New Developments in Laboratory Microfocus X-ray Sources

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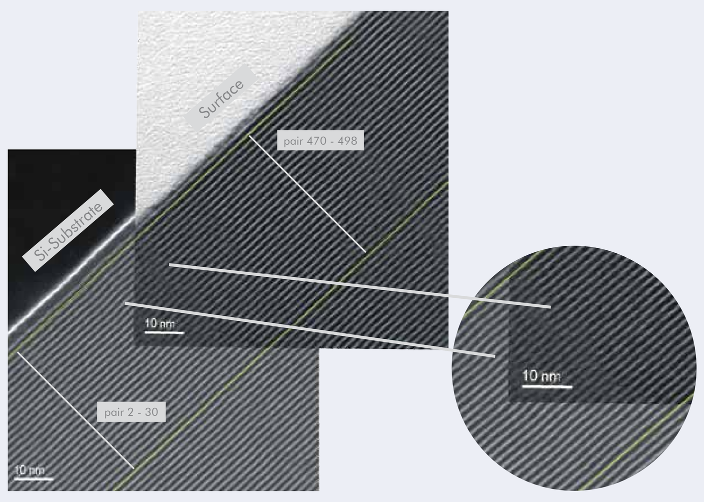
Multilayer Optics Production

At Incoatec we design, manufacture and characterize X-ray optics with optimized properties for customized applications. The multilayer materials, the layer thickness profile, the substrate shape and even complete beam paths are optimized by simulation with the ray tracing method.
Our X-ray optics are graded multilayers which are deposited by magnetron sputtering, a very reliable and reproducible deposition method ensuring homogeneities of ±0.2 % on 6" wafers and allowing coatings on up to 150 cm in length. Thin, single layer optics are produced for total reflection applications. We have experiences with more than 40 different types of layer materials.

Characterization

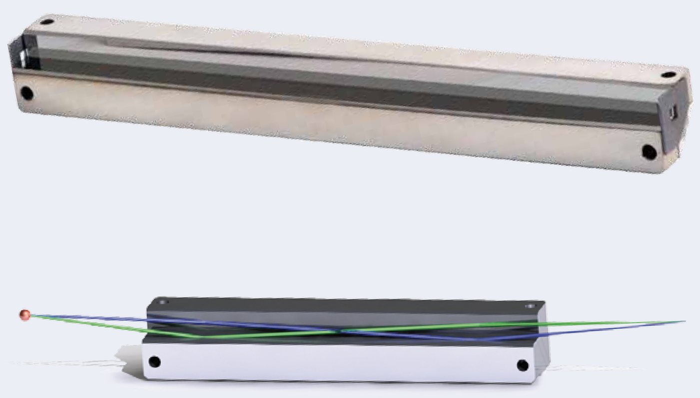
The manufacturing process of most of the optics includes shaping substrates by bending silicon wafers. Their quality is tested with optical profilometry methods. The vertical resolution of our profile is well below 10 nm, and the angular resolution is below 1 arcsec. Typically, silicon wafers which are bent and glued onto backing plates show slope errors of about 5-10 arcsec. For high-end applications in high resolution XRD we use prefigured substrates which achieve slope errors below 1 arcsec or 1/3600 deg. We test the quality of the grown thin films by X-ray reflectometry. With transmission electron microscopy (TEM) images we can further show the perfect stacking throughout the multilayer.



TEM image of a multilayer with 500 pairs of layers. The magnification shows a perfect matching of the layer thickness throughout all pairs. (Prof. Jäger, University of Kiel)

Beam Shaping in 2D with Montel Optics

Montel optics are two mirros mounted side-by-side in an L-shape enabling a 2-dimensional beam shaping. A Montel optics with two elliptically shaped mirrors is point focusing, whereas two parabolic mirrors enable a collimated beam. A line focus is created with a hybrid optics, a combination of an elliptic and a parabolic mirror. The quality of the beam shaping due to the optics is demonstrated by the beam properties in the focus. The Montel optics accumulate a lot of flux within a well-shaped, gaussian-like spot of expected size measured by 2D detectors or pin diodes. Nowadays, Montel optics are also used at synchrotrons, where they substitute the KB (Kirkpatrick-Baez) mirrors achieving a more compact design.



Montel optics (top) and corresponding optical scheme (bottom) of a focusing multilayer mirror.

