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Fabrication and characterization of doped-YBCO large grains

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Fabrication and Characterization of Doped-YBCO Large Grains

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Abstract

In many engineering applications of the high-temperature oxide superconductor, its current-carrying capacity is one of the most important factors for consideration. Thus many concerted attempts have been made to enhance the critical current density by means of chemical doping, apart from processing techniques like electron, neutron and heavy ion irradiation. The work reported in this thesis aims at a better understanding of doping effects on high-temperature superconducting $YBa_2Cu_3O_{7-\delta}$ (YBCO or Y123), in the form of large grains, fabricated by top seeded melt-growth process. Batches of variously doped Y123 large grains were characterized by trapped field, levitation force, superconducting transition temperature (T_c), microstructure, and of course critical current density (J_c). Except the case of Ag doping, all fabricated samples were single domain.

Pt doping results in the refinement of 211 particles and therefore the enhancement in levitation force and trapped field. Being non-superconducting, Y_2BaCuO_5 (211) particles act as pinning centers. The optimum doping level is found to be 0.2 wt%.

In Ag-doped Y123, the melting and the solidification temperatures drop as the Ag content increases, but bottoms out at concentrations over 5 wt%. At a cooling rate of 0.6 $^{O}C/h$, with decreasing Ag, trapped field and levitation force are improved. At a high doping level (15 wt%), improvement can be attained by reducing the cooling rate during sample fabrication.

For Y-site doping by Pr, T_c is depressed in proportion to the doping level. Above certain level, therefore, trapped field and levitation force are enhanced due to local regions of suppressed superconduction.

No strengthening of δT_c- pinning was observed with Ba-site doping with Sr, even at very low doping concentrations. This may be due to the suppressed superconductivity being too small. Consistently, no noticeable enhancement in trapped field and levitation force were measured.

The last part of our work concerns doping with Co, Ga, Ni and Zn which have ionic sizes similar to, and are isoelectronic with Cu. The rate in T_c suppression with dopant concentration varies significantly among different dopants. Zn-doping shows the highest depression rate, followed by Ni, Ga and Co-doping. This we attribute to the fact that Zn and Ni substitute at Cu (2) sites on CuO_2 planes in the lattice, whereas Co and Ga occupy Cu (1) sites along CuO chains and they have different magnetic moments. Trapped field, levitation force and J_c are enhanced due to local suppressed superconducting regions, and the enhancement effects are the highest in the case of Zn doping.

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