Preisach model for soft-hard bilayers

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I. Introduction

In recent years, the studies of magnetic properties of materials based on the First-order Reversal Curves (FORC) diagrams developed at a high rate due to the proven qualities of the method [1-3].

In the case of systems with two phases of different average coercivity this method was able to evidence the existence of the two phases and opened the possibility to study these materials as a function of the relative weights of the two phases [4].

We chosed CoPt bilayer systems with layers of different hardness and different thickness for a systematic study and for testing a new variant of Preisach model. The CoPt bilayers were produced by magnetron sputtering at ambient temperature on oxidized Si (111) substrates. To modify the structure of the bottom layer, from soft to hard magnetic, films of 30 nm are annealed in high vacuum to crystallize the high anisotropy phase. Then, the sample is cooled to room temperature and a top (soft) CoPt layer is deposited. When decreasing the thickness of the soft layer from 30nm to 6nm, the shape of the major hysteresis loop changes dramatically, from a wasp-waist shaped loop where the contributions of the two phases are clearly separated - for the thick sample - to a major loop similar to one characteristic to homogenous systems for the thin sample. In Fig. 1 one presents the experimental FORC diagrams which show complex features for the thick sample (left), features which become much simpler for the case of the thin sample (right). In each case, the FORC diagram shows clearly the presence of two phases even if on the major loop no special features are observable.

II. Modeling

Based on the conclusions drawn from the FORC analysis we have performed micromagnetic simulations on two systems similar to the experimental samples. By simply changing the thickness of the system we were able to obtain the same effects as observed in the experimental FORC diagrams. Moreover, using the micromagnetic simulations we were able to analyze the dynamics of the interaction field distribution for different components of the systems during the magnetization processes allowing us to establish useful rules for Preisach modeling of this kind of systems.

In order to simulate the behavior of this kind of systems using Preisach model we have used a Preisach distribution

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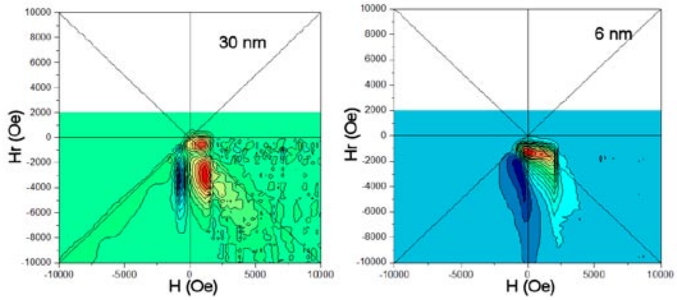

Fig.1. FORC diagrams for two samples with different thickness.

with three components: one corresponding to the hard magnetic phase, the second corresponding to the part of the soft magnetic phase which is coupled with the hard phase and the third corresponding to the free soft magnetic phase.

In fig. 2 Preisach simulations are presented (for the thick sample the contribution to the total magnetic moment of the three components was considered to be: 66% soft uncoupled phase, 17% soft coupled phase and 17% hard phase while for the thin sample was 0%, 50%, 50% for the same three components; all other parameters of the model were kept constant).

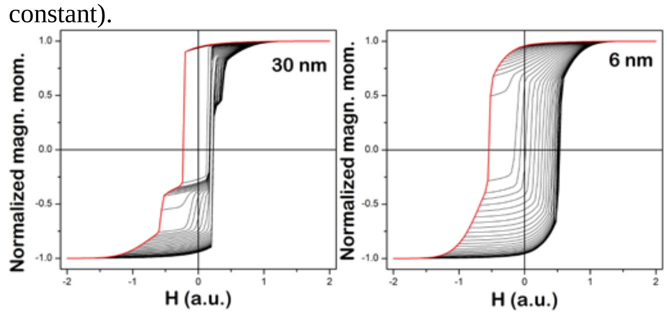

Fig.2. Simulation results from the 3 distribution Preisach-type model.

We will also present the results of the micromagnetic simulations, which are in very good agreement with the experimental data, and the way the mean field interaction terms used in the Preisach model were determined

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