The Incoatec Microfocus Source IμS$^{High\ Brilliance}$

Five years after the successful launch of the IμS, we are introducing the next generation: the new Incoatec Microfocus Source IμS$^{High\ Brilliance}$. This new source includes all familiar advantages of the previous IμS system: air-cooling, no moving parts, long lifetime without maintenance and it combines the advantages of a sealed-tube system with the superior data quality of conventional rotating anode systems. The new IμS$^{High\ Brilliance}$ includes the latest type of Montel optics and delivers compared to the classic IμS an increase in intensity of about 30% for Cu, 50% for Ag and 60% for Mo. Furthermore, integrated memory chips enable faster, better and easier remote diagnostics and service.

The source

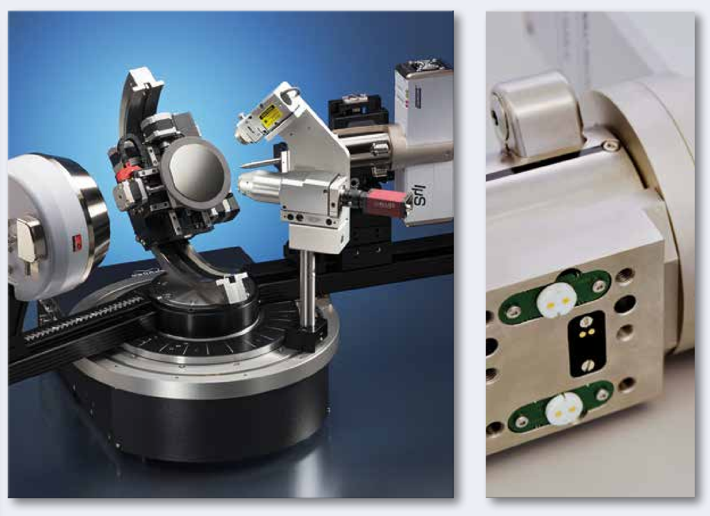
- air cooled
- Cu, Mo, Ag, Cr and Co available
- component recognition
- improved safety features
- fully compliant with Machinery Directive 2066/42/EC

Quazar Optics

- 2-dim beam shaping
- collimating or focussing
- patented housing for high stability and easy alignment
- motorized alignment (optional)

Optics	Divergence (mrad)	Focal size (μm)	Flux (10^8 ph/s)	Flux density (10^9 ph/(s/mm^2))
SAXS (Cu)	1.0	800	> 2.1	
Cr	1.0	800	> 1.2	
Co	1.0	800	> 1.5	
SAXS ultra (Cu)	0.5	2000	~ 5.0	
SAXS (Mo)	0.5	650	> 0.16	
Cu	5.1	250	> 7.8	> 6.5
Cr	5.1	330	> 5.0	> 1.5
Co	5.1	280	> 2.0	> 3.0
Mo	4.9	110	> 0.3	> 1.9
Ag	4.9	95	> 0.1	> 0.9

Standard models of the IμS$^{High\ Brilliance}$ (others on request).

