Mechanism of ferromagnetism in plastically deformed Pt_3Fe antiferromagnet

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Pt_3Fe ordered alloy has the $L1_2$-type superlattice structure and exhibits magnetic phase transitions at $T_N = 170$ K [1]. Below T_N the alloy shows the antiferromagnetic (AFM) ordering, characterized by propagation vector **q** =(0.5 0.5 0). However, light plastic strain makes the alloy strongly ferromagnetic (FM) even at room temperature [2]. Superlattice dislocations with Burgers vector of (**a**/2)<110> and glide plane of {111} are induced and the nearest neighbor Fe pairs are produced at the antiphase boundary (APB), which separates AFM matrix. The strain-induced ferromagnetism was explained by the formation of FM domains around APB through the ferromagnetically coupled Fe pairs. However, the morphology which may lead to a rich variety of magnetic features such exchange bias [3], magnetocaloric effects was not understood. In this study, we performed neutron diffraction experiments to elucidate an interplay between FM domains and AFM matrix in a platically strained Pt_3Fe single crystal.

Neutron diffraction experiments were carried out in zero field, using four-circle neutron diffractometer (FONDER). A Pt_3Fe single crystal without plastic strain or with plastic strain up to 11.6% was mounted in a closed-cycle He-gas refrigerator, to achieve a low temprature down to 10 K.

First, we checked magnetic reflections for Pt_3Fe single crystal without plastic strain to compare with earlier works [1,4]. We found that **q**=(0.5 0.5 0)-type reflections develop below $T = 180$ K, whereas **q**=(0.5 0 0)-type reflections, which were observed below $T \sim 100$ K [4], were not detected in our sample. Considering our magnetization data, our crystal is a stoichiometric Pt_3Fe [1]. Figure 1 shows temperature dependence of integrated intensities at (0.5 0.5 0), (0.5 0 0.5), and (0 0.5 0.5) for 11.6% strained crystal. As the temperature decreases from 300 K, magnetic reflections at the three Bragg points start to develop at $T \sim 180$ K and their intensities steady increase. This indicates that the AF ordering for three equivalent domains, characterized by **q** = (0.5 0.5 0), (0.5 0 0.5), and (0 0.5 0.5), is not affected effectively by the 11.6% plastic strain. However, even at the lowest-temperature of 10 K, the intensity did not saturate, suggesting magnetic fluctuations near the boundaries between the AFM matrix and ferromagnetic regions. Within an experimental accuracy, magnetic reflections, which originate from FM domains, were not detected, possibly due to random spin orientation (or spin freezing) in the FM domain under zero applied field.

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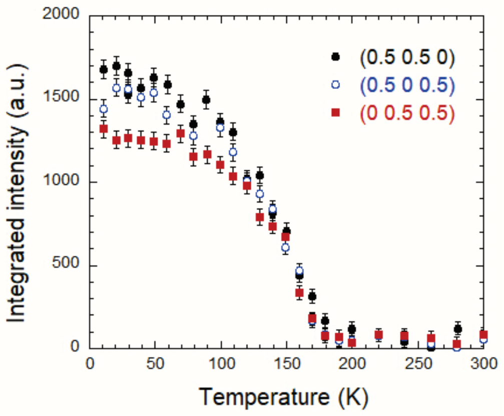

Fig. 1. Integrated intensities as a function of temperature at magnetic Bragg points, (0.5 0.5 0), (0.5 0 0.5), and (0 0.5 0.5) for 11.6% plastically strained Pt_3Fe single crystal.