Uniaxial pressure induced first-order phase transition in Pt_3Fe alloy

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The ordered Pt_3Fe alloy has an $L1_2(Cu_3Au)$-type structure, in which the corner sites are occupied by Fe and the face center sites by Pt, respectively. Since Pt atoms carry no magnetic moments, Pt_3Fe alloy is considered to be a simple cubic antiferromagnet. Below the Néel temperature ($T_N \sim 180$ K), Pt_3Fe alloy undergoes an AF-AF phase transition at T_S ($T_S \sim 80$ K). At the high temperature phase, magnetic structure is a (1/2 1/2 0)-type, but at the low temperature phase, the (1/2 0 0) Bragg peak coexists with decreasing of the (1/2 1/2 0) Bragg peak intensity.

Among simple cubic antiferromagnetic structure, both (1/2 1/2 0)-type and (1/2 0 0)-type structure have ferromagnetic and antiferromagnetic nearest neighbor spin couplings, suggesting existence of spin frustration. Then, we can expect strong effect for the magnetism of Pt_3Fe alloy by an external perturbation field. To study the spin correlations in simple cubic antiferromagnet, we carried out the neutron scattering experiments on a single crystal specimen of Pt_3Fe alloy under uniaxial pressure. The uniaxial pressure was applied along the [0 0 1] axis using a hard coil spring, which destroys the cubic symmetry of the lattice. The measurements were performed at the T1-1 triple axis spectrometer, JRR-3M.

We first measured the temperature dependence of the (1/2 1/2 0) Bragg peak intensity and obtained the results that the Néel temperature increases with increasing uniaxial pressure, indicating that the (1/2 1/2 0)-type magnetic structure is stabilized by uniaxial pressure. Further, we observed that the phase transition at T_N under the high uniaxial pressure looks like of the first-order. In order to conform the first-order phase transition at T_N, the temperature dependence of the (2 0 0) Bragg peak intensity was carefully studied at the slightly off point (1.994 0 0). Results are given in Fig. 1 together with the data for free state. The data clearly shows the lattice expansion at T_N with decreasing temperature under the uniaxial pressure, indicating that the magnetic ordering accompanies with the lattice deformation, thus, the first-order phase transition. The lattice expansion at T_N is estimated to be 1.3×10^{-4} using the linear thermal expansion coefficient of Pt (8.9×10^{-6} at RT)

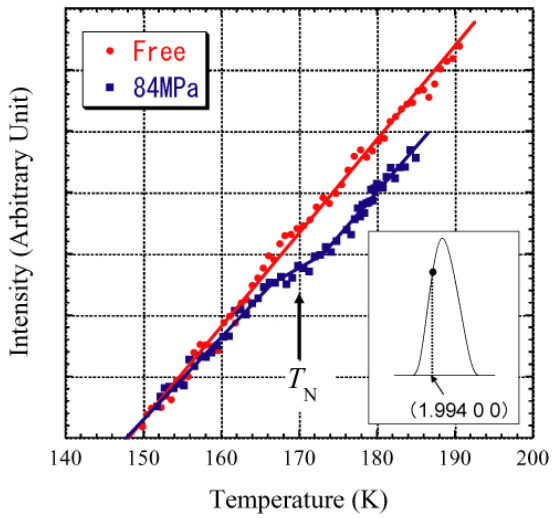

Fig. 1. Temperature dependence of the intensities studied at (1.994 0 0) Bragg peak position