Magnetic correlations of ferromagnetic domains in plastically strained Pt_3Fe antiferromagnet

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Pt_3Fe ordered alloy with the $L1_2$-type superlattice structure exhibits antiferromagnetic (AFM) ordering below T_N = 170 K with propagation vector **q** =(1/2 1/2 0) [1]. When a plastic strain is applied, this alloy becomes ferromagnetic (FM) even at room temperature due to the formation of antiphase boundaries (APBs) on {111} glide planes [2]. The strain-induced ferromagnetism was explained by the formation of FM domains around APB and can be responsible for various magnetic features such as exchange bias effect which appears below 50 K [3]. Previous low-temperature neutron diffraction measurements up to T =200 K revealed the appearance of (1,0,0) magnetic reflections which may be attributed to FM domains. However, their higher-temperature behavior at and above 200 K was not clearly elucidated partly due to λ/2 contamination. In this study, we performed neutron diffraction measurements up to 400 K using TOPAN (6G) for Pt_3Fe single crystals with 22% plastic strain.

Figure 1 shows the temperature dependence of (1,K,0) transverse scan along the b* direction. At the lowest temperature of 22 K, there are broad and sharp peaks, located at K ~ 0 and 0.07, respectively. As the temperature increases, both intensities gradually decrease and that of (1,0,0) almost vanishes at T ~ 200 K, whereas that of (1,0.07,0) persists even at T = 400 K. A broad peak was also observed in the (H,1,0) transverse reciprocal scan, though a sharp peak was absent in all the temperature range. The temperature dependence of the integrated intensities of broad (1,0,0) and (0,1,0) peaks is summarized in Fig. 2.

Both the neutron intensities monotonically decrease and vanish at around T ~ 200 K. This temperature is close to AFM ordering temperature of T_N = 170 K in the $L1_2$-matrix. This suggests that the AFM ordering triggers the development of FM domains around {111} glide planes though the exchange coupling between AFM matrix and FM domains, which leads to the appearance of exchange bias effects below T ~ 50 K.

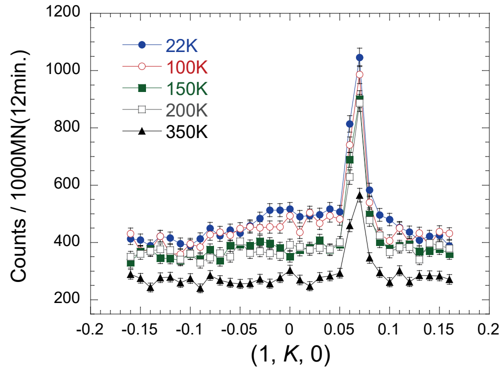

Fig. 1: Temperature dependence of (1, K, 0) reciprocal scan

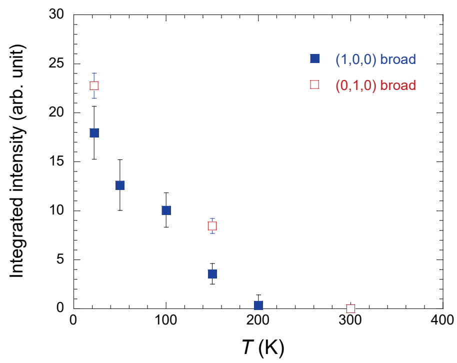

Fig. 2: Temperature dependence of neutron intensities of broad (1,0,0) and (0,1,0) peaks.

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