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Pressure effect on the Curie temperature of the Heusler alloys Rh_2MnZ (Z = Sn, Ge)

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Abstract

The pressure effect on the Curie temperature (T_C) of Rh_2MnZ (Z = Sn, Ge) has been investigated by measuring the temperature dependence of initial permeability at various pressures up to about 1 GPa. The Curie temperature T_C and its pressure coefficients $(1/T_C)dT_C/dp$ were obtained to be 431 K and $+2.6 \times 10^{-2}$ GPa^{-1} for Rh_2MnSn, and 471 K and $+1.7 \times 10^{-2}$ for GPa^{-1} Rh_2MnGe, respectively. It was found that a pressure induced phase transition occurs around 0.6 GPa in Rh_2MnGe.

Keywords: Heusler alloys; Pressure effect; Curie temperature

1. Introduction

The Heusler alloys Rh_2MnZ (Z = Sn, Ge) have the $L2_1$-type crystal structure. Rh_2MnSn is ferromagnetic with the Curie temperature T_C of 412 K and has a total magnetic moment of $3.1\mu_B$/formula [1]. Rh_2MnGe is also ferromagnetic with T_C of 450 K and a magnetic moment of $4.3\mu_B$/formula [2]. The electronic structure and magnetic moment of Rh_2MnX (X = Ge, Sn and Pb) were calculated by Pugacheva and Jezierski [3]. Their results show that mostly magnetic moments are localised on the Mn atom and depend on the local atomic order in the alloys. The magnetic moment on the Rh atom is small (approximately $0.4\mu_B$/atom) and the magnetic properties of these alloys are mainly connected with those of the Mn atoms. The relationship between the Mn–Mn interatomic distance and the Curie temperature has been studied for $L2_1$-type and $C1_b$-type Heusler alloys [4]. The results show that the Curie temperature of both alloys depends on the Mn–Mn interatomic distance and the number of valence electrons.

In this paper we report on the pressure dependence of the Curie temperature and discuss the interatomic distance dependence of the exchange interaction in the ferromagnetic Mn Heusler alloys.

2. Experimental details

The polycrystalline samples of Rh_2MnZ (Z = Sn, Ge) were prepared from Rh (99.9%), Mn (99.99%), Sn (99.9999%) and Ge (99.9999%). They were mixed in the desired proportion and sealed in evacuated silica tubes. To prepare Rh_2MnSn, the mixture of Rh, Mn and Sn was heated at 250 °C for 7 h, annealed at 700 °C for 6 days and quenched in water. The reaction products were pulverized, mixed, heated again in evacuated silica tubes at 700 °C for 6 days, and then quenched in water. To prepare Rh_2MnGe, the mixture of Rh, Mn and Ge was annealed at 950 °C for 6 days and quenched in water. The reaction products were pulverized, mixed, heated again in evacuated silica tubes at 950 °C for 6 days, and then quenched in water.

The powder X-ray diffraction measurements were performed with Cu Kα radiation at room temperature. The obtained diffraction patterns indicated that the prepared samples were single phase with the ordered $L2_1$-type structure. The lattice parameters a of Rh_2MnSn and Rh_2MnGe are determined to be 6.24 and 6.03 Å, respectively.

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