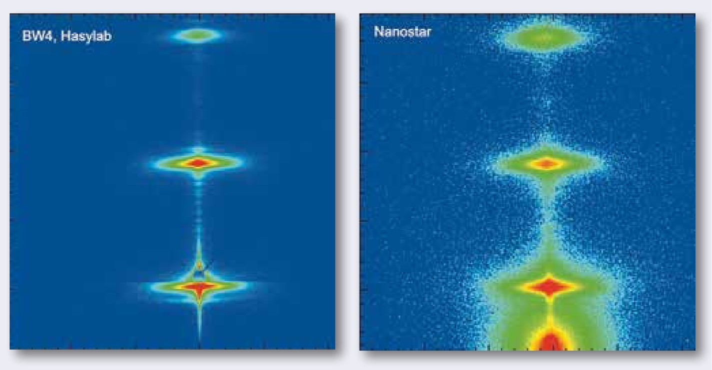
Applications with the Incoatec Microfocus Source IμS

IμS for Small Angle X-ray Scattering

Grazing Incidence SAXS of thin films

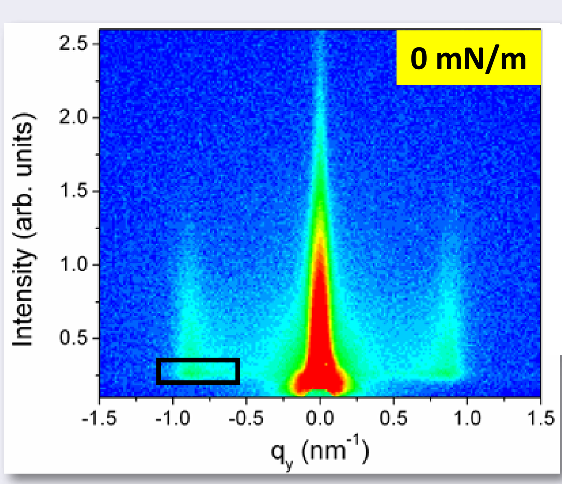
The development of Bruker´s NANOSTAR with integrated IμS allows measurements, which usually need synchrotron facilities, to be performed in the home-lab. The figures show the results of a Mo/Si multilayer measured with the NANOSTAR and the synchrotron beamline BW4 at the Hasylab. Both measurements clearly show three Bragg sheets. In comparison the NANOSTAR results have a higher background and thus a lower resolution. However, all features required for data processing are visible. This striking result gives the opportunity to plan future experiments without the restriction of beamline time. Due to the IμS the NANOSTAR now enables a more efficient use of synchrotron beamline time and gives the opportunity to envision e.g. time- or temperature-resolved long-term experiments.

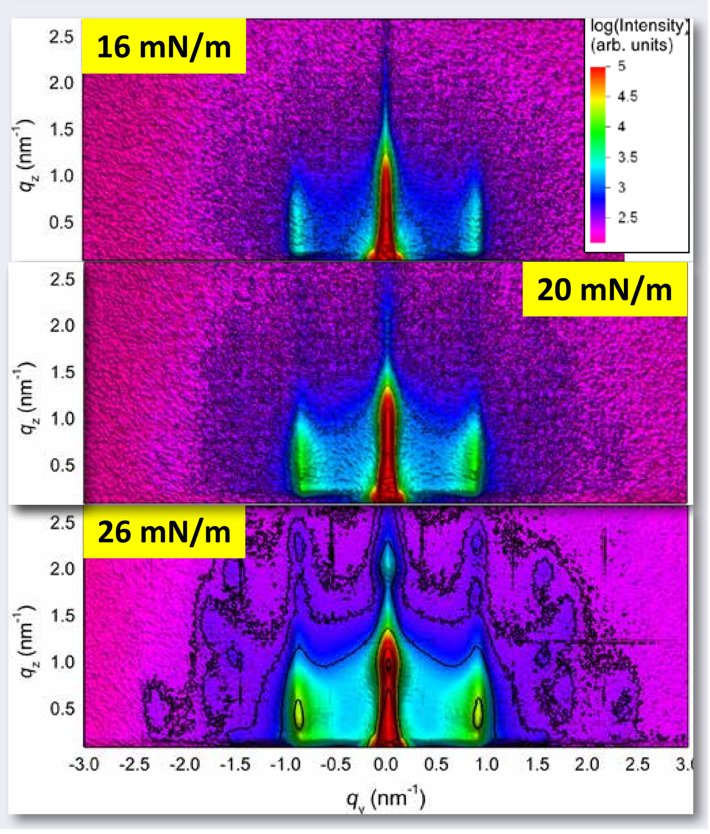


In-situ GISAXS with liquid samples

For rapid GISAXS measurements of liquid samples our IμS was combined with a Dectris Pilatus detector. Silver particles on a Langmuir film were analyzed at different surface pressures which were applied by means of a reduction of the surface area. It was possible to study the formation process from unordered islands to ordered layers by increasing the pressure on the surface.

