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PRESSURE DEPENDENCE OF THE CURIE TEMPERATURE IN MnAlGe

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Abstract-The pressure dependence of the Curie temperature was determined in 2-dimensional like ferromagnet, MnAlGe up to a maximum pressure of 7.5 GPa through measurements of electric resistance vs temperature curves. The pressure coefficient was positive with a considerably high rate of 9 K/GPa in the low pressure ragion, while it decreased gradually down to one order of magnitude smaller value at the maximum pressure. It was concluded that ther is an upper limit of about 550 K in the super-exchange type ferromagnetic interaction between Mn layers.

I. INTRODUCTION

The ternaly intermetallic compound, MnAlGe is a ferromagnet of which the Curie temperature is 503 K at the ambient pressure [1]. This compound has the Cu_2Sb type crystal structure, in which there are two sites of Cu atoms, Cu_I and Cu_{II}. In MnAlGe crystal, Mn atoms occupy the Cu_I site, and the Cu_{II} site is filled with Al atoms. In this structure Mn atoms construct 2-dimensional like layer structure, each Mn layer being separated by two nonmagnetic layers of Al and Ge atoms.

This structure is magnetically unique, and it seems interesting to observe magnetic properties as functions of the distance between Mn-layers. We report a measurement of the pressure dependence of the Curie temperature in MnAlGe in a high pressure range up to 7.5 GPa.

II. EXPERIMENT

To generate a high pressure of the range of several GPa, a two-stage multi-anvil apparatus was operated by a 15000 ton press [2]. The pressure was generated within a space of pyrophyllite media of octahaedral shape of the dimension of 10 mm.

The Curie temperature was determined as a turning point of the electric resistance vs temperature curve. A four-lead technique was adopted to observe the resistance.

To obtain a direct relationship between the Curie temperature and the lattice parameters, X-ray diffraction measurements were made at room temperature under high pressures up to 10 GPa.

Observed diffraction patterns were shown in Fig.1, where no structural phase transition was seen and the Cu_2Sb-structure retains up to the maximum pressure.

The pressure dependences of a- and c-values are shown in Fig.2. Along c-axis, the absolute value of the initial slope is small, while it increases above 5 GPa. No anomaly was seen in the pressure dependence of a-value up to 10 GPa.

III. RESULTS AND DISCUSSION

Observed electric resistance vs temperature curves at various pressures were shown in Fig.3. From these curves the Curie temperatures were determined and plotted in Fig.4 as a function of pressure.

Observed shift of the Curie temperature was positive and depends upon the range of pressure. In the low pressure region between 0.5 and 2 GPa, the increasing rate was as large as 9 K/GPa, while it decreased with increasing the pressure and reached almost one order of smaller value at 7.5 GPa.

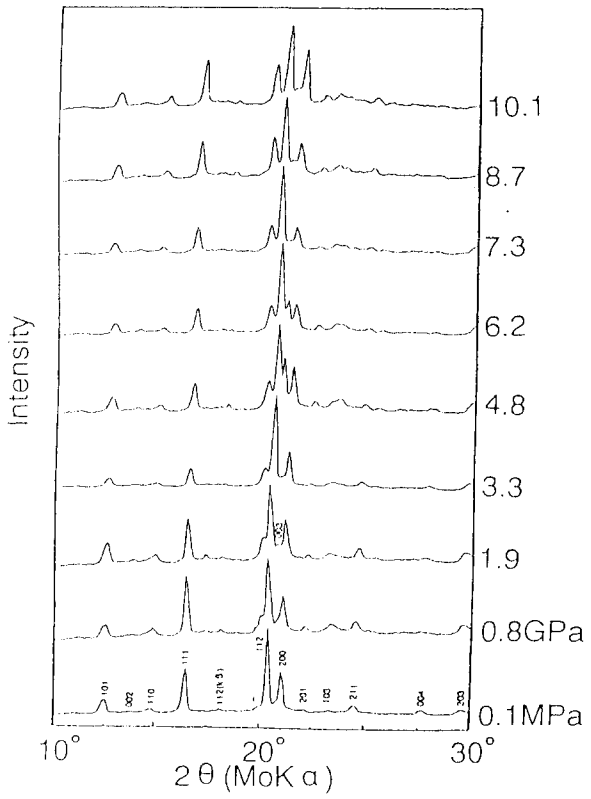

Fig.1 X-ray diffraction profiles of MnAlGe under various pressures at room temperature.

