Detecting magnetic atom diffusion of Mn and Co at the $Co_3Mn/Mn_{3-\delta}Ga$ interface studied by x-ray magnetic circular dichroism

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Magnetic ordered alloys have attracted significant attention for use as spintronics materials because they are highly likely to exhibit perpendicular magnetic anisotropy (PMA). Using the advantage that $Mn_{3-\delta}Ga$ is a hard magnetic film, the deposition of other ferromagnetic materials on $Mn_{3-\delta}Ga$ layers can be used to induce perpendicular exchange coupling through exchange interactions without the use of heavy metal elements [1]. The PMA is induced in ultra-thin *bcc* Co_3Mn alloy layer deposited on $Mn_{3-\delta}Ga$ and the magnetic coupling is manipulated ferromagnetically or antiferromagnetically, depending on their annealing conditions. Since the high tunnel magnetoresistance is reported using Co_3Mn alloys [2], the abruptness and the magnetic Mn and Co atom diffusion by annealing with element-specific magnetic properties at the interfaces between $Mn_{3-\delta}Ga$ and Co_3Mn layers must be clarified explicitly. Here, X-ray magnetic circular dichroism (XMCD) is employed to investigate the element-specific magnetic properties at an interface. In particular, we discuss the interfacial coupling, which may be ferromagnetic or antiferromagnetic depending on the annealing of the samples. Further, the element-specific structural properties are also investigated using extended x-ray absorption fine structure (EXAFS) analysis.

The samples were prepared by magnetron sputtering on MgO substrates. On the 30-nm-thick MnGa, 1-nm Co3Mn was deposited at room temperature and capped by 2-nm MgO. We prepared the samples of as-grown and post-annealed at 250 and 350°C. The X-ray absorption spectroscopy (XAS) and XMCD were performed at BL-7A in the Photon Factory (KEK). The total-electron-yield mode was adopted, and all measurements were performed at room temperature and the geometries were set to normal incidence configuration. EXAFS at Co *K*-edge was performed at BL-12C in the florescence yield mode.

The XAS of Mn and Co $L_{2,3}$-edges in Co_3Mn/MnGa shows clear metallic line shapes. After the annealing at 250°C, the Co L_3-edge XAS intensity decreases and XMCD intensities drastically suppressed, suggesting the compensation of Co spins. By the annealing of 350 °C, further Co atom diffusion occurs and the signs of XMCD are reversed in both Co and Mn within the XMCD probing depth of 3 nm because of Mn-Co antiferromagnetic coupling. By comparing these spectral line shapes with the cases of Co/MnGa [3], the local coordination around the Co atoms is also modulated, which is evident that the EXAFS shows the expansion of nearest neighbor distance in the Co sites by annealing. In the presentation, we discuss the interfacial element-specific magnetic properties depending on the annealing processes.

References

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