Superconductor, Topological Insulator, and their Heterogeneous Structures

S&T Campaign: Materials Research
Photonics
Imaging Sensors & Optics

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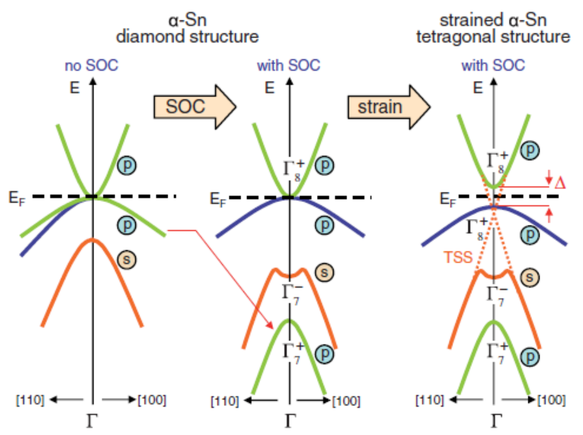
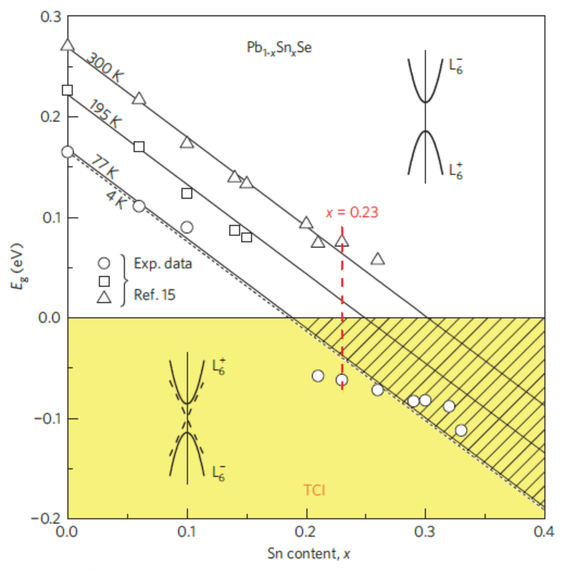
Research Objective

- **To explore new physics and chemistry at the interfaces of topological insulating and superconducting materials**
- **To acquire and build new knowledge base for development of potential new electronic applications in areas of sensor, energy, and quantum computing**



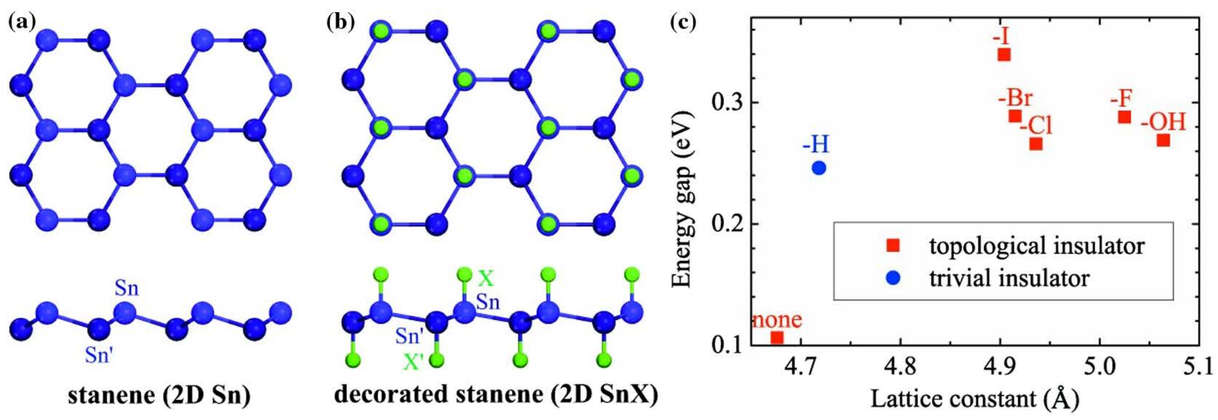
Band structure schematic of semiconductor tin
From Barfuss et al. PRL 111, 157205 2013



Compositional dependence of the bandgap of $Pb_{1-x}Sn_xSe$ at various temperatures. Positive, negative bandgaps denote normal and topological crystalline insulators (TCIs) respectively.
Dziawa et al., Nature Mat. 11, 1023 (2012)

