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Effects of Split Gap on the Microwave Properties of YBCO Microstrip Ring Resonator

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Recently, we have succeeded in fabricating HTS ring resonators by using the double-side YBCO films deposited on $LaAlO_3$ (LAO) substrates. Quality factor (Q) over 10^4 at 5 K with resonating frequency of 3.61 GHz has been demonstrated. Furthermore, by creating a narrow gap in the same ring structure, we found that the resonating frequency splits into two, one occurred at half and three halves of the original one (i.e. at 1.80 GHz and 5.33 GHz, respectively). The temperature dependence of the resonating frequency and Q-value were studied in detail. We found that although the resonating frequency changes by introducing the gap, the Q-value remains essentially unchanged.

1. INTRODUCTION

Microwave ring resonators made of high-T_c superconducting (HTS) thin films are of considerable interest owing to their geometry advantages in possibly resolving the extremely non-uniform current distribution commonly encountered by the stripline resonators. As is well known from microstrip ring resonator, it travels clockwise and anticlockwise resulting in two degenerate modes occurred at resonance frequency [1, 2]. If the ring resonator is of symmetrical geometry, only one degenerate mode can be observed since the modes are orthogonal to each other and no coupling occurs between them [2]. On the other hand, if the geometry of the resonator is asymmetric, the splitting of the resonance frequency will occur and can be excited with different amplitudes.

In this study, we used a double-tuned circuit bandpass filter to demonstrate that two degenerate modes can be, indeed, excited on a microstrip ring resonator with or without a gap. The result should enable us to explore how various types of asymmetry with the generation of various frequencies can be realized.

2. EXPERIMENTAL

The YBCO thin films were deposited epitaxially on both sides of a 0.5 mm thick $LaAlO_3$ substrate by pulsed laser deposition [3]. The substrate temperature was kept at 830 °C, the oxygen partial pressure was 280 mTorr during the deposition. Both films were c-axis oriented, with thickness of 500 nm and T_c = 90 K. One side of the films was then patterned into the ring shaped microstrip line with or without a split gap, as shown schematically in Figure 1.

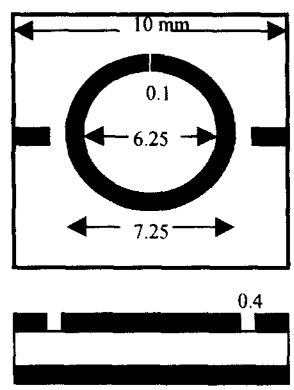

Figure 1. The ring-shaped of split gap microstrip resonator adopted for surface impedance measurements on YBCO thin film.

The temperature dependence of the resonance frequency f(T), frequency shifts Δf(T) and the unloaded quality factor Q(T) were measured by a HP8510C microwave vector network. Where Q(T) is

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defined as $Q(T) = f / [(1-S_{21})\ \Delta f]$, and S_{21} is the forward transmission coefficient.

3. RESULTS AND DISCUSSION

Figure 2(a) shows the frequency dependence of the forward transmission coefficient S_{21} obtained at 5 K on a full-circled microstrip ring resonator, exhibiting the single resonant mode occurred at 3.61 GHz. Figure 2(b) shows the similar S_{21} obtained on the ring resonator, with essentially the same dimension as in (a), except for the split gap implemented as shown in Figure 1. The splitting of the original resonance frequency from 3.61 GHz to 1.80 GHz and 5.33 GHz is evidently detected. This is qualitatively consistent with that predicted by Wolfe [2]. As also shown in Figure 2(b), the intensity between splitted modes is slightly different and both are diminishing as compared to the single mode case.

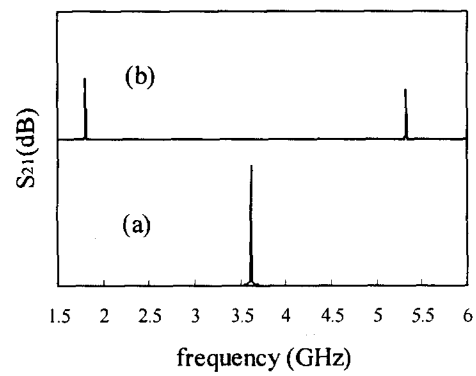

Figure 2. (a) The frequency dependence of the forward transmission coefficient S21 obtained at 5 K on a full-circled microstrip ring resonator,. (b) shows the similar S21 obtained on ring resonator, with essentially the same dimension as in (a).

Figure 3 denotes the temperature dependence of the quality factor for a ring resonator and a split gap ring resonator, respectively. They all exhibit the same temperature dependence of the Q-factor. In other words, their quality factors are not affected as we break the symmetry of the ring resonance, indicating that it may persist nondispersive relation on the structure of our samples. From practical point of view, we regard that such HTS microstrip ring resonator disturbed by a gap would be possibly used to build a bandpass filter with the very high Q-value and frequency tuning capabilities.

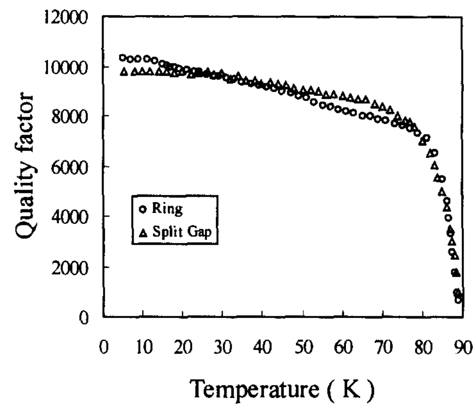

Figure 3. The temperature dependence of the quality factor between a ring resonator and a split gap ring resonator.

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