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MAGNETO-OPTICAL KERR EFFECTS OF AMORPHOUS Nd-Co FILMS

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Abstract. - The complex off-diagonal components of conductivity tensor ($\sigma_{xy}^* = \sigma'_{xy} + i\sigma''_{xy}$) of Co, a-Nd-Co and a-Y-Co was obtained by measuring magneto-optical Kerr effects, reflectivity and transmissivity in the range of $\hbar\omega = 0.8 \text{ eV} \sim 5 \text{ eV}$. Nd-Co showed much greater $\omega\sigma''_{xy}$ than Y-Co and the difference was deduced to be due to $4f \uparrow \rightarrow 5d \uparrow$ electron transition of Nd.

1. Introduction

Magneto-optical (MO) properties of amorphous light rare earths such as Pr and Nd alloyed with Fe or Co are of current interest because of their large MO effects in the visible to ultraviolet region [1, 2]. In our previous work, the Kerr spectra of Nd-Co were compared with those of Y-Co and it was supposed that the MO contribution of Nd in Nd-Co is significantly large around $\hbar\omega = 4 \sim 5 \text{ eV}$ [3, 4]. But origins of large MO effects are still ambiguous in view of electron transition, so in this paper we made an effort to understand them by measuring the optical spectra such as polar Kerr rotation (θ_K), Kerr ellipticity (η_K), reflectivity (R) and transmittance (T) together with X-ray photoemission spectra (XPS).

2. Experimental

Co, Nd-Co and Y-Co films were prepared by means of dual source e-beam evaporation on quartz substrate in the same condition as our previous report [3], except that samples for transmission measurement are composed of quartz substrate, 400 Å thick magnetic layer and 100 Å thick SiO layer. Spectra of θ_K and η_K have been measured from the substrate side at room temperature.

Figure 1 shows the spectra of θ_K and η_K for Co, Y₂₅Co₇₅ and Nd₂₅Co₇₅. It is noticed that the peak at 4.2 eV in the Kerr spectra of Co disappears in Y-Co. The spectrum of θ_K for Nd₂₅Co₇₅ has peaks at 4.2 eV and 1.3 eV, almost the same energy as those for Co, but in case of Nd-Co, the peak of 4.2 eV is much greater than that of 1.3 eV.

The complex refractive index was calculated from the data of R and T considering the multiple reflection at film/substrate, film/SiO, and SiO/air interfaces.

Figure 2 shows the spectra of off-diagonal component of conductivity tensor ($\sigma_{xy}^* = \sigma'_{xy} + i\sigma''_{xy}$) for Nd₂₅Co₇₅ and Y₂₅Co₇₅ which were calculated according to the equations of Argyres [5]. Comparing the spectra in figure 2 with those in figure 1, it is seen that σ''_{xy} corresponds to θ_K . We further calculated the

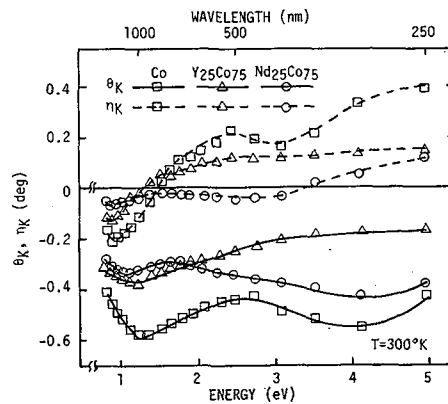


Fig. 1. - Wavelength dependence of Kerr rotation θ_K and ellipticity η_K for Co, Y₂₅Co₇₅ and Nd₂₅Co₇₅ at room temperature.

