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Report:

In spite of the recent theoretical and experimental efforts to understand the origin of the 2D electron gas (2DEG) observed at the interface of polar $LaAlO_3$ and non-polar $SrTiO_3$ insulators [1], no consensus has been achieved yet. The original "electronic reconstruction" idea [1-2], which affirms that the "polarization catastrophe" instability is eliminated by a transfer of electrons to the interface, has been challenged by the experimental evidences of cation intermixing and by the role of oxygen vacancies, both phenomena known to dope STO crystals. In order to solve this puzzling issue we attempted to study by synchrotron radiation the properties of LAO_{film}/STO_{sc} interfaces tuning a metal-insulating transition by electric field effect (SI1853 and HE2990 report). More recently, we have studied by grazing incident diffraction the structural properties of LAO/STO interfaces across the thickness induced metal-insulator transition [4]. The result suggests that above 3 uc of LAO_{film} (the threshold for conductivity) polar distortions are no more able to compensate the strong electric field associated to the polar LAO layers and a simultaneous relaxation takes place [5]. Moreover, we have found that polar distortions in STO, in form of rumpling of the planes, accompanies an orbital reconstruction of the interface 3d states already when 2uc LAO layers are deposited on STO. This result was confirmed during SI2335 experiment, where we performed GIXD measurements and a complete structural refinement of another 2uc LAO/STO insulating interface grown at the DPMC University of Geneva.

These results were obtained on samples characterized by low T mobility, much lower than 10^3 V s cm^{-2} at 4.2 K, and exhibiting superconducting transition below 0.3 K. Recently several groups, including the Geneva group, have found methods to enhance the mobility well-above 10^3 V s cm^{-2} values in LAO/STO heterostructures based on STO single crystals. For the first time in this system Shubnikov–de Haas oscillations with a

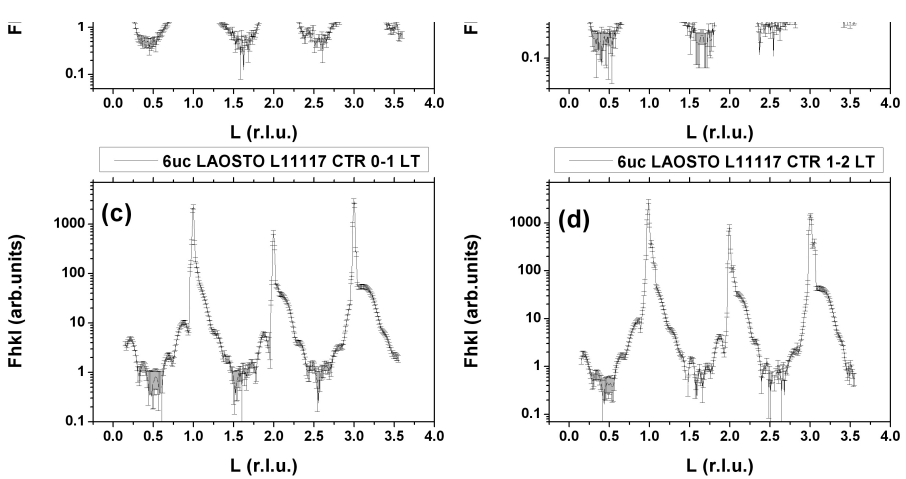

Fig.1: (a) Examples of CTR's obtained from integration of 2D-Maxipix data on high -mobility LAO/STO interfaces grown at the DPMC in geneva. (a) and (b) data on 4uc LAO/STO, (c) and (d) data on 6 uc LAO/STO

As suggested in the proposal, during SI2335 experiment we performed comparative structural studies on high mobility LAO/STO samples composed by 4uc and 6uc LAO layers. The measurements were performed at room temperature and at 10 K with the idea to verify the influence, if any, of the cubic to tetragonal phase transitions taking place in the STO bulk at 105 K.
In order to acquire large data sets we used the 2D Maxipix detector and a beam energy of 24 KeV. An example of CTR's acquired in less than half hour is shown in Fig. 1.

The analysis of the experimental data is complex and is under-way. We are using both direct methods and standard fitting procedures (using ROD) to get a complete refinement of the structures of these samples to obtain information about intermixing and rumpling of the planes. In particular we have acquired up to 15 inequivalent (H, K) crystal truncation rods (CTR's) for each sample, i.e. the structure factor F_{hkl} (q) measured by the GXID technique as function of L. Here, (H, K) are the Miller index corresponding to the in plane reciprocal lattice units (r.l.u.), while L is the Miller index for the out of plane r.l.u. We did observe at low temperatures fractional order rods, indicative of the tetragonal low T phase. However, the half integer reflections, associated to the rotations of the oxygen-octahedra, have a bulk character, since low intensity between Bragg peaks is detected. This could indicate that if a rotation of the oxygen octahedra around the Titanium ions are taking place, they are contributing very little to interface diffraction, which could happen if no rotation at all is present, or the rotation pattern is short range ordered (thus not giving intensity along an half-integer rod). Thus the same 1x1 structural model (P4mm symmetry), which includes a bulk STO unit cell and a surface model composed by 6 STO uc and a number n+1 of LAO uc (with n= 4 and 6), will be employed to refine the structure of the samples measured, at both room and low temperatures.

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