Magneto-optical Kerr rotation spectra in ordered and disordered phases of Fe–Pt alloy films

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The magneto-optical Kerr rotation (θ_K) spectra and the related properties have been measured in ordered and disordered phases of several kinds of Fe–Pt alloy films. The $|\theta_K|$ in as-deposited (disordered) films becomes gradually larger with increasing Fe content until about 50 at% Fe, but the shape of θ_K spectra does not change so much. After annealing, however, all the θ_K spectra were changed. A considerable change of the θ_K spectra near 300 nm, which would be expected by the anti-parallel alignment of the polarized Pt spins to Fe spins after annealing, was not observed in the films with approx. 50 at% Fe.

Recently, considerable attention has been focused to the 3d-metals/Pt multilayers because they have a potential as magneto-optical recording media [1,2]. For the applications, a large magneto-optical Kerr effect is required. So far, many studies have been done on the magneto-optical Kerr effect of Co/Pt and Co/Pd multilayers [1–5]. In general, the wavelength dependence of θ_K (θ_K spectra) of the 3d-metals/Pt multilayers bear much resemblance to that of the corresponding disordered alloy [5,6]. It is also found that there is some difference in θ_K spectra between ordered and disordered phases in these alloys. However, only a few researches have reported on the Kerr effect in these alloys [5,6]. Especially, θ_K spectra of ordered phases of these alloys has hardly been investigated. In this paper, θ_K spectra and the related properties have been measured in ordered and disordered phases of Fe–Pt alloy films.

The samples were prepared onto glass or quartz substrates by means of RF sputtering using tip-on-targets. θ_K spectra were measured with a Kerr rotation spectrometer from 250 to 800 nm. The incident angle of the light beam was 10°. An annealing step was carried out with an electric furnace in pure H₂ gas. Saturation magnetization (M_s) was measured with SQUID at 5 and 295 K. Structural changes were examined with X-ray diffraction.

Fig. 1 shows the M_s as a function of Pt content in as-deposited (disordered) Fe_{1-x}Pt_x alloy films. The M_s of Fe_{1-x}Pt_x alloys has, in general, a tendency to become higher than the values of the corresponding dilution (dashed line). At about 60 at% Fe there may be a small amount of ordered phases in the film because of the dent in the curve. This behaviour is rather in good agreement with that in the literature [7,8]. The lattice constants of the alloy films prepared before (face-centered-cubic, fcc) and after (face-

centered-tetragonal, fct) annealing are also in good agreement with the data in the literature [7,8].

Fig. 2 shows the θ_K spectra for several as-deposited Fe–Pt alloy films. Compared to Fe there is a negative θ_K peak at about 260 nm which has a minimum at about 50 at% Fe, while it tends to shift slightly toward a shorter wavelength with increasing Fe contents. Towards 800 nm, $|\theta_K|$ gradually increases with increasing Fe contents. At more than 65 at% Fe, the θ_K spectra are gradually approaching that of Fe. The θ_K spectra of the Fe–Pt alloy films resemble reasonable that of the Fe/Pt multilayers [5]. This suggests that a possible alloy phase which will be formed at interface of multilayer is fcc structure.

Fig. 3 shows the X-ray diffraction patterns of as deposited (disordered, fcc) and annealed (almost ordered, fct) Fe₅₃Pt₄₇ alloys. The coercive force (H_c) and

Fig. 1. The M_s as a function of Pt content (x) in as-deposited (disordered) Fe_{1-x}Pt_x alloy films.

Fig. 2. The θ_K spectra for several kinds of as-deposited (disordered) Fe-Pt alloys.

Fig. 4. The θ_K spectra for disordered and ordered phases in $\text{Fe}_{53}\text{Pt}_{47}$ alloys.

the axis ratio c/a in the ordered phase are about 7 kOe and 0.95, respectively. These values are in good agreement with those in the literature [7,8]. However, since the M_s value is somewhat higher than that in the literature [7,8], the phase transition to fct phase might not occur completely in this alloy.

Fig. 4 shows the θ_K spectra for disordered and ordered phases in $\text{Fe}_{53}\text{Pt}_{47}$ alloys as an example. $|\theta_K|$ after annealing is smaller than that of the as-deposited one. Although a larger decrease of M_s after annealing is clearly observed, we do not see a large change of the

θ_K spectra near 300 nm, which would be expected if the anti-parallel alignment of the polarized Pt spins to the Fe spins [8] after annealing would occur. The decrease of M_s is explainable by a change of the spin structure since it was reported that the polarized Pt spins aligned in anti-parallel to Fe spins in ordered fct alloys near 50 at% Fe [7,8]. However, the difference of θ_K spectrum can not be explained simply by a change of spin structure. This suggests that there is also possible a difference in the electronic structure between ordered and disordered states. Fig. 5 shows the θ_K spectra of disordered and ordered $\text{Fe}_{27}\text{Pt}_{73}$ alloy films as another example. There is much difference between as-deposited and annealed ones. The considerable decrease of θ_K is thought to be originated from the change of spin structure by annealing in which the Fe spins align anti-parallel to each other [8].

As a conclusion, it is found that $|\theta_K|$ in as-deposited films becomes gradually larger with increasing Fe content until about 50 at% Fe, but the shape of θ_K spectra shows the same tendency. After annealing,

Fig. 3. The X-ray diffraction patterns of as-deposited (disordered, fcc) and annealed (almost ordered, fct) $\text{Fe}_{53}\text{Pt}_{47}$ alloy. Annealing was carried out at 600 °C for 25 h.

Fig. 5. The θ_K spectra of as-deposited (disordered) and annealed (ordered) $\text{Fe}_{27}\text{Pt}_{73}$ alloy.

however, all the θ_K spectra were different. A considerable change of the θ_K spectra near 300 nm, which would be expected by the polarized Pt spins to Fe spins after annealing, was not observed between as-deposited and annealed films with approximately 50 at% Fe. One (T.K) of the authors wish to thanks gratefully to The Netherlands Organization of Scientific Research (NWO) for financial support of the staying at University of Twente.

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