Workshop on Quantum Materials Epitaxy
Room Ballroom A - Session QME-SaM2

Topological and Magnetic Materials I

Moderator: Dr. Nitin Samarth, Pennsylvania State University

10:30am **QME-SaM2-11 Invited Paper*, Stuart Parkin,*** Max Planck Institute of Microstructural Physics, Germany **INVITED**

11:00am **QME-SaM2-13 The Art and Science of Molecular Beam Epitaxy ——from Topological Materials to Interfacial Superconductivity*, Cui-Zu Chang,*** Pennsylvania State University **INVITED**

In this talk, I will focus on the molecular beam epitaxy (MBE) growth of quantum materials, spanning from topological materials to interfacial superconductors. I will talk about two solid-state phenomena with zero resistance: the quantum anomalous Hall (QAH) effect and the interface superconductivity. The QAH insulator is a material in which the interior is insulating but electrons can travel with zero resistance along one-dimensional conducting edge channels. Owing to its resistance-free edge channels, the QAH insulator is an outstanding platform for energy-efficient electronics and spintronics as well as topological quantum computations. With many efforts, we were the first to realize the QAH effect in MBE-grown Cr- and V-doped topological insulator (TI) thin films. I will briefly talk about the route to the QAH effect and then focus on our recent progress on the high Chern number QAH effect and three-dimensional QAH effect in MBE-grown magnetic TI multilayers. Finally, I will talk about the interfacial superconductivity in MBE-grown TI/iron chalcogenide heterostructures. Moreover, the TI/iron chalcogenide heterostructures fulfill the two essential ingredients of topological superconductivity, i.e. topological and superconducting orders, and thus provide an alternative platform for the exploration of Majorana physics towards the scale topological quantum computations.

11:30am **QME-SaM2-15 Epitaxial Control of Topological Semimetals*, Kirstin Alberi,*** National Renewable Energy Laboratory **INVITED**

Three dimensional topological semimetals exhibit properties that hold promise for a wide range of applications, including electronics, spintronics, photodetectors and thermoelectrics. In order to use them for these purposes, we must integrate them into device structures with control of defects, interfaces and the Fermi level. We must also learn how to manipulate the electronic structure and behavior of topological semimetals through the addition of impurities or alloying. The aim of our research is to enable these capabilities through epitaxial synthesis as well as understand how various forms of disorder (defects, impurities and interfaces) impact the resulting film properties. In this talk, I will detail our work on two relevant materials: the Dirac semimetal Cd_3As_2 and the Weyl semimetal TaAs. We grow these films by molecular beam epitaxy using elemental sources, which allows us to control point defects and incorporate impurities. In Cd_3As_2, the As/Cd flux ratio can be selected to adjust the balance of native Cd vacancy and interstitial defect concentrations, permitting the free electron concentration to be varied with the 10^{16} to 10^{18} cm^{-3} range. This control has allowed us to study the role of point defects on magnetotransport behavior. Likewise, the addition of Zn can be used to induce n-to-p doping and topological semimetal-semiconductor transitions. More recently, we have achieved epitaxy of single crystal-like TaAs films of arbitrary thickness directly on GaAs substrates. We map out the growth window of this material and comment on the challenges ahead for epitaxial growth of monopnictide Weyl semimetals more generally.

This work was performed by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding was provided by the U.S. Department of Energy, Office of Science, Basic Energy Sciences, Division of Materials Sciences and Engineering, Physical Behavior of Materials Program under the Disorder in Topological Semimetals project.

12:00pm **QME-SaM2-17 Growth and Investigations of Topological and Quantum Phenomena in Epitaxial Semimetallic Thin Films*, Chris Palmstrøm,*** University of California, Santa Barbara **INVITED**

Controlling electronic properties via band gap engineering is at the heart of modern semiconductor devices. We have extended this concept to band structure engineering of quantum materials utilizing confined thin film geometries, hetero-epitaxial interfaces and epitaxial strain to engineer the electronic structure in elemental, rare-earth monopnictide and Heusler materials. The growth and tuning of the band structure of epitaxial films have been investigated through a combination of molecular beam epitaxial growth, in-vacuo angle-resolved photoelectron spectroscopy, scanning tunneling microscopy and spectroscopy and ex-situ low temperature magnetotransport and hybrid density functional theory.

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