Enhancement in Pinning and Critical Current Density in RE-Ba-Cu-O Superconductor with the Nano-particle Addition

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The coherence length of RE-Ba-Cu-O (RE=rare earth) superconductor is in the range of nano-meter, therefore, nano-scale additions can be used to act as extrinsic pinning centers in melt-growth superconductors. A superconducting phase with lower T_c was observed in samples with nano particle additions by the direct current R-T transport analysis, which can be attributed to the origin of $\Delta\kappa$ (or $\mathbf{dT_C}$) pinning and related to the improvement of critical current density (J_c) at high field regions. In this study, different types nano-scale non-superconducting-particles, includes RE_2BaCuO_5 (RE211) and RE_2O_3 (RE: rare earth elements, includes Ce, Sm, Nd, and Gd) were added in the precursor powders. The J_c-H and H_{irr}-T (irreversibility vs. temp.) curves exhibit enhancement compared with that of control sample (no nano-particle additives). The scaling theory analysis of volume pinning force $F_p(H)$ of these different samples show two different types of pinning mechanisms. The Ce sample shown that the size of non-superconducting 211-particles reduced and the number of 211-particles increased significantly, which resulted in the increasing lattice defect near the 123/211 interface as normal (or $\mathbf{dl}$) pinning. In other samples (e.g. Nd, Sm, and Gd additions), nano-scale compositional fluctuations (with T_c varying in a nano-scale) resulted in the formation of ?κ (or $\mathbf{dT_C}$) pinning. The micro-analysis of the nano-scale compositional fluctuations found in the 123 matrix of different types of additives were investigated by TEM/EELS, which will be correlated with the processing parameters. The relationship between microstructure and flux pinning/motion at different temperatures and orientations by the addition of nano-scale additive will be reported.

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Reference:

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