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PRESSURE-INDUCED MAGNETIC TRANSITION IN Fe_2P

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The weak field ac susceptibiltiy and the resistivity of Fe_2P single crystals were measured as functions of temperature from 4.2–300 K and as functions of hydrostatic pressures up to 20 kbar, using a newly designed clamp-type pressure cell. The Curie temperature, and the first-order transition temperature, decreased rapidly with increasing pressure, and ferromagnetism vanished at about 13 kbar at 0 K. A second-order transition temperature, as well as the first-order transition, appeared in the region below 170 K and above 5 kbar (triple point) and a new pressure-induced magnetic phase was found. The phase is proposed to be antiferromagnetic for reasons discussed in the paper.

1. Introduction

A study of pressure-induced magnetic phase transitions seems to be valuable for a basic understanding of magnetic materials, since the variation of lattice parameter or volume induced by pressure may control the electronic structure with some advantages over the usual alloying effect, in which the various magnetic phases can be controlled by varying the composition.

In this respect iron phosphide Fe_2P, the magnetic and crystallographic characteristics of which have been extensively investigated [1–7], would be one of the most appropriate materials to be investigated for the following reasons. (i) The transition at the Curie temperature T_c is of first order. (ii) According to Goodenough et al. [5], referred to as [G] hereafter, T_c decreased rapidly with increasing pressure, and they have suggested a pressure-induced transition at 0 K from a ferromagnetic to metamagnetic state at about 13 kbar. (iii) A recent thorough investigation by Lundgren et al. [7], referred to as [L] hereafter, of non-stoichiometric $Fe_{2-x}P$ as well as of stoichiometric Fe_2P has shown that an increase in x, or an increase in the number of introduced vacancies caused a rapid decrease in T_c and suggested the appearance of metamagnetic phase. (iv) Fruchart et al. [3] have found in a system $(Fe_{1-x}Mn_x)_2P$ that a very small substitution of manganese for iron into Fe_2P may induce the metamagnetism. The present authors et al. [8] have recently found the existence of an antiferromagnetic region in the same system.

In view of the results given above, we have investigated the pressure–temperature magnetic phase diagram of Fe_2P by measurements of the weak field ac susceptibility and the resistivity, using single crystal specimens. The hydrostatic pressure was generated up to 20 kbar in a clamp type pressure cell and the measurements were made from 300 K down to 4.2 K. As a result, a new pressure-induced phase was found.

2. Experimental

Single crystal specimens were cut out from the single crystal ingot. The compound was prepared by solid–vapour reaction, and the single crystal was grown by thermal annealing. Details of the preparation have been described by Fujii et al. [6] referred to as [F] hereafter. The specimens were the c-axis rectangular rods of $1 \times 1 \times 2$ mm^3 for the measure-