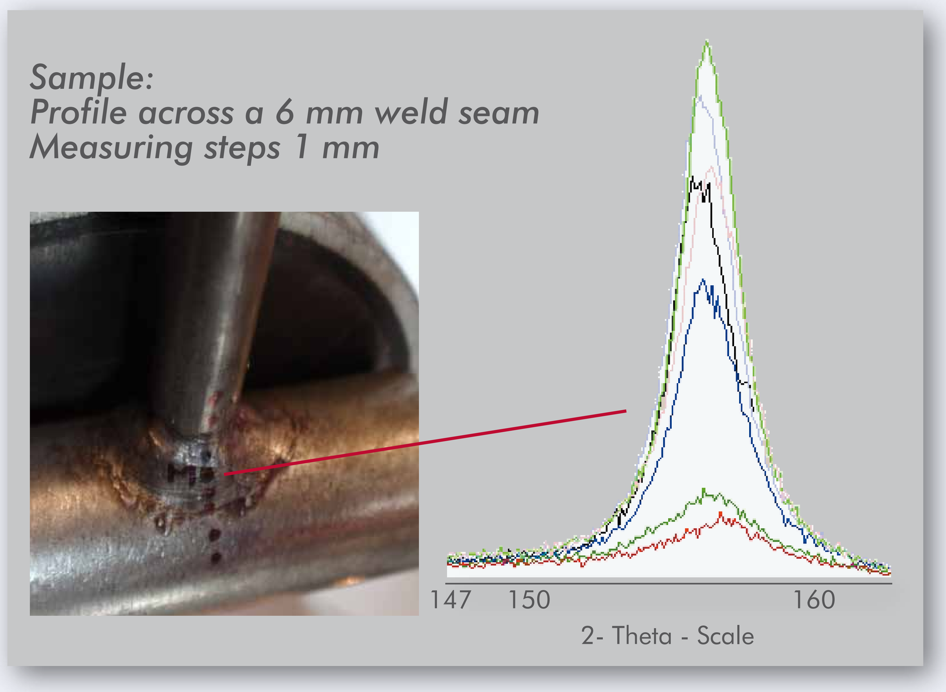


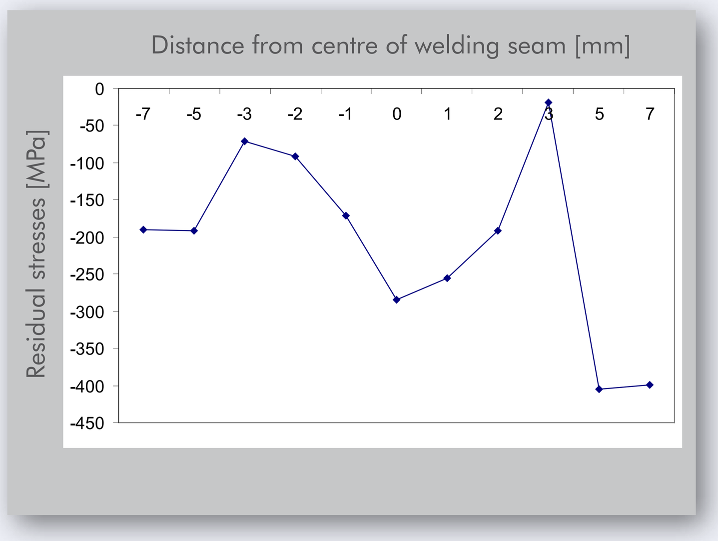
D8 Advance: XRD^2 system with IμS$^{High\ Brilliance}$ (left). Integrated memory chips store information provided by the manufacturer and during use (right).

IμS with Cr Radiation

Best for Position Sensitive Stress Analysis

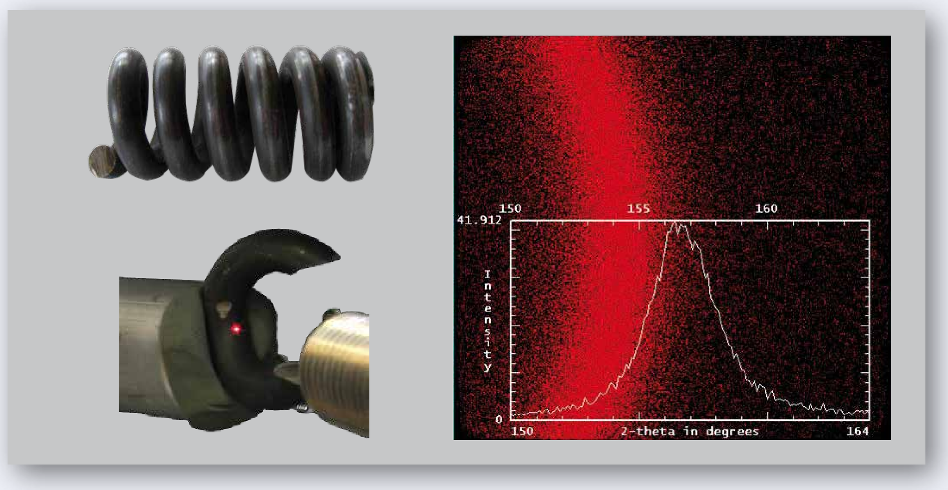
Using a 15W Cr-IμS measurements of samples containing iron are possible without exciting fluorescence radiation. This source with a focussing optics can also be used for position sensitive measurements on steel parts, for example across a welding seam. The spot size of the focal point of the beam is 330 μm. Measurements in steps of 1 mm are possible as shown in the example.

