Highlights

Activity B - Superconducting and correlated low dimensional materials and devices for quantum electronics and spintronics - 2021

Irreversible multi-band effects and Lifshitz transitions at the $LaAlO_3/SrTiO_3$ interface under field effect

I. Pallecchi[1], N. Lorenzini[2], M. A. Safeen[3], M. M. Can[4], E. Di Gennaro[5,6], F. Miletto Granozio[6], D. Marré [2,1]

[1]CNR-SPIN, Sede Genova c/o Università di Genova, Via Dodecaneso 33, 16146 Genova, Italy
[2]Università di Genova, Dipartimento di Fisica, Genova, Italy
[3]Department of Physics, University of Poonch, Rawalakot, Pakistan
[4]Renewable Energy and Oxide Hybrid Systems Laboratory, Department of Physics, Istanbul University, Vezneciler, Istanbul, Turkey
[5]Università di Napoli "Federico II", Dipartimento di Fisica "E. Pancini", Napoli, Italy
[6]CNR-SPIN, UOS Napoli c/o Complesso di Monte S. Angelo, via Cinthia 21, 80126 Napoli, Italy

ADVANCED ELECTRONIC MATERIALS 7 (2021) 2001120

We investigate the irreversible effects of an applied electric field on the magnetotransport properties of $LaAlO_3/SrTiO_3$ conducting interfaces, with focus on their multiband character. We study samples of different types, namely with either crystalline or amorphous $LaAlO_3$ overlayer. Our two-band analysis highlights the similarity of the electronic properties of crystalline and amorphous interfaces, regardless much different carrier densities and mobilities. Furthermore, filling and depletion of the two bands follow very similar patterns, at least in qualitative terms, in the two types of samples. In agreement with previous works on crystalline interfaces, we observe that an irreversible charge depletion takes place after application of a first positive back gate voltage step. Such charge depletion affects much more, in relative terms, the higher and three-dimensional d_{yz}, d_{zx} bands than the lower and bidimensional d_{xy}, driving the system through the Lifshitz transition from two-band to single band behavior. The quantitative analysis of experimental data reveals the roles of disorder, apparent in the depletion regime, and temperature.

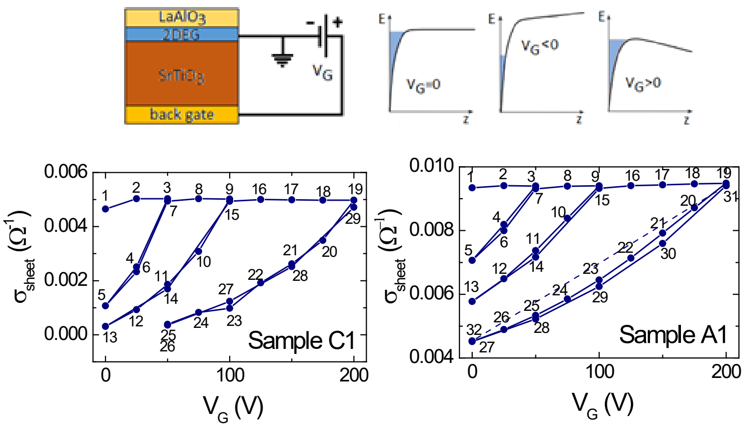

Fig. 1: Top: Sketches of the two dimensional electron gas (2DEG) at the interface and circuital configuration. Bottom: Zero field longitudinal conductance σ_{sheet} of crystalline (C1) and amorphous (A1) samples as a function of applied gate voltage V_G, in successive V_G ramps from zero to $V_{Gmax}^{(i)}$, with increasing values $V_{Gmax}^{(i)}$, measured at 20 K.

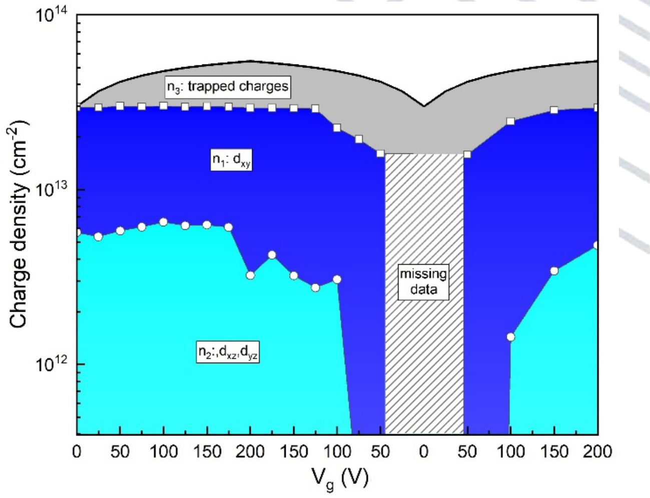

Fig. 2: Schematic diagram of charge densities in the two bands and in localized trap states during two increasing ramps up to 200V and one decreasing ramp. The n_1 and n_2 values represent our experimental data. The total charge, delimited by the black line, includes a calculated V_G-dependent carrier density, allowing to deduce by difference the amount of trapped charge n_3 as a function of the gate voltage.