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. Specs of often used optics are given in Table 1.
The IμS in detail:

The source
- high brilliance
- $< 50\ \mu m$ spot size
- 30 W and air-cooled
- Cu, Mo, Cr and Ag radiation available
- convenience of sealed-tube

The optics
- new Montel type optics named Quazar
- 2-dim beam shaping
- collimating (LD), focussing (SCD) or collimating + focusing (hybrid)
- patented housing for high stability and easy alignment
- motorized alignment (optional)

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

IμS System with optics housing and 19" wide generator

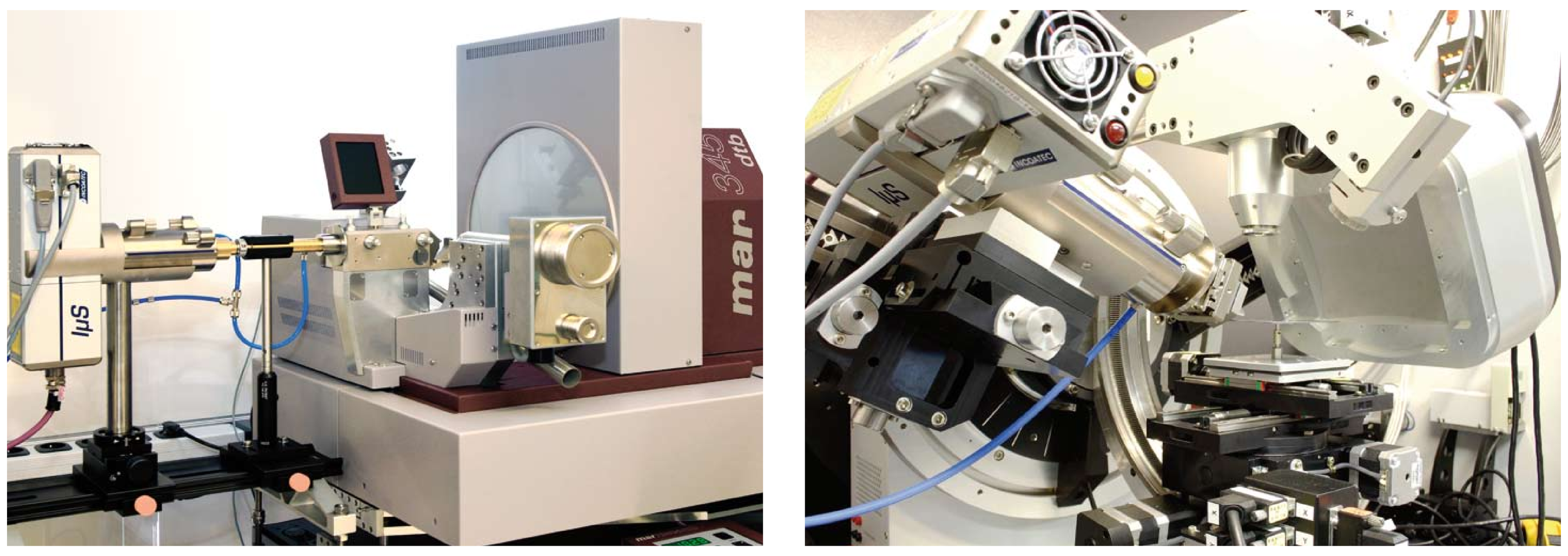


Figure 1: IμS System integrated in a mar desktop beamline (left) and in a Bruker AXS GADDS system (right).

	type	length (mm)	divergence (deg)	beam size (mm)
E 23 (Mo)	focusing	150	0.28	0.12
E 31 (Cu)	focusing	150	0.69	0.23
E 32 (Cu)	collimating	60	0.06	0.65
HY (Cu)	hybride	60	0.24 x 0.06	0.65 x 0.18

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

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 $YBa_2Cu_3O_7$ (YBCO) was deposited on a strontium titanate substrate ($SrTiO_3$) using chemical solution deposition. An Hf-compound was added to the chemical precursor in order to form $BaHfO_3$ nanoparticle with a size of 10 to 20 nm inside the YBCO matrix acting as pinning centers for an improvement of the critical current density J_c in magnetic fields. The main goal of the measurement was to clarify the orientation distribution of the $BaHfO_3$ nanoparticles with respect to the epitaxially grown YBCO matrix.
In Fig. 2 a frame recorded with the GADDS system is shown. The (0 0 l) spots of the single crystalline $SrTiO_3$ and of the epitaxially grown YBCO are clearly visible together with (1 1 0) and (0 0 2) Scherrer rings from $BaHfO_3$. Additionally, a small (0 0 2) peak was found at $2\theta \approx 30°$ arising from an epitaxial $BaHfO_3$ component.

