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Crystal Structure and Magnetic Properties of TbTSn Compounds (T = Pt and Rh)

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Abstract: The TbTSn compounds (T = Pt, Rh) have been prepared by arc-melting in purified Ar atmosphere. Crystal structures were studied by X-ray powder diffraction. The Rietveld analysis shows the single phase in hexagonal ZrNiAl-type structure for TbPtSn and TbRhSn compounds. Magnetic properties and specific heat measured by mean of Physical Properties Measurement System (PPMS) demonstrated the phase magnetic transition at Néel temperature T_N.

Keywords: Crystal structure, Magnetic properties.

1. Introduction

The crystal structure, specific heat and magnetic properties of the equiatomic ternary compounds of RMX have been studied (R = rare earth, M = transition metal and X = Si, Ge, Al, In and Sn) [1-3]. Ternary equiatomic rare-earth R = Ce, Pr, Nd compounds RMX crystallized in the orthorhombic TiNiSi-type structure (space group: Pnma) [4]. Among the RMX compounds, Tb compounds TbNiSn and TbRhGe exhibit strongly anisotropic physical properties reflecting their crystal symmetry. The existence of successive magnetic transitions with temperature as well as the multistep metamagnetism under high field has been clarified for TbNiSn and TbRhGe single crystals [5–10]. For another isostructural compound TbPdSn, the results of bulk magnetic measurements on polycrystalline samples have been reported so far [11–13]. In this studies, we present crystal structure, specific heat and magnetic properties of TbPtSn, TbPdSn, TbNiSn compounds at low temperature.

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2. Experimental

The TbPtSn and TbRhSn alloys were prepared from the pivot elements Tb, Pt, Rh 99.9% (3N) and Sn of 99.99% (4N) by using an arc-melting method in the argon atmosphere. The crystal structure characterization was analyzed by the *X-ray* diffractometer Rigaku Rint-2000 with $CuK\alpha_1$ radiation with wavelength λ = 1.54059 Å. The analysis of phases was processed by mean of the Rietveld profile fitting method as discussed in Ref. [14]. The Superconducting Quantum Interference Device magnetometer (SQUID, Quantum Design) was used to obtain the results of magnetization in the temperature range from 1.8 to 300 K and the field up to 7 T. The specific heats were measured by using a PPMS system in the temperature range from 2 to 30 K.

3. Results and discussions

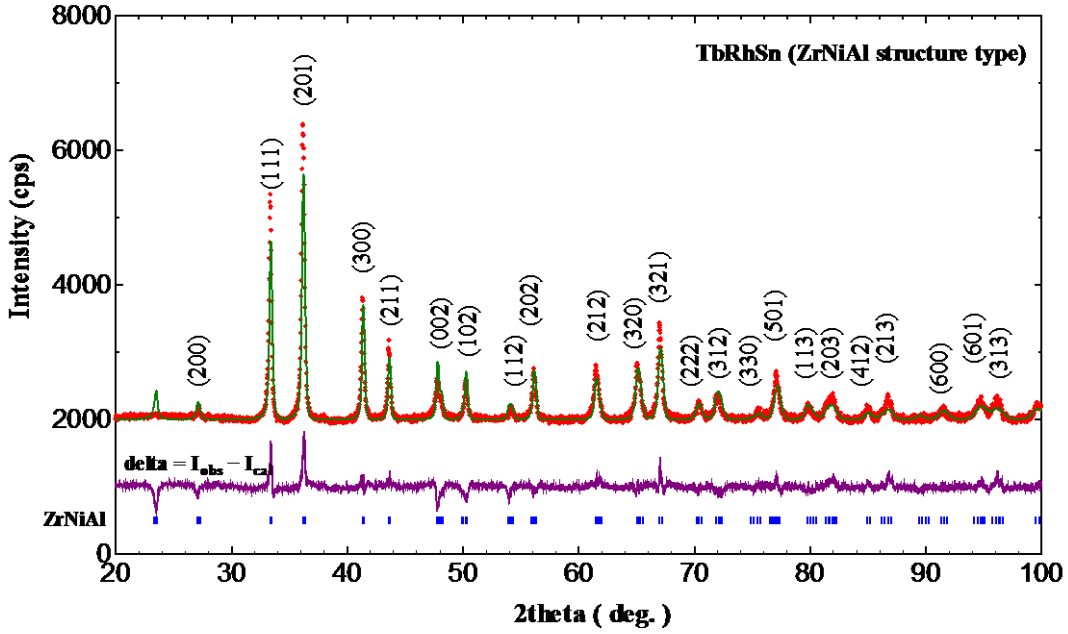

Fig.1. The X-ray diffraction patterns of TbRhSn compounds.

