"Charge-to-spin conversion and spin-orbit torques in MBE-grown quantum materials"

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Hammond Auditorium (Engineering 120)

Abstract

The demonstration of current-induced spin-orbit torques (SOTs) in heavy metal thin films has provided exciting new ways to harness spin-charge conversion at the device level for the next-generation magnetic-based memory technology. While the targeted material systems are prepared mainly by sputtering in SOT studies, epitaxial quantum materials have still been largely unexplored in this context. In this talk, I will present our recent research on the SOT phenomena in quantum material heterostructures grown via molecular beam epitaxy.

In the first part, I will discuss the charge-to-spin conversion in topological materials [1-3], including the topological insulator BiSb alloy and the topological semimetals. We show that the topological material heterostructures enable unique pathways to test fundamental scientific concepts, such as the bulk-boundary correspondence, in the context of spintronics. We also show that the complicated SOT phenomena in the topological semimetals depend strongly on whether the semimetals are in a pristine or naturally oxidized state.

In the second part of my talk, I will report the synthesis and characterizations of a full van der Waals epitaxial heterostructure consisting of a Dirac semimetal, $ZrTe_2$, and a two-dimensional ferromagnet, $CrTe_2$ [4]. We observe robust ferromagnetism in $CrTe_2$ thin films down to one-unit-cell thickness. Furthermore, anomalous Hall measurements suggest the existence of chiral magnetic structures in thicker $CrTe_2$ films. Finally, we demonstrate SOT-assisted magnetization switching in the $CrTe_2$ via the current-induced spin-torques from $ZrTe_2$.

[1] "Spin Hall conductivity in $Bi_{1-x}Sb_x$ as an experimental test of bulk-boundary correspondence" Ou *et al*, arXiv:2311.11933.

[2] "Spin and charge interconversion in Dirac semimetal thin films", Yanez, Ou *et al*, Physical Review Applied 16, 054031 (2021) (Editor's Suggestion).

[3] "Giant dampinglike-torque efficiency in naturally oxidized polycrystalline TaAs thin films", Yanez, Ou *et al*, Physical Review Applied 18, 054004 (2022) (Editor's Suggestion).

[4] "$ZrTe_2/CrTe_2$: an epitaxial van der Waals platform for spintronics" Ou *et al*, Nature Communications 13, 2972 (2022).

Biography

Dr. Yongxi Ou received his PhD in physics from Cornell University in 2018. After that, he joined Prof. Nitin Samarth's group at Pennsylvania State University as a postdoctoral researcher and then became a research assistant professor in the Department of Physics. His research interests include the study of spin-orbit interactions and spin-orbit torque phenomena in heavy metal thin films deposited via sputtering technique, as well as in quantum and low dimensional material heterostructures grown via molecular beam epitaxy.