Ferroelectric-Control of Magnetotransport in Ruddlesden-Popper Strontium Iridates

X. Hong[1]

[1] *Department of Physics and Astronomy & Nebraska Center for Materials and Nanoscience, University of Nebraska-Lincoln, Lincoln, Nebraska, USA*

The Ruddlesden-Popper 5*d* iridates $Sr_{n+1}Ir_nO_{3n+1}$ (SIO) represents a model system where the close competition between charge itinerancy, strong spin-orbit coupling, and onsite Coulomb energy can lead to a rich phase diagram. Nonvolatile voltage control of their electronic and magnetic properties is of intensive research interests for designing emergent quantum states and developing novel energy-efficient device applications, which is yet to be demonstrated. This talk discusses the tuning of magnetotransport properties of ultrathin SIO (n = 1, 2, ∞) films via interfacial ferroelectric $PbZr_{0.2}Ti_{0.8}O_3$ (PZT) (Fig. 1a). Nonvolatile polarization control of metal-insulator transition (MIT) has been achieved in $SrIrO_3$ and $Sr_3Ir_2O_7$. Bulk $SrIrO_3$ is a correlated semimetal. In the 2D limit, $SrIrO_3$ thin films exhibit weak (anti)localization [1], which are modulated via PZT polarization reversal. Anomalous Hall and topological Hall effects are observed in PZT/$SrIrO_3$ close to the MIT, signaling emergent magnetism. All-oxide ferroelectric tunnel junctions (FTJs) composed of $LaNiO_3$ (LNO)/PZT/$Sr_3Ir_2O_7$ exhibit significantly enhanced electroresistance (ER) at room temperature (RT) compared with FTJs exploiting other correlated oxide electrodes (Fig. 1b), which can be attributed to polarization induced MIT in interfacial $Sr_3Ir_2O_7$ [2]. While single-layer Sr_2IrO_4 is a J-1/2 Mott insulator, the PZT/Sr_2IrO_4 heterostructure shows transport characteristic of a 2D correlated metal (Fig. 1c) due to the interfacial charge transfer effect [3]. The in-plane magnetoresistance (MR) and out-of-plane anisotropic MR show distinct temperature and magnetic field dependences for single-layer Sr_2IrO_4 and PZT/Sr_2IrO_4 (Fig. 1d), suggesting polarization controlled magnetic anisotropy and possible emergence of incipient ferromagnetism. These results showcase how charge-, lattice-, and symmetry-mediated interfacial coupling with ferroelectrics can be leveraged to induce emergent phenomena and design voltage-controlled functionalities in 5*d* iridates.

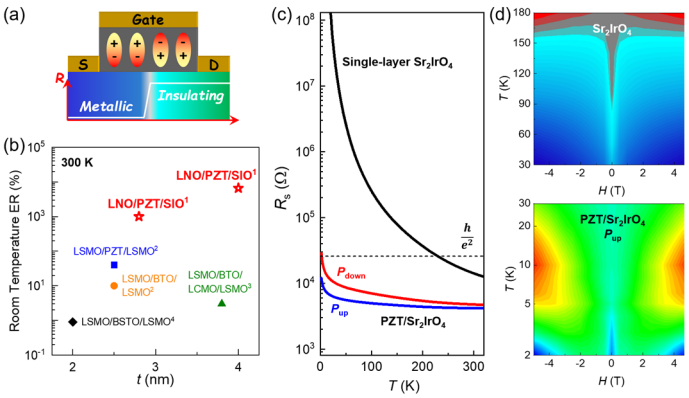

Figure 1 (a) Sample schematic. (b) RT ER vs tunnel barrier thickness for all-oxide FTJs with various correlated oxide electrodes [2]. (c) $R_s(T)$ for Sr_2IrO_4 film and PZT/Sr_2IrO_4 heterostructure [3]. (d) In-plane MR vs T and H for Sr_2IrO_4 film and PZT/Sr_2IrO_4 heterostructure [3].

[1] L. Zhang et al, APL Materials **8**, 051108 (2020).
[2] Y. Zhang et al, Applied Physics Letters **125**, 102904 (2024).
[3] Y. Zhang et al, Advanced Physics Research **4**, 2400208 (2025).

[+] Author for correspondence: xia.hong@unl.edu