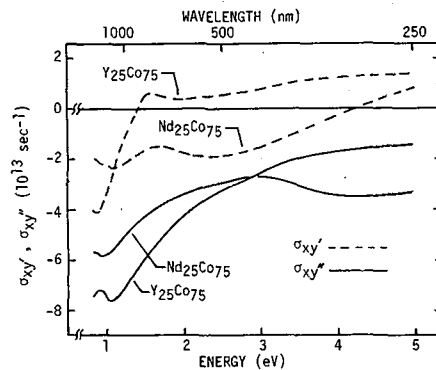


Fig. 2. - Spectra of the complex off-diagonal conductivity $\sigma_{xy}^* = \sigma'_{xy} + i\sigma''_{xy}$ for Nd₂₅Co₇₅ and Y₂₅Co₇₅.

values of Faraday rotations from σ_{xy}^* in figure 2. It was confirmed that the wavelength dependence of the calculated rotations of Nd₂₅Co₇₅ was similar to the experimental data of McGuire *et al.* [6], but the calculated values are much smaller than the experimental ones.

Figure 3 shows the spectra of $\omega\sigma''_{xy}$ for Co, Y₂₅Co₇₅ and Nd₂₅Co₇₅. It is noticed that in the energy region

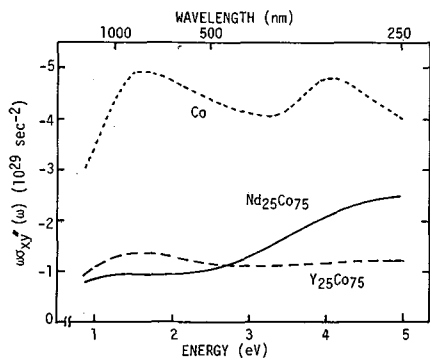


Fig. 3. - Spectra of the absorptive part of the complex off-diagonal conductivity multiplied by angular frequency of light $\omega\sigma''_{xy}$ for Co, $\text{Nd}_{25}\text{Co}_{75}$ and $\text{Y}_{25}\text{Co}_{75}$.

lower than 2 eV, the spectra of $\omega\sigma''_{xy}$ for $\text{Nd}_{25}\text{Co}_{75}$ shows almost the same tendency as those for $\text{Y}_{25}\text{Co}_{75}$, but in high energy region, $\omega\sigma''_{xy}$ of $\text{Nd}_{25}\text{Co}_{75}$ becomes larger than $\text{Y}_{25}\text{Co}_{75}$. We may consider that the frequency dependence of $\omega\sigma''_{xy}$ has a significant relation with interband MO transitions [7], and that 3d electron state of Co in Nd-Co is quite similar to that of Y-Co, because Y has a strong resemblance to Nd in respects to the atomic radius, electronegativity and electronic structure of outer shell. Therefore the difference between Nd-Co and Y-Co in $\omega\sigma''_{xy}$ is thought to be due to the magnetization of Nd, and thus large MO effects in high energy region is thought to be resulting from the interband transition of electrons bound to Nd.

Figure 4 shows XPS for Co, Nd, Nd-Co and Y-Co in the range from -10 eV to Fermi level. A very broad

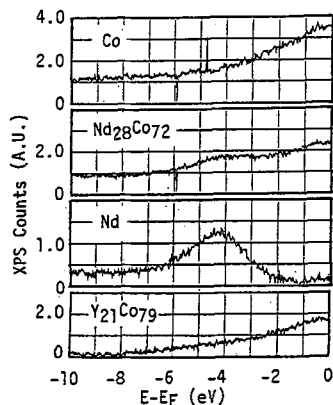


Fig. 4. - X-ray photoemission spectra for Co, Nd, Nd-Co and Y-Co.

shoulder is visible in the XPS of Nd and Nd-Co films at about -4.2 eV. The peak of Nd was attributed to 4f electrons [8]. So it may be possible that 4f $\uparrow \rightarrow$ 5d \uparrow transition contributes to the large $\omega\sigma''_{xy}$ as well as θ_K around $\hbar\omega = 4 \sim 5$ eV.

3. Conclusion

Kerr rotations of amorphous Nd-Co alloys increases with increasing energy in the visible to ultraviolet region in contrast to the case of Y-Co. The difference of Kerr spectra of Nd-Co and Y-Co in this region is due to the transition of 4f electrons, possibly 4f $\uparrow \rightarrow$ 5d \uparrow transition.

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