JOURNAL OF THE PHYSICAL SOCIETY OF JAPAN, Vol. 44, No. 1, JANUARY, 1978

Magnetic Properties of Single Crystals of the System $(Fe_{1-x}Ni_x)_2P$

Hironobu FUJII, Tsuneo HŌKABE,† Hiroshi FUJIWARA†† and Tetsuhiko OKAMOTO

Faculty of Integrated Arts and Sciences, Hiroshima University, Hiroshima
†Faculty of General Education, Kagoshima University, Kagoshima
††Faculty of Sciences, Hiroshima University, Hiroshima

(Received May 19, 1977)

The magnetic properties of $(Fe_{1-x}Ni_x)_2P$ single crystal compounds were studied by the measurements of magnetization, susceptibility and electrical resistivity. It was found that the Curie temperature takes a maximum at about $x=0.1$, while the magnetic moment decreases monotonically with increasing x and the compounds with $x \geqq 0.8$ show the Pauli paramagnetism. The anisotropy constant K_1 was found to decrease rapidly with increasing x and becomes almost zero near $x=0.3$. The exchange interactions in Fe_2P are briefly discussed on the basis of the concentration dependence of T_c of this system.

§1. Introduction

As a series of the systematic research of M_2P compounds systems, we studied for the first time the magnetic properties of Fe_2P single crystal.[1] Subsequently, we have extended our study to the compounds of $(Fe_{1-x}Ni_x)_2P$ system for the purpose of elucidating the effect of substituting Ni for Fe in Fe_2P on the magnetic properties. The compounds of $(Fe_{1-x}Ni_x)_2P$ system has a hexagonal structure with the space group $P\bar{6}2m(D_{3h}^3)$ in the whole range of the composition. In this structure, there are two metal atom sites: the tetrahedral site M_I and the pyramidal site M_{II} surrounded by four P atoms and five P atoms, respectively. The Mössbauer experiment[2] of $(Fe_{1-x}Ni_x)_2P$ system has revealed that Ni atoms occupy M_I site preferentially in the range $0 \leqq x < 0.3$, but M_{II} site for $x > 0.7$.

Fruchart *et al.*[3] have measured magnetizations of the $(Fe_{1-x}Ni_x)_2P$ compounds on the polycrystals. They have shown that Ni_2P is a Pauli paramagnet of $\chi_g = 3.2 \times 10^{-6}$ emu/g, and the Curie temperature T_c takes a maximum of 342 K at $x=0.08$ and decreases below 100 K at $x=0.5$. But no saturation magnetizations have been measured by them. Until now, there has been no further study on the magnetic properties of this system.

This paper is concerned with the magnetic properties on the single crystals of the system $(Fe_{1-x}Ni_x)_2P$, which have been studied from the measurements of magnetization, susceptibility and electrical resistivity.

§2. Experimental

The compounds $(Fe_{1-x}Ni_x)_2P$ were made at an interval of $x=0.1$ by solid-vapor reaction. The stoichiometric mixtures of the elements, 99.99% in purity, were sealed in an evacuated quartz tube, then heated slowly up to 900°C in three days, kept at that temperature for two weeks and cooled in the furnace. The product was ground into powder, again sealed in a quartz tube in an argon atmosphere, melted at 1400~1450°C for about 30 minutes and rapidly cooled in water. The compound thus prepared was checked by X-ray diffraction and confirmed to have a single phase. The single crystals were grown by thermal annealing of the ingots just below the melting point. For the measurements of magnetization and susceptibility, a portion of the single crystal ingots was shaped into spheres of 2~3 mm in diameter by a two-pipe lapidary method. For the measurements of electrical resistivity, rectangular parallelpiped specimens of $1 \times 1 \times 7$ mm^3 having the c axis parallel to the longest dimension were prepared by cutting the ingots.

Magnetization was measured in the range from 4.2 K to 250 K within an error of 1% with a Foner type vibrating-sample magnetometer in applied fields up to 50 kOe. Paramagnetic susceptibility was measured in the range from 77 K to 800 K within an error of