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Systematic incorporation of hybrid APCs into YBCO thin films for enhancing the critical current properties

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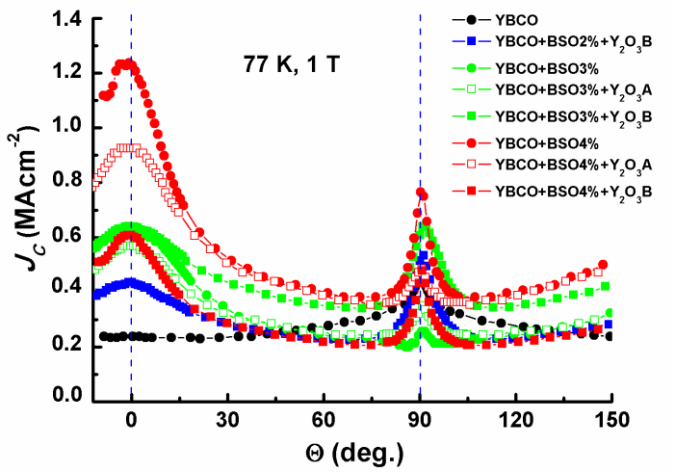
In this paper, we discuss the effect of hybrid (columnar and spherical) artificial pinning centers (APCs) on the vortex pinning properties of YBCO thin films. The structural, microstructural and transport properties of YBCO thin films with varying concentration of $BaSnO_3$ (BSO) and Y_2O_3 nanoscale inclusions will be presented. The effect of systematic incorporation of hybrid APCs on the critical current properties of YBCO thin films on single crystal substrates will be discussed in detail. Mixed targets of YBCO+BSO with Y_2O_3 sectored piece on the top have been used for the deposition of YBCO based nanocomposite thin films. At 77 K and an applied magnetic field of 1 T, J_C of pure YBCO film has been obtained as 0.25 MA which increases up to 1.24 MA for the nanocomposite film whereas, the pinning force density ($F_{pmax.}$) value increases from 2.54 GN/m^3 for pure YBCO film to ~ 18.5 GN/m^3 for the nanocomposite film. Apart from the increased J_C and F_p values, the nanocomposite films also exhibit reduced anisotropy in J_C-B-Θ measurement. In the figure below, systematic change in the J_C peak along the c-axis can be seen. The table presented here contains several superconducting parameters of pure YBCO film and YBCO+BSO+Y_2O_3 nanocomposite films. Controlling the proportion of hybrid APCs into YBCO thin film is expected to result in much better critical current density performance of YBCO thin films.



Variation of J_C with the orientation of applied magnetic field with respect to the c-axis for YBCO, YBCO+BSO and YBCO+BSO+Y_2O_3 nanaocomposite films measured at 77 K and 1 T.

Composition	$T_C(0)$ (K)	J_C 0 T, 77 K B ∥ c (MA cm^{-2})	J_C 1 T, 77 K B ∥ c (MA cm^{-2})	J_C 1 T, 77 K B ∥ a-b (MA cm^{-2})	Anisotropy ratio (J_{Ca-b}/ J_{Cc}) 77 K, 1 T	$F_{pmax.}$, 77 K B ∥ c (GN m^{-3})	$B_{max.}$ 77 K
YBCO	89.8	1.72	0.25	0.47	1.88	2.54	2
YBCO+BSO2%+ Y_2O_3B	85.5	2.02	0.43	0.53	1.23	9.0	4
YBCO+BSO3%	89.0	1.92	0.61	0.26	0.43	8.25	2
YBCO+BSO3%+ Y_2O_3A	88.7	2.26	0.57	0.35	0.61	8.27	2.6
YBCO+BSO3%+ Y_2O_3B	88.3	1.32	0.64	0.65	1.02	10.9	2.8
YBCO+BSO4%	88.1	4.11	1.24	0.76	0.61	18.5	2.2
YBCO+BSO4%+ Y_2O_3A	87.6	3.51	0.93	0.48	0.52	16	2.8
YBCO+BSO4%+ Y_2O_3B	86.8	2.69	0.61	0.48	0.79	10.3	2.8

The comparison of various superconducting parameters for YBCO, YBCO+BSO and YBCO+BSO+Y_2O_3 nanocomposite films with varying concentration of BSO and Y_2O_3