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Electrically Controllable Complex Oxide Interfaces

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Complex oxide interfaces emerge as one of the most exciting subjects among condensed matters due to their unique physical properties and new possibilities for next-generation electronic devices. Three types of complex oxide interfaces have been established. Among them, the most explored interface is the artificially constructed heterointerfaces. Various interactions at the interface have resulted in a number of exciting discoveries, such as highly mobile quasi-two dimensional electron gas (2DEG) forming between two band insulators ($LaAlO_3$ and $SrTiO_3$). Moreover, in ferroic oxides, domain walls dictate natural homo-interfaces as a consequence of the minimization of electrostatic and elastic energies. Several key studies have pointed out interesting observations, such as local conduction, on domain walls in multiferroics. Recently, new tubular oxide interface has been developed in the self-assembled heterostructures and the local conduction at the tubular interfaces of $BiFeO_3$ (BFO)-$CoFe_2O_4$ (CFO) heterostructure was found. Such results create a huge playground to explore and design intriguing properties of complex oxide interfaces. However, in the push for practical applications, it is desirable to have the control of the interface functionalities through external stimulus. In this presentation, a non-volatile modulation of the local conduction at the homo- (BFO domain walls) and hetero-interfaces ($LaAlO_3$/$SrTiO_3$) will be demonstrated. By inserting a ferroelectric layer, the polarization can tune and modulate the conduction at the $LaAlO_3$/$SrTiO_3$ heterointerface. The XPS and XSTM/S results reveal the electrostatic predictions of the conducting state modulation, demonstrating the possibility of non-volatile control. In addition, we went back to the BFO-CFO tubular interfaces and showed the interface conduction can be modulated non-volatily and reversibly via an external electric field by using conducting AFM. A memristive-like electronic conduction was observed, that is strongly correlated to the motion of oxygen vacancies (donor impurities) at the interface and in turn modifies the junction characteristics between the measurement tip and the interface. Our results complete the control of the conduction at complex oxide interfaces and suggest the possibility for new devices based on complex oxide interfaces.