Local structural study of TaO_x thin films

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TaO_x is one of the most promising candidates for capacitor and gate insulator materials of the next generation Si-based semiconductor devices because of its high dielectric constant. Large leak current of TaO_x thin films was a big issue for practical use, but the property has revealed to be improved by heat treatment after the film deposition. Introduction of additional oxygen atoms into the films is believed to cause the change of the property; however, changes of the local structure of the films are not fully understood. In this study, XAFS analysis of TaO_x films with various heat treatments was applied to clarify the difference of Ta-O bonds in the films.

TaO_x films of 30 nm thick were prepared by sputtering method on Si (100) wafer. After deposition, the films were annealed in various atmospheres. All the samples were revealed to be amorphous by laboratory XRD. XAFS measurements were performed at BL16B2 in the total electron yield method using a conversion electron / He ion detector.

Figure 1 shows XAFS spectra of an as-deposited film, a film annealed in vacuum, and a film annealed in oxygen atmosphere. The spectra show similar vague oscillations, which are consistent with the diffraction results. Figure 2 shows the derivatives of the three spectra in Ta-L_3 edge region. The peak top energy of the derivative curves is 9883.0 eV for the as-deposited sample, while 9882.5 eV for the one annealed in vacuum, and 9883.5 eV for the other. This result confirms that the oxygen atoms in the films are not tightly combined with Ta atoms when as deposited state, and the films can easily be deoxidized by annealing in vacuum, and oxidized by annealing in oxygen-rich atmosphere. Detail analysis is in progress to obtain the difference of the local structure around Ta atoms among the samples.

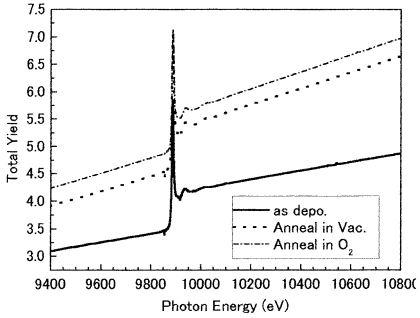

Fig. 1 XAFS spectra of TaOx films.

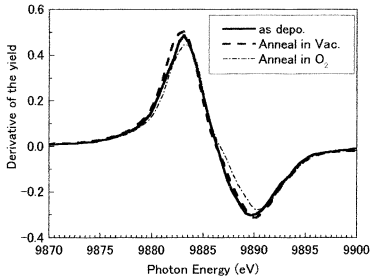

Fig.2 Derivatives of the XAFS spectra in the Ta-L3 edge.

Fluorescence XAFS Study of Co-based Alloy Magnetic Thin Films

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Co-based alloy magnetic thin films are used for magnetic recording media of hard disk drives. Additional atoms to a magnetic layer play important roles in determining the magnetic properties and recording characteristics of these films. Hence it is necessary to estimate and control the local structures of these additional atoms in order to improve recording density. XAFS is a powerful method for this purpose.

At the beamline BL16B2 in SPring-8, we have measured the Pt L_{II}-edge XAFS spectra of two Co-Cr-Pt-Ta alloy magnetic thin films (50 nm thick) ; one was grown at high temperature by heating the substrate and the other was at room temperature, leading to quite different magnetic properties. Data were collected in fluorescence yield mode using Ge solid state detector.

The EXAFS spectra of Co-Cr-Pt-Ta thin films are shown in Fig.1. For comparison, the spectrum of a Pt foil measured in transmission mode and the FEFF calculated spectrum of Pt substituted to hcp Co are also shown. The spectral shape of the Co-Cr-Pt-Ta thin films are apparently different from that of the Pt foil, but similar to that of the Pt substituted to hcp Co, which suggest that Pt atoms in the magnetic layers are alloyed with Co atoms.

Figure 2 shows Fourier transformations of the k^3-weighted EXAFS oscillations (*i.e.* radial distribution functions around Pt atoms). The peak positions of the Co-Cr-Pt-Ta thin films are about 0.3Å shorter than that of the Pt foil. On the other hand, little difference is shown between the radial distribution functions of two Co-Cr-Pt-Ta thin films, suggesting that the local structures around Pt atoms are almost the same. Hence, in this case the difference in magnetic properties are not caused by the existing conditions of the Pt atoms, but other factors.

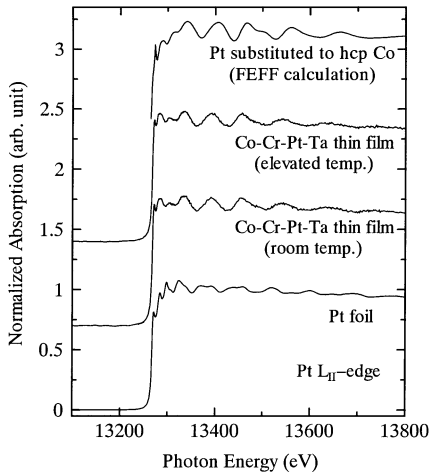

Fig.1. Normalized EXAFS spectra of Co-Cr-Pt-Ta alloy thin films, Pt foil and Pt substituted to hcp Co.

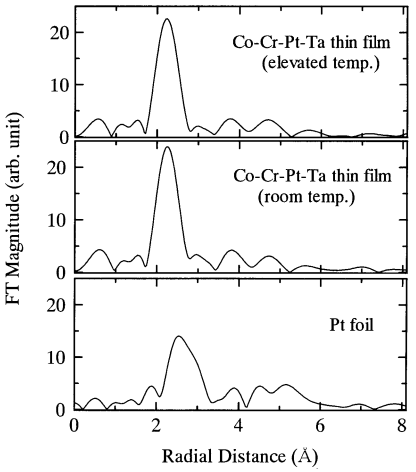

Fig.2. Radial distribution functions of Co-Cr-Pt-Ta thin film samples and Pt foil.