Measurement of In-plane Thermal Conductivity of High-$T_c$ Superconducting YBCO Thin Films by the Photothermal Reflectance Method (Wet Etch Process for Removing SrTiO$_3$ Substrate)

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High-$T_c$ superconducting thin films (YBa$_2$Cu$_3$O$_{7-\delta}$: YBCO) have been developed for practical use. In the application systems, it is necessary to understand the thermal behavior of the YBCO thin films. Recently, we have measured the out-of-plane (c-axis) thermal conductivity of epitaxially grown YBCO thin films (250 nm, 500 nm, and 1000 nm) in the temperature range from 10 K to 300 K [1]. However, the in-plane thermal conductivity of superconducting thin films has never been measured under low temperatures. The cuprate superconductors have a large anisotropy of the thermal conductivity. Therefore, the purpose of our study is to measure in-plane thermal conductivity of high-$T_c$ superconducting YBCO thin films. For measurement of in-plane thermal conductivity, we prepared YBCO thin films which were deposited on the SrTiO$_3$ substrate with a 10 nm CeO$_2$ buffer layer. Thermal conductivity of SrTiO$_3$ is the lowest among available substrate materials for YBCO thin films. However, thickness and thermal conductivity of SrTiO$_3$ are much greater than those of YBCO. It is necessary to reduce the thickness of SrTiO$_3$ for measurement. Our simulation probed that thickness of SrTiO$_3$ should be thinner than that of YBCO. This means we should remove SrTiO$_3$ to a thickness of less than 1 \textmu m from 100 \textmu m. For removal of SrTiO$_3$, we used a wet etching process. Hydrofluoric acid (HF) solutions are highly selective for etching SrTiO$_3$ over YBCO, and were used as wet etching solutions. We applied the photothermal reflectance method for the measurement, which is suitable for film-on-substrate samples.

References: