Hysteretic transport in manganite/graphene hybrid planar nanostructures

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Abstract

We report on the fabrication and magnetotransport characterization of innovative hybrid graphene-based planar nanodevices with epitaxial nanopatterned $La_{0.7}Sr_{0.3}MnO_3$ manganite, grown on $SrTiO_3$ (100), as ferromagnetic current injector electrodes. The few layers graphene (FLG) was deposited onto the predefined manganite nanowires by using the PMMA transfer technique. These nanodevices exhibit hysteretic transport as measured by IV curves. The resistance can be reversibly switched between high and low states yielding a consistent non-volatile memory response.

1. Introduction

Since their discovery, colossal magnetoresistance manganites have focused a large research effort due to the interesting physics underlying the strong electronic correlations. In particular, the half metallic character of $La_{0.7}Ca_{0.3}MnO_3$ (LCMO) or $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) perovskite oxides has motivated their use as sources of spin polarized carriers in spintronic devices. Although many examples can be found in the literature were these oxides have been used as magnetic electrodes in multilayer devices for perpendicular transport along 3D pillars, planar devices involving nanostructured electrodes are to our knowledge very scarce [1]. This may be related to difficulties in nanostructuring these materials due to their mechanical hardness, or to the alteration of their electronic properties caused by etching processes. Yet, having access to single domain manganite wires could be of interest for non local spin injection. In this communication we report on our recent effort on fabricating complex oxide nanostructures.

2. Materials and Methods

The 18 nm c-axis LSMO thin film samples were grown on (001)-oriented $SrTiO_3$ single crystals in a high-O_2-pressure (3.4 mbar) r.f. sputtering system at 900 °C. In situ annealing was done in 800 mbar O_2 pressure and 550 °C for 30 min [2]. LSMO wires 200 and 500 nm wide were fabricated by using conventional Electron Beam Lithography and wet etching processes. In particular, 200nm thick ma-N2403 negative resist (from MicroResist GmbH) was spun on the LSMO thin film and 10 kV, 100 pA electron beam lithography parameters were used in order to define the manganite nanowires. The LSMO wet etching was done diping the sample in a hydroclhoridryc acid solution for few seconds. The mechanically exfoliated FL-graphene on SiO_2/Si wafer was moved onto predefined $La_{0.7}Sr_{0.3}MnO_3$ manganite nanowires by using the PMMA transfer technique (fig.1a).

3. Results and Discussion

The magnetic behaviour is examined by measurements of the anisotropic magnetoresistance AMR in magnetic fields with various orientations with the direction of the wire. In LSMO wires we find evidence for a magnetic state up to room temperature and resistivity values close to those found in large thin films, suggesting that the electronic state is little affected by the lithography process. Different coercive field values were found as function of the nanowire width. Abrupt resistance switching at coercivity is consistent with a single domain state. For magnetic fields oriented perperdicular to the wire AMR displays complex futures suggesting domain wall resistivity. The resistivity vs temperature measurement shows a typical metal-insulator transition (MIT) acompanied with a strongly non linear transport with hysteretic IV curves characteristic. In particular, we find a typical memristive-like behaviour in the metallic regime and pinched-diode behaviour in the insulator regime (fig.1b). Interestingly, the bistable resistance states display a nonvolatile memory response.

LSMO

Figures

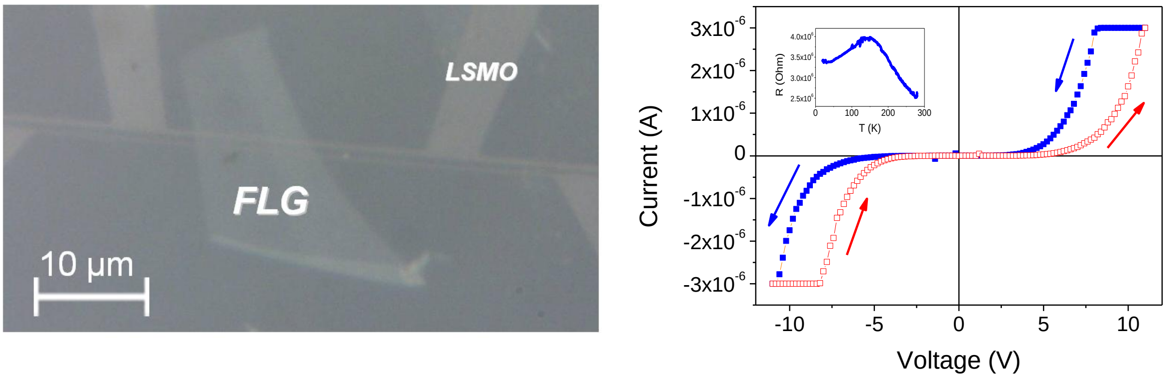

Figure 1: a) Micrograph showing a few layer graphene (FLG) on two LSMO wires of 500 and 200 nm thickness. b) Typical hysteretic IV curves measured at 140 K (inset resistance vs temperature curve of the FLG/LSMO device measured at $I=1\cdot10^{-7}$A).

4. Conclusions

New kind of hybrid LSMO/FLG nanodevices were fabricated and characterized. A peculiar hysteretic transport has been found at temperatures ranging from 10 to 300 K. This behaviour could be related to the contact resistance between the oxide and the graphene and could be used in the future as graphene-based non-volatile memory, in nanoelectronic applications. Further work will be necessary to identify the origin of such an intriguing response in these complex oxide/graphene nanostructures.

References

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