

3D analysis of pinning centers in superconductive $\text{GdBa}_2\text{Cu}_3\text{O}_{7.8}$

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There is a large anisotropy in J_C characteristics for magnetic field direction in high-temperature superconductor (HTS) type superconductors, due to its anisotropic crystal structures, short coherence length and transport properties. This intrinsic limitation could be overcome by incorporation of artificial pinning centers (APC) into HTSs, which reduces the current dissipation in applied magnetic fields via pinning of magnetic flux lines.

We applied STEM-LAADF tomography to identify both 3D distribution and morphology, and the angular distributions of 1D-APCs in $\text{GdBa}_2\text{Cu}_3\text{O}_{7.8}$. A GdBCO layer was deposited on Hastelloy with bi-axially textured $\text{CeO}_2/\text{Gd}_2\text{Zr}_2\text{O}_7$ buffer layers by pulsed layer deposition using a KrF excimer laser. During the formation of the GdBCO layer, a 5.0 vol% yttria-stabilized-zirconia (YSZ)–GdBCO mixed target was used as a target material, wherein the reaction between YSZ and GdBCO took place to form BaZrO_3 . Focused ion beam method was applied to prepare pillar- and thin-foil TEM specimens.

A typical distribution of 1D-APCs within a GdBCO grain is seen in Fig. 1. The number density was found $\sim 2.5 \times 10^{16} \text{ cm}^{-3}$ and the ratio of the 1D-APCs was ~ 4.7 mol%, almost consistent with the starting target material. The average size of 1D-APCs were found as ~ 60 nm in length and ~ 5 nm in diameter. In addition, angular distributions of individual 1D-columnar precipitates from the growth direction of matrix, c -axis, were examined from the 3D reconstructed volume of the thin foil specimen. Figure 2 shows that they are declined a few degrees to almost 60° from c -axis, peaked at 20° , which influenced the J_C characteristics for magnetic field direction.

Acknowledgement

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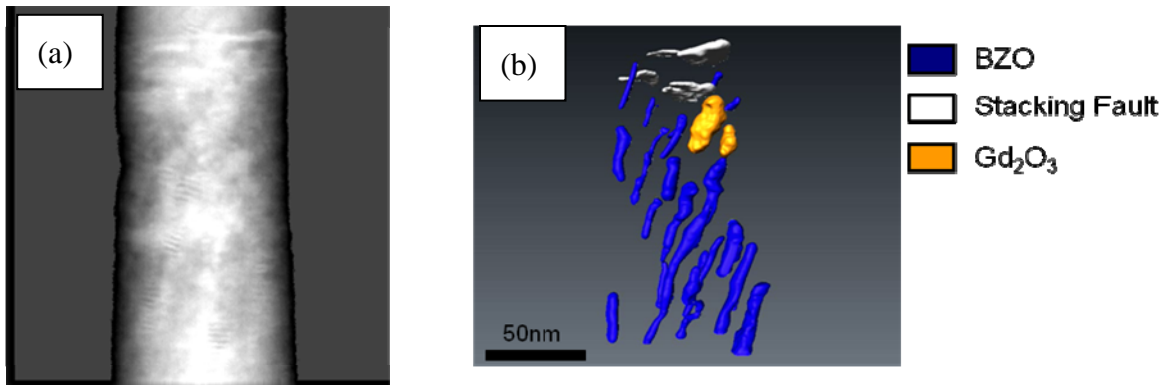


FIG. 1(a) A low-magnified cross-sectional TEM image of GdBCO and (b) 3D reconstruction from the similar field of view.

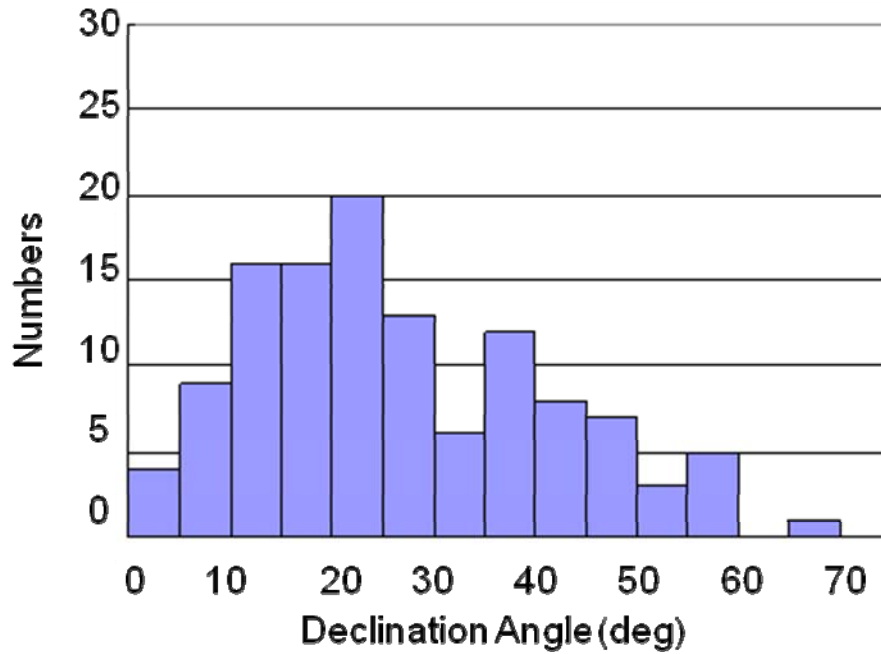


FIG. 2. The angular distribution of 1D-APCs from the growth direction of the matrix (*c*-axis) and the declination angle, θ .