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ANNEALING EFFECT IN AMORPHOUS HoCo THIN FILMS[1]

ВОЗДЕЙСТВИЕ ОТЖИГА НА АМОРФНЫЕ ТОНКИЕ ПЛЕНКИ HoCo

I. GOŚCIAŃSKA*, H. RATAJCZAK**, Poznań

Changes in the temperature dependence of electrical resistivity, magnetic compensation point T_{comp}, and Hall parameters of amorphous HoCo thin films after gradual annealing up to 850 K have been studied. Very thin films exhibit a decrease in T_{comp} after annealing which may be understood as due to a partial oxidation of Ho, and a subsequent variation in the composition of the alloy. Variations in T_{comp} for thicker films depend rather on structural changes in the atomic alignment. It was found that crystallization of the film yields not only a reduction of electrical resistivity but also a drastic decrease of the extraordinary Hall coefficient.

The ageing and ordering effects in amorphous magnetic alloys yield changes in the magnetic properties of these materials [1—4]. On the other hand, the study by Hoffmann et al. [5] suggests a strong influence of RE-atoms oxidation on the magnetic behaviour of rare earth-transition metal (RE-TM) amorphous films. In the present paper we report results of our study of the influence of heating and annealing on the Hall parameters in HoCo thin films.

The amorphous HoCo films were prepared by the flash evaporation technique in the ultra-high vacuum of 2×10^{-7} Pa onto glass substrates cooled with liquid nitrogen. The samples were equipped with electrodes for the Hall measurements. The measuring and current supplying terminals were welded to the same electrode on both ends of the film. The measurements were carried out on two sets of samples, HoCo-25 and HoCo-30, with thicknesses of 48 and 136 nm, respectively. The heating and annealing were carried out with simultaneous measurement of the resistance in a vacuum of 10^{-5} Pa.

The resistance of the thinner film remained constant during a heating up to 850 K. It decreased linearly with subsequent temperature decrease and its value was 14 % lower than the initial one at room temperature. The temperature coefficient of the resistivity (TCR) $\alpha_{300} = 2.7 \times 10^{-4}$ K proves that a change in the structure has taken place in the film.

Results of the thermal treatment of the sample HoCo-25 on the Hall effect are shown in Figs 1 and 2. The temperature dependence of the Hall resistivity $|\varrho_H(T)|$ is about 20 times lower than that before heating (Fig. 1). We observe also a decrease of the compensation temperature T_{comp}. Taking into account the partial oxidation of holmium in the film [5] one can explain the T_{comp} decrease as being due to a Ho diminution of about 1.8 % in the HoCo alloy composition [6].

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** Institute of Physics, A. Mickiewicz University, Grunwaldzka 6, PL-60 780 POZNAŃ.
** Institute of Molecular Physics, Polish Acad. Sci., Smoluchowskiego 17/19, PL-60 179 POZNAŃ.

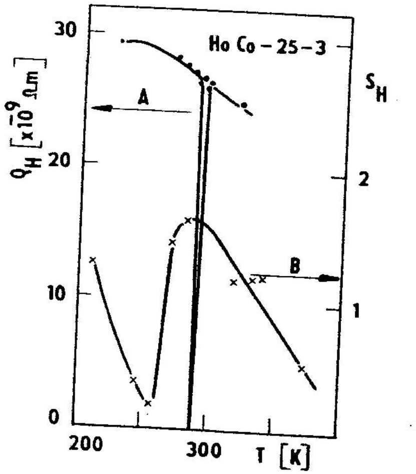

Fig. 1. Temperature dependence of Hall resistivity $|\varrho_H(T)|$ of the HoCo-25 film: a) before, and b) after heating up to 850 K.

The value of the extraordinary Hall coefficient R_1 decreased strongly after heating (Fig. 2). The ordinary Hall coeficient R_0 increased on the contrary to about 0.6×10^{-9} Ω m/T (being close to zero before heating). R_0 occurred independent of temperature in the measure range. The changes in R_1, R_0 and the extended minimum of the $|\varrho_H(T)|$ curve in the vicinity of T_{comp} seem to be due to structural changes and to the growth of inhomogeneities of the alloy as a result of the Ho oxidation.

