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Letter

Magnetic phase diagrams of $TbCo_2Si_2$, $DyCo_2Si_2$, $TbCo_2Ge_2$ and $DyCo_2Ge_2$

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Abstract

Magnetization curves up to 140 kOe have been measured in the temperature range 4.2–45 K on polycrystalline oriented samples of $TbCo_2Si_2$, $DyCo_2Si_2$, $TbCo_2Ge_2$ and $DyCo_2Ge_2$. For all compounds a two-step metamagnetic transition is observed. The values of the critical fields were determined from the differential magnetization dM/dH. The magnetic phase diagrams for all samples are presented.

1. Introduction

RCo_2Si_2 compounds have been investigated intensively over the past few years [1]. Problems of magnetic phase transitions in these materials are interesting. For a large number of these compounds a change in magnetic field is observed [2–7]. In this work new results of high-field magnetization measurements on (Tb, Dy)Co_2(Si, Ge)$_2$ compounds up to 140 kOe are reported.

2. Experiments and results

Experiments were carried out on polycrystalline (Tb, Dy)Co_2(Si, Ge)$_2$ samples oriented in a magnetic field ($H = 100$ kOe). The magnetic measurements were carried out at low temperatures using a vibrating sample magnetometer in high magnetic fields up to 140 kOe in the "solenoid" installation.

Results of the magnetic measurements for $TbCo_2Si_2$, $DyCo_2Si_2$, $TbCo_2Ge_2$ and $DyCo_2Ge_2$ at high magnetic fields and different temperatures are shown in Fig. 1. For $TbCo_2Si_2$ and $DyCo_2Si_2$ the magnetization curves at low temperatures reflect a two-step metamagnetic

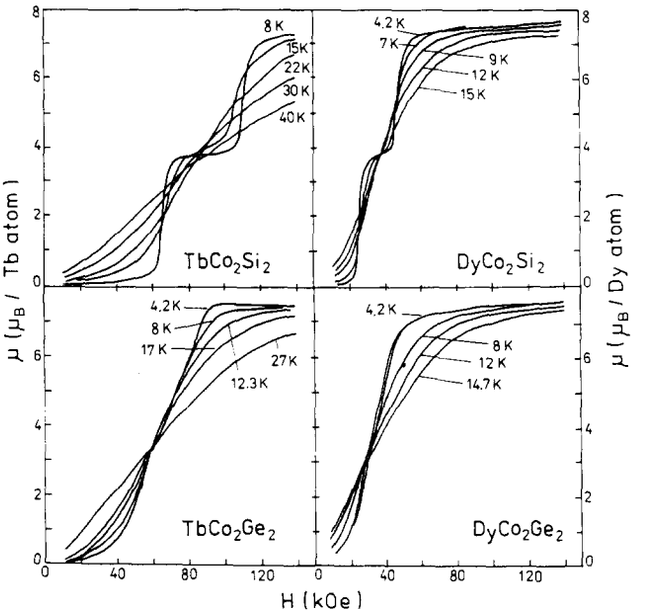

Fig. 1. High field magnetization curves at different temperatures for $TbCo_2Si_2$, $DyCo_2Si_2$, $TbCo_2Ge_2$ and $DyCo_2Ge_2$.

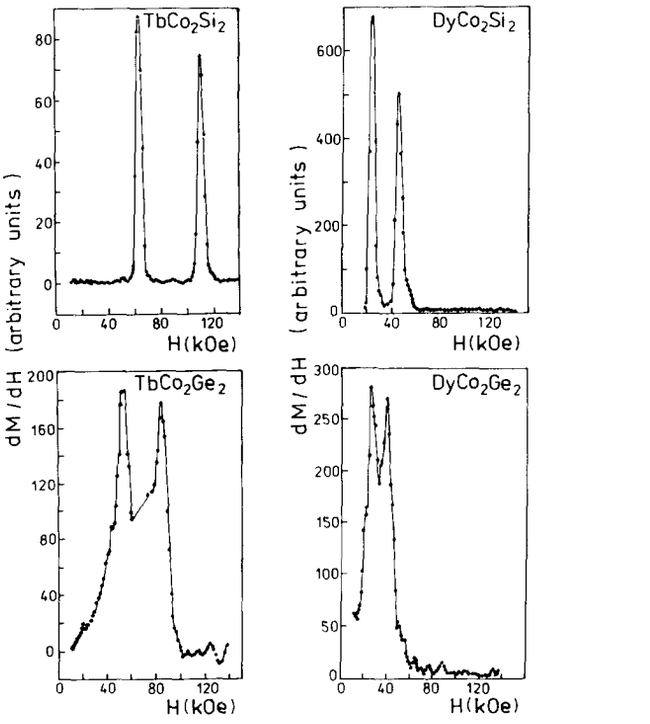

Fig. 2. Magnetic field dependence of the differential magnetization of $TbCo_2Si_2$, $DyCo_2Si_2$, $TbCo_2Ge_2$ and $DyCo_2Ge_2$.

