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Electron Transfer and Ionic Displacements as the Origin of the 2D Electron Gas at the LAO/STO Interface: Direct Measurements with Atomic-Column Spatial Resolution

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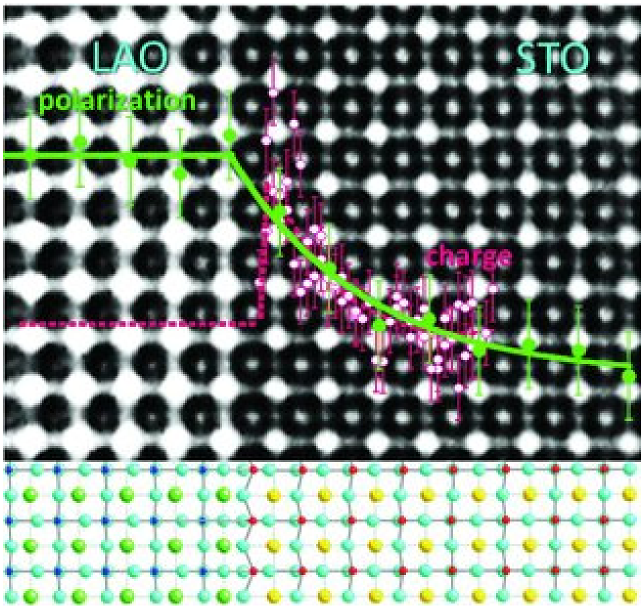
Interfaces between correlated oxides are currently among the most investigated systems in condensed matter. The interface between LaAlO3 and SrTiO3, which hosts a high-mobility 2D electron gas (2DEG) in spite of the large bandgap of its bulk constituents, is among the most intensely debated worldwide. After several years of sustained theoretical and experimental work, there is no consensus regarding the dominant mechanism responsible for electrical conductivity, superconductivity, and magnetism in this system. First principles calculations correctly predict the metallicity of the interface, as a result of a so-called electronic reconstruction (ER) taking place in response to the diverging electrostatic energy generated by the polar nature of the LaAlO3 lattice. However, theoretical studies presuppose an atomically abrupt interface with negligible defects and/or disorder and a substantial polarization of the whole heterostructure. No conclusive evidence about these open issues has been reported so far.



Using state-of-the-art, aberration-corrected scanning transmission electron microscopy and electron energy loss spectroscopy with atomic-scale spatial resolution, experimental evidence for an intrinsic electronic reconstruction at the LAO/STO interface is shown. We demonstrate that in a highly perfect interface, where cation intermixing is negligible, the lattice polarization and the amount of injected charge are in agreement with the predictions of the ER model.

Fig.: High resolution electron microscopy image of a LaAlO3/SrTiO3 interface. The polarization profile, the surface charge density profile ad the lattice deformations are sketched