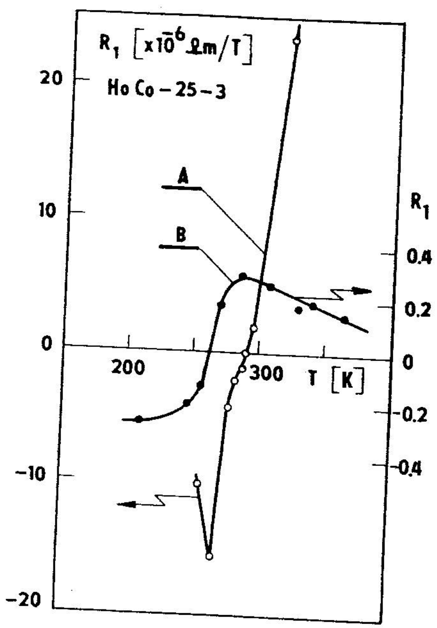

Fig. 2. Temperature dependence of the extraordinary Hall coefficient R_1 for the HoCo-25 film: a) before, and b) after heating up to 850 K.

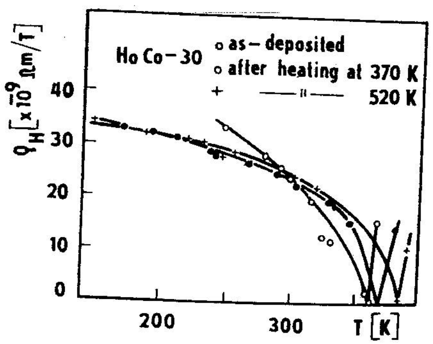

Fig. 3. Temperature dependence of $|\varrho_H(T)|$ for a HoCo-30 film: as-deposited, after annealing for 3 h at 370 K, and after heating up to 520 K.

The thicker film, HoCo-30 was heated at first to 370 K and no resistance changes were observed even after 3 hours of annealing. Similarly, the heating to 520 K did not affect the electrical resistance. The irreversible resistivity changes began at heating up to 850 K. After 2-hours' annealing at this temperature, the complete change of the resitivity was reached. The value of the final TCR (α_{300} = 1.9×10^{-3} K^{-1}) corresponds to that of a crystalline alloy. During the thermal treatment of the sample, described above, no significant changes of the Hall parameters have been observed as long as the resistivity did not change (Fig. 3). A drastic decrease in R_1 and an increase in R_0 were observed after crystallization. Nevertheless, the small variation in the compensation temperature T_{comp} in amorphous films can probably be interpreted as the effect of a compositional short range ordering (CSRO) [2], which takes place during annealing at 370 K causing a decrease in T_{comp}. Heating to higher temperatures, in our case to 520 K, destroys the CSRO and T_{comp} rises. However, the above suggestions require further studies.

One can also see that in thicker films the oxidation of Ho does not play such a great role as in thinner films. On the other hand, crystallization occurred in thicker films easier than in the thinner ones.

REFERENCES

[1] Masumoto, T., Maddin, R.: Acta Met. *19* (1971), 724; Material Science and Engineering *19* (1975), 1.
[2] Müller, H. R.: Phys. Stat. Sol. (a) *49* (1978), K 63.
[3] Chen, Y. N., Egami, T.: J. Appl. Phys. *50* (1979), 7615.
[4] Malmhäll, R., Bäckström, G., Rao, K. V., Egami, T.: J. Appl. Phys. *50* (1979), 7656.
[5] Hoffmann, H., Owen, A. J., Schröph, F.: Phys. Stat. Sol. (a) *52* (1979), 1.
[6] Heiman, N., Lee, K.: Phys. Rev. Lett. *33* (1974), 778.

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