NEBRASKA CENTER FOR ENERGY SCIENCES RESEARCH

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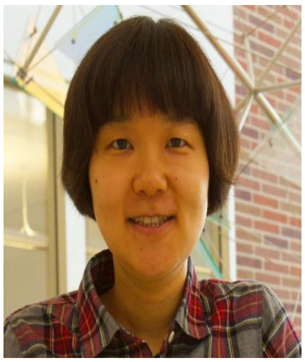

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Harnessing Domain Formation in Ferroelectric Oxides for Weather- and Environment-Resilient Energy Applications

Abstract:
Ferroelectric oxides such as Pb(Zr,Ti)O3 and hexagonal *R*(Fe,Mn)O3 (*R*: rare earth) are versatile material candidates for developing energy applications such as solar cells, mechanical energy harvesting generators, thermoelectric devices, and fast-response energy storage applications. Compared with traditional energy materials, their high mechanical endurance and thermal stability also make these devices weather- and environment-resilient. A key property that affects the density, operation speed, and energy conversion efficiency of ferroelectric devices is domain formation, which is highly sensitive to the interface condition and electrostatic screening capacity of the electrodes. This project aims at understanding and controlling the static configuration and dynamic response of domain structures in ferroelectric oxides by exploiting electrode materials with different screening capacities and lattice matching conditions. Epitaxial Pb(Zr,Ti)O3 and *R*(Fe,Mn)O3 thin films and free-standing ferroelectric membranes will be interfaced with strongly correlated oxides with different crystal structures and metallicity, including (La,Sr)MnO3, NiCo2O4, *R*NiO3 and SrIrO3, two-dimensional van der Waals semiconductors such as MoS2, as well as high-*k* dielectric layers for tunable depolarization. Viable temperature piezoresponse force microscopy will be used to image domain structures, which will be used to examine domain wall roughness and creep behavior. To probe the charge and lattice switching dynamics, transient negative capacitance measurements will be combined with time-resolved x-ray diffraction technique. The screening capacity of the electrode and charge doping effect from the ferroelectric will be examined via x-ray/photoelectron spectroscopy. This study will identify the critical role of electrostatic boundary condition on ferroelectric domain formation and disentangle its interplay with the interfacial lattice effects, such as epitaxial strain and crystal symmetry. The gained knowledge can facilitate the material design of ferroelectric oxide-based energy applications with high density, fast time response, low operation power, high endurance, and enhanced thermal stability, which provides a promising pathway for achieving weather- and environment-resilient energy infrastructure.