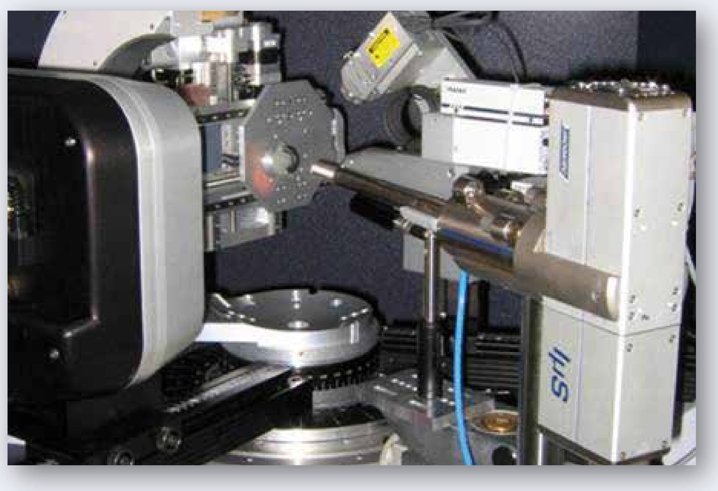


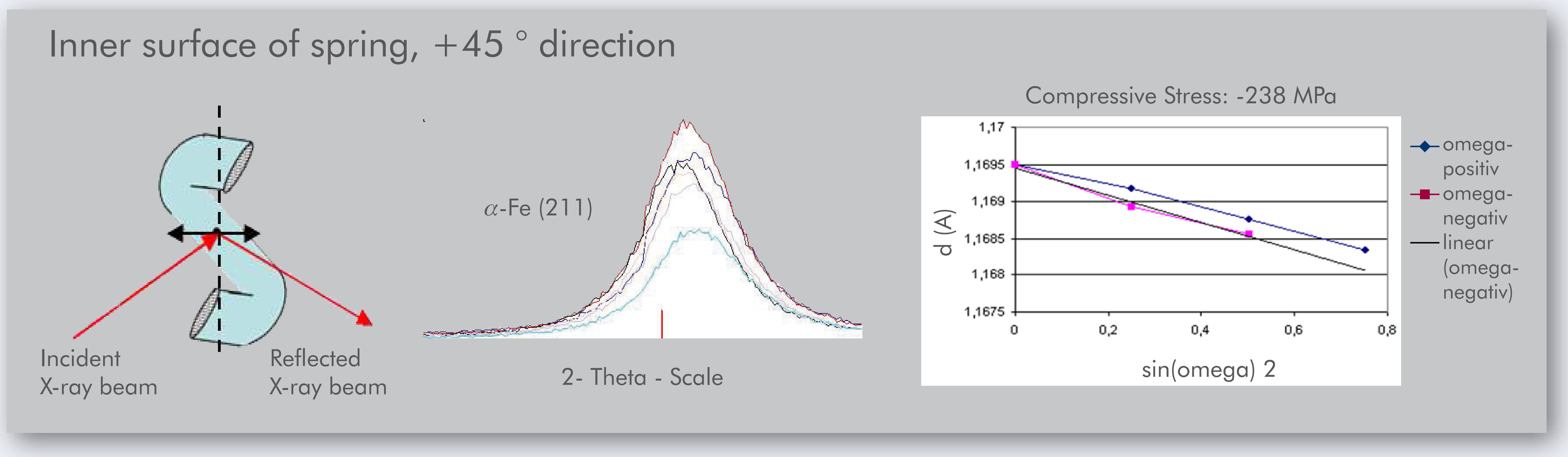


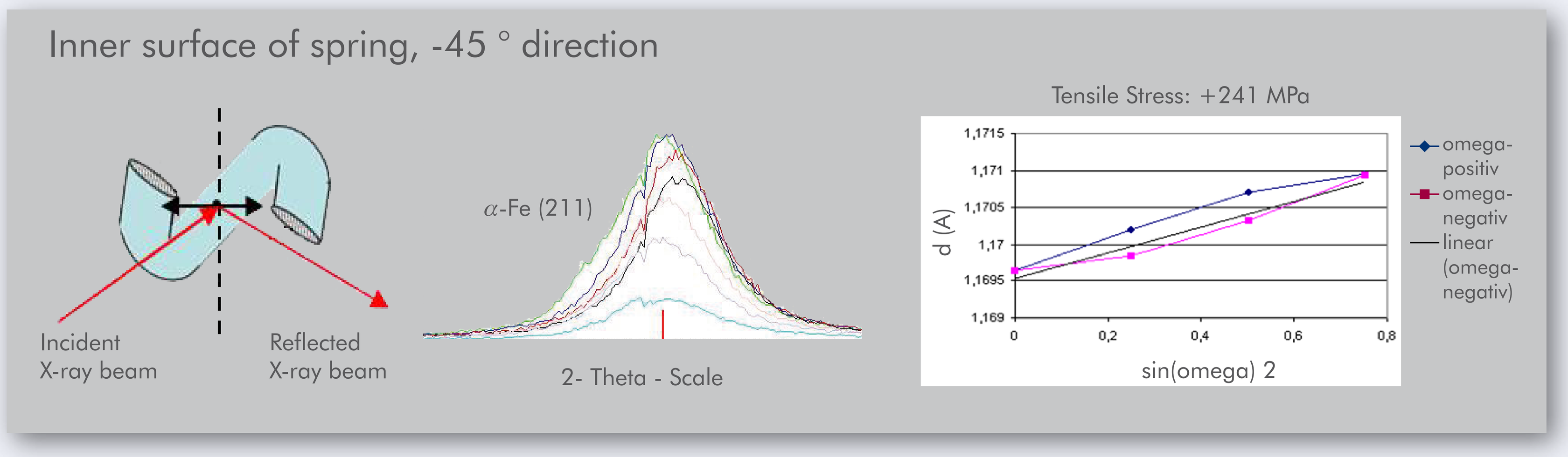
Fast Stress Analysis with High Local Resolution: Steel Spring

