Pressure-induced structural transition in a ferromagnet MnRhP

Tetsujiro ETO[1], Masayuki YAMAGISHI[1], Shinya SAWADA[1], Nobutoshi FUJII[1], Mamoru ISHIZUKA*[1, 2], and Shoichi ENDO[1, 2]
[1]Research Center for Materials Science at Extreme Conditions, Osaka University, Toyonaka, Osaka 560-8531, Japan
[2]CREST, JST, Kawaguchi, Saitama 332-0012, Japan

Introduction

Intermetallic compounds MM'X (M=Cr, Mn; M'=Ru, Rh, Pd; X=P, As) crystallise in a hexagonal Fe_2P-type structure (***Pb6m***). The compound MnRhP is a metallic ferromagnet with a Curie temperature T_C of about 400 K and T_C increases linearly with pressure at the rate of 15 K/GPa [1-3]. We have investigated the crystal structure of MnRhP under high pressure to understand the effect of pressure on the magnetic interaction of this compound.

Experimental

Powder sample was prepared by the ceramic method. Angular dispersive powder x-ray diffraction experiments were carried out at BL-18C under high pressures up to about 60 GPa using monochromatic x-ray (λ=0.06199 nm) and an imaging plate. High pressure was generated using a diamond-anvil cell (DAC) with the culet diameter of 0.4 mm. The measurements were made at room temperature. A 4:1 mixture of methanol and ethanol was introduced into the sample chamber as the pressure medium, and the sample pressure was determined by ruby fluorescence technique.

Results and discussion

Figure 1 shows x-ray diffraction patterns at several pressures, in which the diffraction peaks at 19.3 GPa are indexed as the hexagonal system. The intensities of several peaks begin to weaken at 34.1 GPa and new peaks indicated by asterisks appear instead, showing that a structural phase transition occurs in MnRhP at around 34 GPa.

It was found that the diffraction patterns of the high-pressure phase was well described in terms of an orthorhombic cell and its crystal axes almost satisfied the following relations with those of the low-pressure hexagonal cell: $\boldsymbol{a}_0=\boldsymbol{a}_h$, $\boldsymbol{b}_o=\sqrt{3}\boldsymbol{a}_h$ and $\boldsymbol{c}_o=\boldsymbol{c}_h$. The space group of the high-pressure phase could not be determined from this experiment. Orthorhombic TiNiSi-type structure (***Pnma***) or the tetragonal Cu_2Sb-type one (***P4/nmm***) may be a candidate of the high-pressure phase because of nearly the same value of a cohesive energies as that of the Fe_2P-type structure, but neither of them satisfied the observed diffraction patterns. In order to determine the lattice parameters and the atomic coordinates of the low-pressure Fe_2P-type phase, the diffraction patterns were analysed by Rietveld refinement using the program RIETAN-94. The first-nearest neighbouring Mn-Mn distance extrapolated to 34 GPa (the transition pressure) was 0.3 nm, which is nearly equal to the Mn-Mn distance at which the sign of the effective exchange interaction coefficient between Mn atoms turns from positive to negative according to the interaction curve obtained by Yamada ***et al***.[4].

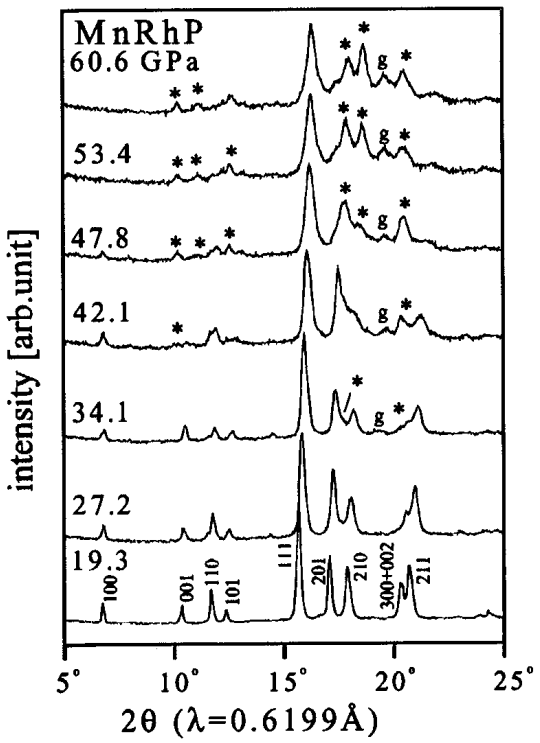

Fig. 1. x-ray diffraction patterns of MnRhP at various pressures up to 60.6 GPa at room temperature. g indicates peaks from gasket of DAC.

References

[1] T. Kanomata ***et al***., J. Appl. Phys. **69**(1991)4639.
[2] K. Sato ***et al***., J. Magn. Magn. Mater. **177-181**(1998)1381.
[3] N. Suzuki ***et al***., J. Alloys Comp. **281**(1998)77.
[4] T. Yamada ***et al***., J. Phys. Soc. Jpn., **28** (1970) 615.

*ishizuka@rcem.osaka-u.ac.jp