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Soft x-ray photoemission spectroscopy on buried interfaces

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At the interface between complex oxides, unexpected electronic properties different from those of the constituent bulk materials can arise. A particularly interesting example is the appearance of 2-dimensional conductivity at the interface of the band insulators LaAlO3 (LAO) and SrTiO3 (STO) [1–3] above a critical LAO thickness of 4 unit cells (u.c.) [4].
A very recent related heterostructure is the diluted system of (LaAlO3)x(SrTiO3)1−x/SrTiO3 (LASTO:x/STO) which also shows interfacial conductivity above a certain critical LASTO thickness which scales inversely to the LAO content [5].
The interfaces of LaAlO3/SrTiO3 and (LaAlO3)x(SrTiO3)1−x/SrTiO3 heterostructures have been investigated by soft x-ray photoelectron spectroscopy for different layer thicknesses across the insulator-to-metal interface transition. The valence band and Fermi edge were probed using resonant photoemission across the Ti L2,3 absorption edge. We measured, for the first time to our knowledge, clear spectroscopic signatures of Ti3+ signal at the Fermi level in fully oxygenated samples of LAO/STO and the related system of mixed LASTO:0.5/STO. Our results show that Ti3+-related charge carriers are present in both systems, but only for conducting samples. No Fermi-edge signal could be detected for insulating samples below the critical thickness. Furthermore, the angular dependence of the Fermi intensity allows the determination of the spatial extent perpendicular to the interface of the conducting electron density.

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