Magnetic structural analysis of Pt_3Fe antiferromagnet by single crystal neutron diffraction under uniaxial pressure

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Pt_3Fe exhibits antiferromagnetic ordering below T_{N1}~170 K with a propagation wave vector $\mathbf{q_1}$=(1/2, 1/2, 0). When the chemical compostion slightly deviates from the stoichiometric Pt_3Fe towards Fe rich side, additional magnetic phase transition occurs at T_{N2}~110 K and two types of magnetic ordering with $\mathbf{q_1}$ = (1/2, 1/2, 0) and $\mathbf{q_2}$ = (1/2, 0, 0) coexist [1]. So far, both magnetic domain model and noncollinear magnetic structural model were proposed [2]; however, the magnetic structure is still controversial. Our previous study revealed that in addition to magnetic structure at T=120 K, the domain model explains the observed intensities at T=10 K below T_{N1}, when different volume fraction of (0 1/2 1/2), (1/2 0 1/2), (1/2 1/2 0), (1/2 0 0), (0 1/2 0), (1/2 0 0) magnetic domains was assumed. Further, noncollinear magnetic structural model might be possible to explain the observed intensities if each domain should have different spin tilt angle.

In this study, we investigated a detailed magnetic structure for non-stoichiometric Pt_3Fe by a single crystal neutron diffraction under uniaxial pressure where the volume fraction of magnetic domain was controlled.

We used the Pt_3Fe (Fe:25.6 at.%) single crystal with dimensions of 2.2×2.4×2.6mm^3. A clamp pressure cell where an uniaxial pressure of 120 MPa was applied along the [001] axis at R.T. was installed in a 3K refrigerator. Neutron diffraction measurements were performed using four-circle off centered diffractometer (FONDER). We measured approximately 35 and 45 magnetic Bragg reflections for (1/2 1/2 0)-type and (1/2 0 0)-type magnetic structures, respectively, at T=10 K and 120 K.

Figure 1 shows the temperature dependence of the neutron intensities for (1/2 1/2 0)-type and (1/2 0 0)-type magnetic ordering. At low temperatures below T_{N2}, the (1/2, 1/2, 0) magnetic reflection disappears whereas both (1/2, 0, 1/2) and (0, 1/2, 1/2) reflections remain. Moreover, the (0, 0, 1/2) magnetic intensity significantly increases as compared with both (1/2, 0, 0) and (0, 1/2, 0) ones. At temperatures above T_N, magnetic reflections with $\mathbf{q_2}$ = (1/2, 0, 0) completely disappear. At the same time, the (1/2, 1/2, 0) magnetic reflection recovers and develops. Interestingly, the (1/2, 1/2, 0) intensity is larger than both (1/2, 0, 1/2) and (0, 1/2, 1/2) intensities.

Despite such unequality of neutron intensities, the integrated intensities at T = 10 and 120 K can be well explained by magnetic domain model. However, the dominance of magnetic domains is related to alignment of magnetic moments with respect to uniaxial pressure; below T_{N2} magnetic domains with $\mathbf{q_1}$ = (1/2, 1/2, 0) and $\mathbf{q_2}$ = (1/2, 0, 0), with magnetic moments along the uniaxial pressure tend to vanish and survive, respectively. These results suggest that the uniaxial pressure modifies the balance of competing interactions in Pt_3Fe, leading to a complicated domain formation in Pt_3Fe.

[1] G.E. Bacon et al., Proc. R. Soc. A 272, 387, 1963.

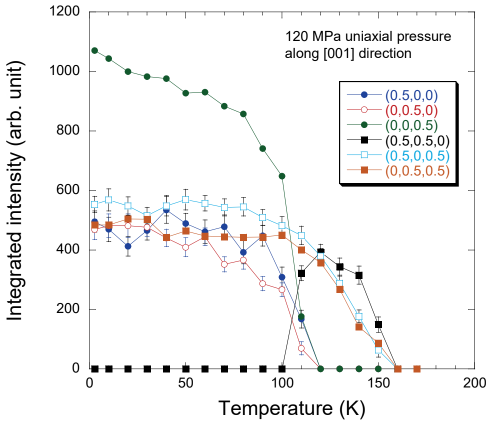

Fig. 1. Temperature dependence of magnetic neutron intensities under uniaxial pressure along the [001] direction