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TARGETS FOR MAGNETRON SPUTTERING OF YBCO SUPERCONDUCTOR THIN FILMS

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The pioneering discovery of Bednorz and Müller[1] of superconductivity over 30 K in the La:Sr:Cu:O system led to worldwide investigation of new cuprate based compounds, especially since the identification of $YBa_2Cu_3O_7$ as a bulk superconductor having its T_c about 90 K[2,3]. The great attention is payed to the investigation of high T_c ReBaCuO bulk materials (Re is rare earth element). Technology of bulk materials is relatively simple and good results may be obtained when pure materials are available[4,5].

However the technology of thin Re:Ba:Cu:O films is more complicated due to film-substrate interaction at high temperatures and other effects connected with diffusion, dilatation mishmash, adhesion, interdiffusion, lattice parameters differencies etc.[6,7].

Among many possible thin film technologies used for their deposition, as for instance:

- electron gun evaporation including the evaporation from few independent sources[8,9]
- sputtering DC, HF, magnetron DC, HF, ion beam and their combinations[10,11]
- pulse laser beam evaporation[12,13]
- molecular beam epitaxy[14,15]
- classical thermal evaporation from a few vapour sources in vacuum[16,17]
- pyrolysis from nitrate[18,19] or
- organic acid salts solution on the substrate[20,21].

We have chosen a DC magnetron sputtering for thin films high temperature superconductors deposition. One of the basic requirements which must be satisfied is the availability of a good target for used magnetron gun. To our knowledge there is a little information about technology of the target fabrication in literature, so we have tried to describe our experience here.

Among many possible constructions of magnetron sputtering guns[22] we have chosen the planar magnetron gun.

Due to brittleness of Y:Ba:Cu:O ceramic material of approximative composition 1:2:3 and its tendency to crack up under the temperature gradients influence the target must be soldered in the target holder which helps to preserve the target from cracks during sputtering process.

The most essential requirements for good quality targets are:

- the average chemical composition of target must not vary without the target volume. Microinhomogeneities of the composition (0.1 mm) are acceptable
- low electrical resistivity of target material (essential for DC magnetron)
- good target geometry with the ideal cylinder shape within ± 0.25 mm
- the powder particles must be well bahed together to prevent "dusty" sputtering
- the mechanical characteristics of the target must be the same within the whole to prevent the crackin up during exploitation.

For the target preparing we have used classical technology based on mixing, milling, sintering, firing of powder components[23,24]. We have used chemically clean components as follows below:

Y-component : Y_2O_3

Ba-component : $BaCO_3$, BaO or BaO_2

Cu-component : Cu, CuO_2 or CuO.

It is possible to use powder mixture of any combination of the above components which are mixed together givin the desirable stoichiometry relation of Y:Ba:Cu. Having chosen in our case Y, Ba and Cu component combination and knowing the corresponding molecular weights M_I, M_{II} and M_{III} of Y, Ba and Cu component, respectively, and knowing total mass m_t of our mixture, we can calculate corresponding masses of the components in our mixture from the formulae:

$$m_I = \frac{M_I \cdot S_I}{\Sigma} \cdot m_t$$

$$m_{II} = \frac{M_{II} \cdot S_{II}}{\Sigma} \cdot m_t$$

$$m_{III} = \frac{M_{III} \cdot S_{III}}{\Sigma} \cdot m_t,$$

where S_I, S_{II} and S_{III} are the stoichiometric coefficients in formulae $Y_{S_I}Ba_{S_{II}}Cu_{S_{III}}O_x$.

As one knows the thorough drying of powders is desirable prior weighing of components, because some of powders used may have absorbed water in serious ammounts. After choosing

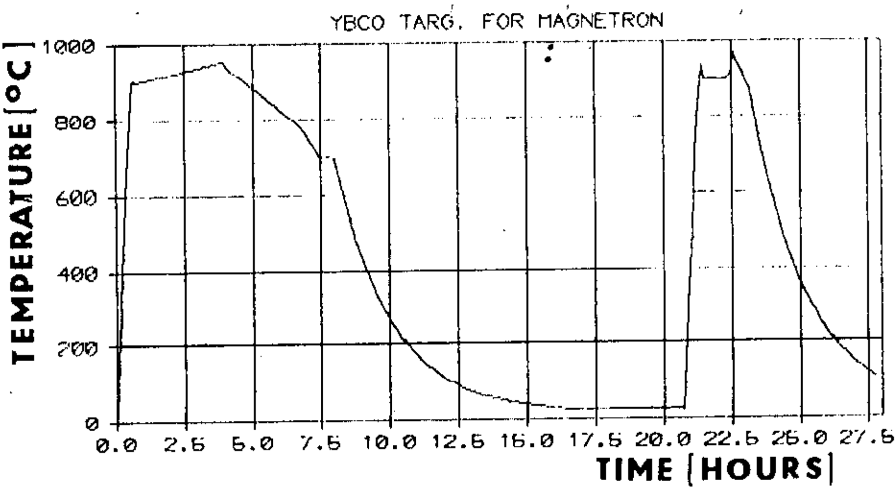

Fig.1. The temperature regime by the firing of the target.

