Emergent Phenomena at Ferroelectric/van der Waals Heterointerfaces

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The heterointerfaces between ferroelectrics and two-dimensional (2D) van der Waals materials present a versatile platform for achieving novel interfacial coupling, nonvolatile field effect control, and nanoscale programmable functionalities. In this talk, I will discuss a range of emergent phenomena in ferroelectric/vdW heterostructures mediated by interfacial coupling of charge, lattice, and polar symmetry. By combining polarization doping with nanoscale domain patterning in a ferroelectric polymer P(VDF-TrFE) top-gate, we create directional conducting paths in an insulating 2D channel, which reveals highly anisotropic conductivity in monolayer (1L) to 4-layer 1T'-ReS_2 between the directions along and perpendicular to the Re-chain (Fig. 1a) [1]. The interface-epitaxy between P(VDF-TrFE) and ReS_2 leads to large scale P(VDF-TrFE) thin films composed of highly ordered, close-packed, 10 and 35 nm wide crystalline nanowires (Fig. 1b) [2]. We observe enhanced polar alignment, piezoelectricity, and Curie temperature in thin $CuInP_2S_6$ (CIPS) flakes prepared on ferroelectric oxide $PbZr_{0.2}Ti_{0.8}O_3$ (PZT) (Fig. 1c), which can be attributed to the interfacial strain imposed by PZT [3]. An unconventional filtering effect of second harmonic generation (SHG) signal is enabled by the polar coupling of 1L MoS_2 with either the polar domain or the chiral dipole rotation at the domain wall surface in PZT thin films (Fig. 1d) or free-standing membranes (Fig. 1e) [4,5]. Our study showcases the rich research opportunities offered by integrating ferroelectrics with 2D materials.

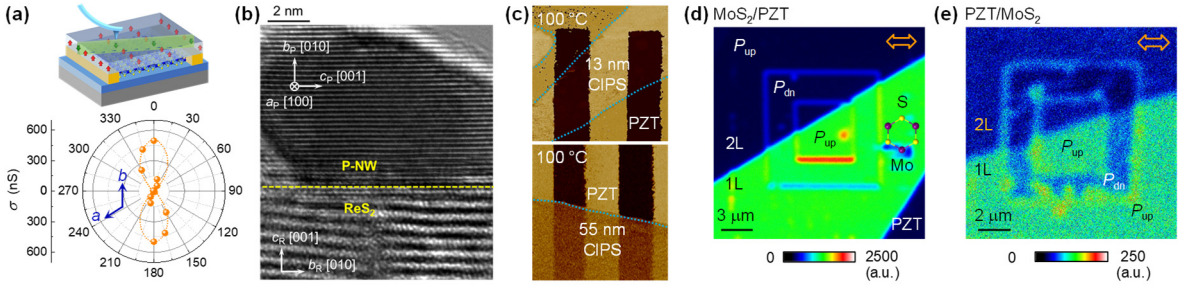

Figure 1 (a) Directional conducting nanowires defined by P(VDF-TrFE) top-gate reveals strong transport anisotropy in 4-layer ReS_2 [1]. (b) HRTEM image of epitaxial interface between P(VDF-TrFE) nanowire and ReS_2 [2]. (c) PFM images show T_C of 13 nm (55 nm) CIPS on PZT is above (below) 100 °C [3]. (d-e) SHG mapping of 1L MoS_2 on PZT thin film (d) and PZT membrane on 1L MoS_2 (e) [5], with PZT patterned into polarization up (P_{up}) and down (P_{dn}) domains.

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