Supercond. Sci. Technol. **19** (2006) 190–199 doi:10.1088/0953-2048/19/2/007

EBSD study on YBCO textured bulk samples: correlation between crystal growth and 'microtexture'

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Received 24 August 2005, in final form 11 November 2005
Published 10 January 2006
Online at stacks.iop.org/SUST/19/190

Abstract
This work describes an electron backscattered diffraction (EBSD) study of the perovskite-derived structures $YBa_2Cu_3O_{7-\delta}$. After having pointed out the difficulties of EBSD analyses in resolving the orientations of these pseudo-cubic structures, various YBaCuO bulk samples are analysed and the correlation between the microstructure, crystal growth and global texture, determined by neutron diffraction, is carried out. Homogeneous 'microtexture' with small subdomain misorientation of 12° are measured for YBCO top seeding melt textured growth (TSMTG) samples. YBCO perforated samples also exhibit misoriented subdomains, giving rise to a heterogeneous 'microtexture' correlated to the YBCO growth front and to the pattern used for the perforating.

(Some figures in this article are in colour only in the electronic version)

1. Introduction

The quantitative determination and interpretation of crystallographic textures is of fundamental importance in materials like $YBa_2Cu_3O_{7-\delta}$ (Y123) in which the anisotropic character is aimed to be used in practical applications. The well-established x-ray or neutron diffraction quantitative texture analysis (QTA) global techniques can nowadays be complemented by local orientation determinations like microbeam Laue diffraction [1, 2], sometimes called *'microtexture'* analyses. Local orientation determinations have received increasing attention with the development of EBSD mounted on scanning electron microscopes (SEMs) [3], because they provide microstructural insights such as grain orientation mapping or misorientation distribution functions. The main drawback of global techniques is the lack of possible correlation of the crystallographic orientation information with the microstructure, but they do however provide other crucial information on microstrain, crystallite sizes, structure, phase fractions, residual strains and so on in their developments called 'combined analysis' [4]. Global techniques provide information on all these parameters in a statistically relevant way in terms of number of probed crystallites, because they analyse large volumes, typically at the cubic centimetre scale for neutrons, and moreover 10^4 times less for x-rays in such materials. Local characterization obtained by EBSD could in principle probe for structure determination, residual stresses and so on but up to now these approaches have not been developed. However, the great advantage of EBSD lies in its capabilities to provide spatial location of the grains coupled [5] with crystal information such as phase, orientation, crystallinity, and grain boundaries.

2. Experimental details

2.1. Classical top seeding melt textured growth (TSMTG) process

The practical applications of the bulk superconductors $YBa_2Cu_3O_{7-\delta}$ depend crucially on the quality of the texture in the material and, more precisely, on the grain boundary misorientations [6–8], which are known to influence detrimentally the transport critical current density [9–15]. As a ceramic, Y123 specimens can encounter typical

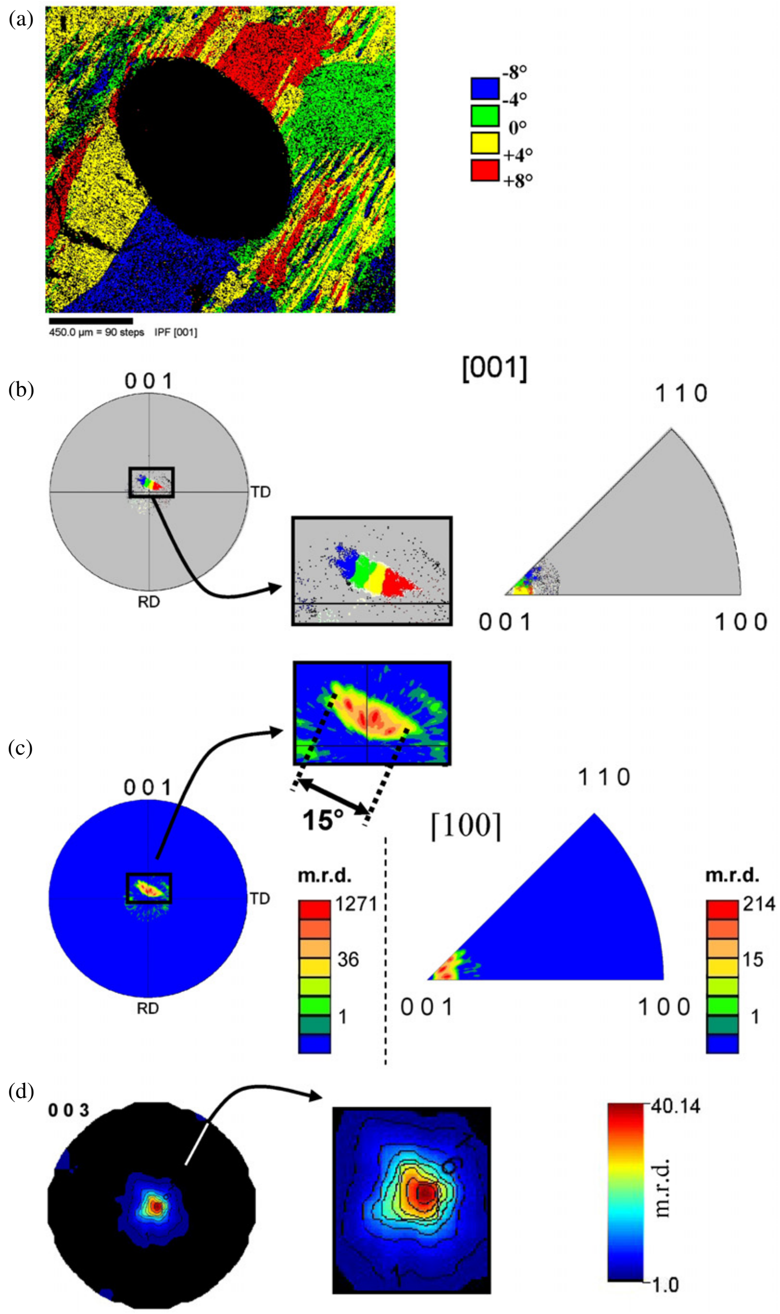

Figure 8. (a) Misorientation map calculated from 001 pole figure data; (b) unnormalized (001) pole figure (stereo area projection) and [001] inverse pole figure; (c) calculated (001) pole figure (logarithm density scale, stereo area projection) and calculated [001] inverse pole figure (logarithm density scale) and (d) calculated neutron (003) pole figure (logarithm density scale, stereo area projection).

the holes, in order to detect eventually more local texture perturbations introduced by hole patterning. The sample characterization (figure 6) was performed following the same procedure as for the classical TSMTG pellets. We present here a detailed study of the zone located around one hole (figure 7).

Image quality mapping of the sample (figure 7(a)) reveals that low IQ indices are located on a 25 μm thick zone around the hole and cracks. The associated EBSD patterns shown for the matrix in this region clearly show the worse quality of the near-hole diagram. Interestingly, the associated phase distribution map (figure 7(b)) suggests a high concentration of Y211 inclusions near the holes and cracks. This could result from a worse image quality as an overall feature for Y211 patterns. However, the IQ levels are typically the same for both Y211 and Y123 phases, and EDX analyses under SEM could not evidence composition variations near holes. But areas close to holes (or cracks) also are less planar and regular. Since EBSD is very sensitive to surface perfection, this confusing indexing is attributed to it.

The Y123 growth remains strongly textured, as denoted by the inverse pole figure map calculated for the direction of hole axes (Z-direction, figure 7(c)). But the orientation