The purity of phase of compounds was checked by X-ray analysis. Figure 1 shows the XRD patterns of TbRhSn compound. It can be seen clearly that the compound exhibits an excellent phase quality. The phase was indexed as hexagonal ZrNiAl type structure (space group $P\bar{6}2m$) for TbPtSn and TbRhSn compounds. Further analysis of phase by Rietveld method for TbRhSn showed that the Tb atoms occupied 3g positions (x_1,0,1/2; 0,x_1,1/2; $\overline{x_1}$,$\overline{x_1}$,1/2) and the Sn atoms 3f positions (x_2,0,0; 0,x_1,0; $\overline{x_2}$,$\overline{x_2}$,0), while the Pt atoms the 2c positions (1/3,2/3,0; 2/3,1/3,0), and 1b (0,0,1/2). The analysis resulted for TbRhSn x_1 = 0,5886, x_2 = 0,2541 and lattice constant $a = b$ = 7.44378 Å, c = 3.99993 Å.

This result is consistent with the ones obtained from Neutron diffraction measurements which has been published by A. Szytula [15].

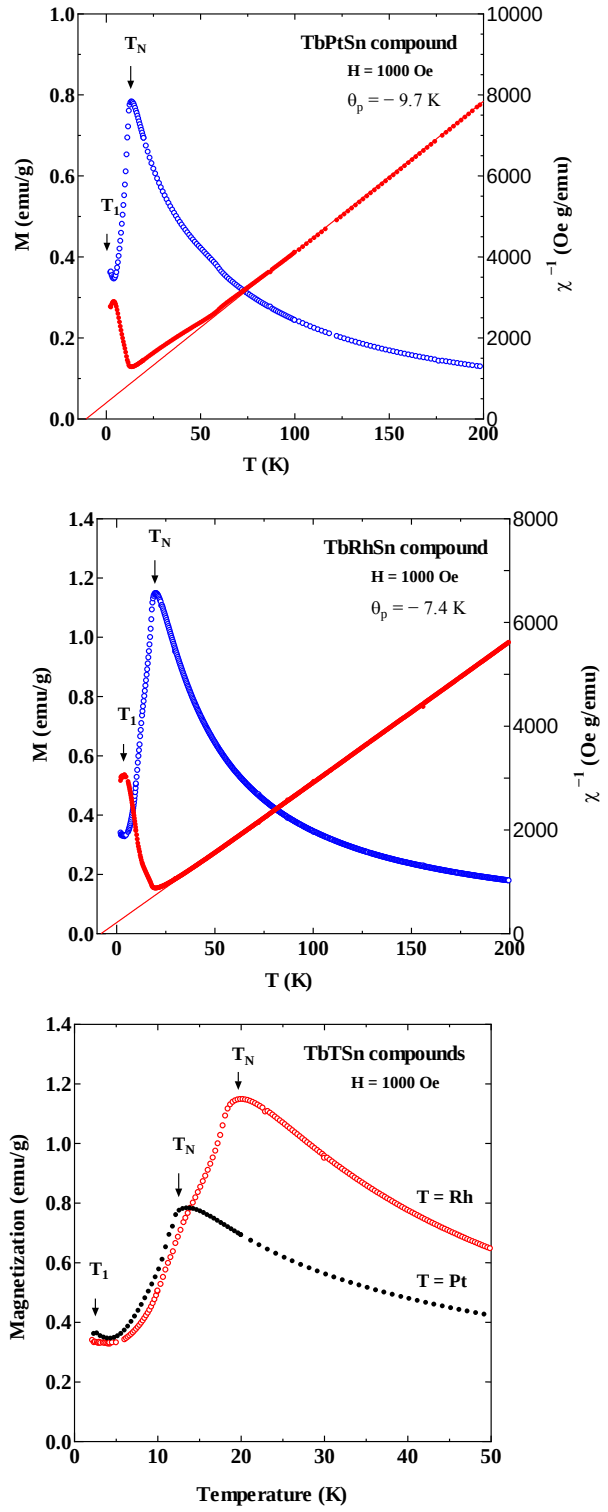

Fig. 2. The temperature dependence of the magnetization $M(T)$ and inverse magnetic susceptibility $\chi^{-1}(T)$ of TbPtSn and TbRhSn compounds.

Figure 2 shows the temperature dependence of the magnetization and the inverse magnetic susceptibility of TbPtSn and TbRhSn compounds at H = 1000 Oe. In the $M(T)$ curves, there are two anomalies indicative of successive magnetic transitions. A antiferromagnetic ordering takes place at T_N = 13.5 K for TbPtSn compound and 19.6 K for TbRhSn compound. A further increase is observed in the magnetization below 5 K for all compounds. The temperature dependence of magnetic susceptibility in magnetic feld of 1000 Oe was described by a