Measurement details:
- angle of incidence: 0.2deg
- measurement time: 180 sec
- aperture 350 μm
- the surface was pressed with 0 up to 26 mN/m

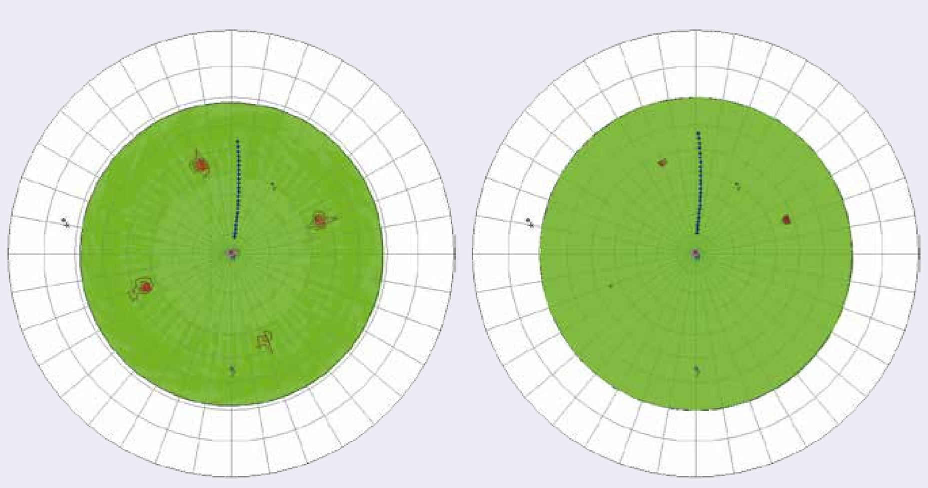


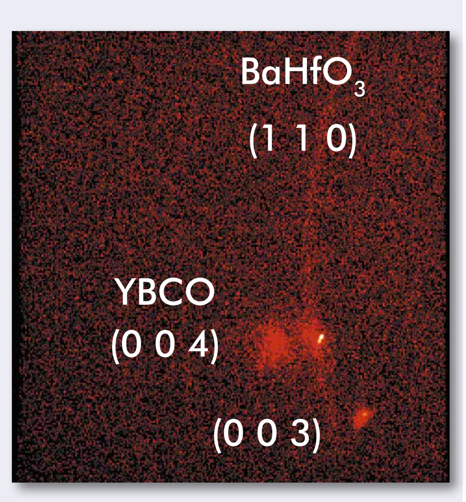


Unpressed surface: islands of nanoparticles are swimming on the surface without connection (top)
Increased surface pressure: intensity increases, islands coalescence (right)
at 26 mN/m: "crystal" peaks appear, vertical formation of hexagonal layers

IμS for Texture Measurements

Sample: $BaHfO_3$ nanoparticles (10-20 nm) in a YBCO matrix (thin film on $SrTiO_3$)
Experimental: Cu-IμS + collimating optics in a Bruker D8 GADDS with eulerian cradle and VÅNTEC2000-detector, total measuring time < 50min.
Result: 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, which has a fourfold-symmetry similar to the YBCO film. With this set-up it is possible to carry out a complete pole figure measurement in less than one hour.

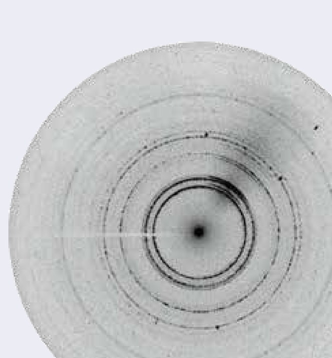


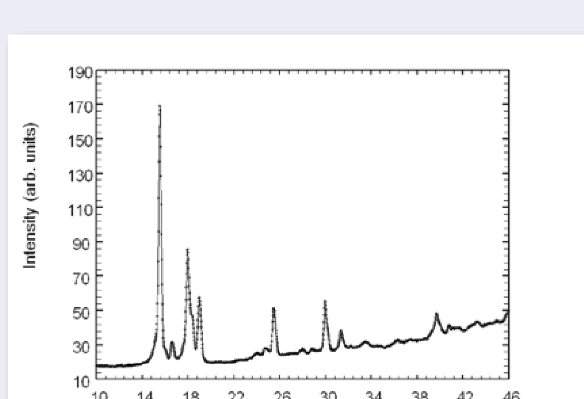


Pole figure of the YBCO (004) reflex (left) and $BaHfO_3$ (110) reflex (middle). Frame (right) at $2\theta=35°$, $\omega=18.7°$, $\chi=54.3°$, exposure time 20 seconds. The Scherrer-ring of the $BaHfO_3$ (1 1 0) peak is visible together with the (0 0 4) and (0 0 3) spots of YBCO.

Measurements in Diamond Anvil Cell with Ag-IμS

Due to its high energy of 22.2 keV silver radiation can easily penetrate diamond anvil cells without much absorption. Another advantage is, that more intensities are in the same 2θ-space compared to measurements with radiation of lower energy, e.g. copper or molybdenium. In this example a measurement of a red color pigment, Pigment Red 170, is shown. The measurement was performed at a mardtb with an imaging plate detector mar345 with 20 minutes exposure time.

