INTRINSIC VACANCY CHALCOGENIDES FOR SPINTRONIC APPLICATIONS

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This project will modify intrinsic-vacancy chalcogenide semiconductors for silicon-compatible, spintronic applications. Experiments are planned to (*i*) incorporate transition metal (TM) impurities in $A_2^{III}B_3^{VI}$ semiconductors, principally Ga_2Se_3, towards development of new dilute magnetic semiconductors and (*ii*) modulate interface kinetics and stoichiometries to control the band alignment when these new materials are grown epitaxially on a silicon substrate. Structure-property relationships of these largely unexplored materials will be investigated with a variety of characterization tools, including *in situ* scanning probe microscopy, photoelectron spectroscopy, and x-ray absorption spectroscopy and *ex situ* transport, magnetometry, x-ray and optical measurements, combined with theoretical calculations.

INTELLECTUAL MERIT: This project explores the physics and materials science of novel dilute magnetic semiconductors, where observation of quantum phenomena requires high materials quality and possibilities for device applications are controlled by nanoscale physics. Intrinsic-vacancy chalcogenides contain flexible bonding constraints and multiple sites for magnetic dopant incorporation that may be controlled through heteroepitaxial growth. The resultant structural tunability creates a unique model system to test proposed magnetic mechanisms in dilute magnetic systems. This research will also advance knowledge regarding nanoscale mechanisms for controlling band offsets and film morphologies in intrinsic vacancy compounds.

Research activities are planned to (*i*) determine the relative importance of free carriers and defects in controlling magnetism in these novel materials where carrier, magnetic species, and defect concentrations are likely to be able to be controlled independently; (*ii*) investigate the roles of mixed valence impurities and intrinsic structural vacancies in controlling nanostructure morphology and sites for dopant incorporation; (*iii*) explore the role of interface stoichiometry in controlling both the band offset and the possibility of spin-polarized transport between silicon and these polar heterovalent materials; and (*iv*) provide educational training for future leaders of the scientific and engineering enterprise within an environment that is both intellectually and culturally diverse. The project builds on the principal investigators' combined experience in chalcogenide semiconductors, dissimilar materials heteroepitaxy, mixed-valence materials, and dilute magnetic oxides.

BROAD IMPACT: This research seeks to develop a new class of novel, Si-compatible, dilute magnetic semiconductors for use in new device technologies based on electron spin. It will also develop means to control band-offsets at dissimilar materials interfaces. These developments would promote further miniaturization and multifunctionalization of Si-based technologies.

Students at the undergraduate, masters, doctoral and post-doctoral level will learn to bridge both disciplines and cultures as they work at the interface between science and engineering in the development of new paradigms, new science and new technologies. Through direct participation at the research frontier, students will acquire essential, transferable skills for their future participation in the scientific and technological workforce. The project strengthens other NSF-funded education efforts at the University of Washington (UW) through the principal investigators' involvement in the Nanotechnology Ph.D. Program (IGERT), UW/PNNL Joint Institute for Nanoscience, and Summer Research Experience for Undergraduates. The principal investigators have demonstrated commitment to advancing the participation of women and minorities in the sciences and engineering, including developing a course and lecture series on these issues, participating in the UW Minority Science and Engineering Program and our new centralized science and engineering minority graduate student recruiting, serving on UW's NSF-ADVANCE leadership team, and working in community science education projects. Expertise and visibility gained through this research project is essential for the success of these outreach and educational activities.