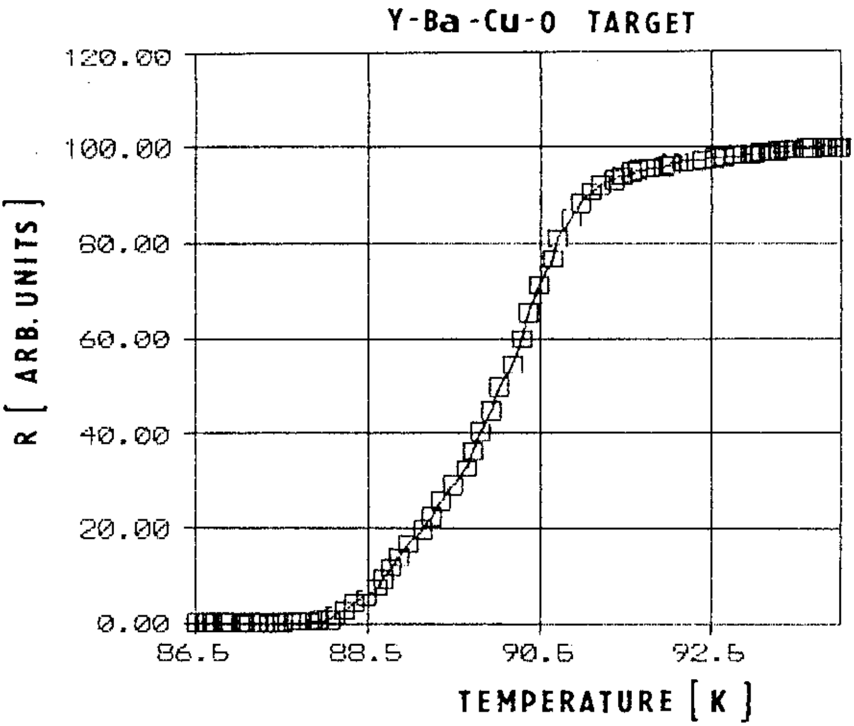

Fig.2. The typical resistance dependence of the target on temperature.

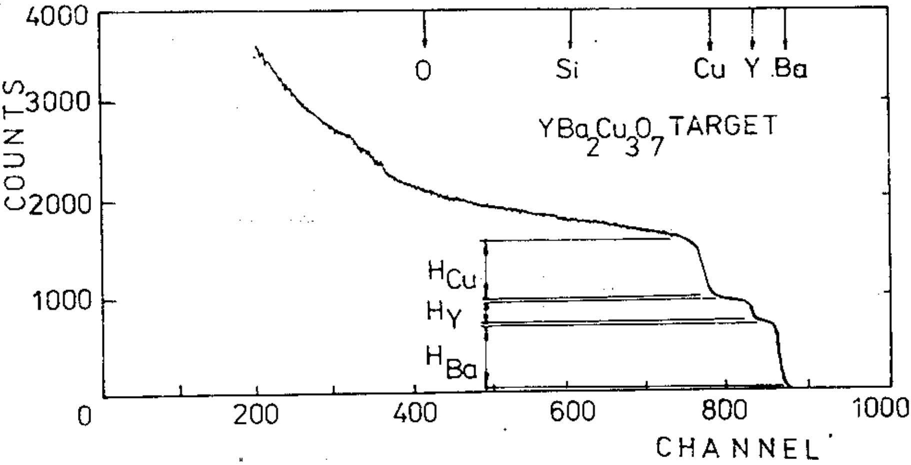

Fig.3.The backscattering spectra from $YBa_2Cu_3O_7$ target. The 3.0 MeV α-particles have been used for irradiation.

the proper components, computing the ammounts and drying the components and preparing desirable mixture of powders we have mixed and grinded them in agate mortar repeatedly. Then we have pressed a tablet Ø 76 mm by force 50 ton in a press. During sintering and firing at a furnace the tablets were layed on $SrTiO_3$ substrate layered with $SrTiO_3$ powder (Ø0.05-0.1 mm). Such a tablet was sintered at 950°C 3-5 hours, milled again and pressed with force 30 ton and fired by temperature regime show in Fig.1. When the pressing of sintered powder makes problems (the tablets are cracking) one may "wett" them by ethylalcohol or heptylalcohol.The resistance measurements were done with a standard four-point probe technique Fig.2.

The atomic concentration of elements (Y, Ba and Cu) can be calculated with the backscattering spectrum of the target Fig.3, (α-particles with energy E_0 = 3.0 MeV) by the plateau height H_Y , H_{Ba} and H_{Cu} with the accuracy not less than 1%/25/.

The typical parameters of our $YBa_2Cu_3O_7$ magnetron targets are listed in the table:

Stoichiometry	: Y :Ba : Cu = 1 : 2 : 3 with accuracy 1%
Dimension	: Ø 76 mm - 1 mm, thickness 2 - 6 mm
Resistance	: > 1 ohm; typical 1 - $5\cdot10^{-2}$ ohm
T_{co}	: 90 - 92 K
T_{ce}	: 86 - 89 K
T_c	: 2 - 3 K.

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