Vol. A53 (1978) ACTA PHYSICA POLONICA No 3

MAGNETIC PROPERTIES OF INTERMETALLIC ALLOYS Sm_xCo_y FOR $1 < x < 3$ AND $1 < y < 17$*

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(Received July 11, 1977)

Polycrystalline samples of Sm_xCo_y alloys with $1 < x < 3$ and $1 < y < 17$ were prepared by the arc melting technique. Their crystallographic structure and lattice parameters were determined by the X-ray method. The effect of Sm content on the magnetic properties of the Sm_xCo_y alloys was studied. It was found that the magnetic moment per formula unit and Curie point strongly decrease with an increase in the Sm concentration in the alloy. A strong magnetic anisotropy was found to be a characteristic feature of the alloys investigated.

1. *Introduction*

Cobalt forms a plurality of intermetallic compounds of various stoichiometric compositions with rare earth elements (*R*) [1, 2]. Crystallographic structures of the compounds formed are connected with each other [3, 4], and each of them can be obtained from a hexagonal cell $CuCa_5$ through a suitable displacement of atoms and shift in the atom layers. The fact that the crystallographic structures are interconnected enables us to suppose that the electron structures of individual phases are similar.

On the other hand a study of the magnetic properties of compounds *R*-Co makes the study of various magnetic interactions in these compounds possible for intermetallic compounds Sm–Co, the magnetic properties were carried out for Sm_2Co_{17} [5, 6], $SmCo_5$ [7–11], and $SmCo_2$ [12]. The alloys $SmCo_5$ and Sm_2Co_{17} are of special interest in connection with possibilities of their practical applications.

The present paper deals with the magnetic study of a full set of intermetallic alloys Sm_xCo_y.

2. *Experimental*

All samples were prepared by melting stoichiometric quantities of the starting metals in an argon arc furnace, with a subsequent continual remelting of the alloys obtained to homogenize them.

Sm (99.9%) was supplied by Koch Light Laboratories Ltd, and Co (99.999%) by Johnson–Mathey Chemicals Ltd.

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* Partly supported by the Institute of Physics, Polish Academy of Sciences.

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An X-ray study of powder samples was performed using $Fe_{K\alpha}$ radiation. The results showed that all the samples were single phase compounds, and their crystal structures and lattice parameters were determined.

The magnetic investigations were performed to align the powder particles in a magnetic field of 26 kOe. The magnetization per gram σ of Sm_xCo_y was measured as a function of temperature T for the 10°K — Curie point range in magnetic fields up to 18 kOe, employing a vibration sample magnetometer and the Faraday method. The temperature dependences of spontaneous magnetization and saturation magnetic moment per formula unit were determined.

The Curie temperature was determined from the isothermal H/σ vs σ^2 curves and from the variation in magnetization as a function of temperature in a magnetic field of 50 Oe.

3. *Results and discussion*

The magnetic and crystallographic data for the compounds investigated are given in Table I. The data obtained for Co, Sm_2Co_{17}, $SmCo_5$, $SmCo_2$ and Sm are in good conformity with those obtained [5–12, 13, 14, 15]. The temperature dependences of the

TABLE I

Magnetic and crystallographic characteristics of Sm_xCo_y compounds

Compound	Saturation magnetization at 0 K		Curie temperature T_c[K]	Coercitive force IH_c[kOe] at 293 K	Crystal structure and lattice parameters at 293 K
	emu/g	μ_B formula unit			
Co	166.1	1.75	1390	0.2	hexagonal $a = 2.50$ Å, $c = 4.06$ Å
Sm_2Co_{17}	96.0	22.40	1180	0.6	rhombohedral $a = 8.40$ Å, $c = 12.17$ Å
$SmCo_5$	92.0	7.32	1020	15.0	hexagonal $a = 4.99$ Å, $c = 3.96$ Å
Sm_2Co_7	67.0	8.55	716	9.8	hexagonal $a = 5.04$ Å, $c = 24.33$ Å
$SmCo_3$	60.0	3.62	520	6.4	rhombohedral $a = 5.05$ Å, $c = 24.59$ Å
$SmCo_2$	29.0	1.40	253	1.4 (77 K)	cubic $a = 7.25$ Å
Sm_2Co	4.7	0.30	80		rhombic
Sm_3Co	1.6	0.15	59		rhombic $a = 7.06$ Å, $b = 9.60$ Å, $c = 6.34$ Å
Sm	above 15 K the susceptibility follows Curie Weiss law with $p_{eff} = 1.8\ \mu_B$ and $\theta = -60$ K				rhombohedral $a = 3.62$ Å $c = 26.25$ Å

spontaneous magnetization of the Sm_xCo_y compounds are given in Fig. 1. Fig. 2 shows changes in the saturation magnetization (extrapolated to 0 K) and Curie temperature vs the Sm concentration in a compound. It was found that an increase in the Sm concentration causes a rapid decrease of the saturation magnetization and Curie temperature.

