Highlights

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

Nanopatterning of oxide 2-dimensional electron systems using low-temperature ion milling

Maria D'Antuono[1,2] , Alexei Kalaboukhov[3] , Roberta Caruso[1,2,4] , Shai Wissberg[5], Sapir Weitz Sobelman[5], Beena Kalisky[5], Giovanni Ausanio[1,2], Marco Salluzzo[2], Daniela Stornaiuolo[1,2]

[1]Department of Physics, University of Naples Federico II Complesso Monte S. Angelo, Napoli, Italy
[2]CNR-SPIN, UOS Napoli c/o Complesso di Monte S. Angelo, via Cinthia 21, 80126 Napoli, Italy
[3]Department of Microtechnology and Nanoscience MC2, Chalmers University of Technology, Sweden
[4]Brookhaven National Laboratory, Condensed Matter Physics and Materials Science Department, USA
[5]Department of Physics and Institute of Nanotechnology and Advanced Materials, Bar-Ilan University Ramat-Gan, Israel

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In this work, we present a "top-down" technique to pattern oxide 2DEGs down to the nanoscale (160 nm) via an Ar ion milling process. Although developed for realizing LAO/ETO/STO devices, it can be applied to all types of oxide heterostructures.
The process is sketched in Fig. 1 . After realizing a resist mask, the sample is glued to a cold finger cooled with liquid nitrogen and patterned using low energy Ar ion milling. The lower panels of Figure 1 show Atomic Force Microscope images of some of the nanodevices we realized.
Electrical transport and scanning Superconducting Quantum Interference Device measurements (Fig. 2) demonstrate that the low-temperature ion milling process does not damage the 2DEG system properties, including gate tunability and ferromagnetic coupling, nor creates oxygen vacancies-related conducting paths in the STO substrate.
The presented technique shows some advantages compared to those used up to now for patterning of oxide 2DEG systems. Being a "top-down" approach, it does not involve manipulation of the substrate and it is suitable for the patterning of every kind of interfacial systems. The procedure can be applied also to pre-tested heterostructures, increasing the yield of the nanofabrication process and, unlike other nanopatterning techniques, it allows to expose the 2DEG along the in-plane directions. This last aspect opens the way to the realization of hybrid devices, where the 2DEG systems could be coupled other advanced materials.

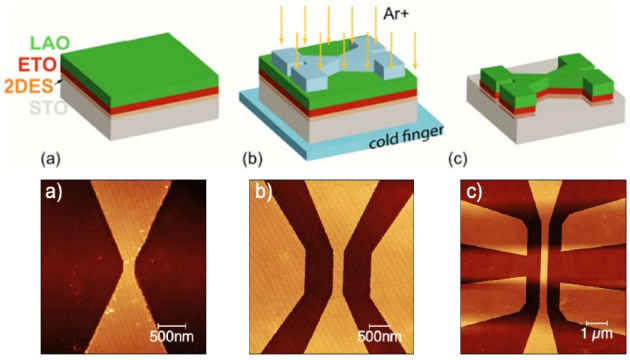

Fig. 1: Sketch of fabrication process of the LAO/ETO/STO nanodevices and AFM topography images of some of the LAO/ETO/STO devices realized: a) Dayem bridge, b) side gate device with one pair of lateral electrodes, c) side gate device with two pairs of lateral electrodes. In the AFM images, the lighter areas are the LAO/ETO bilayers, under which the 2DEG develops, while the darker areas are the exposed STO substrate.

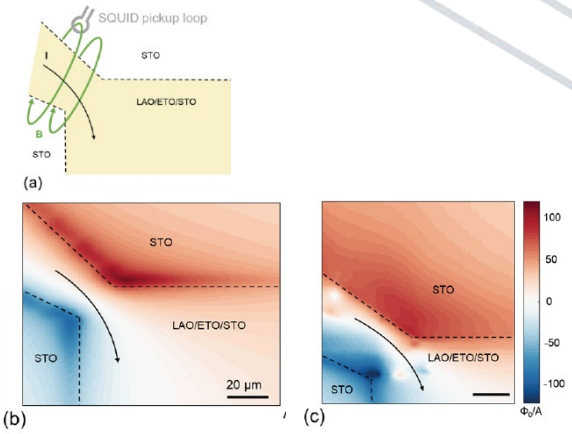

Fig. 2: (a) Schematic of scanning SQUID pickup loop capturing field lines near the surface of a current carrying device. (b) Simulation of the magnetic flux pattern in a homogeneous conductor with the same geometry as the measured LAO/ETO/STO device. (c) Scanning SQUID data over a patterned LAO/ETO/STO device taken at 4 K.