Magnetic properties in Fe/FePd multilayers

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We have studied the magnetic properties of Fe/FePd bilayers. Three sample were prepared by vacuum evaporation on Si/SiO_2 substrates, keeping a constant FePd layer thickness (53 nm) while varying the Fe layer thickness (35, 70 and 72 nm). Alternating gradient field magnetometry and magnetic force microscopy were used for magnetic characterisation. The increase of thickness of Fe layer leads to an increase in saturation of magnetisation as a consequence of presence of an excess of Fe and the formation of the soft α-Fe phase. The exchange coupling between the phases is demonstrated by the changes in the hysteresis cycle shape and first order reversal curves.

Keywords: Fe/FePd; multilayer, Magnetic hysteresis; exchange coupling.

1. Introduction

Magnetic thin film multilayers are integral to devices like magnetic tunnel junctions and recording media, with exchange coupling between layers critically influencing device performance. Incorporating soft and hard magnetic phases enhances permanent magnet design by improving the maximum energy product (BH_{max}) [1]. Optimizing factors such as interface conditions, soft-hard volume fractions, and microstructures is essential for effective coupling. The FePd binary system, known for its high magnetocrystalline anisotropy when in the $L1_0$ phase, serves as an ideal model for nanoscale exchange coupling studies. However, soft phases like Fe (or Co) usually react with the other phases present in the FePd matrix [2], and can potentially reduce the magnetic moments and energy products. In this report, we study the magnetic properties of Fe/FePd bilayers. Three sample were prepared by vacuum evaporation on Si/SiO_2 substrates, maintaining a constant FePd layer thickness (53 nm) while varying the Fe layer thickness (35, 70 and 72 nm): for simplicity the samples are labelled Fe(35)/FePd, Fe(70)/FePd and Fe(72)/FePd. This approach aims to investigate how the soft Fe layer thickness influences the magnetic properties and exchange coupling between the magnetic bilayers.

2. Results and discussion

Figure 1 and Table 1 show that the shape of the hysteresis loops for all the samples is narrow and curved, confirming that all as-deposited samples are soft ferromagnets.

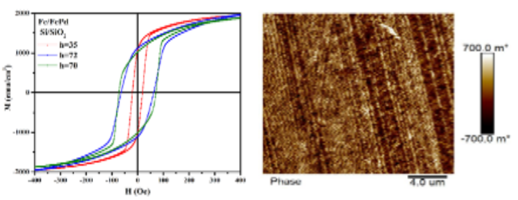

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Figure 1: Magnetic hysteresis loops and MFM image of Fe/FePd bilayers.

Sample	Hc(Oe)	Ms (emu/cm^3)
Fe(35)/FePd	20	1802
Fe(70)/FePd	71	1974
Fe(72)/FePd	64	2071

Table1: coercive field (HC) and saturation magnetisation (Ms) values of Fe/FePd bilayer.

Magnetic measurements showed that the samples behave as single magnetic phases with smooth magnetization varying with the thickness of the Fe phase. The weak magnetic contrast seen by magnetic force microscopy confirms the low anisotropy values of these samples. It can be seen that the coercivity values for both samples with Fe layer thickness of 70 and 72 nm were almost the same, while for the sample with Fe layer thickness of 35 nm the coercivity reduces to 20 Oe. Moreover, also the values of the saturation magnetisation change with the soft Fe layer thickness, increasing with it. It is worth comparing the magnetic properties of the bilayer films with FePd thin films without a Fe layer [3], [4]. A general increase in M_s is observed with increasing Fe content (Ms_{FePd}=1236 emu/cm^3), because of the presence of an excess of Fe and the formation of the soft α-Fe phase [5]. We observed a significant change in the hysteresis loop shape that might attributed to weak exchange coupling between the phases presented in the bilayer film, which will be further studied with first order reversal curves.

References

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