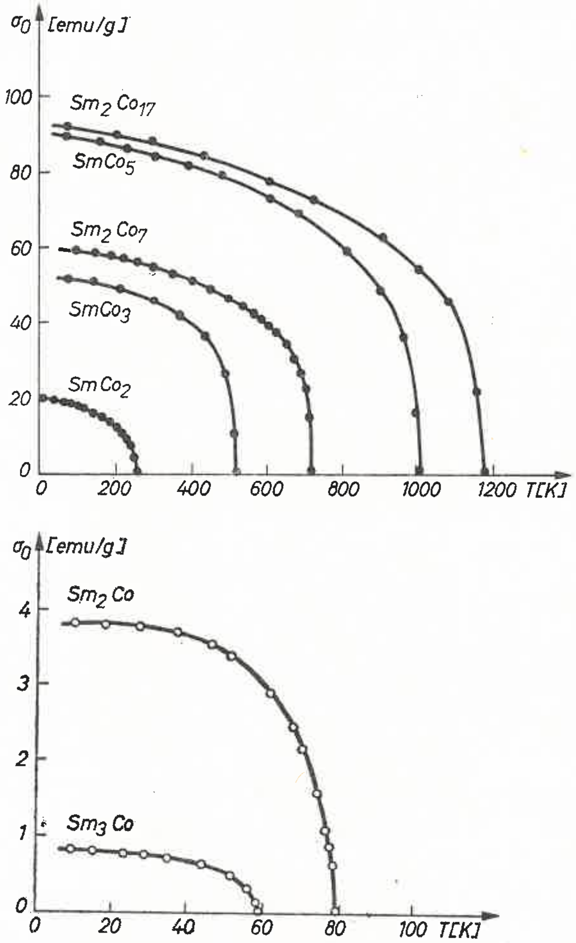

Fig. 1. The temperature dependences of the spontaneous magnetization of the Sm_xCo_y compounds

Applying the results of magnetic investigations and assuming a ferromagnetic coupling of the magnetic moments of Sm and Co, their mean magnetic moments were calculated by the CPA method [16]. It was found that the mean magnetic moment of Co decreases with an increase of Sm concentration from 1.75 μ_B and attains a value close to 0 for Sm_3Co. The mean magnetic moment of Sm practically does not depend on its concentration in the range below 50 at. %, but above this value it diminishes with an increase in the Sm concentration.

The effect of the crystalline field on the energy levels of Sm ions or a partial change of their valence (from Sm^{3+} to Sm^{2+}) can account for the small values of the mean magnetic moment in the compounds Sm_2Co and Sm_3Co (rhombic symmetry).

Diminution of the mean magnetic moment of Co in the compounds investigated is due to the filling of the 3d shell of Co with electrons of the 5d shell of Sm. Curie temperature of the compounds Sm_xCo_y decreases with the magnetic moment of Co. The results obtained suggest that in the compounds investigated, a substantial part is played by a sublattice formed by Co atoms, and interactions between them determine the magnetic properties of Sm_xCo_y. The conclusions drawn from the investigations performed agree with the results of studies on systems Y–Co and Gd–Co [5, 7, 17, 18].

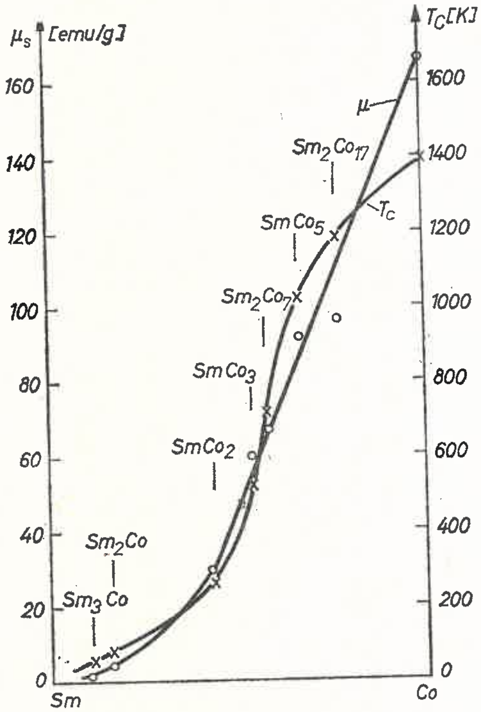

Fig. 2. Changes in the saturation magnetization (extrapolated to 0 K) and Curie temperature vs the Sm concentration in Sm_xCo_y compound

The magnetic study carried out on aligned powder particles have shown that compounds Sm_xCo_y are characterized by a strong uniaxial magnetocrystalline anisotropy. The coercivity attaining max. values at the Sm concentration near to 40 at. %.

High values of the saturation magnetization and Curie temperature of $SmCo_3$ and Sm_2Co_7, their strong magnetocrystalline anisotropy and better structural stability compared to $SmCo_5$, make their practical use for production of permanent magnets of high BH_{max} values possible.

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