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SURFACE RESISTANCE OF LARGE-AREA YBCO AND BSCCO FILMS FOR SUPERCONDUCTING ANTENNAS

Shigetoshi Ohshima, Hitoshi Kohno, Norio Horiguchi, Shiro Kambe,
Katsuro Okuyama, *Keisuke Noguchi, *Kunio Sawaya and *Saburo Adachi
Electronic and Information Engineering, Yamagata University, Yonezawa, 992, Japan
*Electrical Engineering, Tohoku University, Sendai, 980, Japan

1. Introduction

The realization of small surface-resistance films is very important for high frequency applications of oxide superconductors. Recently, many investigators reported the surface resistance, Rs, values of oxide superconducting films which were prepared by sputtering[1], CVD[2] and laser ablation[3] methods. They pointed out in these reports that high quality films had very small Rs values. Microwave resonators[4], delay lines[5] and band-pass filters[6] using these films were also reported. These devices were superior to devices prepared using normal metals.

However, high efficiency superconducting antennas and electrical transmission lines are not yet reported, because both high-quality and large-area are required for the films for these applications and it is very difficult to prepare such films by sputtering, CVD and laser ablation methods. Screen printing, doctor blade method and plasma spray methods can easily prepare a large area films, but Rs values of these films were relatively large.

In this paper, we show the formation process, superconducting properties and surface resistance of large-area superconducting films for superconducting antennas prepared by screen printing, doctor blade and MOCVD methods. We also show the configurations of superconducting antenna prepared by doctor blade and screen printing.

2. Experimental procedure

2-1 Sample preparation

(A) Screen printing

$YBa_2Cu_3O_{7-y}$ thick films were prepared by screen printing. The procedure is as follows. $YBa_2Cu_3O_{7-y}$ compounds prepared by solid state reaction were crushed to fine powders by ball milling and then mixed in etyl cellulose and terpineol to make a paste. YBCO strip-lines configuration ($\sim$5 x100 x0.1 mm^3) to measure the superconducting properties and surface resistance were fabricated on YSZ substrates. Screen printing was repeated for several times in order to get a homogenious films. The strip lines were annealed at between 920 and 980°C for 12 hours.

(B) Doctor blade

$Bi_2Sr_2Ca_1Cu_2O_y$ (2212) strip lines were prepared using green sheets made by doctor blade method. BSCCO (2212) green sheets were cut into a strip-line configuration ($\sim$3x100x0.1 mm^3) and put on alumina substrates. The organic compounds in the sheets were dissolved at 650 °C for 3 hours and then annealed at 860~930 °C for 10~60 min..

(C) MOCVD

YBCO thin films were prepared by MOCVD method. The system used is a conventional horizontal hot-wall type. The source materials used are β-diketonate metal chelates: $Y(DPM)_3$, $Ba(DPM)_2phe_2$ and $Cu(DPM)_2$. Vapors of the chelates were carried out by Ar gas flow and introduced into a quartz reactor. YSZ (50x50x0.1 mm^3) substrates were used for preparation of YBCO thin films.

2-2 Measurement of superconducting properties and surface resistance

The grain orientation, phase analysis and lattice constants were measured by X-ray diffraction. Superconducting transition temperature and critical current density were measured by the conventional four probe method. The surface resistance was measured by stripline resonance method using cavity. The measuring system was reported elswhere[7]. The surface resistance of strip lines can be calculated from the value of the quality factor Q which were measured by a network analyser.

