Magnetic and electric transport characterization of a single nickel nanowire isolated by dielectrophoresis

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The growing interest in magnetic nanowires (NWs) is connected to possibility of employing them for advanced applications in wide technological fields, such as building blocks for data storage and memory, advanced scanning-probes, as well as biotechnological applications.[1] In addition, NWs can be used as sensor for several applications, since they present high sensitivity to their environment. One of the major challenges to perform transport investigations and build devices using NWs is to trap them between electrodes. In this work, electrically neutral Ni nanowires (NiNWs) were deposited on pre-patterned Pt electrodes by dielectrophoresis (DEP) method (Figure 1), which uses non-uniform AC electric fields to selectively move neutral NWs dispersed in an electrolytic medium,[1] in order to investigate their magneto-electric transport properties. Our objective is to characterize the electric resistivity and magnetoresistance (MR) signal of a single NiNW (35 nm of diameter and 4 µm-long), under temperature and magnetic field influence. The NWs were fabricated by electrodeposition technique on nanoporous alumina membranes.[2] Electric resistivity measurements were taken using a standard four-probe technique in a Physical Property Measurement System (PPMS). The temperature evolution between 2 and 300 K exhibits a metallic behavior (Figure 2), as expected, with a residual resistivity of 27 Ω.cm, which in good agreement with NiNWs of similar dimension.[3] The MR signal, measured with the current flowing perpendicular to the applied magnetic field (Figure 3), decreases down to around -1% at room temperature as the magnetic field increases, as observed for NiNW arrays.[2]

Finally, DEP process seems to be a promising feature to trap individual NWs between pre-patterned electrodes, since they can be manipulated and isolated with relatively high efficiency. In addition, as NiNWs present ferromagnetic properties, which allow their low current levels to be controlled through magnetic fields, they can be thought as an alternative for single-NW magnetic sensors as well as a promising alternative to the traditional Si-based MOSFET.

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[2] Leitão, D. C., Sousa, C. T., Ventura, J., Amaral, J. S., Carpinteiro, F., Pirota, K. R., Vazquez, M., Sousa, J. B., Araujo, J. P., 2008, *J. Non-Cryst. Solids* **354**, 5241.

[3] Ou, M. N., Yang, T. J. Harutyunyan, S. R., Chen, Y. Y., Chen, C. D., Lai, S. J., 2008, *Appl. Phys. Lett.* **92**, 063101.

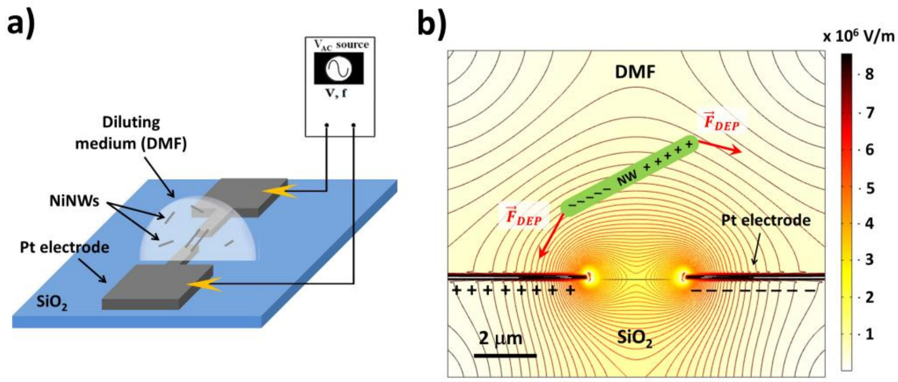

Figure 1: (a) Schematic of the DEP experiment. (b) DEP mechanism, in which the electric field gradient induces attraction forces on the nanowire toward the gap between electrodes.

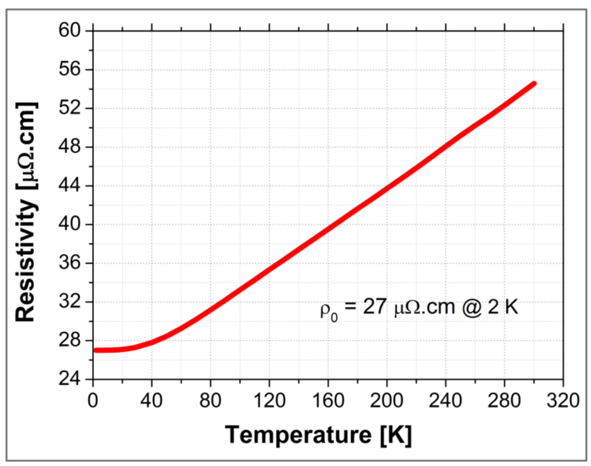

Figure 2: ρ x T curve of one single NiNW measured with a PPMS system, showing metallic behavior and a residual resistance of 27 μΩ.cm at 2 K.

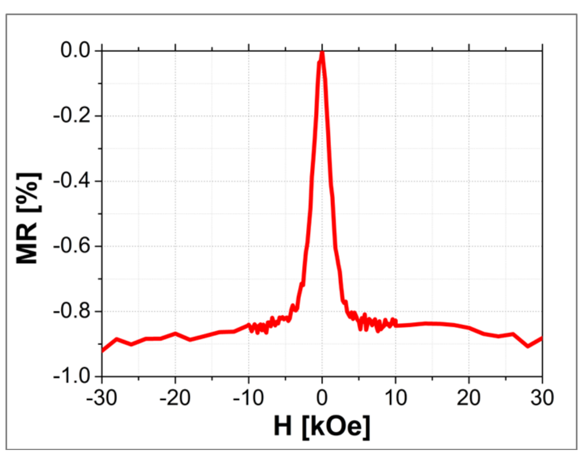

Figure 3: *MR* x H of a single NiNW showing a MR signal of ca. -1% for fields above 10 kOe.