Scanning probe piezoresistance: a new experimental tool (or what happens when you put an elephant on stilettos)

N. Domingo[1,6], L. López-Mir[1,2],* X. Martí[1,3,4], M. Paradinas[2], C. Ocal[2] and G. Catalán[1,5]

neus.domingo@cin2.es

[1] ICN2 - Institut Catala de Nanociencia i Nanotecnologia, Campus UAB, 08193Bellaterra (Barcelona), Spain
[2]Institut de Ciència de Materials de Barcelona, ICMAB-CSIC, Campus UAB, 08193 Bellaterra (Barcelona), Spain
[3]Institute of Physics ASCR, v.v.i., Cukrovarnická 10, 162 53 Praha 6, Czech Republic
[4]Department of Condensed Matter Physics, Faculty of Mathematics and Physics, Charles University, Ke Karlovu 5, 12116 Praha 2, Czech Republic
[5]ICREA - Institucio Catalana de Recerca i Estudis Avançats, 08010 Barcelona, Spain
[6]CSIC - Consejo Superior de Investigaciones Cientificas, ICN2 Building ,08193 Bellaterra (Barcelona), Spain

Mechanical stimuli induced by the tip of an atomic force microscopy (AFM) is the basis for the generation of different types of phenomenologies, from flexoelectric fields that can lead to mechanical writing in ferroelectric materials [1] to piezochemical effects due to the dynamics in ionic systems [2].

In this presentation, I will introduce a new electromechanical effect that can be studied by AFM: the piezoresistance coefficients and gauge factors of sensor materials. In this work [3], we have induced an insulator-to-metal transition by applying uniaxial pressure to the material through an Atomic Force Microscope (AFM) tip, measuring a record gauge factors for an oxide material at the nanoscale. We achieve the reversible mechanical control of dielectric gap in a semiconductor oxide that lead to metal-insulator transitions induced by uniaxial stress, demonstrating that local electronic structures can be locally changed by applying uniaxial pressure through an AFM tip. The AFM tip also acts as a sensor and transport measurements through the AFM tip are done through different approaches. In all cases the experimental setup consist of the sample and tip placed in series resulting in a capacitor where the tip is the top electrode and an LSMO thin film substrate between SIO and STO is the bottom electrode. While the features of the I(V) for the lowest applied forces resemble those of a semiconductor, linear Ohmic behavior is achieved for increasing forces with increasing slopes. From the obtained results, we observed an outstanding and reversible decrease of the resistance of the Sr_2IrO_4 thin film as a function of increasing mechanical loading force on the AFM tip. We attribute this behaviour to an insulator-to-metal transition caused by pressure induced changes in the Ir-O-Ir bond angle in the plane which produce a closure of the band gap.

References

[1] H. Lu, et al., Science 336, 59 (2012).
[2] Y. Kim, et al.,Nanoletters 13 (2013) 4068.
[3] N. Domingo, et al, submitted for publication.

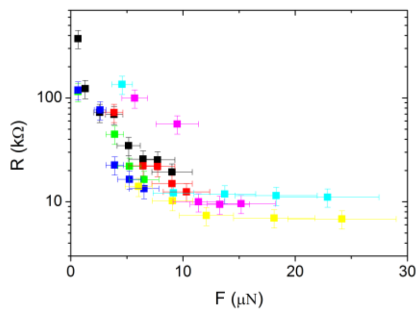

Figure 1. Resistance as a function of the applied forcé through an AFM onto Sr_2IrO_4.