Oral

ELECTRICAL TRANSPORT PROPERTIES OF METALLIC NANOWIRES AND NANOCONSTRICTIONS CREATED WITH FIB/SEM DUAL BEAM

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Fascinating phenomena such as large ballistic magnetoresistance have been recently studied in nanoconstrictions based on magnetic materials [1]. However, the lack of systematic and reproducible results in these constrictions calls for further investigation before implementation in real working devices [2]. We use focused-ion-beam techniques in combination with in-situ electrical measurements to create atomic-sized magnetic metallic constrictions and explore their magneto-transport properties (see Figure 1). We have recently reported that by means of low-energy focused-ion-beam (FIB) Ga etching of a metallic electrode it is possible to control the formation of atomic-sized constrictions with milling-time, observing steps in the conductance in the range of the conductance quantum ($G_0=2e^2/h$), just before entering the tunneling regime [3]. Such behaviour has been observed in particular in Fe-based electrodes (see Figure 2). These constrictions are highly stable with time due to the adherence to a substrate, which allows further studies such as the detailed current-voltage transport investigation, thus being a promising route to study physical phenomena in the verge of the metal-tunnel conduction crossover. In this contribution, we will report the two procedures followed by our group to obtain Fe-based constrictions using FIB-based techniques and the corresponding in-situ transport measurements. In the first procedure, a 4 x 1 μm^2 electrode area is FIB-milled, which brings about continuous and smooth resistance variations but the exact position of the nanoconstriction inside the milling box is not controlled [3]. In the second procedure, a progressive narrowing of the sides of the electrode is carried out, which allows the control of the exact position of the nanoconstriction [4]. This is also desired to have a defined current direction, which is required for ballistic anisotropic magnetoresistance measurements. The possibilities to stabilize the formed nanocontacts for ex-situ applications will be subsequently discussed and the obtained magnetoresistance data presented. In particular, first results in the ballistic tunnelling regime show magnetoresistance values ten times larger than before performing the FIB milling.

References:

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Figures:

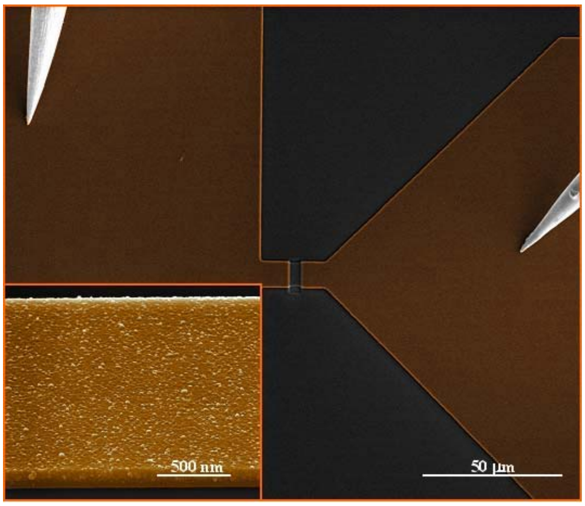

Figure 1. *An SEM image of the micrometric electrodes patterned by optical lithography. The two microprobes are contacted for real-time control of the electrode resistance. The inset is an SEM image of the electrode previous to the Ga etching.*

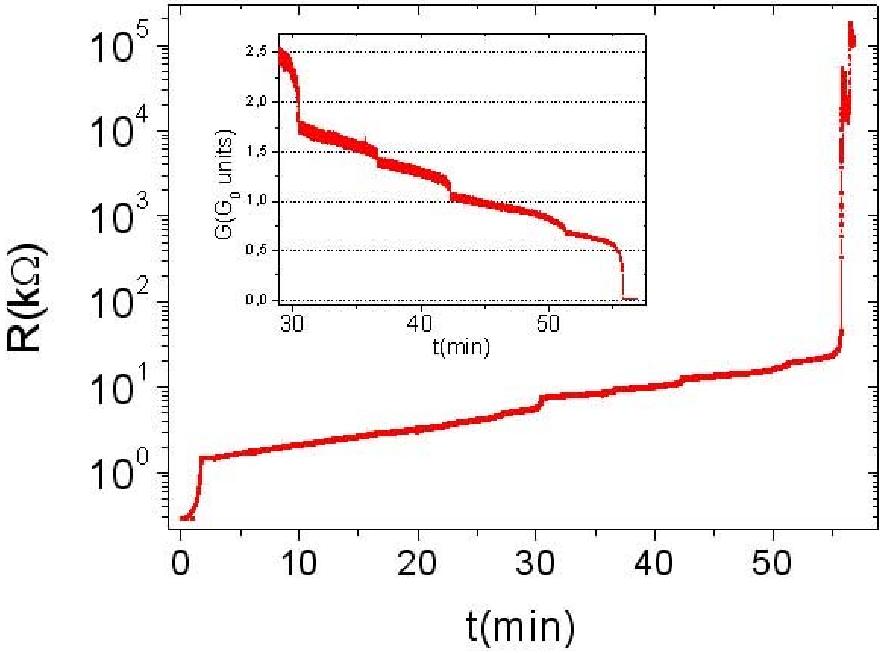

Figure 2. *Resistance versus time in a typical ion etching process of an Fe electrode, where discrete jumps are observed before the tunnelling regime is reached. The inset shows the corresponding conductance (in* $G_0=2e^2/h$ *units) versus etching time. In this stage of milling, steps of the order of some fraction of* G_0 *are seen, corresponding to discrete thinning of the contact area of the order of one or a few atoms. The last step is followed by a sharp decrease of conductance, corresponding to the crossover to the tunnelling regime.*