modified Curie-Weiss law: $\chi(T) = \chi_0 + C/(T - \theta_P)$. In the paramagnetic phase the inverse susceptibility obeys a modified Curie Weiss law with the paramagnetic Curie θ_P = - 9.7 K for TbPtSn compound and θ_P = - 7.4 K for TbRhSn compound.

Figure 3 shows the plot of specific heat C_p versus temperature T for TbPtSn compound. The two jumps in the specific heat are observed at corresponding temperatures T_N = 13.5 K and T_t = 5 K, respectively. The anomaly at 13.5 K should be the paramagnetic to antiferromagnetic state. The latter anomaly should be order-order transition. The total specific heat was assumed to be composed of three parts: electron, lattice and magnetic contributions. Here, the electronic part was neglected. The main issue was to evaluate the lattice part in the magnetic compound [16].

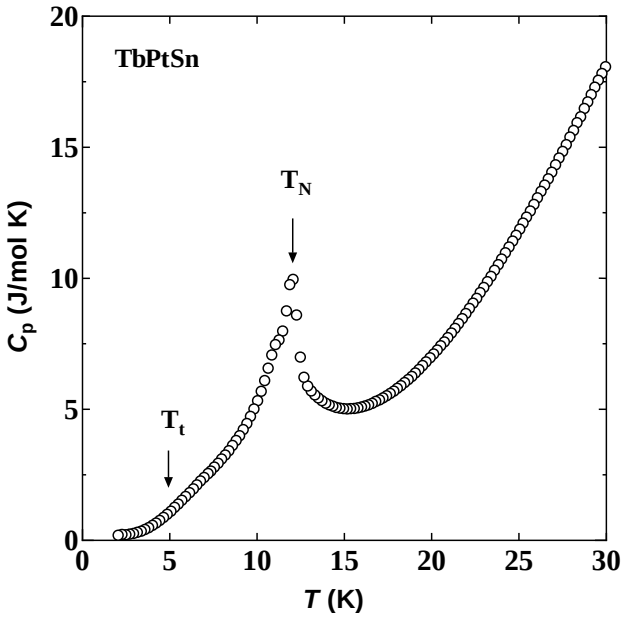

Fig. 3. Specific heat versus temperature for TbPtSn compound.

A model for the magnetic structure change at Tt is suggested to account for the anomalies found in the magnetization and specific heat.

4. Conclusion

We have prepared TbPtSn and TbRhSn with a single phase in hexagonal (ZrNiAl-type structure). The lattice constants have been calculated as a = b = 7.44378 Å, c = 3.99993 Å for TbRhSn. The temperature dependence of inverse magnetic susceptibility and specific heat shows that compounds are in anti-ferromagnetic state and Néel temperature 13.5 K for TbPtSn and 19.6 K for TbRhSn compound. And the anomaly should be order-order transition below 5 K for all compounds.

Acknowledgements

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