

Study of NiCu multilayer magnetic nanowires

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Abstract

Magnetic nanowires play an important role both in basic research, since they can exhibit new physical phenomena, and technological applications, such as magnetic storage and magnetic sensors. It was investigated the magnetic properties of magnetic nanowires composed of multilayers made of Ni and Cu, fabricated by electrodeposition method in alumina porous template. We obtained their magnetization curves at 2 K and 300 K, and it was intended to perform magnetoresistance measurements. The latter was not done, because it was encountered difficulties in trapping the nanowires between electrodes.

Key words:

Nanomagnetism, nanowire, magnetoresistance.

Introduction

Magnetic nanowires are cylindrical structures whose diameter is of the order of nanometers (10^{-9} m), length of the order of micrometers (10^{-6} m), and usually present at least one element among the ferromagnetic triplet Fe, Ni, Co, besides other possible transition metals.¹ These samples are of interest both for basic research, because they can show physical phenomena that occur exclusively within the nanoscale, and for technological applications, such as magnetic sensors and high density magnetic recording media.¹

The study objects were seven samples of magnetic nanowires made of several alternating layers of Ni and Cu. They were fabricated by the traditional method of electrodeposition in alumina porous membranes.² The objectives are to perform the magnetic characterization of the samples, through their hysteresis loop, to identify the process of magnetization reversal and to perform measurements of electrical transport, specifically magnetoresistance measurements.

Results and Discussion

The magnetic characterization was made by SQUID and VSM magnetometers at 2 K and 300 K, so it was obtained the hysteresis loops of each sample. The interest parameters are shown in Tab. 1, namely the coercivity H_c and the saturation magnetic moment m_s . It is expected that both H_c and m_s decrease with temperature. This was indeed observed for all samples, except for PNWM_B. A more detailed study of the sample should be done for finding the reasons for this behaviour, as visualization of the nanowire structure and composition by some microscopy technique and micromagnetic simulations.

Table 1. Coercivity H_c and saturation magnetic moment m_s of each sample at 2 K and 300 K.

Sample	Coercivity H_c (Oe)		Saturation magnetic moment m_s (10^{-4} emu)	
	2 K	300 K	2 K	300 K
PNWM_C	412,2	206,4	9,3	6,8
PNWM_30.1	469,85	409,65	114	101
PNWM_1.2	298,25	248,5	44	39
PNWM_14.2	388,15	245,15	36,8	33,9
PNWM_B	647,75	749,5	265	228
PNWM_16.2	394,2	288	28	25
PNWM_14.1	14,4	9,65	9,5	7,5

The magnetization curves give information about the whole nanowire matrix, while electrical transport measurements give information about an individual nanowire. To perform the latter, however, it is necessary to trap a unique nanowire between two electrodes. This can be accomplished by dielectrophoresis (DEP) method.³ It was encountered great difficulties in establishing the contact. We believe that the contact resistance between the nanowires and the electrodes is the principal responsible for this,³ and also may exist an insulating oxide coating in the Cu layers. By repeatedly performing DEP and changing parameters, we achieved a good contact for the sample PNWM_B. Unfortunately, the time employed in DEP was bigger than expected for this reason, and the magnetoresistance measurements were not made yet.

Conclusions

The magnetization curves are hysteresis loops as expected. The coercivities H_c and the saturation magnetic moments m_s decrease with temperature for all samples except for PNWM_B, and we could not find an immediate explanation for this deviation, so a directed study should be done in this sense. We unfortunately did not perform magnetoresistance measurements because of the difficulty encountered in establishing contact between the nanowires and the electrodes, which we believe that was principally due to the contact resistance between them. Micromagnetic simulations together with magnetoresistance measurements can give information about the magnetization reversal mechanism dominant in the samples.

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¹ GUIMARÃES, A. P. *Principles of Nanomagnetism*. Springer, 2009. 230 p.

² PIROLA, K. R. et al. Novel magnetic materials prepared by electrodeposition techniques: arrays of nanowires and multi-layered microwires. *Journal of Alloys and Compounds*, v. 369, p. 18-26, 2004.

³ DOS SANTOS, M. V. P. et al. Dielectrophoretic manipulation of individual nickel nanowires for electrical transport measurements. *Journal of Vacuum Science & Technology B*, v. 33, n. 3, 2015.