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Defect formation and improved critical current density in YBCO superconducting films by electron beam irradiation

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The effects of electron beam (EB) irradiation on the defect formation and critical properties of YBCO thin films were investigated. The YBCO superconducting films were irradiated using an EB accelerator with an energy of 0.2 MeV and a dose of E15-E16 e/cm2. The value of the critical temperature (Tc) decreased and the superconducting transition broadened by the EB irradiation. In spite of the decrease in Tc, the critical current density (Jc) at 20 K, 50 K and 70 K increased at the EB doses of 7.5E15 e/cm2 and 2.2E16 e/cm2. Further irradiation decreased Jc. This indicated that there was an optimum level of EB dose for improving the Jc value of a YBCO film. The X-ray diffraction analysis showed that the c-axis lattice parameter was elongated and the full width at half maximum (FWHM) value increased as the EB dose increased, which is strong evidence of the atomic displacement by EB irradiation. The transmission electron microscopy analysis showed that the amorphous layer formed in the vicinity of the surfaces of the irradiated films. The amorphous phase was often present as an isolated form in the interior of the films. In addition to the formation of the amorphous phase, many striations running along the a-b direction of YBCO were observed. The high magnification image showed that the striations were stacking faults. The Jc enhancement by EB irradiation is likely to be due to the lattice distortion and the formation of defects such as vacancies and stacking faults, which act as a flux pinning center. The Jc decrease at a high EB dose is attributed to the extension of the amorphous region of a non-superconducting phase.
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