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①SURFACE RESISTANCE OF $\text{YBa}_2\text{Cu}_3\text{O}_7$ FILMS DEPOSITED ON LaGaO_3 SUBSTRATES

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Superconducting films of $\text{YBa}_2\text{Cu}_3\text{O}_7$ deposited onto LaGaO_3 substrates were prepared by e-beam and magnetron sputtering techniques. Surface resistance measurements made at 22 GHz, 86 GHz, and 148 GHz show that these films are superior to those deposited by similar techniques onto SrTiO_3 . Typical surface resistance values measured at 22 GHz and 12 K are $\sim 2 \text{ m}\Omega$ with the lowest value being $0.2 \text{ m}\Omega$, which is only 2-4 times higher than Nb. The surface resistance is proportional to the square of the measuring frequency.

1. INTRODUCTION

Surface resistance (R_s) measurements on high-temperature superconductors are necessary to determine their suitability for practical applications. Several measurements of R_s for films of $\text{YBa}_2\text{Cu}_3\text{O}_7$ (YBCO) on SrTiO_3 have been made at various frequencies and temperatures.²⁻³ SrTiO_3 is not the best substrate for high-frequency applications because of its high dielectric constant. A more suitable substrate is LaGaO_3 .

2. EXPERIMENTAL

Thin films ($0.5\text{-}0.8 \mu\text{m}$) of YBCO were deposited onto single-crystal (001) LaGaO_3 substrates by either e-beam or magnetron sputtering techniques. X-ray diffraction data showed that the films were highly c-axis and a-axis oriented with only trace amounts of impurities. Pole-figure analyses of selected films showed that all films were well aligned with the single-crystal substrate.

Surface resistance measurements were made at three frequencies (22 GHz, 86 GHz, and 148 GHz) as a function of temperature using the same experimental technique. In each case the end wall

of a cylindrical cavity (TE_{01n} mode family) was replaced by the superconducting sample. R_s is computed from the difference in Q values of the bare cavity and the cavity with the superconducting end wall.

3. RESULTS

Shown in Fig. 1 are typical surface-resistance curves for films of YBCO e-beam deposited onto SrTiO_3 and LaGaO_3 measured in a Cu cavity at 22 GHz. The data are plotted as $\log R_s$ vs. T_c/T ($T_c = 90 \text{ K}$). For this measurement the sensitivity of the Cu cavity is $\sim 2 \text{ m}\Omega$; thus the $1 \text{ m}\Omega$ value shown in the graph is only an upper limit. Utilizing a Nb superconducting cavity, R_s was re-measured at 4 K and 22 GHz and found to be $0.2 \pm 0.1 \text{ m}\Omega$, which is only a factor of 2-4 higher than Nb.

Figure 2 shows R_s vs. T data measured at three different frequencies for a YBCO film deposited onto LaGaO_3 by magnetron sputtering. The frequency dependence of these data is given in Fig. 3 for $T = 70 \text{ K}$ and 30 K . The best fit gives $R_s \propto \omega^n$ with $n = 2.06 \pm 0.14$ and 2.02 ± 0.47 , respectively. This quadratic dependence is

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consistent both with BCS theory and with experimental measurements on conventional superconductors.

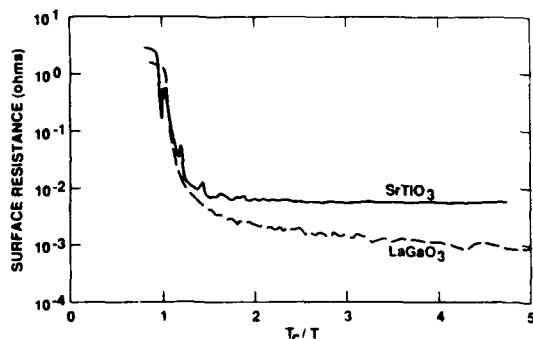


FIGURE 1. R_s vs. reduced temperature ($T_c = 90$ K) for 0.8- μm films of YBCO deposited onto SrTiO_3 and LaGaO_3 substrates.

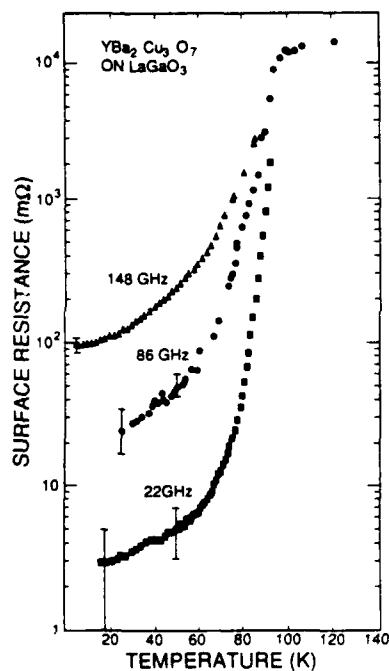


FIGURE 2. R_s vs. T for a 0.5- μm film of YBCO deposited onto a LaGaO_3 substrate.

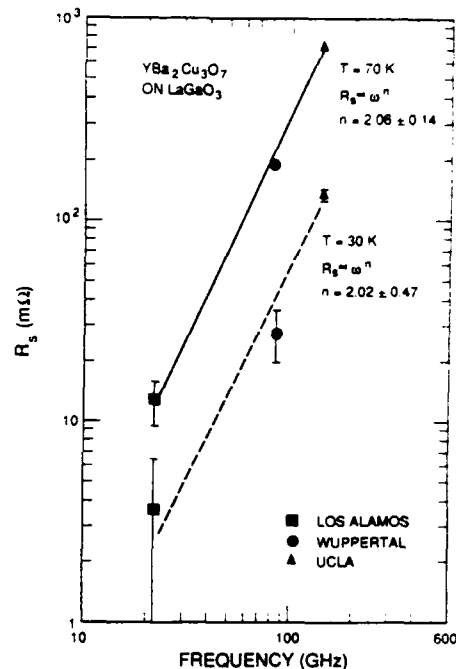


FIGURE 3. Frequency dependence of R_s taken from the data shown in Fig. 2.

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