Development of Strong and Isotropic $BaZrO_3$ Artificial Pinning Centers in YBCO Films

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Abstract – **Artificial pinning centers (APCs) with controlled morphology, dimension, and concentration are key to optimal pinning in superconducting thin films and coated conductors. Strain-mediated self-assembly of APCs is regarded as a viable approach to form APCs in $YBa_2Cu_3O_{7-x}$ (YBCO) during growth. This makes understanding the growth mechanism essential to controllable formation of desired APCs that provide strong and isotropic pinning. In this work, an integrated study of theoretical modeling and experimental exploiting is presented focusing on the goal to controllably generate 3D pinning landscape by employing several approaches: 1) $BaZrO_3$ and $BaSnO_3$ single doping with variable concentrations by manipulating local and global strains; 2) $BaZrO_3$ and Y_2O_3 double doping to impede $BaZrO_3$ nanorods formation using Y_2O_3 and to promote 3D $BaZrO_3$ APCs at high $BaZrO_3$; and 3) low temperature growth of $BaZrO_3$ doped YBCO film to impede $BaZrO_3$ nanorods, followed with fast thermal annealing at higher temperature to promote 3D $BaZrO_3$ APCs, The resulted 3D pinning landscape affects directly the scaling behavior of pinning J_c (T, H,θ). In particular, by fitting the Dew-Hughes equation of the pinning force F_p (H) at different temperatures of T=30-77K and angles of the applied magnetic field H from parallel (θ=0), to θ=45 deg. and to perpendicular to (θ=90 deg.) the c-axis, we extract the scaling behaviors of the F_p (H) to provide insights on the pinning efficiencies of the of APCs interactively as their concentrations are varied to cause strain field overlap.**

***Keywords, Index Terms*—YBCO films, artificial pinning centers, strain-mediated self-assembly, critical currents, pinning force, scaling**

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