Optimization of spin injection in Lateral Spin Valves

Estitxu Villamor [1], Luis E. Hueso [1,2], Fèlix Casanova [1,2]

[1] CIC nanoGUNE Consolider, 20018 Donostia-San Sebastian, Basque Country, Spain
[2] IKERBASQUE, Basque Foundation for Science, 48011 Bilbao, Basque Country, Spain

e.villamor@nanogune.eu

Creation and manipulation of spin currents is a key ingredient in spintronics, which has as a goal the use of the spin of the electron in addition to its charge. One way to create such spin currents is by using ferromagnetic (FM) / non-magnetic (NM) lateral spin valves (LSV). Due to their non-local geometry (see Fig. 1), it is possible to decouple a pure spin current from the charge current [1].

In a LSV, spin-polarized current is injected from a FM electrode into a NM metal, generating a spin accumulation at the interface which diffuses along the NM. Another FM electrode is used to measure the voltage, which is proportional to the spin accumulation. The measured voltage, normalized to the injected current is called non-local resistance (R_{NL}). R_{NL} changes, due to the relative magnetization of the FM electrodes, under an applied magnetic field. When the magnetizations are parallel (antiparallel), R_{NL} is positive (negative). The difference between the positive and negative non-local resistances is the spin signal (see Fig. 2).

The LSV devices from this work are fabricated by using a two-step electron-beam lithography process. In the first step, FM electrodes are deposited and, in the second one, the NM metal is put on top. Transparent interfaces are important in order to maximize the spin current density in the devices [2]. With this purpose, Ar-ion milling is performed on the FM surface after the first step, to remove oxide and resist left-overs. The interface milling time is systematically changed in order to achieve an optimal spin injection.

Optimized LSV devices are fabricated with different FM electrodes (cobalt and permalloy) with copper as the NM channel. In these devices, the spin signal is measured at different temperatures (see Fig. 2) in order to obtain the spin polarization of the FM metal and spin diffusion length of copper as a function of temperature. Whereas the spin diffusion length in Cu shows a consistent behavior due to surface effects [3], the results in the spin polarization for the various FM metals help understanding the role of the FM/NM interface in the electrical spin injection. This is a fundamental issue for the creation of pure spin currents.

The authors acknowledge funding from the Spanish MICINN (MAT2009-08494), the Basque Government (PI2011-1) and the European Commission (“ITAMOSCINOM”, Marie Curie Actions). E.V. thanks the Basque Government for the Ph.D. fellowship “Programas de ayudas para formación y perfeccionamiento de personal investigador”.

References

[1] F. J. Jedema, M. S. Nijboer, A. T. Filip, B. J. van Wees, Physical Review B, **67** (2003) 085319.
[2] F. Casanova, A. Sharoni, M. Erekhinsky, I. K. Schuller, Physical Review B, **79** (2009) 184415.
[3] T. Kimura, T. Sato, Y. Otani, Physical Review Letters, **100** (2008) 066602.

Figures

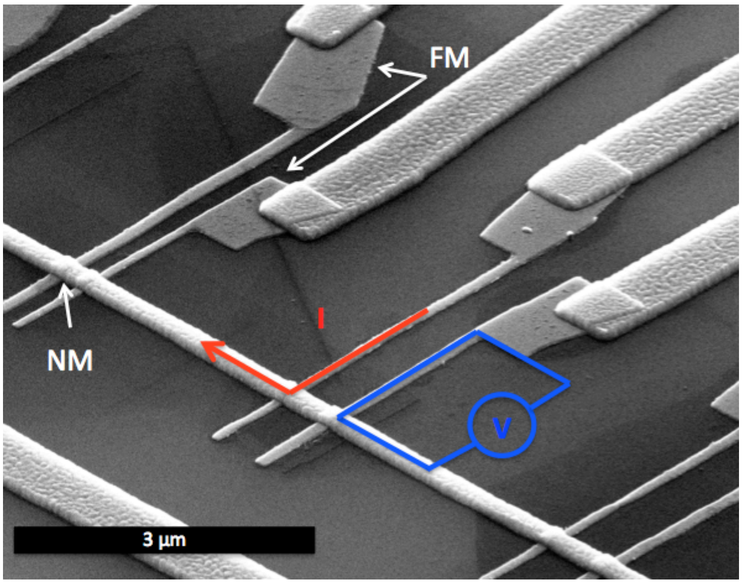

Figure 1: Scanning electron microscope image of a sample with three LSV devices. Current is driven in the direction of the red arrow, and spin signal is measured as blue circuit shows. Ferromagnetic electrodes (FM) and non-magnetic metallic channel (NM) are tagged in the image.

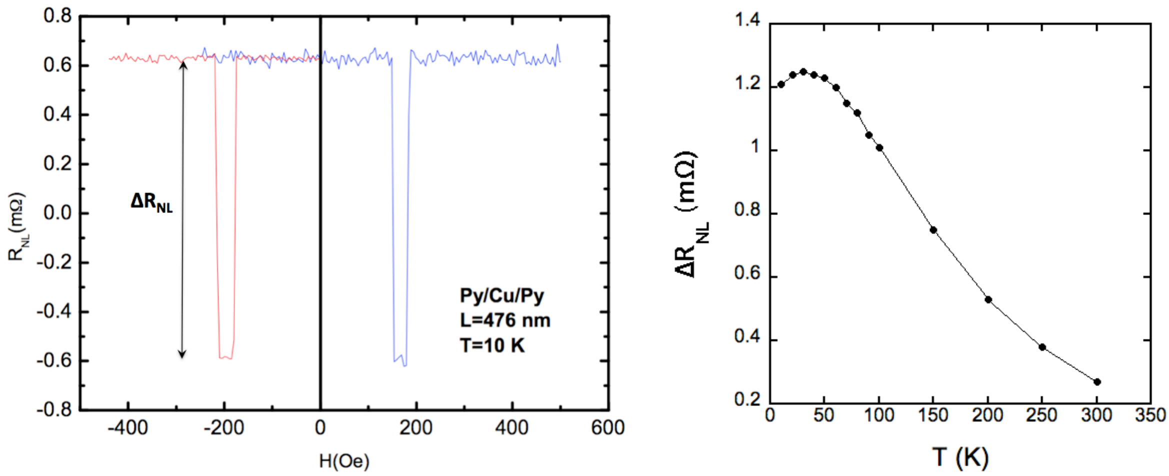

Figure 2: Left: non-local resistance as a function of the applied field, for a LSV device with a distance of 476 nm between the FM electrodes. The measurement has been done at 10 K. The arrow indicates which is the spin signal. **Right:** Spin signal measured as a function of temperature for the same LSV device.