Abstract: Layered van der Waals materials have enabled novel electrical, optical, and mechanical properties that are not observable in conventional 3-dimensional materials. 2D ferroic (ferromagnetism, ferroelectricity) materials are bringing us new opportunities in controlling material response to external stimuli. Here I am sharing some of the novel material platforms we developed for the exploration of 2D ferromagnetism and ferroelectricity. The first example is the MX (M= Sn, Ge; X=S, Se) material family with ferroelectric responses. We experimentally demonstrate the spontaneous polarization states in MX materials such as SnSe. Our growth method allows the AA stacking of 2D SnSe layers, which preserves the broken inversion symmetry of the crystal structure, which is also confirmed by optical second harmonic generation. We further demonstrate the co-existence of in-plane and out-of-plane polarizations in different thicknesses of SnSe sheets. More importantly, the switching voltage of the SnSe sheets scales down with the thickness and approaches sub-0.3V regime, offering great potential for low-power electronic device applications. The second example is a novel approach to achieve diluted magnetic oxides at the 2D limit. We show that zinc ions can be intercalated into the van der Waals gaps between graphene oxide template layers, which allows the creation of monolayers and bilayers of ZnO in the van der Waals phase. Such approach also allows us to introduce magnetic dopants in ZnO sheets, such as Co atoms. By controlling the doping level of ZnO, we observed the transition from paramagnetic phase to ferromagnetic phase. This 2D magnet has a Curie temperature higher than room temperature and is stable in ambient conditions, thus providing numerous new opportunities, such as the exploration of novel spintronic devices and the miniaturization of memory devices.

Bio: Prof. Jie Yao obtained his PhD from the University of California, Berkeley in 2010 and conducted postdoctoral research at Stanford University after that. He joined the Department of Materials Science and Engineering at UC Berkeley as an assistant professor in 2013. His research interests are mainly focused on optical materials and nanophotonics, including metamaterials, plasmonics and photonic crystals. He is also developing novel 2D materials with ferroic responses for electronic and spintronic applications. Prof. Yao has won the CAREER award from the National Science Foundation and Early Career award from SPIE, the International Society of Optics and Photonics. He is also a Heising-Simons Faculty Fellow and a recipient of the Hellman Fellowship from the Hellman Foundation.