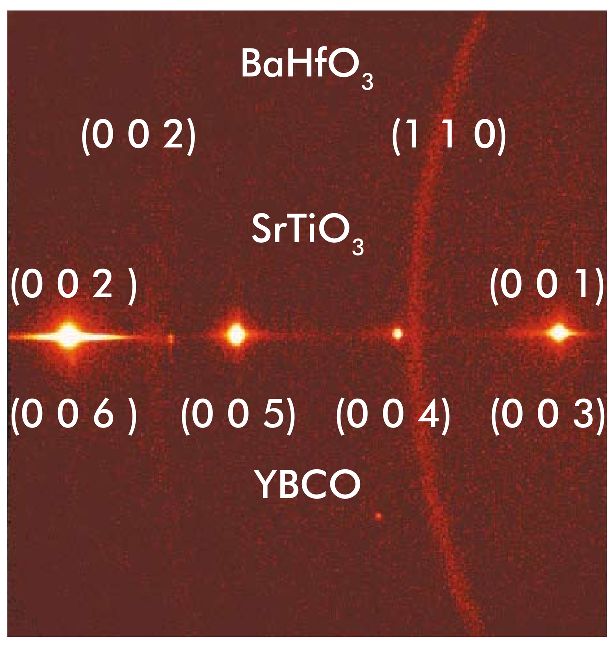
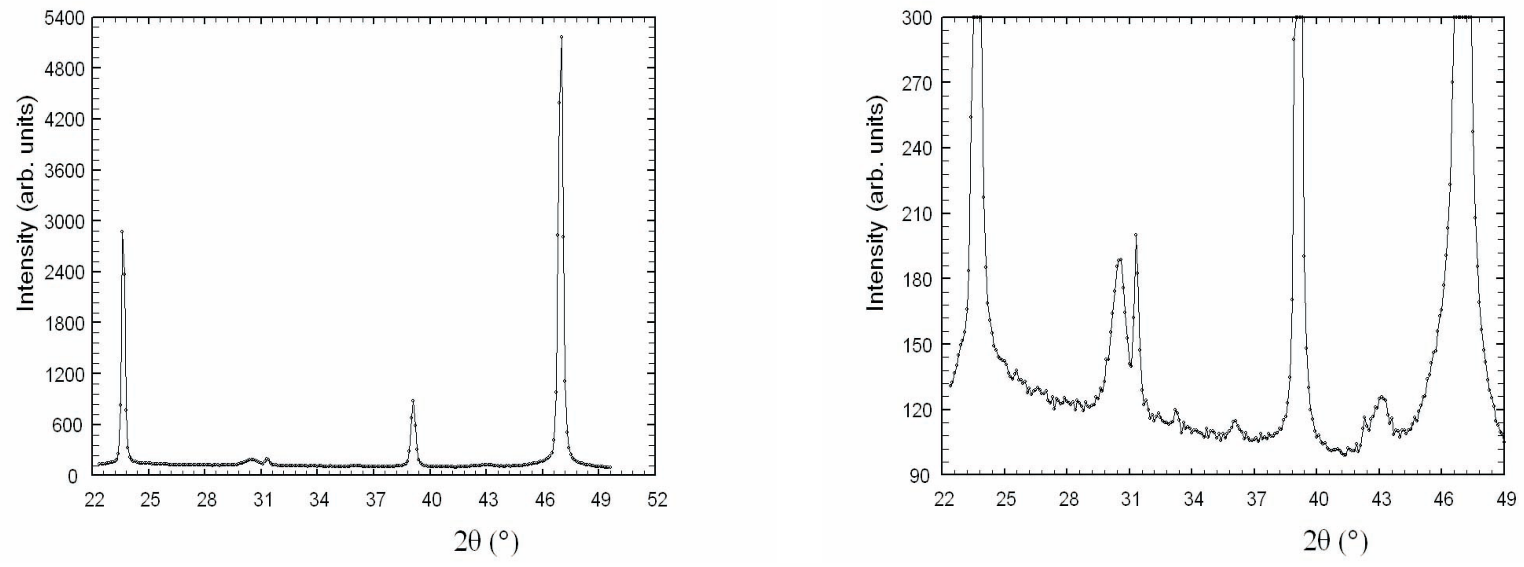


Fig. 2: Frame of the sample with the 2θ-range from 22° to 49° with 600 s exposure time. During exposure the sample was rotated in ω, so the Bragg-conditions for the YBCO spots are fulfilled. The integration of the frame is shown below.



To measure a pole figure of the (1 1 0) reflex of the $BaHfO_3$, with the program MULTEX (Bruker AXS) a measurement scheme of 126 frames was planed, covering the χ-range up to 65°. The frames were recorded with 20 s exposure time each resulting in a total measurement time of about 50 minutes including all movements. Pole figures calculated with MULTEX are shown in Figure 3. The similarity of the orientation is also visible in the frame shown in Figure 4.

