Tunable 2-dimensional electron gas conductivity at oxide heterointerfaces

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Heterointerfaces play a crucial role in observing unexpected and astonishing properties of oxide-based complex material systems [1]. One of the most prominent examples is the formation of two-dimensional electron gas (2DEG) at the interface between two insulating oxides $LaAlO_3$ and $SrTiO_3$ [2], where 2DEG is confined to within ~1 nm of the LaO/TiO_2 interface [3]. The polar interface exhibits superconducting and magnetic ground states [4,5], which originates from electronic phase separation. The conductivity of the interface has been drastically modulated by external electric fields [6,7,8]. More excitingly, bistable conductivities of the interface have been demonstrated using scanning probe microscopy techniques, suggesting the potential application to non-volatile memories [9,10] Due to the strong surface-interface coupling, the interfacial conductivity is also controlled by the surface adsorbates [11,12]. In addition to external perturbations, the conductivity of the $LaAlO_3/SrTiO_3$ interface could be tuned via structural deformation. Bark et al.[13] showed that biaxial strain can be used to tailor 2DEG properties of the $LaAlO_3/SrTiO_3$ heterointerface. Also Jang et al.[14] demonstrated that both biaxial strain and octahedral distortion greatly influence conductivities of oxide hereointerfaces, making them either conducting or insulating.

Here, we report tunable conductivity in $LaAlO_3/Sr_xCa_{1-x}TiO_3$ heterointerfaces. By changing Sr content in $Sr_xCa_{1-x}TiO_3$ films epitaxially grown on $SrTiO_3$ substrates, the orthorhombicity of the films has been varied, while the in-plane lattice parameters of the $Sr_xCa_{1-x}TiO_3$ films were kept constant by coherent growth. Electrical measurements reveal that the interfacial conductivity at the $LaAlO_3/Sr_xCa_{1-x}TiO_3$ heterointerfaces is tuned over 6 orders of magnitude, showing that the transition from metal to insulator is controlled by the Sr content in the films. [15].

In addition, we demonstrate the non-volatile switching of 2DEG conductivity incorporating epitaxial ferroelectric $Pb(Zr_{0.2}Ti_{0.8})O_3$ thin film on $LaAlO_3/SrTiO_3$. The polarization direction of the $Pb(Zr_{0.2}Ti_{0.8})O_3$ overlayer switchable by an electric field electrostatically modulates the 2DEG electrical conductance more than three orders of magnitude. The bi-stable nature of ferroelectric polarization stabilizes the switched conducting state of 2DEG over 50 hours without relaxation [16].

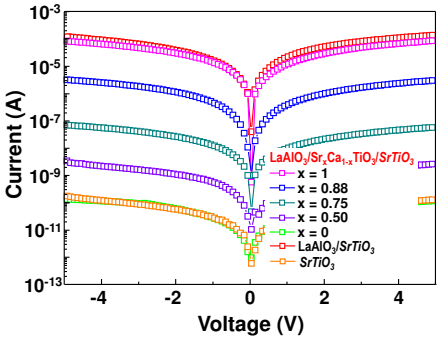

Fig. 1. Tunable conductivity at $LaAlO_3/Sr_xCa_{1-x}TiO_3$ ($0 \leq x \leq 1$) heterointerfaces.

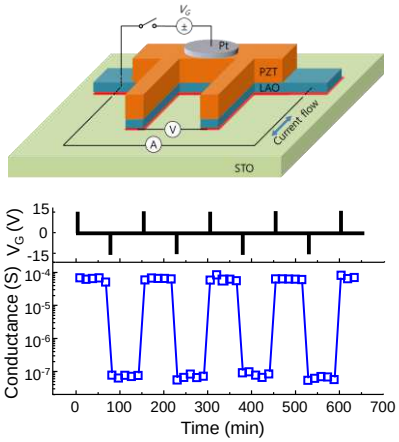

Fig. 2. Nonvolatile control of oxide 2DEG conductivity.

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