Diffusion process for superconducting YBa2Cu3Ox-thin layers
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1. INTRODUCTION
Thin superconducting YBa$_2$Cu$_3$O$_x$ (123)-
layers can be made by e.g. plasma-spray-
ing, laser-ablation and sputtering
(e.g. 1,2,3). Examination of the phase
diagram (4,5), led us to a new method for
the fabrication of superconducting thin
123-layers. This method is based on the
formation of a superconducting thin layer
by a solid state diffusion reaction at
the interface between a non-superconduct-
ing substrate and a non-superconducting
coating.

2. EXPERIMENTAL PROCEDURE AND RESULTS
BaCuO$_2$ layers of about 3 μm thickness
were deposited on hot-pressed Y$_2$Cu$_2$O$_5$
substrates by laser-ablation (substrate
temperature 400°C) from sintered targets.
The samples were annealed for two hours
at 850°C in O$_2$. The resistance of such
samples was measured as a function of
temperature by a standard d.c. four-probe
 Technique. A broad superconductive tran-
sition was observed. Repeating the
annealing gave better results. The $T_c$ of
this sample was 80 K and a relatively
high room-temperature resistance of 120
ohm was measured. The X-ray diffraction
(XRD)-pattern of this sample showed the
presence of Y$_2$BaCuO$_5$, CuO, Y$_2$Cu$_2$O$_5$ and
BaCuO$_2$, in addition to weak reflections
originating from the 123-compound.

The as-deposited BaCuO$_2$-layer appeared
to be very reactive with CO$_2$ or H$_2$O from
the air. In order to avoid these re-
actions, an Y$_2$Cu$_2$O$_5$ capping of about 1 μm
thickness was applied, on top of the
BaCuO$_2$ layer. This capping was also depo-
sited by laser-ablation. Six capped
Y$_2$Cu$_2$O$_5$ / BaCuO$_2$ samples were heat-
treated for various times between 0.5
and 6 hours and at various temperatures
between 825 and 900°C in O$_2$. Now most of
the XRD-patterns showed the orthorhombic
123-compound as the main phase. In fig. 1
an R-T curve of the sample with the
highest $T_c$ is shown. On the SEM fracto-
graph of this sample, shown in fig. 2,
cracks through the layers can be ob-
served. These cracks might be due to a
difference in thermal expansion coeffi-
cients and phase transformations in the
layers.

Superconducting 123-thin films were
also formed by a solid state diffusion
reaction between a sintered CuO sub-
strate and an Y$_2$Ba$_4$O$_7$.CO$_2$ thin layer. In
fig. 3 an R-T curve is shown of a sample
which was heat-treated for 4 hours at
850°C in O$_2$. The Y$_2$Ba$_4$O$_7$.CO$_2$-layer was
deposited by plasma-spraying. In ref. 6
results are described which were obtained
by using the laser-ablation technique for
the Y$_2$Ba$_4$O$_7$.CO$_2$-layers as well as more
experimental details for both types of
samples.

3. DISCUSSION
In capped Y$_2$Cu$_2$O$_5$ / BaCuO$_2$ samples
after annealing, two regions in which Y,
Ba and Cu prevail have been detected by
EDAX, (fig. 2.) In the samples without
capping, only one such layer can be
formed at the interface between the depo-
sited layer and the substrate. In the
XRD-patterns a clear difference is ob-
served between the samples without an
Y$_2$Cu$_2$O$_5$ capping on top of the BaCuO$_2$
layer on the one hand and those with such
a capping on the other hand. From the
samples without capping only very weak
123-lines, originating from the underly-
ing 123-interface, were detected. In con-
trast strong 123-lines, apparently origi-
nating from the 123-top layer, appeared
in the XRD-patterns of the capped
samples. In none of the layers any pre-
ferential orientation was detected by
XRD. Annealing for two hours at 850°C
appeared to be an optimal treatment for the capped Y$_2$Cu$_2$O$_5$ / BaCuO$_2$ samples so far.

In contrast to what was aimed at, the whole capping layer was converted to the 123-compound. Therefore in order to obtain a real interface layer, a thicker capping layer should be applied. This not only prevents chemical degradation but it also gives a better illustration of the idea to form a superconducting thin layer within a solid body.

4. CONCLUSIONS

It is shown that it is possible to form superconducting thin 123-layers by a solid state diffusion reaction between two non-superconducting starting materials. After annealing a CuO substrate with an Y$_2$Ba$_4$O$_7$.CO$_2$ layer a rather broad superconducting transition is obtained. A better result is obtained by using an Y$_2$Cu$_2$O$_5$ substrate covered with a BaCuO$_2$ layer and provided with an Y$_2$CU$_2$O$_5$ capping. For the latter samples a superconducting layer on top of the BaCuO$_2$ layer was found. This indicates that it is worth considering to make a superconducting 123-layer on other polycrystalline substrates by depositing a sequence of layers and applying a heat treatment.

5. REFERENCES

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