MODELLING OF MAGNETIC HYSTERESIS LOOPS IN THE STUDY OF NiFe/Cu/Co SPIN-VALVE SYSTEMS CHARACTERISTICS

Shipkova I., Veretennikova Y., Roschenko S.
National Technical University «Kharkiv Polytechnic Institute», Kharkiv

The layered NiFe/Cu/Co nanosystem is attractive due to the observable effect of giant magnetoresistance. The required condition for the effect is the achievement of a state with an antiparallel alignment of magnetization vectors in adjacent layers, which can be fulfilled in this system due to different values of the coercive force of cobalt and permalloy films. When used in electronic devices, the shape of the field dependence of magnetoresistance is of great importance. This dependence correlates with the shape of the magnetic hysteresis loop and its parameters. In this work it is presented a way to modelling the hysteresis loops of a spin-valve system based on the characteristics of individual films, as well as a study of changing these characteristics during low-temperature annealing.

The sample composition for this study is $Ni_{80}Fe_{20}$/Cu/Co/Cu ($Ni_{80}Fe_{20}$ und Co are magnetic layers and Cu is a nonmagnetic one). The thicknesses of layers were: permalloy – 4-6 nm, cobalt – 2 nm, copper – 2, 2.7, and 10 nm. We have measured the magnetic characteristics of the films in fields up to 1 kOe using a high-sensitivity vibrating sample magnetometer.

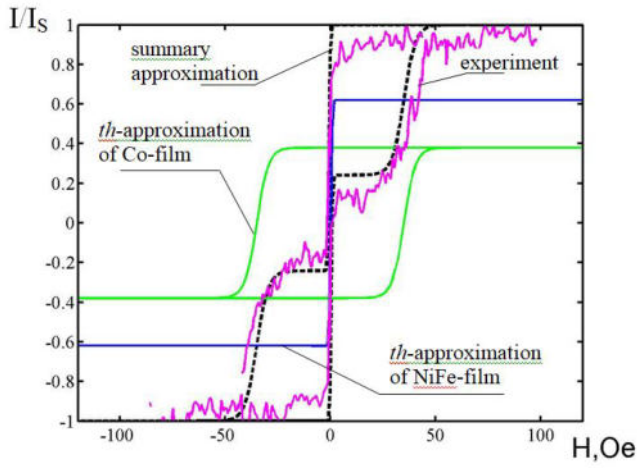
For modelling the shape of the loops, a hyperbolic approximation was used, as shown below:

$$\frac{I}{Is} = \frac{2}{\pi} th\left(\frac{H \pm Hc}{Hc} tg\left(\frac{\pi \cdot s}{2}\right)\right),$$

where I/I_s is relative magnetization, H_C is coercivity, s is relative remanent magnetization.

An example of this approximation is shown in the figure for a system with a thick t_{Cu} >10 nm layer.

According to the modelling results it was found that the magnetic layers into the structure with t_{Cu} >10 nm are magnetied independently of each other and have characteristics close to those of individual films ($H_{C\,Co}$ = 35 Oe, s = 0,9, $H_{C\,NiFe}$ = 0,5 Oe, s = 0,5). In films with t_{Cu} < 2.7 nm the mutual influence of the layers causes the following parameters: $H_{C\,Co}$ = 6 Oe, s = 0,9, $H_{C\,NiFe}$ = 1,3 Oe, s = 0,5).



During successive annealing in the range of 50 - 150°C, the coercivity of the cobalt layer initially increases up to ~100 Oe. At higher temperatures, a non-hysteresis curve is observed, which can be theoretically described by the Langevin function. The characteristics of the NiFe film in this temperature range practically do not change.