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IN-SITU PREPARATION OF $YBa_2Cu_3O_{7-x}$ HIGH T_c THIN FILMS

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ABSTRACT: Thin films of the high T_c compound $YBa_2Cu_3O_y$ with good electrical and structural properties have been prepared. Our method consists of d.c. sputtering by an YCu_3 target and thermal Ba evaporation in O_2-Ar atmosphere. The obtained films have transition onset at $\simeq 90K$ and $T_c(R=0)=70K$. 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 photolitographic technique has also been realized.

We report on a very simple method that allows to fabricate thin films of the high Tc compound $YBa_2Cu_3O_y$ 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 YCu_3 target by a d.c. magnetron triode type gun[(1)].

The use of metallic sources allows a great stability in the sputtering parameters and very high deposition rates, an overall growth rate of 10 Å/sec is easly 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°C in a oxygen-argon atmosphere of $5x10^{-3}$ mbar with a O_2 partial pressure of $1x10^{-3}$ mbar. After the deposition the films were cooled down to 400°C in an oxygen atmosphere of $5x10^{-3}$ 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 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°C for two hours to correctly adjuste the oxygen content of the films. Typical film thicknesses are about 1 μm

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 $YBa_2Cu_3O_y$ film on sapphire substrate is reported. The sample shows a transition with an onset at $\simeq 90K$ and zero resistance at $\simeq 70K$.

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 $5x10^{-4}$ A/cm^2.

Preliminary Ic 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 $YBa_2Cu_3O_y$ 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.

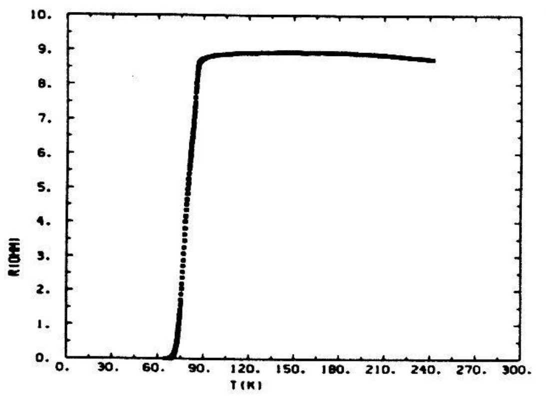

Fig.1 Resistance vs temperature for a film deposited on sapphire substrate

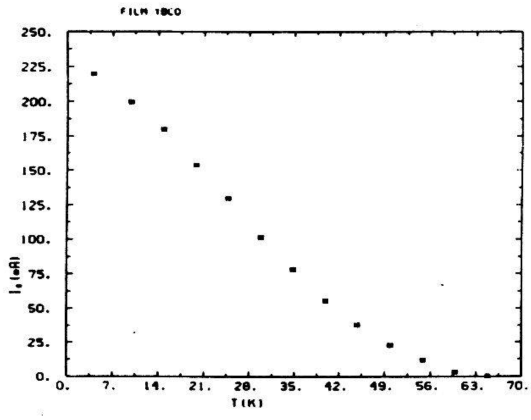

Fig.2 Typical behaviour of critical current vs temperature.

REFERENCE

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