Preprint

Physical Review B

EDWA-LR-72-0041

EFFECT OF PRESSURE ON THE FERROMAGNETIC TRANSITION OF $MnAs_xSb_{1-x}$ SOLID SOLUTIONS*

L. R. Edwards and L. C. Bartel

Sandia Laboratories, Albuquerque, New Mexico 87115

ABSTRACT

The ferromagnetic transition temperature of $MnAs_xSb_{1-x}$ solid solutions for $0 \le x \le 1$ have been measured as a function of pressure up to 4.5 kbar. Previous work has shown that for the solid solutions in the concentration range $0.9 \lesssim x \le 1$ the magnetic transition is first-order and is accompanied by a hexagonal to orthorhombic structure transformation, while for $0 \le x \lesssim 0.9$ the magnetic transition is second-order with no structural change. We have found that the initial pressure derivative of the transition temperature, $\partial T_c/\partial P$, changes discontinuously in the narrow concentration range $0.87 \lesssim x \le 0.90$, further demarcating the first and second-order regions. We show that an itinerant electron ferromagnet model can be applied to the solid solutions which exhibit second-order behavior. From the experimental values of $\partial T_c/\partial P$ a minimum value of the Stoner enhancement factor, $(\overline{I} - 1)^{-1}$, is estimated for the second-order solid solutions. We also find that substituting Sb for As in the first-order region increases the critical pressure, P_c, which stabilizes the orthorhombic phase to lowest temperature. This further supports Goodenough's observation of a critical molar volume range in which the first-order transformation occurs.

I. INTRODUCTION

The isomorphic metallic compounds MnAs and MnSb have different magnetic properties which are believed to be due to differences in the Mn-Mn separation distance. For increasing temperature, MnAs exhibits a first-order ferromagnetic (FM) to paramagnetic (PM) transition at 313°K which is accompanied by a change in crystal symmetry from the hexagonal NiAs structure (B 8_1) to the orthorhombic MnP structure (B 31). (Hereinafter we use FM to denote ferromagnetic, ferromagnet, or ferromagnetism, and similarly for PM.) On further heating, a second-order transition involving a change from a low-spin PM to a high-spin PM phase and a change in crystal symmetry from the orthorhombic (B 31) to hexagonal structure (B 8_1)[1] is observed at 398°K. On the other hand, MnSb has a second-order FM to PM transition at 572°K with the crystal structure remaining hexagonal (B 8_1) through the transition.[2] A complete series of solid solutions is formed by MnAs and MnSb in which the hexagonal lattice parameters decrease monotonically from MnSb to MnAs.[3]

The various magnetic transition temperatures and crystal structures of the solid solutions $MnAs_xSb_{1-x}$ as reported by Sirota and Vasilev[4] and Goodenough et al.[5] are summarized in Fig. 1. Here, for increasing temperature, T_c denotes the FM to PM transition temperature, T' denotes the PM to PM transition temperature at which the effective moment decreases, and T_t is a PM to PM transition temperature at which the effective moment increases and the crystal structure changes from orthorhombic to hexagonal. For the solid solutions in the concentration range $0.9 \le x \le 1.0$ the transition from the FM hexagonal phase to the PM orthorhombic phase is first-order. All other transitions are second-order.

From Fig. 1 we see that over the concentration range $0 \le x \le 0.80$ the FM to PM transition temperature, T_c, decreases with increasing As concentration. In addition, the effect of substituting As for Sb is to decrease the lattice