IEEE-CSC, ESAS and CSSJ SUPERCONDUCTIVITY NEWS FORUM (global edition), Issue No. 56, March 2024

Comparative Analysis of Particle Irradiation and Second-phase Additions Effects on the Critical Current Densities of $YBa_2Cu_3O_7$ Single Crystals, Thin Films, and Coated Conductors

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***Abstract*–The study of irradiation effects in cuprate HTS has been a topic of interest since their discovery in the late 1980s. Enormous progress in the understanding of vortex physics and pinning mechanisms was made in the early 1990's through the irradiation of high temperature superconductor (HTS) single crystals with a variety of particles over a broad range of energies. In the case of $YBa_2Cu_3O_7$ (YBCO), the overall conclusion was that irradiation could increase the critical current density (Jc) by orders of magnitude [1-4]. The interpretation of the results was simplified by the fact that the pristine crystals were very clean, with few strong pinning centers and quite low Jc, thus essentially all the pinning in the irradiated crystals could be attributed to the controllably added disorder. The case of the YBCO epitaxial thin films and coated conductors (CC) is more complex, because the pristine samples already have high Jc due to the presence of large densities of strong pinning centers, which are fabrication-method and processing dependent. The most popular and efficient method to further increase Jc in CC has been the incorporation of artificial pinning centers (APC) by chemical incorporation of second phases. Efforts by many groups worldwide demonstrated that a diversity of APC can be effective [5-13], and it is now clear that mixed pinning landscapes, nanoengineered by the combination of defects of various shapes and sizes, produce the best results [7,17]. In some cases, particle irradiation is still effective at enhancing Jc in CCs, but by more modest factors than in the single crystals [14-18]. Interaction with preexisting defects cannot be ignored, resulting in both cooperating and competing effects [16,17]. In this talk, I will compare and contrast the vortex pinning generated in YBCO by defects of various geometries (aligned columnar, splayed columnar, randomly distributed nanoparticles, point defects) created either by particle irradiation, incorporation of second phases, or combinations of both routes.**

***Keywords (Index Terms)*–YBCO single crystals, thin films, coated conductors, critical currents, pinning enhancement, irradiation, second phase additions**

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IEEE-CSC, ESAS and CSSJ SUPERCONDUCTIVITY NEWS FORUM (global edition), Issue No. 55, January, 2024.
Invited presentation given at IREF 23, Nov. 2023, Arona, Italy