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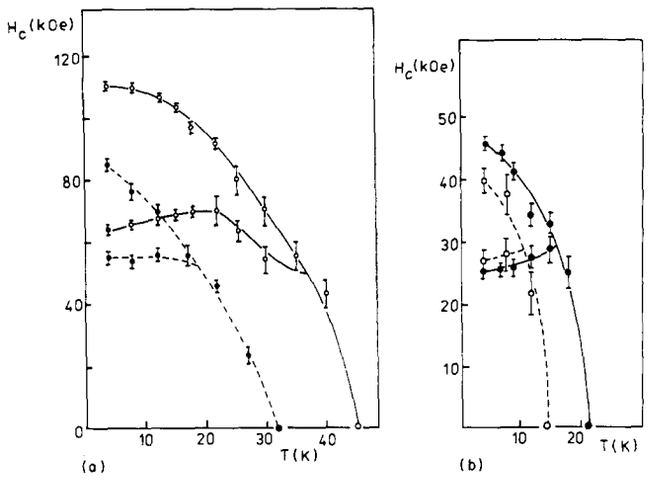

Fig. 3. Magnetic phase diagrams for (a) $TbCo_2Si_2$ (—), $TbCo_2Ge_2$ (– – –); (b) $DyCo_2Si_2$ (—) and $DyCo_2Ge_2$ (– – –).

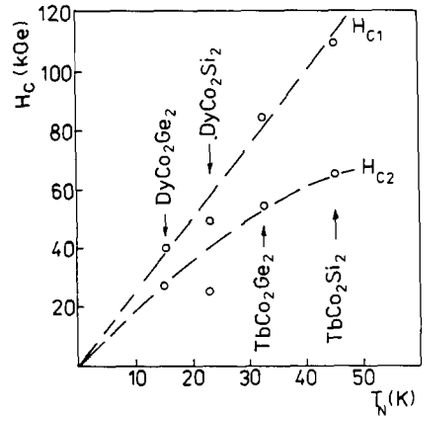

Fig. 4. Plots for metamagnetic transition field H_{C1} *vs.* temperature T_N.

process (see Fig. 1) with critical field $H_{C1}=61$ kOe and $H_{C2}=110$ kOe for $TbCo_2Si_2$ and $H_{C1}=24$ kOe and $H_{C2}=46$ kOe for $DyCo_2Si_2$. The two-step metamagnetic transitions are clearly seen in the differential magnetization dM/dH (see Fig. 2). The values of the critical fields are determined with the field dependence of dM/dH. The temperature dependences of the transition fields are shown in Fig. 3. Using these data the magnetic phase diagrams were determined.

The magnetization curves for $TbCo_2Ge_2$ and $DyCo_2Ge_2$ (see Figs. 1 and 2) have a similar character to those observed for isostructural silicides. The magnetic phase diagrams determined are shown in Fig. 3.

3. Discussion

All compounds investigated at zero magnetic field and $T=4.2$ K are antiferromagnets with a simple magnetic structure of AFI type [1]. The magnetic moment localized on the rare earth atoms forms a magnetic structure which could be displayed as a piling up of the ferromagnetic sheets along the c axis with the sequence $+-+-$ etc. and with the magnetic moments parallel to the [001] direction [1].

This type of magnetic ordering is stable in the temperature range 4.2 K–T_N and magnetic fields up to H_{C1}.

The magnetization curves have a two-step character. Below H_{C1} the collinear antiferromagnetic structure AFI is observed. In the intermediate region ($H_{C1}<H<H_{C2}$) the ferromagnetic order with a $+++-$ sequence [4] or a modulated one [6, 7] is observed. For $H>H_{C2}$ the ferromagnetic ordering is stable.

The values of the critical fields H_{C1} and H_{C2} at $T=4.2$ K are proportional to the Néel temperatures (see Fig. 4).

The magnetic properties of RCo_2X_2 compounds result from interplay of the charge (crystal electric field) and the spin (exchange) interactions [1]. The magnetic interaction between the f moment is weak, of RKKKY type. The character of the magnetic ordering can be changed drastically under the action of external fields.

The neutron diffraction experiment is necessary to determine the magnetic structure in the intermediate region.

References

1 A. Szytuła and J. Leciejewicz, in K. A. Gschneidner, Jr. and L. Eyring (eds.), *Handbook on the Physics and Chemistry of Rare Earths,* Vol. 12, North-Holland, Amsterdam, 1989, Chap. 83, p. 133.
2 T. Shigeoka, H. Iwata, H. Fujii, T. Okamoto and Y. Hashimoto, *J. Magn. Magn. Mater., 70* (1987) 239.
3 T. Shigeoka, N. Iwata, Y. Hashimoto, Y. Andoh and H. Fujii, *J. Phys., 49* (1988) C8-431.
4 N. Iwata, K. Honda, T. Shigeoka, Y. Hashimoto and H. Fujii, *J. Magn. Magn. Mater., 90/91* (1990) 63.
5 L. Vinokurova, V. Ivanov and A. Szytuła, *J. Magn. Magn. Mater., 99* (1991) 193.
6 H. Fujii and T. Shigeoka, *J. Magn. Magn. Mater., 90/91* (1990) 115.
7 J. A. Blanco, D. Gignoux, D. Schmitt and C. Vettier, *J. Magn. Magn. Mater., 97* (1991) 4.