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

Chen, Yunzhong; Trier, Felix; Christensen, Dennis Valbjørn; Linderoth, Søren; Pryds, Nini

Publication date:
2015

Document Version
Peer reviewed version

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

Y. Z. Chen, F. Trier, D. V. Christensen, S. Linderoth, and N. Pryds
Department of Energy Conversion and Storage, Technical University of Denmark, Risø Campus, 4000 Roskilde, Denmark
yunc@dtu.dk

The discovery of two-dimensional electron gases (2DEGs) at the interface between two insulating complex oxides, such as $LaAlO_3$ (LAO) or gamma-Al_2O_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 $cm^2V^{-1}s^{-1}$ at 2 K and low carrier density in the range of 10^{12} cm^{-2}. These findings open new avenues for oxide electronics.

1. A. Ohtomo & H. Y. Hwang, A high-mobility electron gas at the $LaAlO_3$/$SrTiO_3$ heterointerface. *Nature* **427**, 423-426 (2004).
2. Y. Z. Chen *et al.* A high-mobility two-dimensional electron gas at the spinel/perovskite interface of γ-Al_2O_3/$SrTiO_3$. *Nat. Commun.* **4:1371** doi: 10.1038/ncomms2394 (2013).
3. J. Mannhart & D. G. Schlom, Oxide interfaces: An opportunity for electronics. *Science* **327**, 1607-1611 (2010).
4. F. Miletto Granozio, G. Koster & G. Rijnders, Functional oxide interfaces. *MRS Bullettin* **38**, 1017 (2013).
5. Y. Z. Chen *et al.* Metallic and insulating interfaces of amorphous $SrTiO_3$-based oxide heterostructures. *Nano. Lett.* **11**, 3774 (2011).
6. Y. Z. Chen *et al.* Extreme mobility enhancement of two-dimensional electron gases at oxide interfaces via charge transfer induced modulation doping. *Submitted to Nature Mater.*