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The Role of Uncompensated Spins in Exchange Biasing

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The balance between exchange, anisotropy and dipolar energies usually determines the domain structure in ferromagnetic (FM) films. However, coupling a ferromagnetic film to an anti-ferromagnetic (AF) layer can significantly alter the hysteresis processes and domain structure due to an additional FM/AF-interfacial exchange. The FM/AF interaction provides an effective bias field that gives rise to a horizontal shift in the hysteresis loop, increases the anisotropy of the FM-layer and often enhances its coercive fields[i]. As such, the EB-effect is extensively used in magnetic field sensors, in hard disk read heads[ii] and MRAM applications[iii]. While routinely exploited the microscopic origin of exchange bias is still open to debate.

It is widely accepted that uncompensated spins (UCS) in the AF or at the AF/FM interface are responsible for the EB-effect[iv]. Several experiments have proven the existence of UCS[v,vi,vii]. However, these experiments give conflicting results on the orientation of the UCS relative to the ferromagnetic magnetization as well as their magnitude. Here we present magnetic force microscopy (MFM) and magnetometry (VSM) data on two different types of AF/FM samples with perpendicular anisotropy. We show that the pinned UCS responsible for the EB-effect are aligned antiparallel to the ferromagnetic spins. Pinned UCS aligned parallel to the spins of the FM also do exist, but these are not responsible for the EB-effect. However, in most magnetometry experiments the latter UCS dominate. This can lead to the faulty conclusion that the EB-effect arises from the uncompensated spins parallel to the FM and thus to a wrong determination of the UCS density that is responsible for the exchange coupling.

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