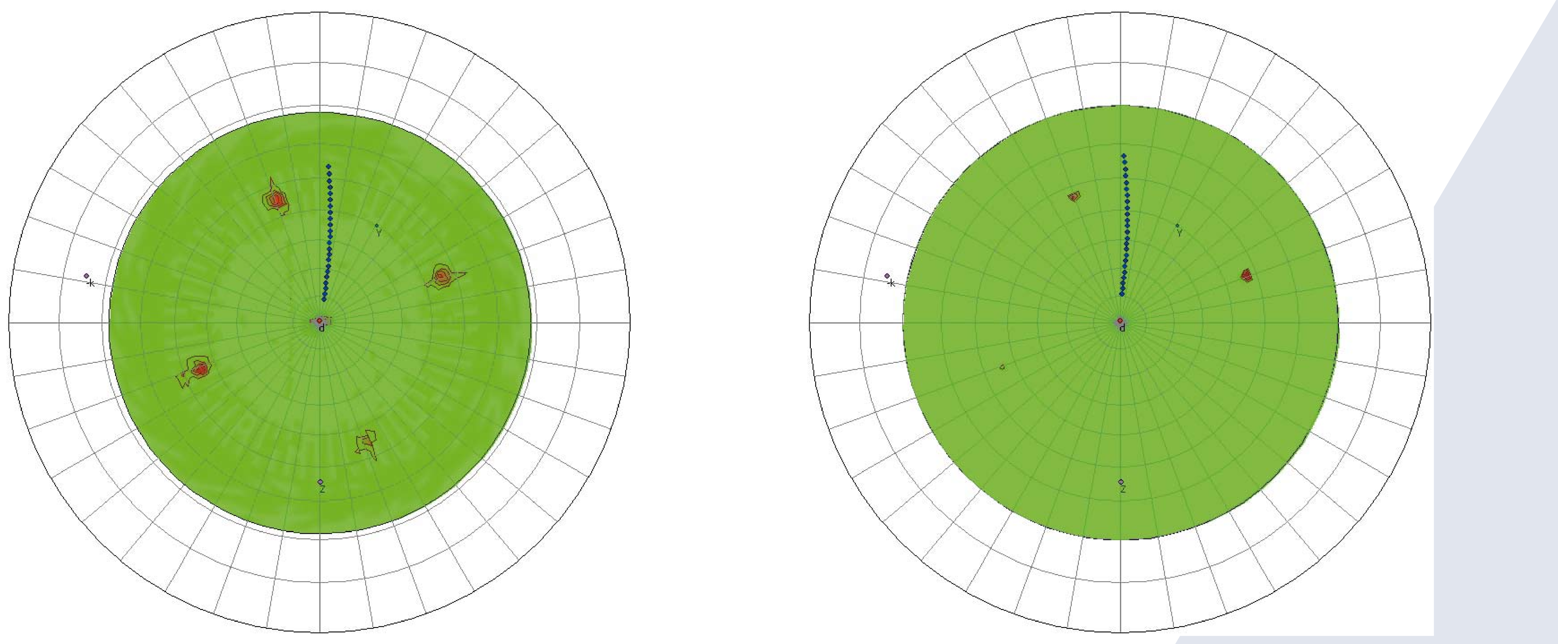


Fig. 3: Pole figure of the $BaHfO_3$-(1 1 0) reflex (left) and the YBCO (0 0 4) reflex (right). A strong orientation of the crystals is clearly visible.

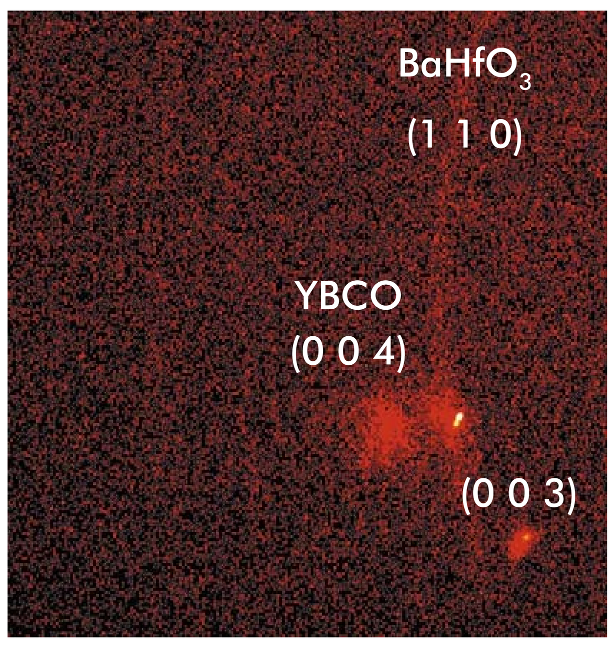


Fig. 4: Frame recorded during the pole measurement at $2\theta=35°$, $\omega=18.7°$, $\chi=54.3°$, exposure time 20 seconds. The Scherer-ring of the $BaHfO_3$ (1 1 0) peak is visible together with the (0 0 4) and (0 0 3) spots of YBCO.

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 $BaHfO_3$ 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

The sample was kindly provided by Bernhard Holzapfel, Thomas Thersleff and Ruben Hühne, Leibniz-Institute for Solid State and Materials Research (IFW) Dresden, Germany. Their help also during the data interpretation in gratefully acknowledged. Many thanks also to Kurt Erlacher, Kurt Helming and Hugues Guerault, Bruker AXS, Karlsruhe, Germany, for help during the measurements.

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