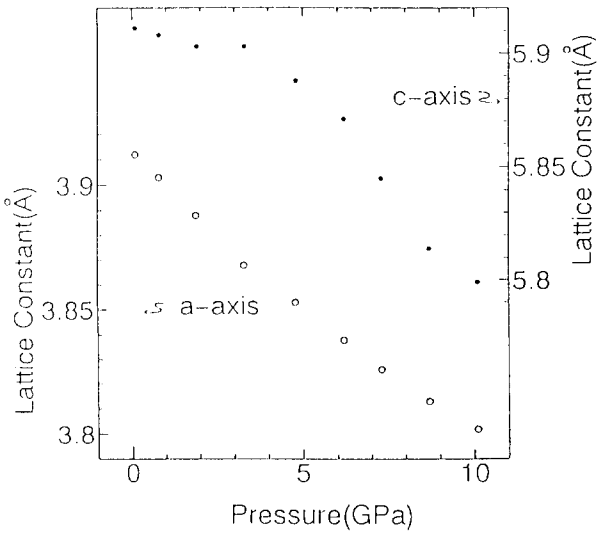

Fig.2 Pressure dependences of the lattice constants a and c.

On the contrary, the pressure dependence of c-value is quite opposit. The initial slope is rather gentle, while it becomes steeper with increasing pressure above 5 GPa. This type of anomaly in the pressure dependence of c-value was also seen in MnGaGe [3], which has the same lattice structure and is also a ferromagnet. The physical origin of this anomaly is not

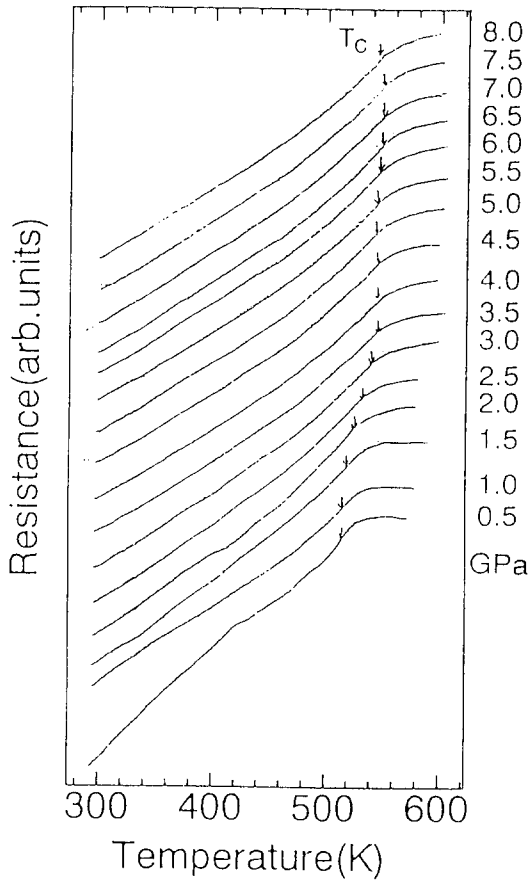

Fig.3 Observed pressure variation of electric resistivity vs temperature curve.

clear, as yet, but may be caused by the half-filled 3d-electron band of Mn atoms in a two-dimensional like structure.

It is also worth emphasizing that the pressure at which the pressure dependence of the Curie temperature tends to saturate coincides with that at which the absolute value of the slope of the pressure dependence of c-value tends to increase.

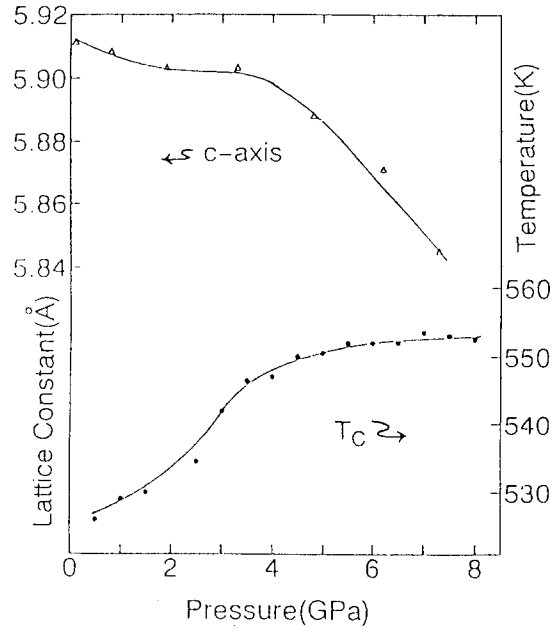

Fig.4 Pressure dependence of the Curie temperature in MnAlGe.

The ferromagnetic exchange between Mn layers is considered to be the super-exchange type, which increases largely with decreasing the layer-distance in the case of MnZnSb [4] and also in MnGaGe [3]. But, from the present experiment it can be considered that there exists an upper limit of about 550 K for the intensity of this type of exchange interaction.

IV. CONCLUSIONS

The pressure dependence of the Curie temperature observed in MnAlGe was positive with a considerably high rate of 9 K/GPa in the low pressure range below 2 GPa, while it decreased gradually down to one order of magnitude smaller at the maximum pressure of 7.5 GPa.

From this fact it was concluded that the super-exchange type ferromagnetic interaction between Mn layers has an upper limit of about 550 K.

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