A CHANGE IN MAGNETIC PROPERTIES OF Ho2Co7 INTERMETALLIC COMPOUND UPON HYDROGEN ABSORPTION

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A CHANGE IN MAGNETIC PROPERTIES OF Ho_2Co_7 INTERMETALLIC COMPOUND UPON HYDROGEN ABSORPTION

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Abstract. – The magnetic properties of the compound Ho_2Co_7 and its hydrides with hydrogen concentration 2.6 and 6 atH/mol are studied. A spin-glass-like and superparamagnetic behaviours are found for the β and the γ hydride phases respectively. Strong reductions in exchange interactions and T_c for both hydrides phases is observed.

1. Introduction

The absorption of hydrogen gas in intermetallic compounds often leads to changes in their magnetic properties. When the magnetism is due to Co atoms ferromagnetic-to-paramagnetic transitions were observed [1].

Most of the rare-earth R_2Co_7-type compounds absorb significant amount of hydrogen under ambient conditions [2]. The previous studies of magnetic properties of Y_2Co_7 [3, 4] and $Y_2Co_{7-x}Ni_x$ [5] hydrides have shown that Co magnetic moment is quite sensitive to the hydrogen concentration.

It has been established [6] that Ho_2Co_7 is a collinear ferrimagnetic with $T_c = 670$ K. In the present work we have investigated the magnetic properties of $HoCo_7$ hydrides in order to elucidate the role of hydrogen absorption on the exchange interactions.

2. Experimental details

The Ho_2Co_7 samples were prepared by arc melting of Ho and Co (purity 99.9 %) under purified Ar atmosphere followed by vacuum homogenization at 1050 °C for 300 h.

Both phase and structural analysis were performed on a standart X-ray diffractometer.

The hydrogen absorption-desorption properties and experimental set up are described elsewhere [7].

The magnetization was studied in the temperature range 4.2-300 K in permanent magnetic fields up to 140 kOe. The thermal demagnetization of samples were performed before each magnetization curve measurement.

3. Results and discussion

X-ray diffractograms show that Ho_2Co_7 samples have rhombohedral (Gd_2Co_7 type) single phase structure.

The desorption pressure-composition isotherms show the presence of β and γ hydride phase formation with hydrogen concentration at 323 K from 2.6 to 3.4 atH/mol and from 6 to above 7 atH/mol respectively. The structural analysis and magnetic measurements were performed on the samples of hydrides with hydrogen concentration 2.6 atH/mol and 6 atH/mol.

X-ray diffraction patterns of the hydrogenated samples can be indexed only as the Gd_2Co_7 type rhombohedral structure. An expansion mainly along the c direction upon formation of the β phase from $a = 4.985$ Å, $c = 36.14$ Å for Ho_2Co_7 to $a = 4.988$ Å, $c = 38.61$ Å for $Ho_2Co_7H_{2.6}$ was observed. Subsequent increasing of hydrogen concentration up to formation of the γ-phase results in an expansion mainly in the basal plane characterized by $a = 5.141$ Å, $c = 38.30$ Å.

Figure 1 displays the initial magnetization isotherms of parent compound and hydrides at 4.2 K. The temperature dependences of magnetization in magnetic field of 5 kOe are shown in figure 2. Both the magnetic moment per molecule of 6.0 μ_B as derived from the saturation magnetization for Ho_2Co_7 and the compensation temperature $T_{comp} = 230$ K are in agreement with those reported in previous study [6].

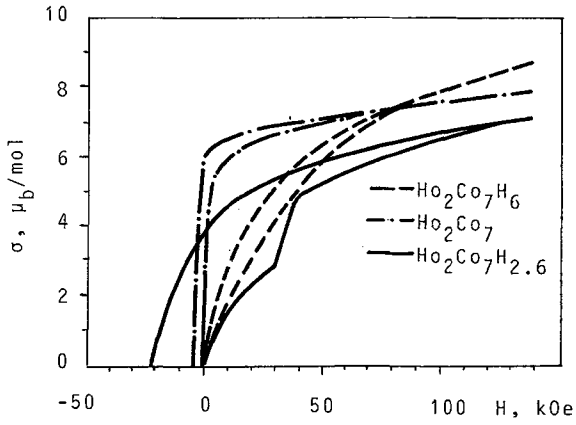

Fig. 1. – Magnetization *vs.* field curves for Ho_2Co_7 hydrides at 4.2 K.

[1] ILHMFLT, Prochnika 95, Wroclaw, Poland.

