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Charge transfer induced modulation doping of two-dimensional electron gas at complex oxide interfaces

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The discovery of two-dimensional electron gases (2DEGs) at the interface between two insulating complex oxides, such as LaAlO$_3$ (LAO) or gamma-Al$_2$O$_3$ (GAO) epitaxially grown on SrTiO$_3$ (STO) $^{1,2}$, provides an opportunity for developing all-oxide electronic devices $^{3,4}$.

However, large enhancement of the interfacial electron mobility remains a major and long-standing challenge for fundamental as well as applied research of complex oxides. Here, we report a 2DEG mobility enhancement of more than two orders of magnitude obtained by inserting a single unit cell (uc) buffer layer at the interface between disordered LaAlO$_3$ and crystalline SrTiO$_3$ created at room temperature. $^5$ The spacer layer suppresses strongly the formation of oxygen vacancies on the SrTiO$_3$ side and leads to an unexpected modulation-doping scheme of the complex oxide 2DEG via interface charge transfer. $^6$ This results in a very high 2DEG mobility exceeding 70 000 cm$^2$V$^{-1}$s$^{-1}$ at 2 K and low carrier density in the range of 10$^{12}$ cm$^{-2}$. These findings open new avenues for oxide electronics.