Exchange-biased ferromagnetic-antiferromagnetic bilayers as supporting structures for magnetoelectronics devices

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The phenomenon of exchange biasing, represented by a hysteresis loop shift in a cooling magnetic field direction, in a ferromagnetic (FM) material coupled for an antiferromagnetic (AFM) one, is related to practical applications in spintronics, especially in spin valves, GMR sensors and magnetic MRAM memories. What was recognized from a time of the discovery by Meiklejohn and Bean in 1956 is that this interfacial phenomenon of exchange-type nature can be tailored in a AFM bulk region due to a controllable creation of a specific domain state. This state can be obtained by a material dilution, substitutions or vacancies creation, during epitaxial growth, or by a structure modification using ion-beam treatment. By a proper choice of sample preparation it was possible to obtain FM layers revealing different magneto-crystalline symmetries and associated required characteristics of exchange bias structures.

The paper presents experimental results of Brillouin light scattering from spin waves in the bilayers of ferromagnetic Co and diluted antiferromagnetic CoO, which were grown epitaxially. The main purpose relied on analysis of resultant in-plane magnetic anisotropies of 2-fold, 4-fold, and 6-fold symmetry. The unidirectional anisotropies constants along with the 2-fold and 4-fold anisotropy constants were derived from Brillouin light scattering (BLS) on Damon-Eshbach spin waves (Fig. 1). Experiments were done at 293K and 140K temperatures. The measurements were supported additionally by the SQUID measurements (Fig. 2).

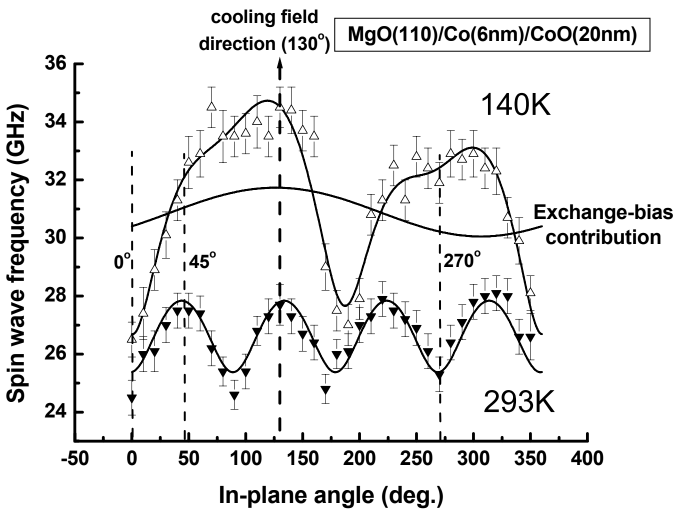

Fig. 1. Brillouin light scattering measurements of the in-plane 4-fold (293K) and unidirectional anisotropies (140K) in the MgO(110)/Co(6nm)/CoO(20nm) exchange-bias bilayer. The SQUID cooling field directions 0°, 45°, and 270° were marked for a convenience.

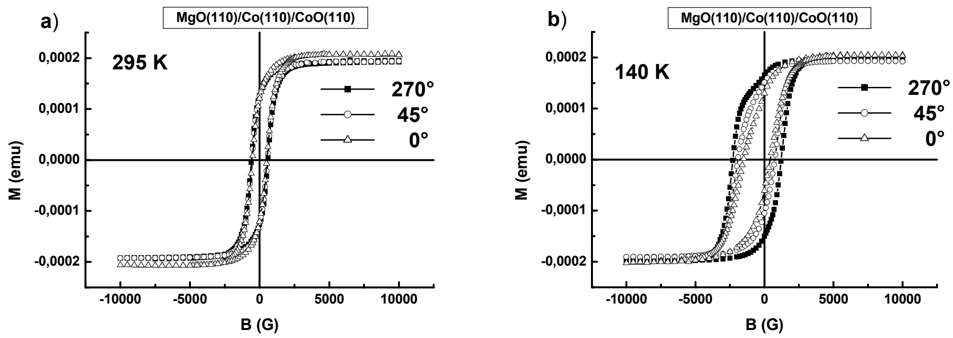

Fig. 2. Hysteresis loops measured by SQUID in the MgO(110)/Co(6nm)/CoO(20nm) sample. Experiments at 293K (a) and 140K (b) were done at the positions of 0^o, 45^o, and 270^o.

The plan for future investigations assumes measurements of layered exchange-bias samples of different crystallographic orientations, mainly in the Co/CoO samples, and additional measurements in the Ni/NiO, Fe-Ni(permalloy)/FeMn systems. The measurements will update previous promising investigation of diluted samples in oxygen atmosphere. This will be carried out by Cu and Zn dilutions. From crystallographic point of view the Co/CoO structures are ideal for basic investigations, because expected effects are observed below room temperature in the 140K-293K range. From application point of view, the FeNi/FeMn and Ni/NiO samples, can be measured at room temperatures what represents normal working conditions for magnetoelectronics devices like MRAM memories, GMR sensors and spin valves.

The standard procedure for exchange bias structures assumes the use of additional supporting experimental techniques like: Kerr spectroscopy (MOKE), time-resolved Kerr spectroscopy (TRKR), electron-diffraction methods (RHEED, LEED), and finally lithography techniques for design efforts of magnetoelectronics prototype devices.

The provided experimental data and the approach for structural analysis of exchange bias Co/CoO systems result from closely connected collaboration with Prof. dr Gernot Güntherodt, and his co-workers (M. Fraune, A. Tillmanns, U. Rüdiger, B. Beschoten), from 2. Physics Institute at the RWTH Aachen (Germany).

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