Magnetic microstructure in stress-annealed FeSiNbBCu soft magnetic alloys studied using Lorentz microscopy and electron holography

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Introduction
The unique physical and magnetic properties of FeSiNbCuB alloys, such as their low coercivity and high saturation magnetization combined with near-zero magnetostriction, make them attractive for high-frequency applications. Furthermore, their magnetic properties can be tailored by applying a magnetic field or stress during annealing, resulting in uniaxial anisotropy. Here, we study the magnetic domain wall structures in stress-annealed Fe73.5Si15.5B7Nb3Cu1 alloy using both the Fresnel mode of Lorentz microscopy and off-axis electron holography in the transmission electron microscope.

Magnetometry
A 600 MPa stress was applied to selected samples during a rapid 4 s annealing, resulting in strong uniaxial anisotropy perpendicular to the stress direction, as confirmed by SQUID measurements performed both at room temperature and at 10 K. The coercivity values of the material were measured to be 17 and 14 Oe at room temperature for a magnetic field applied parallel to the in-plane and out-of-plane directions, respectively.

Domain structure
Fresnel defocus images recorded from Fe73.5Si15.5B7Nb3Cu1 samples that had been (a) annealed at 695 °C for 10 s in the absence of an applied stress and (b) annealed at 690 °C for 10 s in the presence of a stress of 600 MPa.

Domain wall thickness
DW thicknesses were determined using a focal series of Fresnel images and phase shift maps recorded by off-axis electron holography.

APT studies revealed 80 vol.% of crystalline Fe3Si phase with a DO3 structure and 20 vol.% of an amorphous matrix that was enriched in B and Nb. The Fe3Si grain size was measured to be 10 nm while Cu clusters were observed to form with sizes of ~6 nm. The structure of the sample is polycrystalline with randomly oriented grains.

Summary
- Strong uniaxial magnetic anisotropy was induced in rapid annealed Fe73.5Si15.5B7Nb3Cu1 alloy; the coercivity is <20 Oe in the annealed alloy;
- A regular magnetic domain pattern was observed;
- DW widths are ~50 and ~95 nm for 180° and 90° walls;

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