Proximity-induced perpendicular magnetic anisotropy at Fe/Au(111) interfaces studied by synchrotron radiation Mössbauer spectroscopy

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Interfacial magnetic proximity can be a novel technology for developing and enhancing the spin-related functionalities. The designing of orbital hybridization at the interfaces becomes a key issue. Especially, the hybrid structures combining different sin-orbit coupling strength provide the cooperative effect such as perpendicular magnetic anisotropy (PMA) and quadrupole formation. We focus on Au(111)/Fe structure as a magnetic metal and non-magnetic metal interface because the proximity between the Rashba-type spin-orbit coupling constant in Au and magnetic Fe layer brings interfacial PMA [1]. Until now, there are many reports for investigations of electronic structures in magnetic layers on Rashba-type spin splitting [2]. However, the element-specific studies for Au/Fe interface are limited on the x-ray magnetic circular dichroism and photoemission spectroscopy [3]. The Mössbauer spectroscopy (MS) for Fe using synchrotron radiation also becomes a powerful tool by using enriched ^{57}Fe isotope substitution. Here, we adopt MS to investigate Au/Fe interfaces to elucidate the layer-resolved electronic and magnetic properties.

Samples were deposited on Au(111) surface which is grown on sapphire substrate. Fe layer was grown at 150 C by molecular beam epitaxy using ^{56}Fe and enriched ^{57}Fe sources. MS was performed at SPring-8 BL11XU using focused beams of 14.4 keV energy under the magnetic field along sample surface normal and 20 K conditions.

For 3-monolayer-thick Fe sandwiched by Au, where ^{57}Fe is only 1 ML on Au, MS spectra exhibit clear sextet magnetic splitting. Second and fifth peaks disappear at p-polarized beam and six peaks appear in case of non-polarized beam, resulting in the PMA at the interface. This behavior is consistent with the magnetization measurement. Further, MS depicts the layer resolved information. Since the values of hyperfine field are different from those in Fe bulk, interfacial electronic structure of Fe layer facing on Au is modulated and the hybridization between Au *sp* and Fe 3*d* states is essential for PMA. We found that the hyperfine field in Au/Fe interface is different from that previously reported Fe/MgO cases [4,5]. Small quadrupole component is also deduced which is specific in the interfacial layer through the electric-field gradient from Au layer. In the case of ^{57}Fe insertion into the second layer in total 3 ML of Fe layer, spectral line shape almost remains unchanged, suggesting that the proximity effect from the interface propagate to next layer. We discuss the detailed interfacial electronic and magnetic structures by MS.

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