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Anti-ferromagnetic Exchange Interaction of $D0_{22}$-$Mn_{70}Ga_{30}$/CoB Bilayer

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Anti-ferromagnetically coupled ferromagnetic layers are practically important for memory and storage applications in spintronics. Many soft-magnetic layered structures showing anti-ferromagnetic interlayer or interfacial coupling have been reported, whereas only a few were observed for the layered structure with perpendicular magnetic anisotropy (PMA), such as rare-earth-based magnetic multilayers. We recently reported strong interfacial anti-ferromagnetic coupling in MnGa/Co bilayers with large PMA [1, 2]. Here, the coupling in MnGa/$Co_{100-x}B_x$ bilayers was investigated in this report to obtain more insights the mechanism.

Films with the stacking structure of substrate MgO(100)/ Cr(10)/ $D0_{22}$-$Mn_{70}Ga_{30}$(30)/ CoB(d_{CoB})/ Cr(5) (thickness is in nanometers) were prepared. Thicknesses of CoB were 5, 10 and 20 nm. For epitaxy of these films, we used an ultrahigh vacuum magnetron sputtering system with base pressure < 1×10^{-7} Pa. All the layers were deposited at room temperature. The in-situ annealing was employed at 400°C after the MnGa deposition. Ex-situ annealing was performed at 350°C. For characterization of structural and magnetic properties, the X-ray diffractometer (XRD), polar magneto optical Kerr effect (MOKE), and a vibrating sample magnetometer (VSM) were used.

Fig. 1(a) shows MOKE curve and the spin configurations for 10-nm-thick CoB layer. The certain points were marked with 1, 2, 3, 4, 5 and 6 numbers for magnetic hysteresis loop. Magnetization of MnGa and CoB are parallel at H= 20 kOe in step 1. With decreasing magnetic field magnetization of CoB starts to rotate from parallel to anti-parallel state in step 2 and 3, and then the magnetization of MnGa switches from up direction to down direction in step 4. As magnetic field is swept from -20 to 20 kOe magnetization of CoB starts to rotate from parallel state to anti-parallel sate in step 5 and 6 and finally with further increase of magnetic field magnetization of MnGa switches from downward to upward. We marked two magnetic field with H_{s1} and H_{s2} corresponding to saturation field in parallel state ($H^{\uparrow\uparrow}$) and anti-parallel state ($H^{\uparrow\downarrow}$), respectively. If anti-ferromagnetic exchange coupling exists these fields are different. With increase of Anti-ferromagnetic coupling strength, H_{s1} increases whereas H_{s2} decreases. This indicates that larger and smaller magnetic fields are needed for alignment of total magnetization to parallel state, and anti-parallel state, respectively. Fig. 1(b) shows the thickness of CoB layer dependence of H_s. We fitted experimental data by using following equation:

$$H_{s1(2)} = 4\pi M_{eff}^{CoB} \mp \frac{J_{ex}}{M_s^{CoB} d_{CoB}}$$

to evaluate J_{ex}. By using saturation magnetization M_s^{CoB} = 436 emu/cm^3 that was estimated from in-plane curve of VSM, we estimated the J_{ex} to be about -0.43 erg/cm^2. This coupling strength is much smaller than that estimated in the $L1_0$-MnGa/Co bilayer film (J_{ex} ≈ -3 erg/cm^2) from magnetoresistance curve [1].

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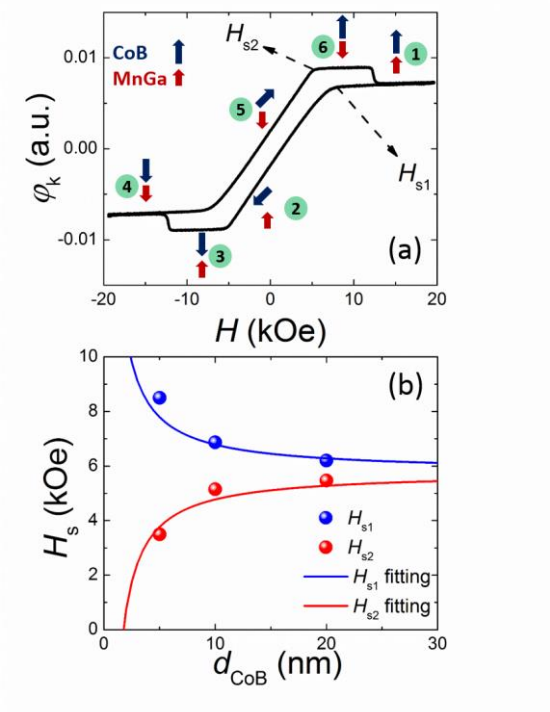

Fig. 1(a) Polar MOKE curve and spin configurations for the MnGa/CoB(10 nm) bilayer (b) CoB layer thickness dependence of H_s.

References

[1] R. Ranjbar, *et al.*, J. Magn. Magn. Mater. **346**, 53-57 (2013).
[2] Q. L. Ma, *et al.*, Appl. Phys. Lett. **101**, 032402 (2012).