Highlights

ACTIVITY B Superconducting and correlated low dimensional materials and devices for quantum electronics and spintronicst - 2020

Quantized conductance in a one-dimensional ballistic oxide nanodevice

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Within the Quantera QUANTOX project, coordinated by the CNR-SPIN, a quantum point contact (QPC) made of LAO/STO 2DEG have for the first time fabricated and **quantization of the conductance has been demonstrated. This work, coordinated by the ESCPI group in Paris, i**n collaboration with the CNRS and CNR-SPIN, is a first important milestone toward the application of oxide 2DEGs in quantum applications. The studied QPC devices were created by electrostatic confinement of the $LaAlO_3/SrTiO_3$ 2DEG with a split-gate configuration. Figure 1 shows a schematic view of a QPC, which is formed by the deposition of a metallic split-gate on top of the $LaAlO_3$ to electrostatically deplete the 2DEG underneath. A 10 μm wide Hall bar was first designed in a 12 u.c. thick $LaAlO_3$ layer using the $LaAlO_3$ amorphous template method. After the growth, a metallic back gate was deposited on the back side of the 500 μm thick $SrTiO_3$ substrate enabling a global control of the electron density in the device. Finally, a metallic split-gate was patterned by lift-off directly on the top of the Hall bar (Fig. 6). Despite the reduced thickness of the LaAlO3 layer ($\approx$5 nm) and the absence of additional insulating dielectric layer, no leakage current was observed in this device. The separation between the two fingers at the center of the split gate is W = 25 nm, which is comparable to the Fermi wavelength of the 2DEG. Near the bottleneck of the constriction, the split-gate imposes a smoothly varying confining potential that can be modeled by a harmonic potential in the transverse direction. Figure 1c shows the evolution of the conductance at zero source-drain voltage as a function of the gate voltage V_{SG} applied on the split-gate. At V_{SG} = -0.2 V the QPC is pinched off. Plateaus corresponding to the quantized values of the conductance in integer value of $G_0=2e^2/h$ appear when the split-gate voltage is increased, which indicates that ballistic transport involving spin-degenerated bands is taking place in the QPC. A maximum of three plateaus can be identified in this gate range, corresponding to $\lambda_F\approx15$ nm. A spectroscopy of the 3d-levels was performed by measuring non-linear transport at finite source-drain voltage (Fig. 1d).

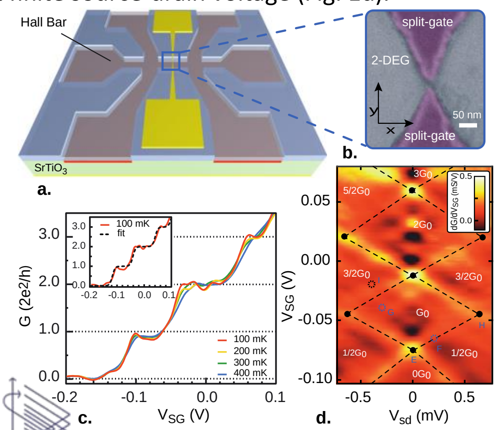

Fig. 1: Scheme of the QPC device in a $LaAlO_3/SrTiO_3$ interface. b) SEM image of the QP. c) Quantization of conductance in integer value of $2e^2/h$. d) Spectroscopy of the energy levels obtained by measuring the transconductance of the device (color code) as a function of source-drain voltage and split-gate voltage. Each diamond represents a well-defined quantized conductance.