Tuning of pinning strength and its anisotropy by using segmented $BaSnO_3$ nanorods in $YBa_2Cu_3O_{7-x}$ films

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Multilayered films comprised of BZO or BSO containing YBCO layers and pure YBCO layers have been studied to tune the spatial distribution, density, and pinning anisotropy of nanorods by using PLD. This technique allows us to produce "segmented" BSO nanorods keeping the designed matching field, since the nanorods nucleate and grow just above the upper portion of nanorods underneath the pure YBCO spacing layer. The pinning anisotropy and the spacing are easily varied by changing the pulse number of PLD. In present work, the segmented BSO nanorods were introduced to YBCO thin films for anisotropy tuning of columnar pins. We found that Birr was systematically changed by selection of average nanorod length l_p and its spacing l_s, and that these variations were explained by the "harmonic oscillator" approach based on the Bose glass state. J_c -B characteristics and field angular dependent J_c also were varied by l_p and l_s, The experimental and theoretical results indicate that segmented nanorods behave as single columnar pin for B || c, in contrast, as nanoparticle pins for B || ab. The tuning of pinning properties can provide us the further opportunities to attain isotropic and high J_c -B performances as well as high B_{irr} in YBCO films.