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Low Temperature Magnetic Properties of MnTe

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Abstract

Electrical resistivity and magnetic susceptibility measurements of antiferromagnetic p-type semiconductor MnTe are presented in the 20K - 300K range. A sharp increase in susceptibility at about 80K is observed and reported for the first time. This rise in susceptibility measurements may be due to a structural phase transition at around this temperature.

INTRODUCTION

Antiferromagnetic p-type semiconductor MnTe crystallizes in the hexagonal NiAs type structure with a direct band gap of 1.3eV. MnTe is an interesting crossroad material because of its non standard magnetic and electronic behaviour [1,2] and having properties similar to those of the NaCl type chalcogenide magnetic insulator but having a crystal structure, which normally supports metallic conductivity. MnTe has fairly low resistivity of about 0.1 to 1 ohm-cm as against 10^3 to 10^6 ohm-cm in other manganese chalcogenides. It orders antiferromagnetically at about 310K [3]. The electrical and magnetic properties have been studied in detail mostly in the temperature range 80K - 800K by several researchers [4,5]. Changes in the temperature dependence of resistivity near Neel temperature T_N have been attributed to spin-disorder scattering [4], a behaviour normally seen in ferromagnetic metals [6].

MnTe was prepared by mixing stoichiometric amounts of finely powdered Mn and Te, pelletized, sealed in quartz ampoule below 10^{-6} Torr and heated for 10 days at 750°C. The phase purity was checked by X-ray diffraction and the lattice parameters were calculated to be a = 4.165°A and c = 6.721 °A. Susceptibility measurements were performed on a Faraday balance and a four probe set-up was used for resistivity measurements.

RESULTS AND DISCUSSIONS

A plot of electrical resistivity for MnTe from 25K to 300K is shown in figure 1. and is in overall agreement with the results of previous workers [5]. The resistivity plot shows a positive temperature coefficient below Neel temperature T_N down to about 101K. This anomaly in the resistivity has been explained to be due to spin disorder scattering with a large contribution from influence of magnon drag [6]. XPS measurements have ruled out metal to metal interaction [7]. Below 101K the resistivity shows negative temperature coefficient. It is to be noted that

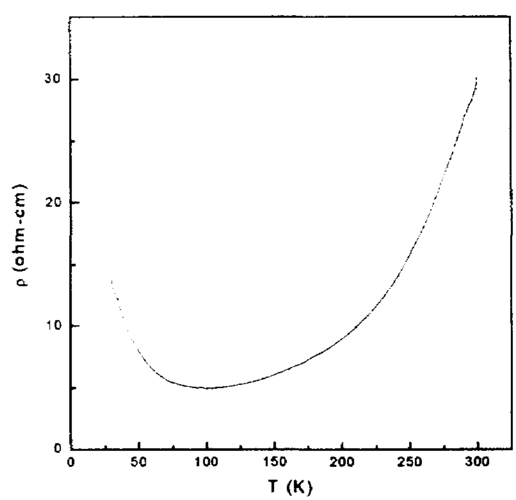

Fig. 1. Electrical Resistivity of MnTe

the resistivity of MnTe above Neel temperature T_N is semiconductor like [3].

A plot of d.c. susceptibility for MnTe in a temperature range between 25K to 325K is shown in figure 2. The plot clearly shows the paramagnetic to antiferromagnetic transition at a Neel temperature T_N of 310K. Below T_N the d.c. susceptibility varies linearly by a small amount down to 83K, at around this temperature an interesting sharp rise in d.c. susceptibility showing a ferromagnetic like transition is seen. The sharpness of the transition hints at a structural transition in MnTe. No report has appeared so far, claiming any phase transition in MnTe below 80K. However Zinc Blend phase of MnTe thin films having a spin glass phase at 60K has been reported, MnTe thin film resistivity measurements at about

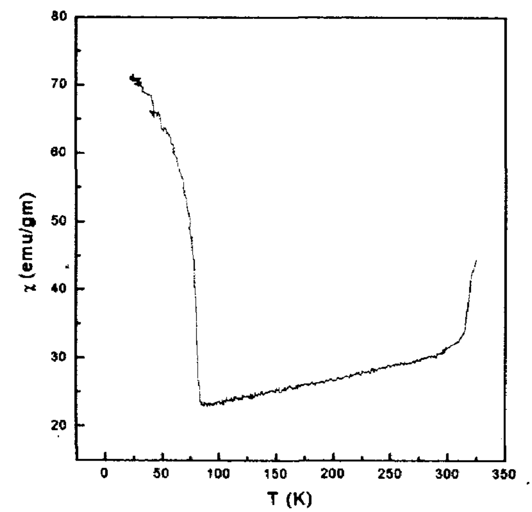

Fig. 2. Magnetic Susceptibility of MnTe

130K shows a metal-semiconductor behaviour and a.c. susceptibility shows a cusp indicating a spin glass behaviour [8]. It is to be noted that the band gap of MnTe changes from 1.3 eV in NiAs phase to 3.2 eV in the Zinc Blend phase [9].

The change in resistivity behaviour around 101K can be correlated with this sharp rise in d.c. susceptibility at about 83K. The decrease in resisitivity from 300K due to spin wave scattering should have continued even at lower temperatures instead of a slow rise below 101K. We feel that around this temperature MnTe undergoes a structural transition which as responsible for the ferromagnetic like behaviour of susceptibility and the negative temperature coefficient of resistivity. To study the low temperature structure and nature of magnetic order, neutron diffraction experiments on MnTe are proposed and will be carried out in near future.

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