The interlayer exchange coupling in CoFe$_2$O$_4$/Cr/Fe systems

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Since the discovery of the interlayer exchange coupling (IEC) in the magnetic multilayer systems [1,2], considerable experimental and theoretical studies have been performed. In particular, the oscillation of the IEC as a function of the non-magnetic layers attracted much attention in the spintronics research fields [3]. The IEC in the metallic systems, such as Fe/Cr, is explained by the RKKY-like interaction or quantum-well model in the spacer layer [4], however, that in the systems including magnetic insulator is left as unsolved issue. In this paper we investigated the magnetic coupling in CoFe$_2$O$_4$/Cr/Fe systems.

The samples were grown epitaxially on MgO (100) and (110) substrates by the reactive molecular beam epitaxy method with oxygen radical. The film structures were MgO(100),(110)/NiO(5nm)/CoFe$_2$O$_4$(30nm)/Cr($t_Cr$=0-4.2nm)/Fe(5nm)/Al$_2$O$_3$(2nm). The NiO layer was inserted to prevent the diffusion of Mg into the CoFe$_2$O$_4$ layers [5]. CoFe$_2$O$_4$ layer was deposited by co-deposition of Fe and Co at 300°C in the oxygen radical atmosphere of 4×10$^{-4}$Pa. The Cr layers were grown at 130°C, and the Fe and Al$_2$O$_3$ layers were deposited at room temperature. The epitaxial growth and the surface morphology were confirmed by RHEED and AFM, and magnetization process was measured by magneto optical Kerr effect (MOKE) at room temperature.

In Figure 1, the saturation fields ($H_S$) of Fe are plotted as a function of $t_{Cr}$. For $t_{Cr}$=0nm, the $H_S$ was enhanced because the Fe layer directly contacts with CoFe$_2$O$_4$ layer. The $H_S$ decreased with increase of $t_{Cr}$ gradually. For $t_{Cr}$=4nm, which is considered to be enough to separate the Fe and CoFe$_2$O$_4$ layer completely, the $H_S$ continued to decrease. It indicated the existence of the IEC, although the orange peel coupling due to the roughness could not be ruled out.

References