Mounting of the Cr-source to a Bruker-GADDS system with VÅNTEC2000 detector allows fast measurements. With this setup stress measurements on a steel spring are possible. Each frame was recorded within 30 seconds.



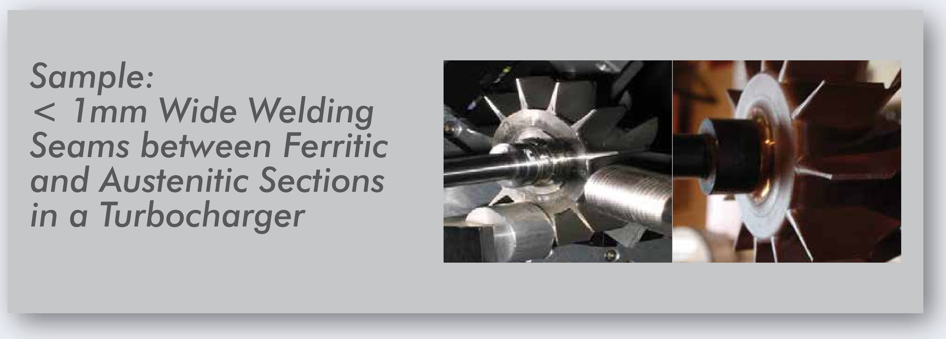


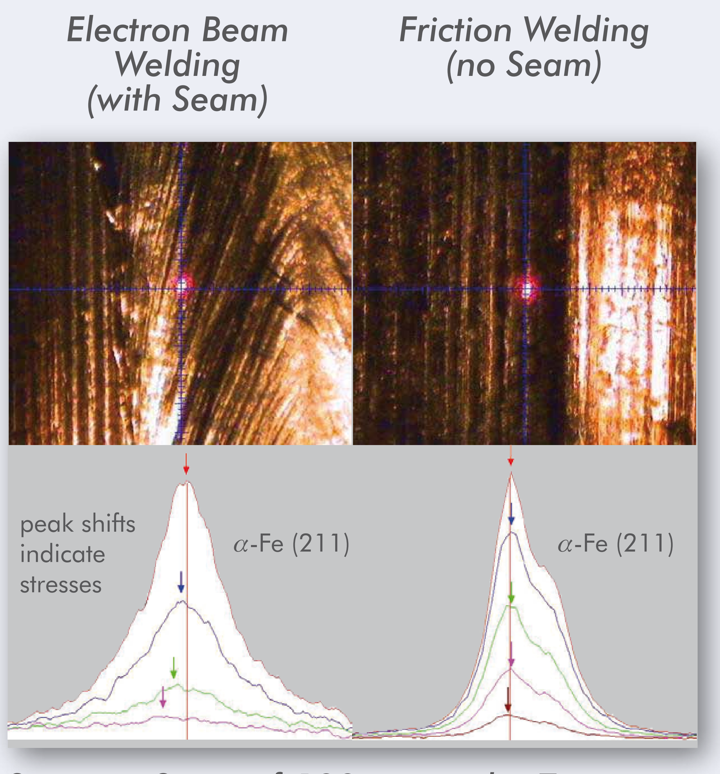




Diffraction Measurements with High Local Resolution

The small spot size of 330 μm (FWHM) of the Cr-source allows measurements with high local resolution. The welding seams between ferritic and austenitic sections of turbocharger were investigated. In electron beam welded components a peak shift across the weld could be observed indicating residual stresses within the structure. Such observations were not done within friction welded components.





Scans in Steps of 100 μm at the Transition between Ferrite (Axis) and Austenite (Turbine).

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