Investigation of Perpendicular Anisotropy in FeCo Alloy Films Covered with Oxygen for Development of Multi Spin Detecting Target

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At Hiroshima Synchrotron radiation center, we have been developing a spin- and angle-resolved photoemission spectroscopy (SARPES) machine using a reflection-type multichannel Very Low Energy Electron Diffraction (VLEED) detector. A current single-channel VLEED spin detection target is Fe(001)p(1×1)-O which possesses in-plane magnetic anisotropy. Therefore, we can observe only in-plane spin polarization. In order to observe all three components of spin polarization (Px, Py, Pz) in VLEED detector, we need a target with perpendicular magnetic anisotropy (PMA) in addition to Fe(001)p(1×1)-O.

We focused on FeCo alloys as potential targets for out-of-plane spin detection. In the case of thin films of the specific substrate, the crystal structure of FeCo alloy changes from the bcc structure to the bct structure due to the chemical pressure applied, which results in PMA [1-4]. Therefore, if we use such thin films it might be possible to observe out-of-plane spin polarization with a VLEED detector. On the other hand, it is also important that PMA is kept stably for a long time for practical use as a target. Current VLEED detector target Fe(001)p(1×1)-O has an oxide overlayer that acts as a protective film, and the lifetime of the target can be extended from several hours to several weeks (several months or more with flash annealing)[5,6]. We supposed it is possible that oxygen can form an effective protective film in FeCo film similar to Fe(001)p(1×1)-O because the crystal structure of FeCo is the same as Fe though half of the Fe atoms are replaced by Co. However, it was not obvious whether PMA was preserved after oxygen termination.

Thin FeCo films were deposited on single crystal Rh(001). LEED and Auger Electron Spectroscopy (AES) were used for sample evaluation. Fig.1 shows LEED patterns of FeCo/Rh(001) and FeCo-O/Rh(001) prepared by oxygen-termination of the FeCo/Rh(001). We observed sharp spots in either film and confirmed that high-quality epitaxial thin films were obtained. Fig.2 shows the results of out-of-plane SARPES of FeCo/Rh(001) and FeCo-O/Rh(001) films. Distinct out-of-plane spin polarization was observed even in FeCo-O surface, indicating that the FeCo-O film retained PMA. Fig.3 shows the change over time of the spin polarization. It was found that the speed of the spin-polarization change, i.e., the lifetime of the spin-polarized film is quite slow in both FeCo and FeCo-O films. In this system, the lifetime of FeCo film is longer than those of FeCo-O film, which is different from the case of Fe and Fe(001)p(1×1)-O surface.

From these results, it was found that FeCo and FeCo-O film has a high possibility of being used as a perpendicular spin detection target.

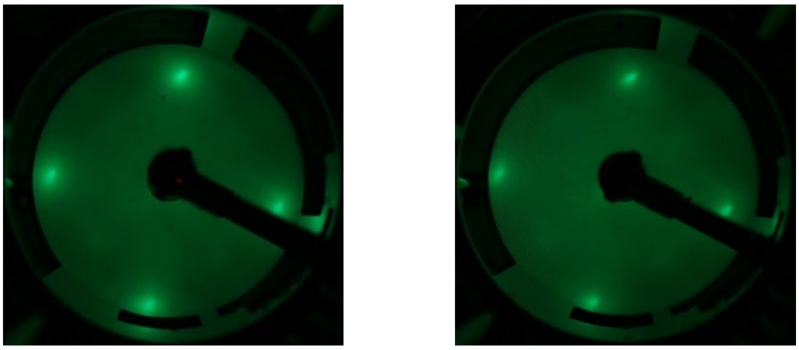

FIGURE 1. LEED patterns of (a) FeCo/Rh(001) films and (b) FeCo-O/Rh(001) films. Both images are 1 × 1 spot.

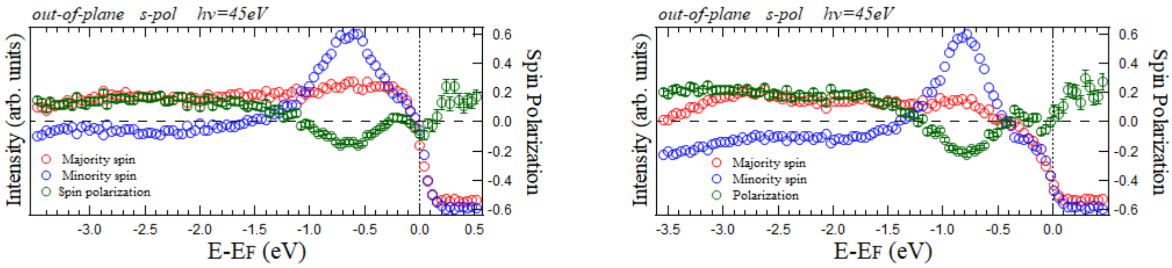

FIGURE 2. Out-of-plane SARPES of (a) FeCo film, and (b) FeCo-O film.

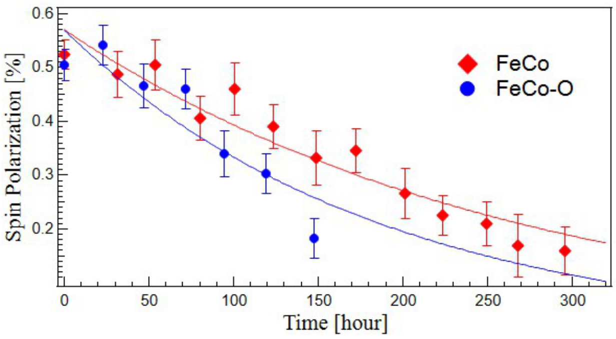

FIGURE 3. Life time of FeCo film (Red, τ =268 hour) and FeCo-O film (Blue, τ =186 hour). The vertical axis is the spin polarization, and the horizontal axis is time. The FeCo-O film was prepared by oxygen annealing the surface-contaminated FeCo film in the oxygen atmosphere.

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