AR-NE1B/2002G008

Magnetic circular soft x-ray dichroism (MCXD) of Electrodeposited Nickel Films on Amorphous Carbon Substrate

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We have studied the electrodeposited(ED) transition-metal films on several kinds of metal or metal alloy substrates. We proposed that the structures and properties of the ED films were determined by the electrochemical behaviour of deposition at the initial stage. This was attributed to the electrochemical free energy drastically changed at that stage, which was effective to the behaviour of the crystal growth subsequently to the nucleation.

We observed abnormal properties of ED nickel films on amorphous carbon. Their magnetization reached to about 5 times larger than that for bulk nickel, with a decrease of film thickness within 5 monolayer range, by means of SQUID. By this technique, however, it is difficult to separate the film's magnetization from one of whole the sample. Therefore, MCXD is a useful probe to detect this one, because of its signal dependent on the element.

Figure 1 shows XAS of Ni $L_{3,2}$ edge for the ED nickel and the electron-beam evaporated (BE) gold(20Å)/nickel(150Å) films on amorphous carbon. About one monolayer (ML) ED nickel was obtained for the pulse current of unit. XAS intensity of L_2 edge was similar for all the sample. And that of L_3 significantly increased, and that of the region between L_3 and L_2, and the region from L_2 to the higher energy point was decreased, with a decrease of ED film thickness. This behavior may be due to the surface oxidation layer. Figure 2 shows the corresponding MCXD intensity for these samples. The intensity of ED films for 50 to 200 p.n. was similar to that of BE one. The intensity of ED film for less than 50 p.n. was decreased dependent on the film thickness. This may be resulted from the non-ferromagnetic surface layer of nickel oxide.

Therefore, we tried to modify the MCXD intensity by taking account of the separation of ferromagnetic nickel and non-ferromagnetic nickel oxide phases. Figure 3 shows the modified MCXD intensity of ED films for less than 50 p.n. compared with that of the BE one. The similar intensity obtained for all the samples. A ratio of nickel phase to all the phases (Ni ratio) was calculated by fitting a given XAS with a pair of the BE and ED 3p.n. XAS, which is shown in an inset of Fig. 3.

Unfortunately it was impossible to obtain the clear modification of MCXD for less than 5 p.n. by this method. We will plan to observe MCXD of the gold-coated ED nickel film, which might be easy to make clear the magnetic moment of the thinner ED nickel films.

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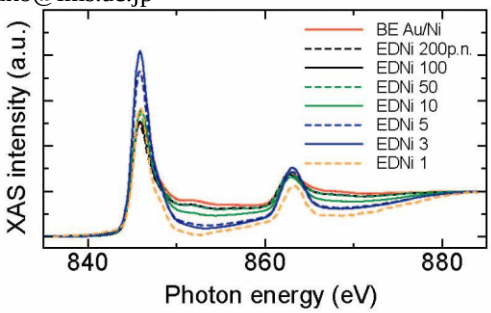

Fig. 1 XAS of Ni $L_{3,2}$ edge for the ED nickel and the BE gold/nickel films on amorphous carbon.

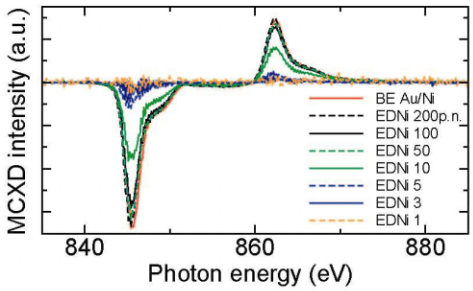

Fig. 2 MCXD of the ED and BE films corresponding to the XAS shown in Fig. 1.

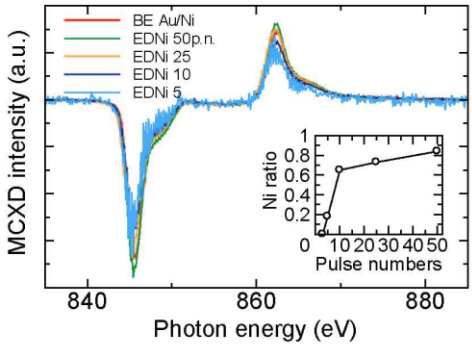

Fig. 3 MCXD modified by the method shown in the text. An inset is the Ni ratio(*see text*) calculated by XAS.)