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Element specific magnetic hysteresis on Fe/Co/Cu(001)

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Introduction

Magnetic properties of Fe/Co/Cu(001) [1] are divided into three regions depending on Fe thickness. In region 1 (0-4 ML) and 3 (>12 ML), Fe shows homogeneously magnetized ferromagnetism. However, in region 2 (5-11 ML), the Fe surface and interface with Co are ferromagnetic but the inner layers are antiferromagnetic (T_N ~ 200K). The Co layer is homogeneously magnetized independent of Fe thickness. The aim of this research is to understand the magnetization reversal process of Fe and Co respectively by element specific magnetic hysteresis (ESMH) making use of XMCD.

Experiments

The experiments were performed at BL-7A and 11A. Co and Fe thin films were evaporated on a clean Cu(001) surface and the thickness was monitored by RHEED. ESMH was measured as follows: The photon energy was fixed at the L_3 absorption edge of the target element (the helicity was also fixed) and the sample current was measured with sweeping magnetic field. The same measurement was performed at the post-edge energy. Then ESMH was obtained as the ratio of the former to the latter. The sample was surrounded by a tungsten mesh with a 900 V bias voltage, which could capture the secondary electrons and improve the S/N ratio. XMCD spectra were measured at remanent magnetization by reversing sample magnetization. In addition, to investigate the magnetic depth profile, the depth-resolved XMCD method [2] was also utilized. The incident angle of X-ray was 20 or 30º from the sample surface.

Results and Discussions

The three Fe regions in Fe(x ML)/Co(3 ML)/Cu(001) were confirmed by XMCD measurements and analyses with the sum rule. When the Fe thicknesses were in region 1 or 3, Fe and Co hysteresis overlapped well with each other. This means Fe and Co magnetic moments rotate coherently because two elements are homogeneously magnetized and ferromagnetically coupled at the interface.

On the other hand, two cases were observed in region 2. At 5 or 6 ML Fe thickness, a difference was observed between the Fe and Co hysteresis curves (Fig.1), while the two loops overlapped at other thicknesses. The depth-resolved XMCD result on Fe(6 ML)/Co(2 ML) shows that XMCD signal of Fe near the surface is opposite to that of Co (Fig.2). This means Fe magnetization near the surface and interface are antiparallel to each other. Therefore, the model of reversal process is thought to be as Fig.1. The magnetizations of each layer are directed in-plane and turn by ~120º per layer. First, Fe interface component rotates with Co, and then the Fe surface and inner layer components rotate slowly (3 to 4 process).

In other thicknesses than 5 and 6 ML, the Fe surface and interface components showed a parallel coupling. Therefore, only when the Fe thickness is in region 2 and the Fe surface and interface magnetization components are antiparallel to each other, the difference is observed between the Fe and Co hysteresis curves.

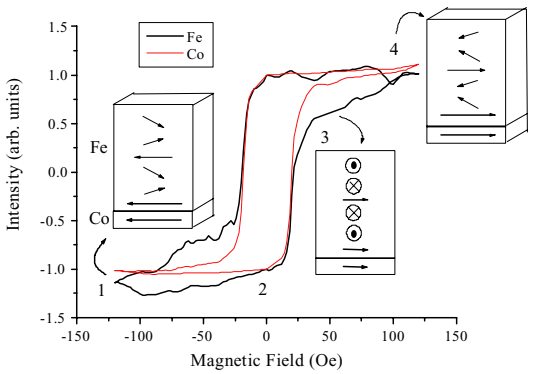

Figure 1. ESMH on Fe(6 ML)/Co(2 ML)/Cu(001)

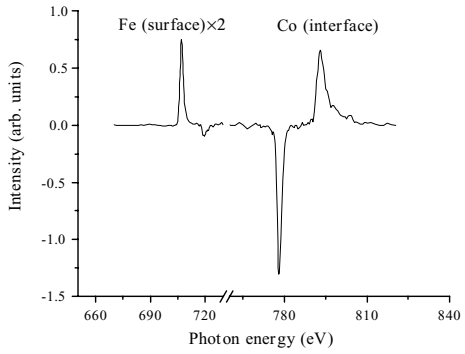

Figure 2. XMCD spectrum of Fe(6 ML)/Co(2 ML)/Cu(001) obtained by the depth-resolved method

References

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