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Laser Induced Circular Texture in Bi-2212 bulk

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Introduction

Laser Zone melting (LZM) has been widely used to induce texture in Bi-2212 bulk materials, both in cylindrical geometries and in monolithic planar samples. Texture is induced due to its strong crystal structure anisotropy, obtaining a microstructure characterized by planar superconducting grains with the a-b plane aligned perpendicular to the solidification front.

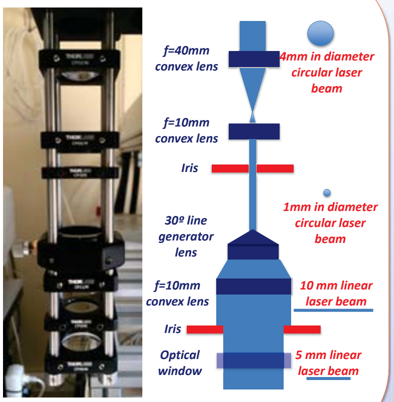
In this work we present the use of Laser Zone melting techniques to process planar monolithic samples either with a ring geometry or with more complex shapes, such helical, or meander, where the current path direction is not constant, and therefore superconducting grains have to change their growth direction. Combining different sample movements LZM processing it is possible to assure that the solidification front is always perpendicular to the current path direction. We have performed a microstructural analysis of these samples in order to analyse the effect of changing growth direction during processing for the different analysed geometries.

Laser processing set-up

A linear laser beam has been obtained combining different cylindrical lenses. This produces a linear laser beam but with a gaussian energy distribution. The laser is a CW Nd-YAG continuous system. Sample is placed on a rotating platform that can be hitched to a linear stage to obtain a movement combination for different geometries.

Different geometries processed with this set-up.

Circular or helical geometries have been fabricated. In order to improve the energy homogeneity in the laser beam a new optical system has been designed.

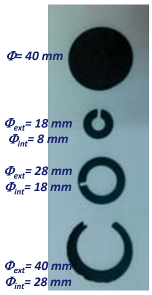


Texturing process

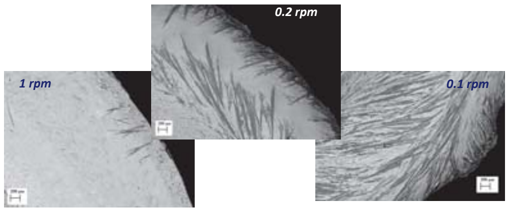
Circular samples (disks or rings) with external diameters between 18 and 40 mm have been processed. The width of the rings was 5 mm.

Before the texturing treatment initial rotation steps are performed at 1, ,0.7, 0.5, 0.3, 0.2, 0.15 and 0.1 rpm in order to initiate the densification process.

Typical rotation speeds between 0.01 rpm and 0.1 rpm have been used in the final texturing process.



Different ring precursors obtained from a 40 mm in diameter disk using a laser cutting protocol.



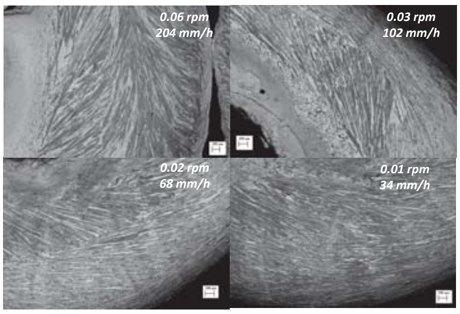
Evolution of the texture in the surface of the processed samples during the initial rotation steps performed before the texturing process.

Influence of the rotation speed

At high speeds the surface microstructure shows a central structure whose origin are grains nucleated in both lateral borders of the textured region.

At intermediate speeds two different regions are observed. The internal one with big grains and a high misorientation with respect to the tangential direction. The external region has smaller grains but with a better alignment.

At lower speeds, this external region increases. It has been observed that this region is the most important in the sample for rotation speeds of 0.01 rpm in samples with an external diameter of 18 mm (linear speed, 34 mm/h).

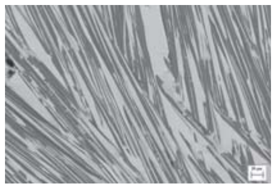


Changes in microstructure associated with different rotation speeds in samples with external diameters of 18 mm.

Developing of the texture in the longitudinal and transverse sections

Solidification front in a sample with an external diameter of 18 mm and processed at 0.01 rpm

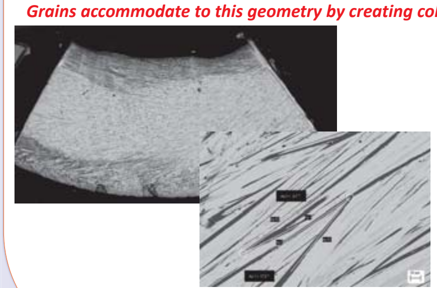
Grain orientation in the same sample



Detail of the grain orientation: black contrast Bi-free phases, grey contrast Bi rich Bi-2201 phase

It is important to control the shape of the solidification front. Grain texture has been determined by measuring the orientation of the Bi-free phases (black contrast in the images). Bi-2201 grains are near parallel. Bi-2212 are obtained after annealing following a similar microstructure.

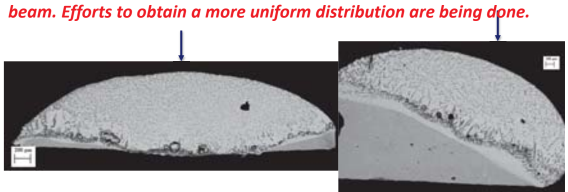
Grains accommodate to this geometry by creating colonies with misorientation angles of the order of 10-25º.



Changes in the microstructure after having polished the upper 143 microns

When the external part of the sample is polished, the amount of Bi-free phases is strongly reduced.

The transverse cross section of the samples shows a thickness distribution that reflects the gaussian energy distribution of the laser beam. Efforts to obtain a more uniform distribution are being done.



Cross sections of different samples. Arrow indicate the centre of the laser beam with higher energy due to the gaussian energy distribution

Conclusions

Laser can be used to texture Bi-2212 materials in circular geometries. Superconducting Bi-2212 grains can accommodate to circular geometries with a microstructure based on grain colonies with grain boundary angles of the order of 10-25º when low rotation speeds are used.

When rotation speed is increased two different regions are clearly observed in the samples.

This can be used to process samples with circular, helical or meander geometries with lower anisotropy in the microstructure than when the stardard linear process is used. More homogeneous energy distributions are required to improve the microstructure of these samples.

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