

TEXTURE ANALYSIS IN YBaCuO SUPERCONDUCTORS

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Technological applications of high temperature superconductors will be possible only for bulk samples or thin films exhibiting high critical current density. The strong anisotropy of the critical current density in YBaCuO gives rise to new interest in texture analysis. Several processing techniques have been developed for the specific purpose of increasing the preferred grain orientation in ceramics.

Quantitative texture studies of oriented YBa₂Cu₃O_{7- δ} bulk samples or films have been carried out by X-ray diffraction pole figures using the Schulz reflection technique. The (00 ℓ) pole figures define the c axis alignment while the (103) and (113) pole figures give information on the rotation about the c axis.

1. INTRODUCTION

The range of applications of high T_c superconductors will be limited by the critical current density J_c . In single crystal YBaCuO, the J_c is strongly anisotropic, the largest values measured in the basal plane being several times greater than those in the c-axis direction. However, the preparation of large crystals sufficient for device applications is very difficult. Therefore, a considerable effort has been made to produce grain oriented ceramics or epitaxial films.

The pole figures technique is shown to be more effective in quantifying the texture, comparing different samples and analysing the effects of processing parameters. Texture analysis of YBaCuO oriented ceramics and thin films are presented.

2. METHOD OF TEXTURE ANALYSIS

X-ray diffraction pole figures of the samples are obtained using the Schulz reflection technique¹. The intensity is measured by fixing the Bragg angle θ and rotating the sample simultaneously around the surface normal axis

(angle β) and the tilt axis (angle ϕ). By the measurement of one set of diffraction intensities we can analyse the texture of an area in the order of 1mm² with about 10 μ m of deepness. The pole figures are plotted from the corrected data on a polar stereographic projection. Iso-intensity lines indicate the relative intensity of the pole; 100% corresponds to the maximum diffracted intensity. The (00 ℓ) pole figures define the c-axis alignment while the (hk ℓ) pole figures give information on the rotation around the c-axis, i.e. the in-plane texture.

3. RESULTS AND DISCUSSION

Pole figures for a magnetically oriented YBCO ceramic from a liquid suspension of single crystals² are shown in figure 1. This "multipoles figure" represents the distribution of two kinds of poles : (007) and (103). The (007) pole figure defines the c-axis alignment ; the localization of these poles within a small area indicates that the crystallites are aligned strongly with their c axes parallel to the magnetic field.

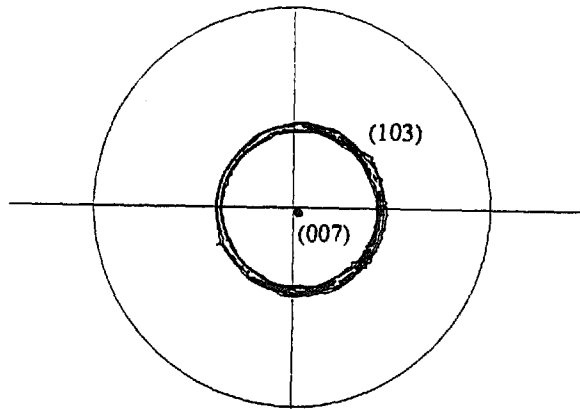


FIGURE 1

"Multipole figure" showing the (007) and (103) of the magnetically oriented YBaCuO sample.

The (103) poles are localized on a ring corresponding to a ϕ angle of 45° which is the calculated value of the angle between the [007] and [103] directions. Taken together, these results allow us to conclude that the sample exhibits a fibrous texture in which the fibre axis coincides with the direction of the applied magnetic field.

Figure 2 shows the pole figures for an oriented ceramic obtained by using a zone melting process³. The (007) pole indicates that the [001] directions of the crystallites make an angle of about 8° with the normal to the surface of the sample and are dispersed along a cone portion of about 20° in β . The (013) poles show a four-fold symmetry as a clear evidence for twinning. In an orthogonal direction related to the previous surface the (200) poles (not shown here) are localized within a small area. Consequently the a-axis direction (or b-axis because of twinning) coincides with that direction. As the pictures of the two studied surfaces remain coherent, we can conclude that the observed texture is a bulk and not a surface property. The zone melting process leads to a tridimensional texture.

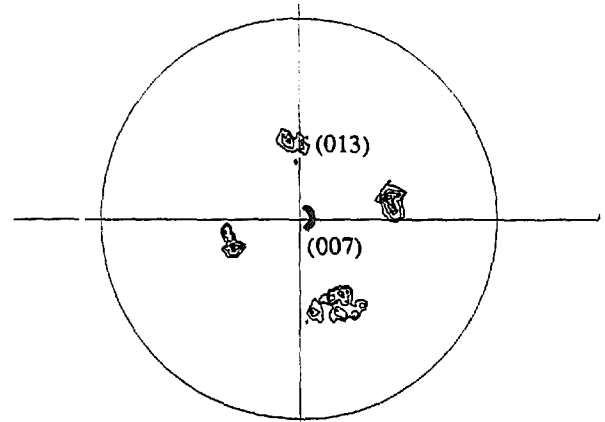


FIGURE 2

(007) and (013) pole figures of a ceramic textured by a zone melting process.

Three pole figures of a YBaCuO thin film grown by CVD on (100) oriented MgO substrate⁴ were analyzed. The extension of the (007) pole shows that the c-axis of the crystallites are perpendicular to the substrate with a dispersion of about 2° . The (013) and (113) pole figures clearly show a strong in plane texturing.

In conclusion the pole figure technique is an effective way to determine the texture of oriented YBaCuO materials and provides more information than Bragg diffraction scans. For well aligned samples strong textures can be quantified.

ACKNOWLEDGMENTS

The authors thank the CRTBT (Grenoble), Alcatel-Alsthom Recherche (Laboratoires de Marcoussis), and the LMGP (St Martin d'Hères) for providing the samples.

REFERENCES

1. L. G. Schulz *J. Appl. Phys.* 20 (1949) 1030.
2. M. Lees et al., *Proc. ICMAS 90 (IITT International)* pp 49-54.
3. A. Vicker *Journées SEE (Caen 1990 France)*
4. O. Thomas et al., *Int. Workshop on HTCS thin films (Rome 1991)*