Measurement of Thickness Dependency of Thermal Conductivity and Thermal Diffusivity of High-Tc Superconducting YBCO Thin Films by Photothermal Sensing Techniques

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Recently, a High-Tc superconducting YBCO superconductor has been developed, but the thermal behavior in YBCO thin films is not considered and thermal properties have not been measured yet. The purpose of our study is to measure thermal conductivity and thermal diffusivity of YBCO thin film under practical environments (low temperature and high magnetic field) using photothermal radiometry and the photothermal reflectance method. In these methods, a sample is heated by a modulated laser beam and the periodic temperature variation is generated. The temperature response on the sample surface is detected by the signal intensity change of infrared radiation or reflected light of probing laser beam. There is a phase-lag including the information of thermal properties between the signal and the modulated laser beam. In the present study, we have measured the thermal conductivity and the thermal diffusivity of YBCO thin films (1000, 500, 250 nm in thickness) under room temperature by photothermal radiometry. We have revealed thickness dependencies of thermal properties of YBCO thin films. By the surfaces visualization of those films using AFM, we have found there is a correlation between thermal properties and YBCO grain sizes. Furthermore, we have newly designed and constructed the measurement system using a cryostat which is able to generate low temperature (1.5 K) and high magnetic field (7 T) environment by the photothermal reflectance method. We verified that the phase-lag has adequate sensitivity to thermal conductivity and thermal diffusivity. By a preliminary measurement of a relation between phase-lag and frequency using this system under room temperature, we have indicated that the apparatus has applicability to a measurement under practical environments.