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 (YBa2Cu3O7-δ: 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 μm from 100 μm. 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:

[1] Yusuke Murakami, Haruna Goto, Yoshihiro Taguchi, and Yuji Nagasaka,*International Journal of Thermophysics*, Vol.38, No.10, Article.160, (2017).