EXCHANGE BIASING IN EPITAXIAL YTTRIUM IRON GARNET MAGNETIC OXIDE THIN FILMS

N. Keller, O. Popova[#], B. Mercey[+], F. Gendron[£], F. Jomard[$], Y. Dumont and M. Guyot
LMOV, Univ. of Versailles - St. Quentin, Versailles, France, [#]Lab. Vaste-Stoffysica en Magnetisme, K.U. Leuven, Belgium; [+]CRISMAT – ISMRA, Caen, France; [£]LMDH, Univ. Paris VI, Paris, France; [$]LPSC, Univ. of Versailles-St.Quentin, Meudon, France

Yttrium Iron Garnet ($Y_3Fe_5O_{12}$ or YIG) is frequently used as a prototype ferrimagnetic material in fundamental and applied research. We have chosen this material as a model system in order to be able to discern easily changes in the magnetic properties due to low dimensional effects as all the bulk properties have been intensively studied in the past.
Epitaxial thin films of YIG have been deposited by pulsed laser deposition on single crystalline Yttrium Aluminium Garnet (YAG) substrate with two different orientations (111) and (110).
Surprisingly, exchange biasing has been observed in these epitaxial YIG films at low temperatures. The hystersis loops are displaced with a maximum bias field of H_{ex} = 20 G at 5K. The corresponding interfacial energy can be evaluated to be 0.17 erg/cm^2 at 5K.
Commonly two different requirement need to be matched in order to observe exchange anisotropy: the presence of a uniaxial anisotropy and a coupled ferromagnetic/antiferromagnetic bilayer.
Angular resolved ferromagnetic resonance measurements permitted to establish that two magnetic phases and a strong uniaxial in-plane anisotropy are present in these epitaxial films. Chemical profiling by secondary ion mass spectroscopy identified the interfacial region between the substrate (YAG) and the film (YIG) as interdiffused by aluminum. This aluminum interdiffusion leads to the formation of a hard magnetic interface layer with reduced magnetization and an increased coercive field. Transmission electron microscopy confirms the presence of a strained layer close to the interface including effectively a uniaxial anisotropy.
The exchange anisotropy can now be identified to originate from the magnetic coupling between a hard interdiffused magnetic interface layer ($Y_3Fe_{5-x}Al_xO_{12}$) with a soft ferrimagnetic YIG overlayers. As proof on the origin of the exchange anisotropy, it can be stated that the strong uniaxial anisotropy as well as the hysteresis loop displacement vanishes on intercalation of a $Gd_3Ga_5O_{12}$ buffer layer.

[1] Landolt-Börnstein, vol. 12, K.-H. Hellwege (ed.), Springer-Verlag Berlin, 1978, 500 p.
[2] E. Popova, N. Keller, F. Jomard, M.-C. Brianso, L. Thomas, F. Gendron, M. Guyot, M. Tessier, Eur. Phys. J. B31 (2003) 69; E. Popova, PhD - thesis, University of Versailles – St.Quentin, 2001