RE08

Exchange Bias and Uncompensated Spins in a Fe/Cr(100) Bilayer

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Exchange bias refers to a shift of magnetic hysteresis (M-H) loop of a ferromagnetic (FM) layer along the applied field axis due to the interfacial exchange coupling to an adjacent antiferromagnet (AFM) layer when FM/AFM bilayer is field cooled through the Néel temperature of AFM or deposited in the applied magnetic field. [1] It is also generally accompanied by the enhancement of coercivity. Although it is commonly believed that pinned and uncompensated AFM spins inside the AFM layers or at the FM/AFM interface hold a key to the exchange bias and unpinned and uncompensated AFM spins contribute to the coactivity enhancement, there are a few reports of uncompensated spins in the exchange biased systems.

To investigate the relation between exchange bias and uncompensated spins, we prepared the 4.3-nm Fe/11.6-nm Cr(100) bilayer on MgO(100) substrate by dc magnetron sputtering and measured the magnetization curves at 3 K after zero field cooling (ZFC) and field cooling (FC) with 3kOe from 380K and spin polarized neutron reflectivities at the same condition as M-H curves using a time-of-flight PORE reflectometer at the high energy accelerator research organization (KEK) in Japan. [2]

Two things are noteworthy here. First, there is a clear evidence of exchange bias for ZFC and FC data with a little difference in the exchange bias values. Second, we observed the M-H loop to shift upward for the FC case when compared with that for the ZFC case. This shift in the magnetization is the direct evidence of pinned and uncompensated Cr spins induced during the FC process in the exchange biased Fe/Cr(100) bilayer. This is further supported by the spin dependent neutron reflectivities. In conclusion, our studies found that pinned and uncompensated spins are induced in the Fe/Cr(100) bilayer after field cooling and all of them may not be necessarily involved in the exchange bias but rather contribute to enhance the coercivity as a signature of the interfacial exchange coupling between FM and AFM spins.

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RE09

Exchange Bias in Epitaxial Fe/CrSb Bilayer

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The exchange bias effect, which shifts not only the magnetic hysteresis but also induces the various interesting magnetic properties between the ferromagnetic (FM) and antiferromagnetic (AFM) layers, was discovered about fifty years ago.[1] The exchange bias has been widely applied to the spintronic devices such as spin-valve and MTJ, and so on. Many scientists have studied noble FM/AFM bilayer structures because of increasing importance in pinning layer. Antiferromagnetic FeMn, IrMn, and NiO have widely been used as a pinning layers in the devices.[2] On the other hand, CrSb has a antiferromagnetism with T_N of 710 K and has NiAs-type hexagonal structure with lattice constant of a=4.122 Å and c=5.464 Å.[3,4] In this talk, we will present the exchange bias effect in epitaxial Fe/CrSb system.We have grown Fe/CrSb bilayer by molecular-beam epitaxial (MBE). Firstly, we grew 1000 Å thick GaAs buffer layer at 550 °C, followed by 1000 Å thick GaSb at 550 °C, 200 Å CrSb at 350 °C and 200 Å Fe at room temperature. Finally, we capped the Fe/CrSb bilayer with 100 Å thick GaAs in order to protect the surface. From the magnetization and transport measurements, we have observed the exchange bias phenomena between Fe and CrSb layers, which will be discussed in detail.

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