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High Rate *in-situ* $YBa_2Cu_3O_7$ Film Growth and Thickness Dependence of Critical Current Density

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High rate in- situ $YBa_2Cu_3O_{7-x}$ (YBCO) film growth was demonstrated by means of molecular beam epitaxy with electron beam co-evaporation. Even though our oxygen pressure is low, ~ 5 x 10^{-5} Torr, we can synthesize as-grown superconducting YBCO films at a deposition rate of around 10 nm/s, with critical current density (J_c) more than 2.0 MA/cm^2. Relatively high temperature, about 900 °C, was necessary in this process so far, and it suggests that this temperature at a given oxygen activity allows a Ba-Cu-O liquid formation along with an YBCO epitaxy. This liquid seems essential for high Jc-YBCO film growth at very high growth rate, related to so-called liquid phase epitaxy, and may be essential for all high rate processes. Thermodynamic consideration of the YBCO phase stability in the liquid Ba-Cu-O this process leads to a possibility of lower temperature growth down to 800 °C, and lower still by the addition of oxyfluorides to the liquid, suitable for coated conductor tape synthesis. We report depth profiling of the critical current density and resistivity of the YBCO films. The method is capable of providing important information on the uniformity of the films, and on the commonly observed property that the critical currents of coated conductor high temperature superconductor films do not scale linearly with thickness. Local critical current density shows a clear correlation with local resistivity. Homogeneous transport properties with a large critical current density (4 ~ 5 MA/cm^2 at 77K, 0T) are observed in top faulted region while it is found that the bottom part carries little supercurrent with a large local resistivity. Therefore, it is possible that thickness dependence of critical current density is a topological variation of good superconducting paths and/or grains in the thin-film bodies. The information derived may be useful in the characterization and optimization of superconducting thin films for electrical power and other applications.

keywords : *in-situ* growth, YBCO coated conductors, critical current density