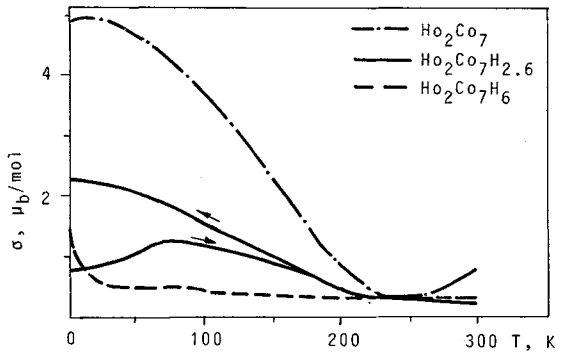

Fig. 2. – Magnetization *vs.* temperature curves for Ho_2Co_7 hydrides at applied magnetic field 5 kOe.

Magnetization *versus* temperature curves at 5 kOe for $Ho_2Co_7H_{2.6}$ (Fig. 2) show thermomagnetic hysteresis which can be interpreted as a consequence of the destruction of long-range magnetic order. It is difficult to measure the Curie temperature from the $\sigma(T)$ dependence because the transition are found to be too smeared, and it is estimated roughly to be about $T_c \sim 200$ K.

Since the hydrogen atoms statistically occupy interstitial sites in the lattice they induce short-range structural desorder. We believe that the fluctuations in hydrogen concentration cause respective exchange fluctuations thus resulting in the spin-glass-like behaviour of the $Ho_2Co_7H_{2.6}$. The magnetization *versus* field behaviour of the $Ho_2Co_7H_{2.6}$ is shown in figures 1 and 3. The lack of saturation and high coercive force (24 kOe for $Ho_2Co_7H_{2.6}$ and 4.3 kOe for Ho_2Co_7 in comparison) reflects the strong influence of the random local anisotropy on the magnetic moments of rare earth ions.

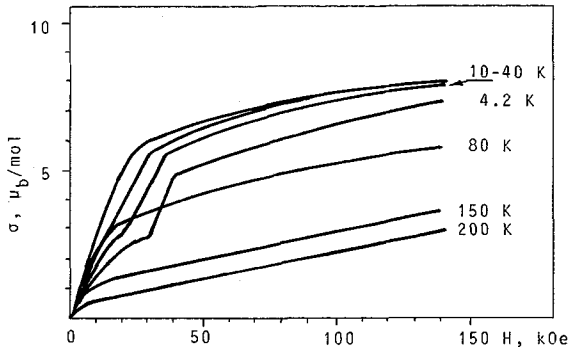

Fig. 3. – Magnetization *vs.* field curves for $Ho_2Co_7H_{2.6}$.

Figure 4 shows the field dependences of the magnetization of the $Ho_2Co_7H_6$ in the temperature range 4.2-200 K. The formation of the γ-phase results in both subsequent strong weakening in exchange interaction and decreasing of the Curie temperature. All magnetization curves exhibit no magnetic hysteresis and the maximum value of magnetization is practically constant at magnetic field of 140 kOe in the temperature range 10-30 K. Moreover the dependences $\sigma(H/T)$ are almost the same in the above temperature range. all these findings in the view of [8] reveal that the $Ho_2Co_7H_6$ behaves as a superparamagnetic. Our calculation show clusters size of about 100 Å.

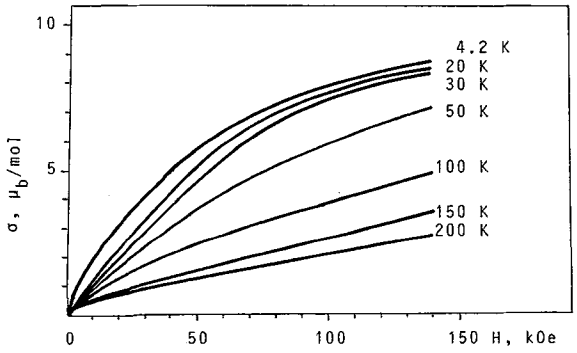

Fig. 4. – Magnetization *vs.* field curves for $Ho_2Co_7H_6$.

[1] Buschow, K. H. J., Bouten, P. C. P. and Miedema, A. R., *Rep. Prog. Phys.* **45** (1982) 937.

[2] Goudy, A., Wallace, W. E., Craig, R. S. and Takeshita, T., *Adv. Chem. Ser.* **105** (1978) 313.

[3] Buschow, K. H. J., *J. Magn. Magn. Mater.* **29** (1982) 91.

[4] Yamaguchi, M., Ikeda, H. and Ohta, T., *J. Less-Common Met.* **106** (1985) 165.

[5] Yamagychi, M., Ohta, T., Goto, T., Sakakibara, T. and Katayama, T., *J. Less-Common Met.* **130** (1987) 47.

[6] Lemaire, R., *Cobalt* **33** (1966) 201.

[7] Apostolov, A., Bozukov, L., Stanev, N., will present at the Int. Symp. on Metal-Hydrogen Systems, Stuttgart (Sept. 4-9, 1988).

[8] Bean, C. P. and Livingston, J. D., *J. Appl. Phys.* **30** (1959) 120S.