

**Zeitschrift:** Helvetica Physica Acta  
**Band:** 62 (1989)  
**Heft:** 6-7

**Artikel:** In-situ preparation of  $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$  high  $T_{\text{C}}$  thin films  
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**DOI:** <https://doi.org/10.5169/seals-116142>

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IN-SITU PREPARATION OF  $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$  HIGH  $T_c$  THIN FILMS

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**ABSTRACT:** Thin films of the high  $T_c$  compound  $\text{YBa}_2\text{Cu}_3\text{O}_y$  with good electrical and structural properties have been prepared. Our method consists of d.c. sputtering by an  $\text{YC}_{\text{u}3}$  target and thermal Ba evaporation in  $\text{O}_2$ -Ar atmosphere. The obtained films have transition onset at  $\simeq 90\text{K}$  and  $T_c(R=0)=70\text{K}$ . X-rays spectra show a preferential orientation of the c-axis perpendicular to the plane of the film. Measurements of critical current have been performed. A photolithographic technique has also been realized.

We report on a very simple method that allows to fabricate thin films of the high  $T_c$  compound  $\text{YBa}_2\text{Cu}_3\text{O}_y$  with good structural and electrical properties on sapphire substrates.

Superconducting thin films have been prepared by a codeposition technique consisting of a thermal evaporation of metallic Barium and of a simultaneous sputtering from an  $\text{YC}_{\text{u}3}$  target by a d.c. magnetron triode type gun<sup>(1)</sup>.

The use of metallic sources allows a great stability in the sputtering parameters and very high deposition rates, an overall growth rate of  $10\text{ \AA/sec}$  is easily obtainable with target-substrate distance of 9 cm.

The vacuum system used is based on a cryogenic pump with an ultimate pressure in the low  $10^{-7}$  mbar range. The substrates are mounted in contact with a molybdenum heater, and oxygen can be spread near the substrates. In all depositions the sputtering target voltage was 250V. The whole process was continuously monitored by an oscillating quartz detector.

The films were deposited on sapphire substrates at a temperature of  $650^\circ\text{C}$  in a oxygen-argon atmosphere of  $5 \times 10^{-3}$  mbar with a  $\text{O}_2$  partial pressure of  $1 \times 10^{-3}$  mbar. After the deposition the films were cooled down to  $400^\circ\text{C}$  in an oxygen atmosphere of  $5 \times 10^{-3}$  mbar. The film were held at this temperature for about 30 minutes and were then allowed to cool down to room temperature always venting the deposition chamber with pure  $\text{O}_2$ .

The deposition process is finally followed by an additional heat treatment in an oxygen pressure of 1 atm and at a temperature of  $400^\circ\text{C}$  for two hours to correctly adjust the oxygen content of the films. Typical film thicknesses are about  $1\text{ }\mu\text{m}$ .

An important result obtained in this kind of process is that the substrate temperature needed for growing films with right structure are substantially lower than the

maximum temperature applied in an ex-situ process. This results opens up the possibility to use silicon and other practical materials as substrates.

The films structural properties was studied by X-ray diffraction. Analysis of X-ray spectra reveal a preferential orientation of growth with the c-axis perpendicular to the plane of the film.

The transport properties of the films were measured using the standard four probe method with silver paint contacts. In fig. 1 the resistive transition of a  $\text{YBa}_2\text{Cu}_3\text{O}_y$  film on sapphire substrate is reported. The sample shows a transition with an onset at  $\simeq 90\text{K}$  and zero resistance at  $\simeq 70\text{K}$ .

Critical current measurements have also been performed, the onset of a voltage greater than a microvolt was used as a measure of the critical current. In fig.2 critical current as a function of temperature is reported. Typical values of the critical current density at liquid helium temperature are about  $5 \times 10^{-4} \text{ A/cm}^2$ .

Preliminary  $I_c$  vs magnetic field measurements show a very slowly decreasing current also at high field values.

This behaviour can be ascribed to a film structure with strongly coupled grains.

In view of realizing devices for tunnel and Josephson effect studies, a photolithographic technique as also been performed. The chemical etching used consists of a highly dilute nitric acid, allowing fine feature definition without degrading the film quality.

In conclusion good results have been obtained producing  $\text{YBa}_2\text{Cu}_3\text{O}_y$  films on sapphire by a new and very reproducible 'in-situ' codeposition method. The realized films have a highly oriented structure and good transport properties.

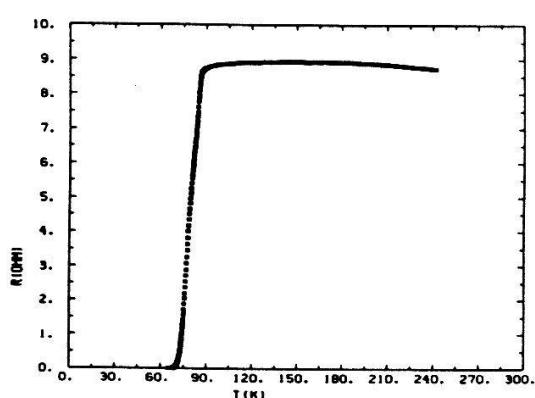


Fig.1 Resistance vs temperature for a film deposited on sapphire substrate

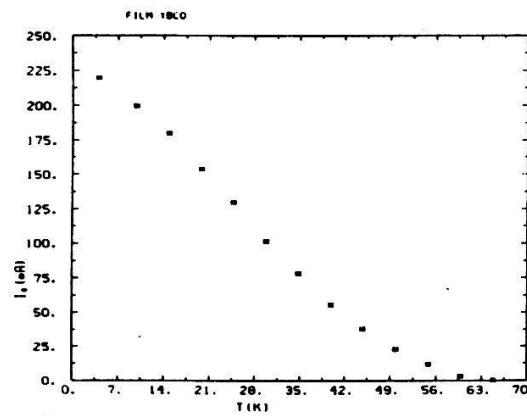


Fig.2 Typical behaviour of critical current vs temperature.

## REFERENCE

- (1) P. Romano et al. IEEE Trans. on Magn., in press