Polarization-Related Electronic Properties of Complex Oxides

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Recently it was demonstrated that the conductivity of the $LaAlO_3/SrTiO_3$ (LAO-STO) interface can be reversibly tuned through a switchable electromechanical response arising from the LAO overlayer in the LAO-STO heterostructures. Bulk $LaAlO_3$ (LAO) is a typical perovskite, which shows paraelectric behavior at room temperature. In this study, we have investigated switchable dielectric propeties of the LAO ultrathin (several unit cells) films grown on top of lattice-matched conducting oxide $Sr_{0.2}Ca_{0.8}RuO_3$ (SCRO) on the (001) $(LaAlO_3)_{0.3}–(Sr_2AlTaO_3)_{0.7}$ (LSAT) substrate. Piezoresponse force microscopy (PFM) studies performed on the LAO/SCRO/LSAT heterostructures show a genuine switchable hysteretic electromechanical behavior resembling that one observed in ferroelectric films associated with induced polarization in the LAO layer. An insight into the underlying mechanism of such behavior has been gained by using temperature-dependent PFM spectroscopic, dielectric and structural measurements. The effect of inhomogeneous strain gradient induced by the PFM probe on polarization in LAO as well as 2DEG conductivity at the LAO-STO interface has been also studied. The proposed mechanism of switchable electromechanical response should be active in many other oxide heterosystems, but its detailed manifestation likely depends on a number of subtleties, such as oxygen octahedra rotations and distortions, strain, and lattice coupling at the nanoscale. Control of this phenomenon will enable new structures and devices that exploit nanoscale electromechanical coupling.