

## Surface Impedance and Complex Conductivity of MgB<sub>2</sub> Films

Sang Young Lee<sup>a,\*</sup>, J. H. Lee<sup>a</sup>, Y. B. Ko<sup>a</sup>, S. H. Moon<sup>b</sup>, M. H. Kim<sup>b</sup>, K. B. Kim<sup>b</sup>, H. N. Lee<sup>c</sup>,  
B. Oh<sup>c</sup>, K. Leong<sup>d</sup>, James C. Booth<sup>d</sup>, and J. H. Claassen<sup>e</sup>

<sup>a</sup> Department of Physics, Konkuk University, Seoul 143-701, Korea

<sup>b</sup> School of Materials Science, Seoul National University, Seoul, Korea

<sup>c</sup> LG Electronic Institute of Technology, Seoul, Korea

<sup>d</sup> National Institute of Standards and Technology, Boulder, CO, U.S.A.

<sup>e</sup> Naval Research Laboratory, Washington, DC, U.S.A.

High-quality MgB<sub>2</sub> films with 350 – 400 nm thickness are prepared on c-cut sapphire using the ‘two-step process’, for which the intrinsic surface resistance and the penetration depth are measured as a function of temperature. The intrinsic surface resistance is obtained at 8.5 GHz using a TE<sub>01p</sub> mode rutile-loaded resonator with the finite film thickness taken into account, and the penetration depth of the films was separately measured using the mutual inductance method. The films show the RS less than 10 μΩ at a frequency of 8.5 GHz and 10 K with the critical temperature (T<sub>C</sub>) of ~ 39 K when they are prepared under optimum conditions. The penetration of these films is as low as 93 nm at 4 K. A reduction of the T<sub>C</sub> and an enhanced resistivity ρ(T<sub>C</sub>) are observed after surface ion-milling, while the penetration depth increases only slightly. The temperature dependences of the R<sub>S</sub> show a crossover between the as-grown and the ion-milled films with the lower RS values observed for the latter at low temperatures. Complex conductivity σ (= σ<sub>1</sub> + iσ<sub>2</sub>) of the MgB<sub>2</sub> films could be obtained from the measured surface resistance and the penetration depth, from which two peaks were observed in the σ<sub>1</sub> vs. temperature data supporting the two-gap scenario for MgB<sub>2</sub> along with the temperature dependence of the RS and the ρ(T<sub>C</sub>) – T<sub>C</sub> relation. The conductivity of the sigma-band appear to contribute significantly to the total conductivity, which is in contrast with the recently reported results by Jin et al. [B. B. Jin et al., preprint (2003)].

keywords : MgB<sub>2</sub> films, microwave surface resistance, penetration depth, complex conductivity.