range of needs for optical applications becomes possible.

2D-ThP-8 Characterizing the Low-Symmetry Crystallographic Axis in Atomically Thin WTe2 Layers Using Raman Spectroscopy for Spin-Orbit Torque Studies, ***Anh Ramirez***, *I. Kao, R. Muzzio, J. Katoch, S. Singh,* Carnegie Mellon University, USA

Low-symmetry crystal structure and topological electronic structure in WTe_2, which is a Weyl semimetal candidate, can be used to generate spin current with controllable spin polarization. Spin-orbit torques (SOT) exerted on a nearby magnetic thin film by the spin current in WTe_2, is appealing for an energy efficient field-free magnetization switching[1]. For the field-free SOT switching, it is essential to distinguish the crystallographic orientation in mesoscopic flakes of WTe_2 a so that charge current can be applied along the low-symmetry axis for generating out-of-plane oriented spin currents. We will present our polarized Raman spectroscopic studies on WTe_2 flakes that we use to prepare SOT switching devices. Raman spectra are collected by rotating the polarization of the incident laser for different angles relative to the a-axis of WTe_2. The polarization angle dependence of the Ag Raman peak at 212 cm^{-1} exhibits minimum intensity when the excitation laser polarization is along the straight edge of the WTe_2 flake, which allows us to characterize the crystallographic axis in WTe_2.

[1]. Kao et al., Nature Materials 21, 1029–1034 (2022)

2D-ThP-11 Designing a Green Synthesis Route and a Green Solvent to Exfoliate Graphene for Cost-Efficient Supercapacitors, *S. Kittur, J. Zhang, A. Pangal, I. Agrawal, S. Raj,* ***Abhiram Hanumanchi***, *N. Sangeneni,* ASDRP

Graphene, the two dimensional counterpart of graphite, is a novel hexagonal lattice structured, single layer sheet of carbon atoms. The material exhibits unique and suitable properties for applications in supercapacitors—notably, high electrical conductivity, lightweight structure, and high tensile strength, The main challenge of producing graphene lies in discovering a process that is green, scalable, and cost-effective. Other processes such as mechanical or electrochemical exfoliation, oxidation/reduction, chemical synthesis, and chemical vapor deposition fall short in at least one of these categories. Instead, our research turns to a more promising method—liquid-phase exfoliation. Refinement of the LPE method included comparisons of bath and probe sonication in their effects on yield. Additionally, we explored the supplementation of magnetic stirring and centrifuging to the process, and the effects of these additions on the end yield. The end yield of graphene was free of trapped oxygen atoms, as confirmed by XRD characterization. Moreover, our experiment did not involve any toxic solvents that pose environmental risks during disposal. Previous research indicates that solvents' properties determine the quality and amount of graphene produced. Solvents with similar surface tensions to graphene are better able to permeate in between the graphite layers during the sonication

process. Ethanol in particular is suitable due to its low boiling point, low toxicity, and mix of polar and nonpolar properties. Ethanol's low surface tension in comparison to graphene was remedied by adding water so that the mixture's surface tension was similar to graphene's. We calculated the ratio of water and ethanol to be used based on their surface tensions, which are 73 and 21 mJm-1 respectively. Adding materials like curcumin to the solvent also decreases the amount of defects in graphene, and gives us a better yield. In addition curcumin also acts as a reducing and stabilizing agent, which helps in avoiding agglomeration and keeping the graphene sheets apart. UV-Vis, XRD, and FTIR spectroscopy were used to characterize impurities in the exfoliated graphene. We prepared inks from the exfoliated graphite and performed cyclic voltammetry and galvanostatic charge discharge to test the energy capabilities of graphene electrodes. To further our research, we plan on conducting characterization with Raman spectroscopy and SEM. A green solvent and synthesis process remains desirable in the field of electrochemistry, providing sustainable storage for electricity without a massive loss in yield.

2D-ThP-12 Chemical Vapor Deposition of Large Grain and Continuous Mos_2 Layers on Catalyzed SiO_2/Si Substrate, *Z. Graham,* ***Matara Indika****, M. Williams,* Clark Atlanta University

MoS_2 has shown to be remarkable in its electrical and optoelectrical capabilities. Studies exemplify that with its modulating band gap and other properties, it can be useful as an excellent semiconductor material in devices such as field-effect transistors, photodetectors, solar cells. A uniform, continuous, monolayer growth of MoS_2 has still been regarded as a challenge in 2-D transition metal dichalcogenide growth. Here in this study, using a conventional CVD (chemical vapor deposition) growth method under particular growth parameters, large-grain and continuous MoS_2 layers can be achieved based on the synergistic reaction of precursor and $Na2SO_4$catalysis on a SiO_2/Si substrate with no powder transition metal precursors. Experimental studies have proven that rather than the Na interfering with the growth process between molybdenum and sulfur, it does in fact act as a catalyst in this reaction and bonds with the SiO_2/Si substrate instead. Confocal laser microscopy, Raman and Photoluminescence techniques will be utilized to study the uniformity/surface morphology, size, thickness, strain, stress, band gap, spin–orbit coupling, etc. of these layers.

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