Magnetic ordering of a plastically strained Pt_3Fe antiferromagnet

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Pt_3Fe ordered alloy has the $L1_2$-type superlattice structure and exhibits antiferromagnetic (AFM) ordering below T_N = 170 K, characterized by propagation vector **q** =(1/2 1/2 0). However, slight plastic strain makes the alloy strongly ferromagnetic (FM) even at room temperature [1,2]. 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. Such FM domains lead to a variety of magnetic features such as exchange bias effect below 50 K, a magnetic entropy change that increases with plastic strain. Strain-deformed Pt_3Fe single crystal can therefore be a unique type of FM/AFM heterogeneous materials, where both exchange bias and magnetocaloric effects are induced by strain in chemically ordered crystal.

Here, to investigate the magnetic nature of FM domains, neutron diffraction measurements were performed at zero field using FONDER and under magnetic fields up to 50 kOe using PONTA in an unpolarized mode, for Pt_3Fe single crystals with 11.6% or 22% plastic strain.

Even for 22% plastic strain, (1/2 1/2 0)-type magnetic Bragg reflections appear below 170 K, although the magnetic Bragg peaks were strongly broadened. This suggests that the AFM matrix is separated by glide planes, with keeping the AFM ordering. At the same time, we found that magnetic reflections newly appear at the (*h k l*) reciprocal lattice points with *h,k,l*=integer for both 11.6% and 22% strain samples. Figure 1 shows the (1 k 0) transverse scan along the *b** direction for 22% strain sample, measured at PONTA. Here, the neutron intensity at zero field and *T*=200 K, which arises from λ/2 contamination, is subtracted. At *H*=50 kOe and *T*=1.6 K, we observed a broad magnetic reflection at around (1 0 0) Bragg point. As the magnetic field is reduced from 50 kOe to 0 kOe, the (1 0 0) neutron intensity largely decreases, but after the subsequent temperature increase to 105 K, the intensity is only slightly reduced. On the other hand, the peak width was almost the same at all the measuring fields and temperature. Considering dc magnetization data obtained with SQUID magnetometer, this implies that magnetization of each FM domain, which aligns along the magnetic field at *H*=50 kOe and *T*=1.6 K, becomes randomly oriented at zero field and high temperature, with keeping magnetic correlations within FM domains.

[1] G.E. Bacon et al., Proc. R. Soc. A 272, 387, 1963.
[2] S. Takahashi et al., J. Phys. Condens. Matter 2, 2133, 1990.

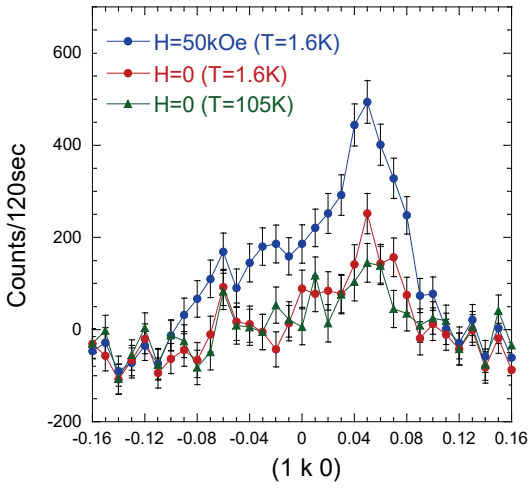

Fig. 1. (1 k 0) transverse scan along the *b** direction for 22% strain sample, taken at different magnetic field and temperature. The data at zero field and *T*=200 K is subtracted.