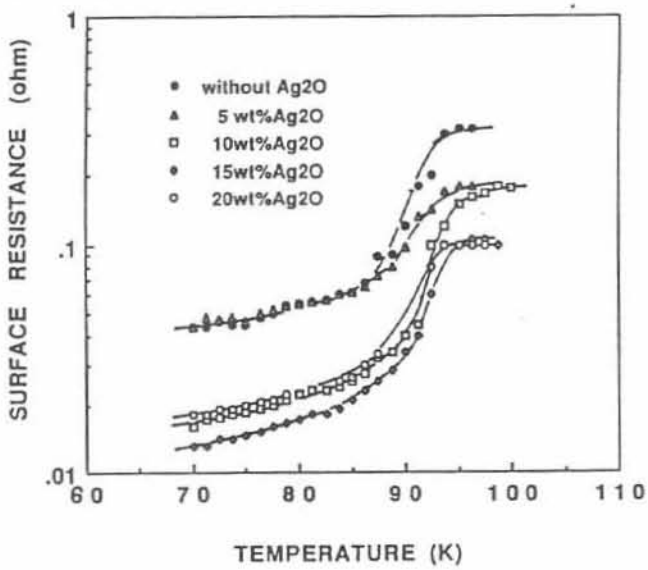

Fig.1. The temperature dependence of Rs for YBCO strip lines with and without Ag_2O addition. Strip lines were prepared by screen printing.

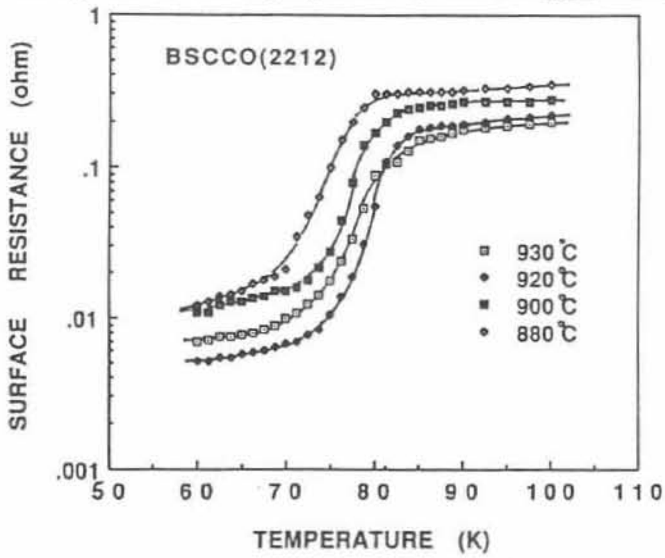

Fig.2. The temperature dependence of Rs values of BSCCO (2212) strip lines prepared by doctor blade method.

3 Results and discussion

3-1 YBCO thick films

Figure 1 shows the temperature dependence of Rs for YBCO strip lines with and without Ag_2O addition. The Rs values decrease drastically at their transition temperature. It can be seen that the Ag_2O included in the samples decreased the Rs. The optimum value of Ag_2O addition to decrease Rs value is about 15 wt.%. The behavior is very similar to that of the samples with Ag addition. O. Ishii[8] et al. reported the reduction of the surface resistance of YBCO films by adding Ag. They pointed out that the improvement is able to the enhanced grain growth and improved c-axis orientation We also measured the orientation and size of YBCO and Ag-, Ag_2O added YBCO grains by X-ray diffraction and SEM observation. The grain size of Ag and Ag_2O added YBCO was larger than that of Ag_2O and Ag free samples. However, there was no clear difference in the c-axis orientation.

3-2 BSCCO thick films

Figure 2 shows the temperature dependence of Rs values of BSCCO strip lines prepared by doctor blade method. The Rs values decrease rapidly below superconducting temperature and the value at superconducting state depends on the annealing temperature. The minimum value is obtained for the sample annealed at 920 °C. From the X-ray diffraction patterns of the BSCCO (2212) strip lines annealed at temperature between 880 and 930 °C it was found that many peaks from (HKL) planes are observed for the strip lines annealed at 880 °C, on the other hand, the strip lines prepared at 920 °C shows very strong (00L) peaks. That is, the latter films have grains oriented with the c axis normal to the substrate. The reduction of the surface resistance of BSCCO strip lines is caused by the improved c-axis orientation.

3-3 YBCO thin films

Figure 3 shows the temperature dependence of the Q factors of the films prepared by MOCVD method. Film size is 50 x 50 mm^2 and sufficiently large to make a superconducting antenna. The Q value increases rapidly below the superconducting transition temperature. It was found from X-ray diffraction patterns that the film was single phase and the c plane of the grain was oriented normal to the substrate.

