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Electron Holography Studies on Interface Magnetism in Fe-Al Ordered Alloy

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Understanding of magnetism in interface regions is important for both materials science and engineering. Magnetic anomaly in an antiphase boundary (APB), which is a planar defect produced in ordered alloys, is one such significant problem related to the interface magnetism. Atomic disordering in an APB has been believed to deteriorate the ferromagnetic spin order [1-5]. This relationship is responsible for several useful material functions, such as pinning of magnetic domain walls and/or magnetoresistance. However, the magnetic degradation in APBs is harmful to spintronic applications because of the impedance for the spin polarized currents. Thus, a big challenge in materials science is to achieve a distinct type of APBs, in which the ferromagnetic spin order is not appreciably depressed, otherwise it can be improved in the APB region. This study, by using electron holography, has demonstrated that the magnetization can be amplified in APBs produced in a B2-type ordered alloy $Fe_{70}Al_{30}$ [6].

Figure 1 provides magnetic flux density maps in an $Fe_{70}Al_{30}$ alloy, observed as a function of temperature. Both the direction and magnitude of the in-plane magnetic flux component are presented with reference to the color wheel in (e). For convenience, the locations of the APBs are indicated in a transmission electron microscope image in (a). The specimen is magnetized approximately in one direction at 293 K. Both the APB and the matrix regions show significant magnetization at this temperature. When the specimen is heated to 573 K, the magnetization in the matrix region is considerably weakened, while the magnetization in APBs remains pronounced. Further heating to 703 K makes the whole area of the specimen paramagnetic, as demonstrated in Fig. 1(e). The observations reveal that the ferromagnetic phase can be stabilized in the APB region in an $Fe_{70}Al_{30}$ alloy. The results are unusual compared with those reported for other alloys [1-5] in which APBs deteriorate ferromagnetic spin order.

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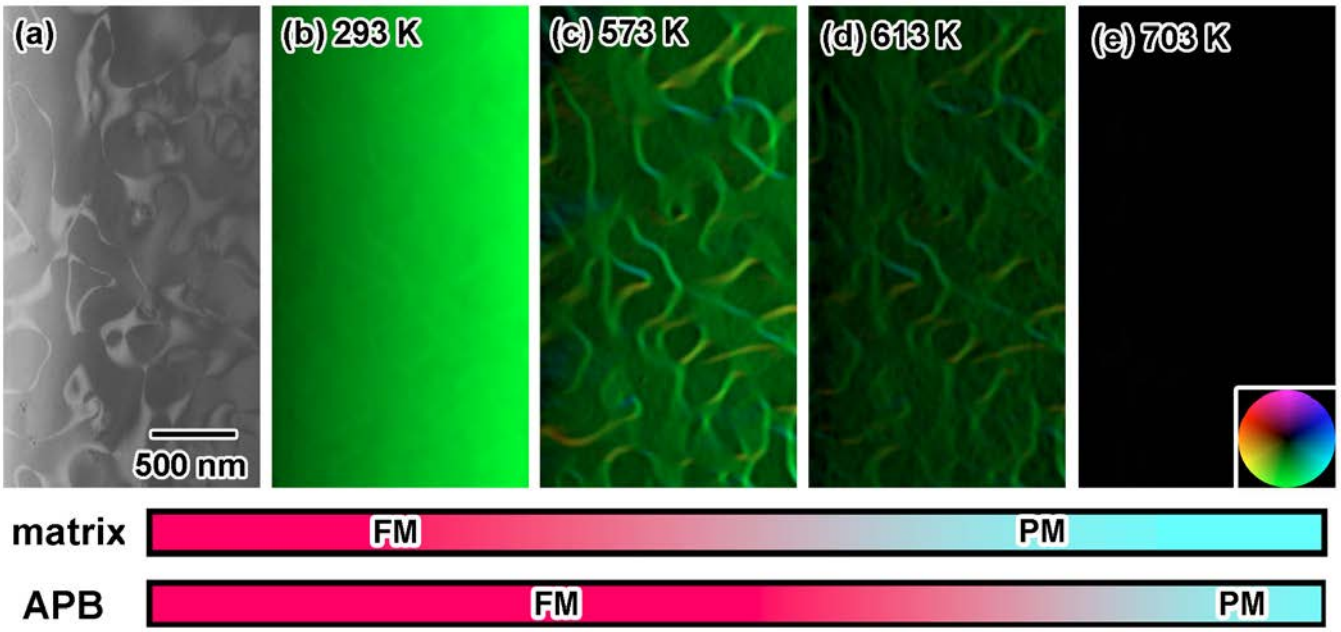

FIG. 1. Magnetic anomaly in APBs observed in $Fe_{70}Al_{30}$. (a) TEM image showing the locations of APBs. (b)-(e) Mapping of the phase gradient, representing the in-plane magnetic flux density. Refer to the color wheel for the direction and magnitude of the magnetic flux. FM and PM represent ferromagnetic and paramagnetic, respectively. Reprinted from Ref. 1.