Challenges

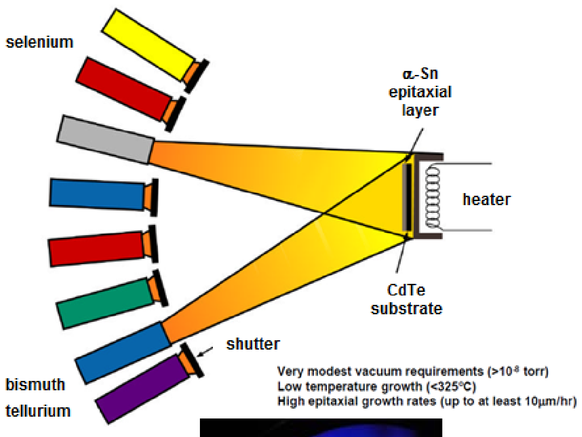
- **Detailed understanding of the interplay of thermal- dynamics and kinetics that govern the process of new composition and structure creation**
- **Precise control of material formation at atomic levels for one and two dimensions, and related hetero-structures**
- **Development of techniques and approaches to take advantages of vast amount of experimental and computational knowledge for better and effective exploration of materials with desired function and performance**

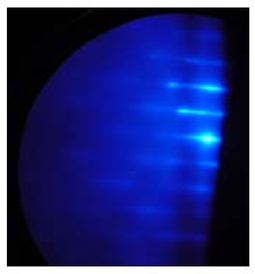


(a) Structure of stanene in two dimension
(b) Structure of decorated stanine
(c) Energy gap vs. lattice constant

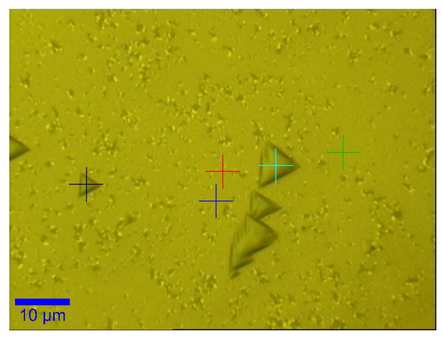
ARL Facilities and Capabilities Available to Support Collaborative Research

- **Molecular Beam Epitaxial (MBE) growth of novel materials**
- **Metal Oxide Chemical Vapor Deposition**
- **State-of-the-Art Materials Fabrication Facility**
- **Raman, Hall Effect, SQUID,XRD, Transport Measurement**
- **DFT calculation and Modeling**

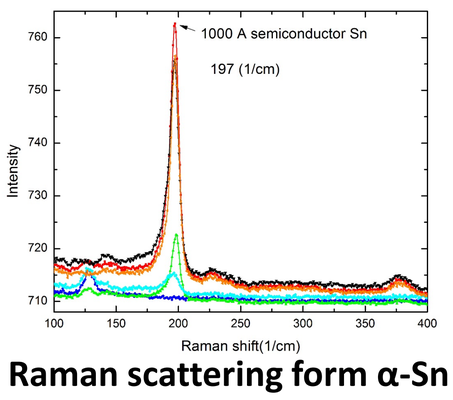




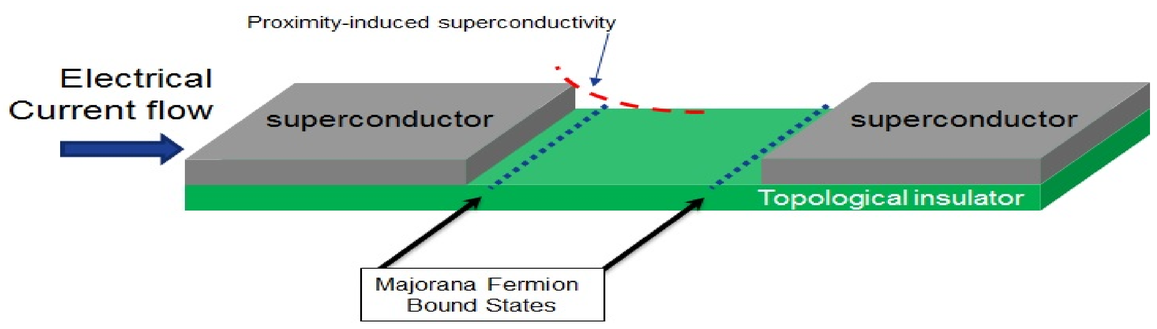
Achieved single crystal α-Sn
Observed RHEED pattern
Unreconstructed (111)



Surface of 20 nm layer



Raman scattering form α-Sn



Hetero-structure of Topological Insulator and Superconductor

Complementary Expertise / Facilities / Capabilities Sought in Collaboration

- **Synthesis technique for materials engineering/hybridization**
- **Characterization technique to understand interactions among atoms, chemical bonding, structures, and phases in details**
- **Appropriate and accurate theory and modeling to support and guide experimental effort**
- **Specialty of nano-scale materials processing with high precision**
- **In situ ARPES capability**