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Letter

Magnetic phase diagram of $TbRh_{2-x}Ir_xSi_2$ in high magnetic fields

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Abstract

The a.c. susceptibility and high field magnetization of $TbRh_{2-x}Ir_xSi_2$ compounds were investigated up to 140 kOe. The (*H, T, x*) magnetic phase diagram was determined. For all compounds an increase in the magnetic fields causes three magnetic phases: antiferro-(for $H<H_{C1}$), ferri-(for $H_{C1}<H<H_{C2}$) and ferro-(for $H>H_{C2}$) appear. The value of H_{C1} practically does not change with the change in concentration *x*, whereas the H_{C2} decreases with increasing *x*.

Keywords: Magnetic phase diagrams; A.C. susceptibility; High field magnetization measurements

1. Introduction

The pseudo-ternary $TbRh_{2-x}Ir_xSi_2$ compounds crystallize in the body centered tetragonal (b.c.t.) $ThCr_2Si_2$-type structure [1]. The compounds are collinear antiferromagnets of the AFI type [2].

The results of the magnetic measurements indicate that in the $TbRh_{2-x}Ir_xSi_2$ system, the magnetic ordering temperature increases with an increase in *x* [1].

In this work the results of a.c. susceptibility and high field magnetization measurements of the $TbRh_{2-x}Ir_xSi_2$ system are reported.

2. Experimental details and results

Experiments were carried out on polycrystalline samples, as reported in the previous paper [1]. The a.c. susceptibility was measured using a mutual inductance bridge. The magnetization of the samples was measured by means of a vibrating sample magnetometer in high magnetic fields up to 140 kOe, produced in a "SOLENOID" installation. The temperature dependence of the magnetic susceptibility for samples with $x=0$, 0.5, 1.0, 1.5 and 2.0 show a typical maximum for the antiferromagnetic-to-paramagnetic phase transition. The value of the Néel temperatures increases with *x*. The data obtained are in agreement with previous data [1].

The results of the magnetization measurements made on samples aligned in a magnetic field and recorded at different temperatures in magnetic fields up to 140 kOe are presented below.

For the samples at $T=4.2$ K with $x=0$ and $x=0.5$, a one-step metamagnetic transition with the critical field $H_{C1}=80$ and 86 kOe, respectively is observed (Fig. 1) (and see Fig. 3 in Ref. [3]). With increase in temperature the two-step metamagnetic transition is observed. For samples with other than *x* 0 and 0.5 the two-step metamagnetic transition only is observed in the temperature range 4.2 K–T_N. The phase diagram determined for all samples is presented in Fig. 2. The first critical field H_{C1} does not change with the change in concentrations, whereas the second critical field H_{C2} decreases with increasing *x*.

3. Discussion

The results presented in this work indicate that the magnetization curves have a two-step character. The data for $TbRh_2Si_2$ reported in Ref. [4] give the critical field H_{C2} equal to 190 kOe. A similar dependence of the magnetization is observed in a large number of the

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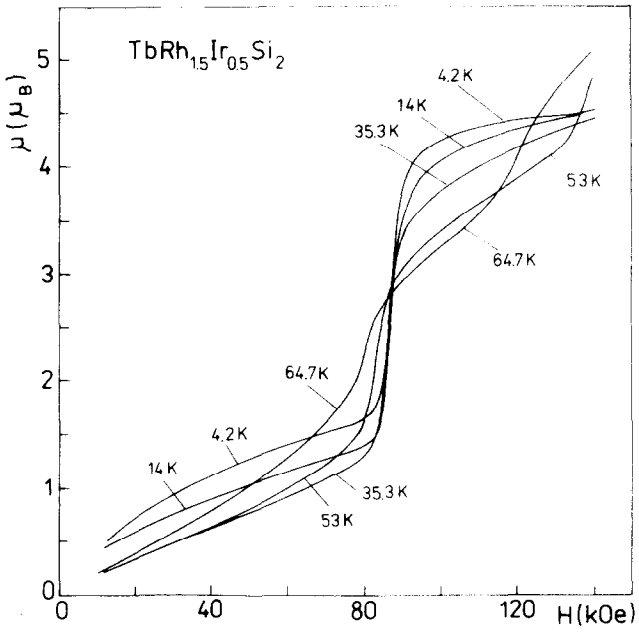

Fig. 1. High field magnetization curves at various temperatures for $TbRh_{1.5}Ir_{0.5}Si_2$.

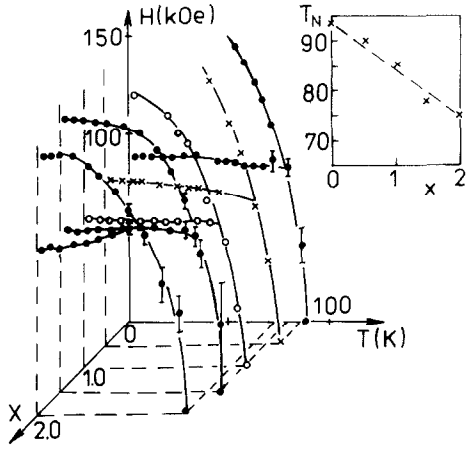

Fig. 2. Magnetic phase diagram (H, T, x) for $TbRh_{2-x}Ir_xSi_2$. Insert presents the composition dependence of the Néel temperature.

RT_2X_2 compounds which are antiferromagnets with a simple magnetic structure of the AFI-type [5]. In the magnetic fields up to H_{C1} and in the temperature range 4.2 K–T_N this type of magnetic ordering can be displayed as a piling up to the ferromagnetic sheets along the c-axis with the sequence $+-+-$. With an increase in magnetic field in an intermediate region ($H_{C1}<H<H_{C2}$) the ferromagnetic order of $+++-$ sequence [6] is observed. For $H>H_{C2}$ the ferromagnetic ordering is stable.

Katsura and Narita [7] showed that for the theoretical calculations an effective Hamiltonian, which includes exchange interactions J_i up to $i=3$ to ensure the appearance of the structure with the $+++-$ sequence in the intermediate region should be used.

The results presented in this work are in agreement with those reported in Ref. [5]. For the RT_2X_2 compounds, in which T is "*nd*" element ($n=3$, 4 or 5) the type of magnetic ordering depends on the number of electrons.

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