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Structural and Electronic Reconstructions at the $LaAlO_3/SrTiO^3$ Interface

M. Salluzzo*[1], S. Gariglio[2], X. Torrelles[3], Z. Ristic[1,2], R. Di Capua[1], J. Drnec[4], M. Moretti Sala[4], G. Ghiringhelli[5], R. Felici[4], and N. B. Brookes[4]

[1] CNR-SPIN and Deparment of Physics University "Federico II" of Naples, Napoli, Italy
[2] Département de Physique de la Matière Condensée, University of Geneva , Switzerland
[3] Institut de Ciencia de Materials de Barcelona (CSIC), Bellaterra, Barcelona, Spain
[4] European Synchrotron Radiation Facility, Grenoble Cedex, France
CNR-SPIN and Department of Physics, Politecnico di Milano, P.zza Leonardo Da Vinci, I-, Milano

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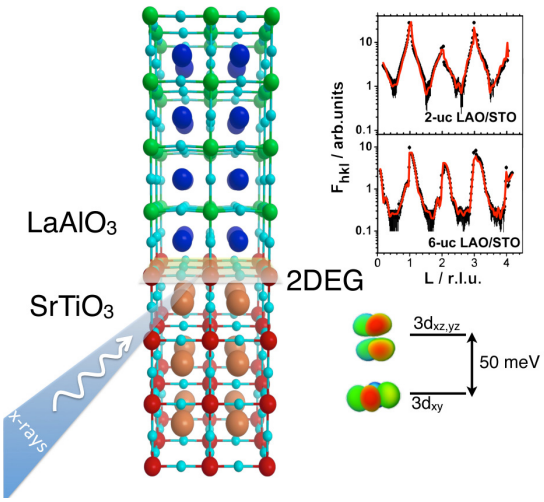

Fig.:
On the right x-rays from synchrotron source are absorbed or diffracted from the interfacial atoms belonging to $LaAlO_3$ (001) (La- blue Al- green and O cyan spheres) and $SrTiO_3$ l (Sr- orange, Ti- red) crystals. On the left, upper panel, we show structural refinement from of crystal truncation rods measured by Grazing incidence x-ray diffraction in LAO/STO samples composed by 2uc and 6uc LAO films deposited on STO. On the left bottom panel, we show the inversion of energy levels, i.e. the crystal field splitting, as obtained by x-ray absorption spectroscopy and x.ray linear dichroism at the Ti- L_{23} edge

In 2004 Ohtomo and Hwang discovered that in some conditions the interface between two of the most popular band insulating oxides, $LaAlO_3$ and $SrTiO_3$, is conducting due to the formation of a high mobility 2D-electron gas (2DEG). The phenomenon is believed to be related to a polar character of $LaAlO_3$ (001) unit cell, which introduce an instability in the system.The so called 'polarization catastrophe' picture predicts, in particular, simultaneous electronic and structural reconstruction of the interface $SrTiO_3$ layers as consequence of the formation of a mobile 2DEG which eliminate the system instability.

Here, by using a combination of advanced x-ray synchrotron-based spectroscopic and structural measurements, we show that this phenomenon is linked to a structural and electronic reconstruction of the interface which precede the appearance of the 2DEG.

In particular, by using x-ray linear dichroism at the Ti-$L_{2,3}$ we find that the 3d splitting of Ti-states in LAO/STO bilayers is opposite to tha one of $SrTiO_3$. However, the phenomenon takes place at a LAO thickness below the critical value of 4uc necessary to get a conducting interface. By using grazing incidence x-ray diffraction we find that the orbital reconstruction takes place when one complete LAO layer is deposited on top of TiO2-terminated STO crystal, and is related to interfacial symmetry breaking, thus preceding the formation of the 2DEG.