Precise Measurement of the Extremely High Unloaded Quality Factor of Dielectric-loaded Resonators using an S-parameter Circle-fit Method

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Accurate measurements of surface resistance (R_S) of high temperature superconductor (HTS) films are essential not only for understanding fundamental properties of HTS materials but also for microwave applications of HTS materials for wireless communications in that quality control of the HTS films can be realized by measuring the R_S. A dielectric-loaded resonator method has been used for measuring the R_S, of HTS films, where extremely high unloaded quality factor (Q_0) of the resonator enable to measure the R_S of HTS films used as the endplates of the resonator with high sensitivity.

Here we use the S-parameter circle-fit method to measure the extremely high-Q_0 of dielectric-loaded resonators with HTS endplates. The TE_{011} mode Q_0 values of sapphire-loaded cavity resonators are measured at the resonant frequency of about 19.6 GHz and the temperature of 30 K~90 K, at which the R_S of the $YBa_2Cu_3O_{7-\delta}$ (YBCO) films on $LaAlO_3$ used as the top plate of the cavity is obtained. Validity of using the circle-fit method is checked by comparing the Q_0 values by the circle-fit method with those by the conventional Lorentzian-fit method. The two fitting methods are compared for two different resonators; one for short-ended resonator with both endplates making contact with the cavity body, and the other for a resonator with a small gap between the cavity and the top plate. It turns out that the measured Q_0 values by the two fitting methods are comparable with each other, despite the input/output coupling coefficient. Best agreements could be found between the two sets of values when the insertion loss is about 30 dB. Meanwhile, variations of the resonant frequency on the temperature appear comparable between the two fitting method when the input/output coupling coefficient is relatively large. Our results show that the circle-fit method is useful to obtain the Q_0 values of a resonator regardless of the symmetry of the measured S_{21} parameter, and that a resonator with an open-gap structure could be useful to measure the variations of the surface reactance of the HTS films at the top plate, which allows the penetration depth of the HTS film that enable to obtain the intrinsic surface impedance of HTS films from the measured effective surface resistance.

keywords : scattering parameter, circle fit, quality factor