Birck Seminar Series

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Developing 2D SnSe for Piezoelectrics[1]

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Wednesday, April 23rd @ 2:00 pm in BRK 1001

Coffee and snacks served before seminar

also on MS Teams link

Abstract: 2D piezoelectric and ferroelectric materials are critically needed for scalable and energy efficient sensors, transistors, and tunnel junctions. SnSe is a 2D material which is centrosymmetric in bulk but becomes non-centrosymmetric when reduced to the monolayer limit, enabling piezoelectricity and ferroelectricity. However, unlike other 2D materials, the strong interlayer bonding limits the exfoliation a monolayer of SnSe. Therefore, direct film growth is necessary to control the layer thickness and promote lateral growth. This talk focuses on the development of processing routes to control the morphology and layering of SnSe thin films for piezoelectric and ferroelectric devices. The bulk *Pnma* phase of SnSe is stabilized over a broad range of Sn:Se flux ratios from 250 – 300 °C on (100) MgO and (0001) Al2O3 substrates. The phase of the SnSe films was confirmed by Raman spectroscopy, exhibiting the characteristic Ag2, B3g, Ag3, and Ag4 phonon modes. In-situ RHEED confirmed the in-plane alignment along the [010] and [001] by RHEED relative to [100] MgO. Then, the deposition timing was varied to grow films from 4-80 nm thick. UV-vis spectroscopy and photoluminescence reveal that the bandgap of SnSe increases from 1.4 eV for 100 nm films to 1.9 eV for 5 nm films and the bandgaps are found to be direct for all measured film thicknesses. Once the critical parameters for depositing oriented films with strict layer control were established, then co-planar devices were fabricated both perpendicular and parallel to the polarization axis of the materials through a lithographic process with Ti/Au electrodes for dielectric, piezoelectric, and ferroelectric measurements. The dielectric response was determined from impedance spectroscopy, which shows clear anisotropy in conductivity from contributions from the surface and bulk of the material. Then the piezoelectric response was measured using an e11,f wafer flexure system. Overall, this study identifies the conditions for the growth of monolayer SnSe thin films necessary for the development of 2D piezoelectric devices.

Bio: Lauren Garten is an assistant professor in Materials Science and Engineering at the Georgia Institute of Technology. Her work focuses on the development of multifunctional ferroic materials for energy and electronic applications, particularly at the nexus between ferroelectricity, magnetism, and photovoltaics. Prior to coming to Georgia Tech she was a staff scientist at the U.S. Naval Research Lab (NRL) working on the growth and characterization of novel piezoelectric and artificial multiferroic heterostructures for sensors and electronics. Prior to this, she was a staff scientist in ferroelectric metrology development at Sandia National Laboratory and a post-doc at the National Renewable Energy Laboratory (NREL) where she worked on the processing and characterization of metastable and photovoltaic materials. She received her Ph.D. in material science from the Pennsylvania State University and her bachelors is in ceramic engineering from the Missouri University of Science and Technology. She has won the ONR Young Investigator Award, AFOSR Young Investigator Award, the Intel Rising Star Award, Jerome and Isabella Karle Distinguished Fellowship, the NRC Associateship, the DOE-BES Postdoctoral Research Award, the Outstanding Mentor Award from NREL, and the CalTech Young Investigator Lectureship

Ref. **1** co-authors: Jonathan Chin, Marshall Frye, Bonnie Gardner, Derrick Shao-Heng Liu, Maria Hilse, Ian Graham, Jeffrey Shallenberger, Ke Wang, Roman Engel-Herbert, Mengyi Wang, Yun Kyung Shin, Nadire Nayir, Adri C.T. van Duin, Lauren M. Garten

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