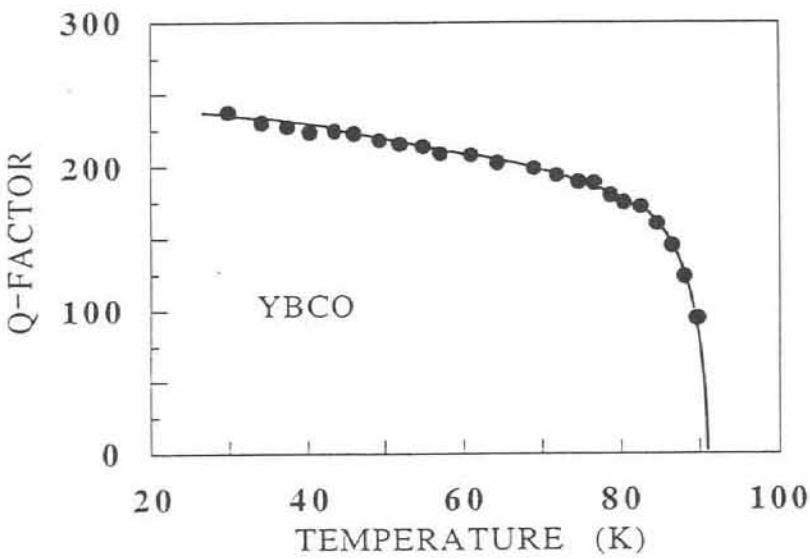

Fig. 3. The temperature dependence of Q factor of the YBCO thin films prepared by MOCVD method. The film size is 50 x 50 mm^2 and thickness of the film is about 0.2 μm.

4. Superconducting antenna

S.K. Khamas[9] et al. and K. Itoh[10] et al. reported the superconducting antenna and obtained a slightly large gains compared with that of a normal antenna, however the high efficient small antenna using high Tc superconductors is not yet realized. In principle, the high efficient small antenna is possible using superconductor because the ohmic loss can be reduced. Figure 4 shows the self-resonant type superconducting antenna model. The superconducting antenna was prepared by doctor blade method. The antenna properties and new type antenna are now under investigation.

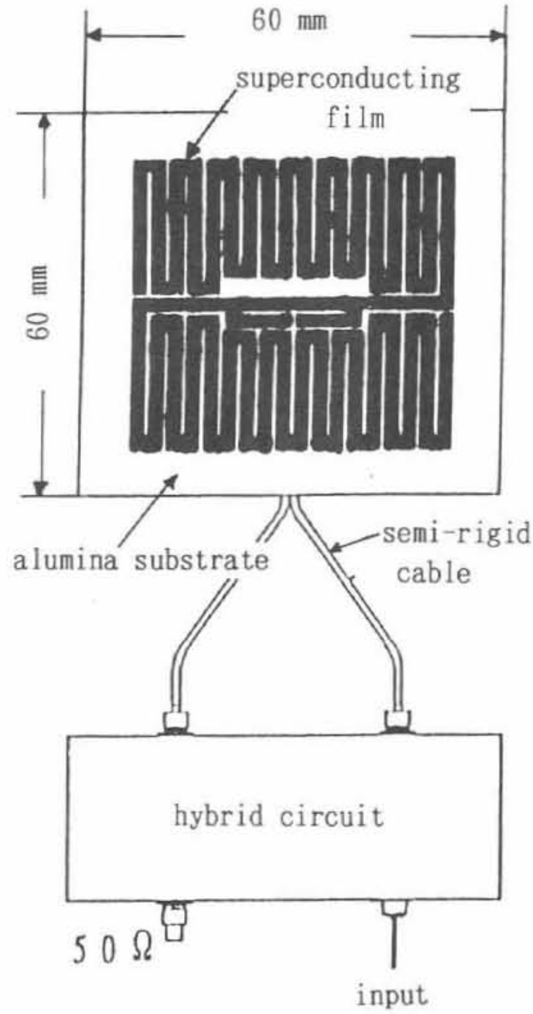

Fig.4. Configuration of self-resonant type superconducting antenna.

Acknowledgments

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