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XMCD study of magnetic thin-films of FeMn alloys grown on h-BN/Ni(111)

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Magnetic tunneling junction (MTJ) structures, where ferromagnetic electrode layers sandwich an insulating barrier layer, show tunnel magnetic resistance (TMR) effect that is widely applied for spintronics devices such as magnetic random-access memory. One of important performance factors of TMR element is magnetic resistance (MR) ratio, which is sensitive to both of interfacial structure and magnetic state. Conventionally, metal oxide layers have been utilized for the barrier layer in the device structures. However, further improvement of MR ratio is difficult in MTJ with such oxide-based barriers, because of crystal disorder arises from lattice mismatch and defect formation at the interface. In recent years, much attention and intensive studies have been devoted to hexagonal boron nitride (h-BN) whose structure is two-dimensional honeycomb formed by stable chemical bonding. Monolayer h-BN is one of good candidates for the ideal burrier layer of TMR devices because the h-BN layer is expected to form a pinhole-less and flat interface with magnetic layers. Recently, in Fe or Co layers grown on the monolayer h-BN uniformly established on a single crystal substrate of Ni(111), anti-ferromagnetic coupling has been found between the overlayer and Ni substrate. An effect of electron filling control in the 3d valence band of the overlayer is of great interest, to investigate the origin of unexpected magnetic coupling through the h-BN monolayer.

In this study, we have investigated interlayer magnetic coupling between the FeMn films and the Ni substrate by means of XMCD spectroscopy at $L_{2,3}$ absorption edges of Fe, Mn and Ni. Ultrathin films of FeMn alloys were fabricated on h-BN/Ni(111) in ultra-high vacuum condition, whose XMCD spectra were measured *in-situ*. In Fig.1(a) and (b), XAS spectra for $Fe_{84}Mn_{16}$/h-BN/Ni(11) are shown at Ni and Fe $L_{2,3}$ edge, respectively. The red (blue) curves are corresponding to excitation light with helicity parallel(antiparallel) to external magnetic field of 1.1 T along to the sample normal direction. XMCD signals of Ni and Fe are opposite each other at both L_2 and L_3 edge. That means anti-ferromagnetic coupling through h-BN monolayer. Overlayer thickness dependence of XMCD for the $Fe_{84}Mn_{16}$/h-BN/Ni(111) sample (shown in Fig.1(c)) indicates gradual change of magnetization direction from antiparallel into parallel to the applied magnetic field, with the thickness increasing. The critical thickness where the sign of XMCD recovers into positive, includes information on energetic stability of interlayer magnetic coupling. The concentration dependence of the critical thickness has also been found in our series of XMCD experiments for the alloy films with different concentration of Fe and Mn.

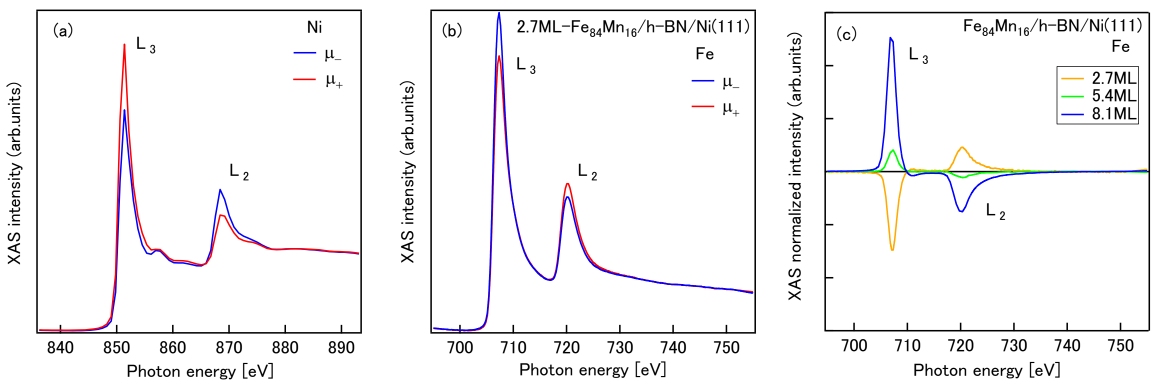

FIGURE 1. XAS spectra for (a) Ni substrate and (b) Fe atomic site in the FeMn alloy layer whose concentration of Fe is 84%. (c) Thickness dependence of the XMCD signals (μ_+ - μ_-) of Fe in the FeMn film on h-BN/Ni(111).