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Nanostructure and Pinning Performance of $YBa_2Cu_3O_x$ Thin Films Added With Artificial Pinning Centers of Different Dimensionality

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In order to be disclosed to the practical applications (lossless current transportation, winding of magnets and so on), superconducting materials should possess not only T_c, but also J_c (critical current density) and pinning force (F_p) as large as possible to have a wide application range. Introduction of nanosized Artificial Pinning Centers (APCs) was widely used to strongly enhance J_c and F_p of High Temperature Superconductors (HTSC) like $YBa_2Cu_3O_x$ (YBCO, T_c = 92 K) in magnetic field.

At first, we considered addition of $BaSnO_3$ (BSO) to YBCO films grown on $SrTiO_3$ substrates by Pulsed Laser Deposition (PLD). By ablation of mixed BSO-YBCO targets with increasing BSO content (2~9 wt%), we obtained high quality YBCO thin films incorporating BSO in form of nanorods, which are classified as one-dimensional APCs (1D-APCs). YBCO films added with 4 wt% BSO have J_c = 0.3 MA/cm^2 and F_p^{MAX} ~ 28 GN/m^3 (77K, 3T and B//c). However, J_c is intrinsically anisotropic with the direction of applied magnetic field (with a maximum for B//c axis) and this is a critical issue for practical applications, since the value of J_c might be constant in all directions of applied magnetic field.

To solve this issue, we tried the incorporation of Y_2O_3 nanoparticles (three-dimensional APCs, 3D-APCs) inside the YBCO film, using surface-modified YBCO targets. Areas of Y_2O_3 sectors on YBCO target were increased (2.51%, 5.44% and 9.22% of the YBCO pellet area). Randomly distributed Y_2O_3 particles, which density was proportional to the area of sector, were incorporated in YBCO films. Consistently with the microstructure, J_c was isotropic. The 5.44 A% Y_2O_3 added sample presented F_p^{MAX} =14.3 GN/m^3 (77K, 3T) which is significantly large, tough inferior to the value reported in YBCO-BSO films in same conditions.

Ultimate approach we tried was combination of advantages of 1D- and 3D-APCs pinning, incorporating BSO nanorods and Y_2O_3 nanoparticles at the same time. By wide screening of BSO and Y_2O_3 contents and optimization of the experimental conditions, it was possible to combine large in-field performance and isotropic behavior. Details will be discussed at the conference.

Overall, microstructure, distribution, concentration and dimensionality of APCs strongly influence the in-field performance of YBCO films and, indeed, represent a powerful tool to understand the pinning mechanisms.