Texture measurements on thin films using an X-ray microfocus source

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Introduction

The Incoatec Microfocus Source IµS is a 30 W air-cooled sealed tube (Fig. 1). It is combined with 2D beam shaping multilayer optics. Specas of often used optics are given in Table 1. The IµS in detail:

- high brilliance
- < 50 µm spot size
- 30 W and air-cooled
- Cu, Mo, Cr and Ag radiation available
- convenience of sealed-tube

Useful accessories
- detectors for beam characterization
- collimators
- pumps + vacuum gauges

IµS System with optics housing and 19° wide generator

Table 1: Different types of standard Quazar optics (others on request)

<table>
<thead>
<tr>
<th>type</th>
<th>length (mm)</th>
<th>divergence (deg)</th>
<th>beam size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E 23 (Mo)</td>
<td>focusing</td>
<td>150</td>
<td>0.28</td>
</tr>
<tr>
<td>E 31 (Cu)</td>
<td>focusing</td>
<td>150</td>
<td>0.69</td>
</tr>
<tr>
<td>E 32 (Cu)</td>
<td>collimating</td>
<td>60</td>
<td>0.06</td>
</tr>
<tr>
<td>HY (Cu)</td>
<td>hybrid</td>
<td>60</td>
<td>0.24 x 0.06</td>
</tr>
</tbody>
</table>

The IµS can be used for different applications, stress and texture measurements, (GI)SAXS, phase identification, or single crystal diffraction to name but a few.

The IµS with copper anode and collimating optics was integrated in a Bruker D8 GADDS-system (Figure 1, right) with eulerian cradle and VÅNTEC2000-detector. This setup was used for pole figure measurements on nano particles.

The Sample

The superconductor YBa۲Cu۳O۷ (YBCO) was deposited on a strontium titanate substrate (SrTiO۳) using chemical solution deposition. An Hf-compound was added to the chemical precursor in order to form BaHfO۳ nanoparticles with a size of 10 to 20 nm inside the YBCO matrix acting as pinning centers for an improvement of the critical current density Jc in magnetic fields. The main goal of the measurement was to clarify the orientation distribution of the BaHfO۳ nanoparticles with respect to the epitaxially grown YBCO matrix. In Fig. 2 a frame recorded with the GADDS system is shown. The (0 0 6) spots of the single crystalline SrTiO۳ and of the epitaxially grown YBCO are clearly visible together with (1 1 0) and (0 0 2) Scherrer rings from BaHfO۳. Additionally, a small (0 0 2) peak was found at 2θ ≈ 30° arising from an epitaxial BaHfO۳ component.

Conclusion

The measurements indicate, that the majority of the nanoparticles are randomly incorporated in the YBCO matrix. Nevertheless, it was possible to measure a (1 1 0) pole figure of the epitaxially grown BaHfO۳ fraction (Fig. 3), which has a fourfold-symmetry similar to the YBCO layer. With a modern set-up it is possible to perform a complete pole figure measurement in less than one hour.

Acknowledgements

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Fig. 3: Pole figure of the BaHfO۳ (1 1 0) reflex (left) and the YBCO (0 0 4) reflex (right). A strong orientation of the crystals is clearly visible.

Fig. 4: Frame recorded during the pole measurement at 2θ=31°, ω=18.7°, χ=54.3°, exposure time 20 seconds. The Scherrer-ring of the BaHfO۳ (1 1 0) peak is visible together with the (0 0 4) and (0 0 3) spots of YBCO.