Investigation of the magnetization dynamics of the Pt/Co/a-Cr_2O_3 thin film system by atomistic spin dynamics methods

We investigated the perpendicular exchange bias system Pt/Co/a-Cr_2O_3 by means of classical spin dynamics simulations. First, we studied a simplified four macro-spin system, where two macro-spins model a ferromagnetic and an antiferromagnetic layer, resp. In our next approach we have modeled the Co and Cr_2O_3 layers of the system by taking into account the true microscopic structure. We have obtained first results for the interlayer exchange coupling, ground states and the resulting switching behavior.

In spin valves the giant magneto resistance (GMR) depends on the relative orientation of two ferromagnetic layers. To change the resistance, one of the layers has to possess a fixed orientation of the magnetization in a certain magnetic field range, while the other is free and can be controlled by an external field.
While the magnetization curve of a pure ferromagnetic is symmetric along the magnetization axes, the system consisting of a free and a fixed layer shows a shift of the magnetization curve, the so called exchange bias.
A multilayer system showing perpendicular exchange bias (PEB) has been investigated by Y. Shiratsuchi *et al.* [1], [2]. The perpendicular orientation of a ferromagnetic Pt/Co film is fixed due to the interfacial exchange coupling to the antiferromagnetic Cr_2O_3.

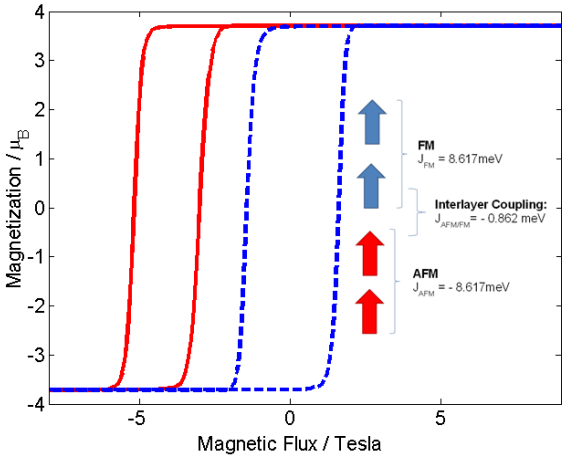

Fig. 1Magnetization curves of simplified 4 spin system without interlayer interaction (blue dashed line) and with antiferromagnetic interlayer interaction (red line).

As a first approach we studied a simplified model consisting of a chain of four macro-spins where two macro-spins represent a ferromagnetic layer and the two other macro-spins represent an antiferromagnetic layer (see Fig. 1). Taking into account only the classical Heisenberg exchange coupling, a small interlayer coupling and the Zeeman-term, the exchange bias effect is already visible without introducing additional anisotropies. To determine the interfacial exchange coupling and its effect on the switching behavior, we have created a microscopic model of a system consisting of a Co(111) thin film superposed on Cr_2O_3(0001) and studied the magnetic properties by classical spin dynamics simulations.

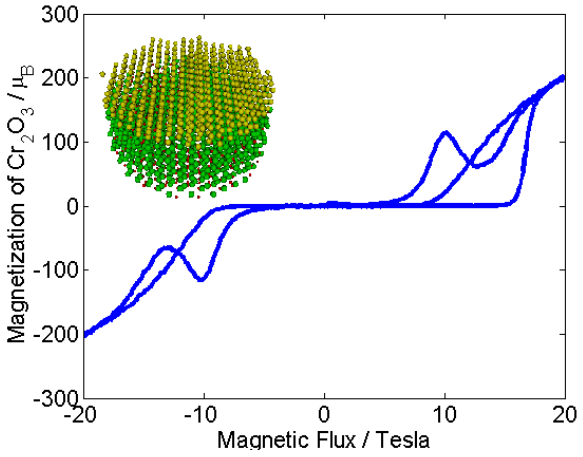

Fig. 2 Simulation of the dynamical hysteresis of Cr_2O_3 in the Pt/Co/a-Cr_2O_3 system with 430 µeV interlayer exchange interaction.

In order to determine the interlayer exchange coupling, our simulated magnetization curves (see Fig. 2) will be compared to experimental data in a future work.

References

[1] Y. Shiratsuchi et al., Appl. Phys. Express 3, 113001 (2010).
[2] Y. Shiratsuchi et al., Appl. Phys. Lett. 100, 262413 (2012).

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