Spatially resolved magnetic reversal in a new exchange bias system

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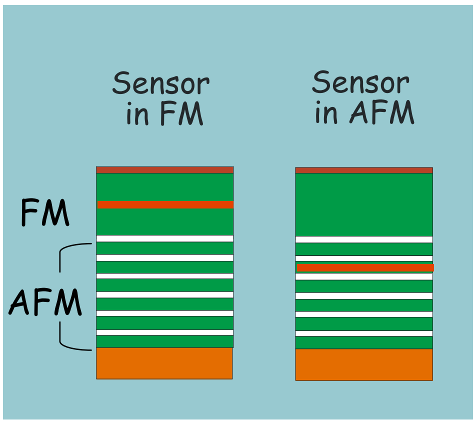
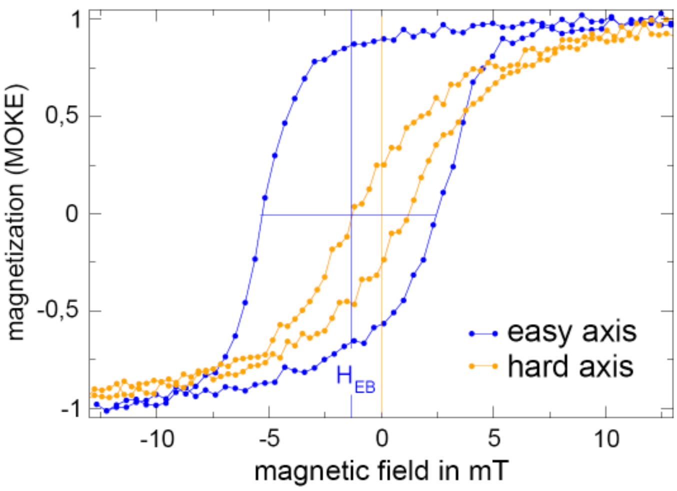
Discovered 5 decades ago and in widespread industrial use for some years the lack of understanding forces the exchange bias effect still to a field of topical interest. Consisting of a ferromagnetic layer (FM) which is exchange coupled to an antiferromagnetic layer (AFM) with unidirectional anisotropy the effect is characterized by a shifted (asymmetric) hysteresis loop and coercivity enhancement of the FM. The investigation of this phenomenon suffers mainly from the difficulties which arise from characterizing buried magnetic layers at the interface AFM/FM which are expected to dominate the coupling behaviour of EB-systems.
In this contribution we present the coupling behaviour of an artificial exchange bias system during the reversal of the FM. Our system consists of a ^{nat}Fe-layer on an antiferromagnetically coupled ^{nat}Fe/Cr-superlattice. This layer system was deposited on a hardmagnetic FePt-layer which pins the first Fe-layer of the afm superlattice to induce a unidirectional magnetic anisotropy into the artificial AFM. MOKE-hysteresis loops show exchange bias like effects like shifted and asymmetric swithing behaviour of the FM (see figure below).
The final magnetic characterization was done via nuclear resonant forward scattering (NRS) of synchrotron radiation. This experimental method enables one to detect a magnetic signal exclusively from isotopic sensor layers (here ^{57}Fe) embedded in the sample. The signal is sensitive to the orientation and magnitude of magnetic fields at the nuclei and allows us to visualize the magnetic reversal of a probe layer. We prepared two artificial exchange bias systems (see figure below) which are chemically identical but with a ^{57}Fe-probe layer in different positions. In sample one the sensor layer is placed in the center of the FM and in the second sample the sensor layer is placed near the AFM/FM interface in the artificial AFM.
We detected the magnetic moment orientation in our artificial exchange bias system in the FM and AFM during the magnetic reversal of the FM and got information about the mechanism which is responsible for the asymmetric switching behaviour. Due to a special detection procedure we can discriminate reversal processes of coherent rotation and domain wall motion.





Left: Exchange bias system with an antiferromagnetically coupled superlattice acting as AFM. ^{57}Fe sensor layers are placed in the FM and AFM.
Right: MOKE minor hysteresis loops show exchange bias like magnetic reversal in the easy magnetization axis.