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Potential Barrier Lowering and Electrical Transport at the $LaAlO_3/SrTiO_3$ Interface

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Interfacial phenomena form the basis for modern-day devices and continue to be an area of fundamental interest in condensed matter research. Advances in oxide thin film fabrication have enabled the synthesis of atomically precise oxide interfaces and hence have allowed for controlled investigation of interfacial phenomena in these materials. With the rich variety of functionalities exhibited by transition-metal oxides, a wide array of novel properties may be achieved at oxide heterointerfaces. An exemplary study is the discovery of metallicity at the interface of two band insulators, $LaAlO_3$ (LAO) and $SrTiO_3$ (STO), which has stimulated many subsequent experimental as well as theoretical studies. However, there is still intense debate on the origin of metallicity, specifically whether it arises from electronic reconstruction or oxygen vacancies. Using a combination of vertical transport measurements across and lateral transport measurements along the LAO/STO heterointerface, we demonstrate that significant potential barrier lowering and band bending are the cause of interfacial metallicity. Transport measurements across the heterointerface, indicate that barrier lowering and enhanced band bending extends over 2.5 nm into LAO as well as STO. We explain the origins of high-temperature carrier saturation, lower carrier concentration, and higher mobility in the sample with the thinnest LAO film on a STO substrate. Lateral transport results suggest that parasitic interface scattering centers limit the low-temperature lateral electron mobility of the metallic channel.

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