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Towards isotropic vortex pinning in YBCO films with BHO-Y2O3 and BZO-Y2O3 artificial pining centers

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Strong and isotropic vortex pinning landscape is demanded for high field applications of high temperature superconductor (HTS) thin film. Double-doping (DD) of different kinds of artificial pinning centers (APCs) has been identified as a promising approach to generate such a pinning landscape. This work presents a systematic study on the critical current density $Jc(H, \theta)$ of 3%Y2O3+2-6 vol.% BZO (BZO DD) and 3%Y2O3+2-6 vol.% BHO (BHO DD) films deposited at their optimal growth conditions. The goal is to elucidate the effect of the secondary APC Y2O3 nanoparticles on the alignment of the BZO and BHO nanorods of comparably diameters and the consequent Jc (H, θ) behavior. Intriguingly, a much enhanced isotropic pinning was observed in BHO DD samples. For example, at 65 K and 9T, the variation of the Jc across the entire θ range from $\theta=0$ (H//c) to $\theta=90$ degree (H//ab) is less than 18 % for BHO DD film, in contrast to about 100% for the BZO DD counterpart. Since the two samples have comparable Jc values at H//c and the larger Jc variation in the latter is primarily caused by the reduced Jc in the larger $\theta>40$ deg especially at $\theta=90$ deg (H//ab), the improved isotropic pinning in the BHO DD samples illustrates the higher tunability of the APC microstructure using secondary APCs.

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