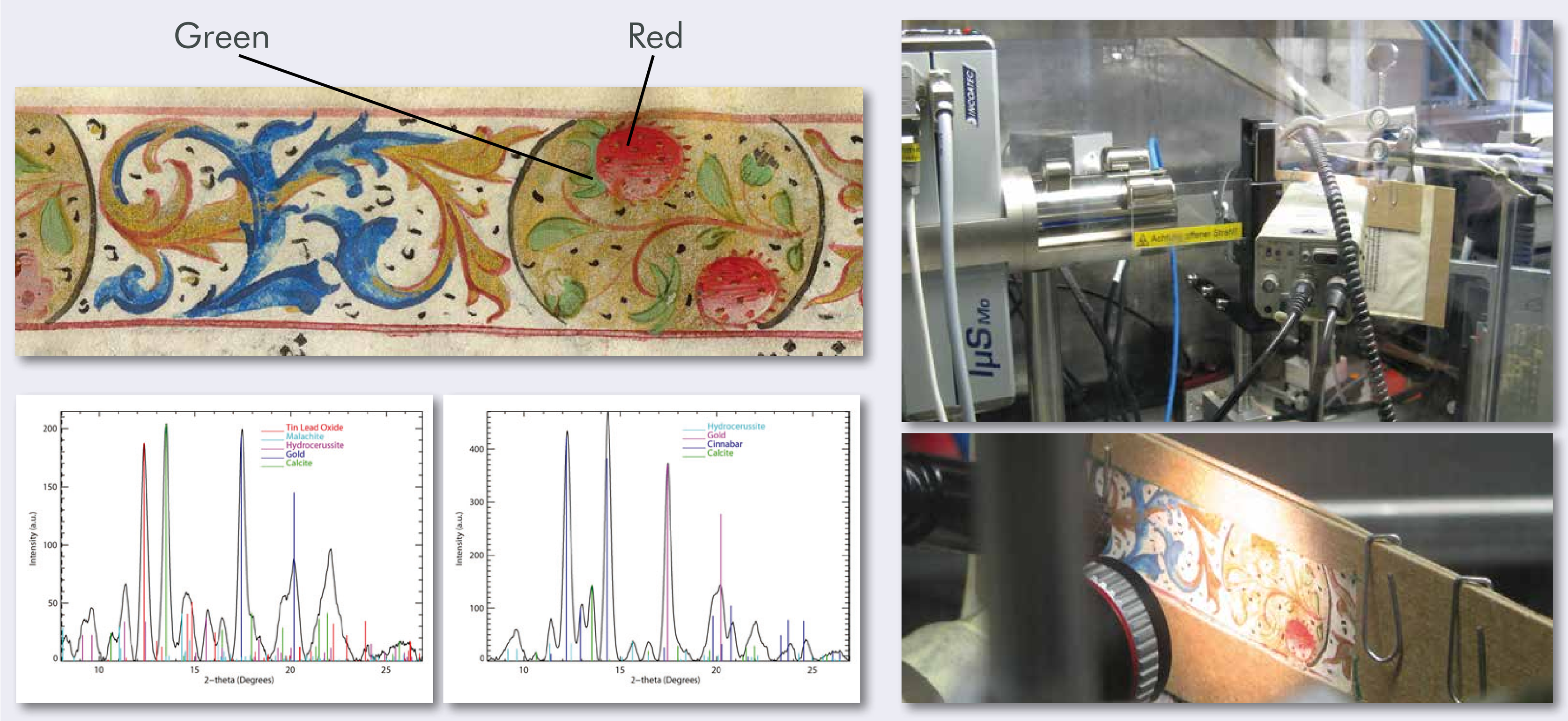




Frame of pigment red 170 in a diamond anvil cell (left) and an integrated pattern (right) showing the sample and also some peaks from the steel gasket.

IμS for Scanning Microdiffraction

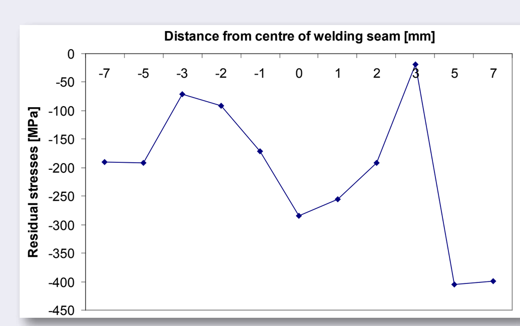
A painting in a medieval manuscript was investigated using a Mo-IμS with focusing optics. Within 30 seconds exposure time frames were recorded using a Smart 1000 detector (Bruker AXS) to identify the color pigments. Such investigation allows statements on repairing, repainting or falsification of art objects. With this setup it was possible to scan in an overnight measurement an area of several square millimeters with a resolution of 150 μm. (Data courtesy of F. Vanmeert and K. Janssens, University of Antwerp, Belgium)

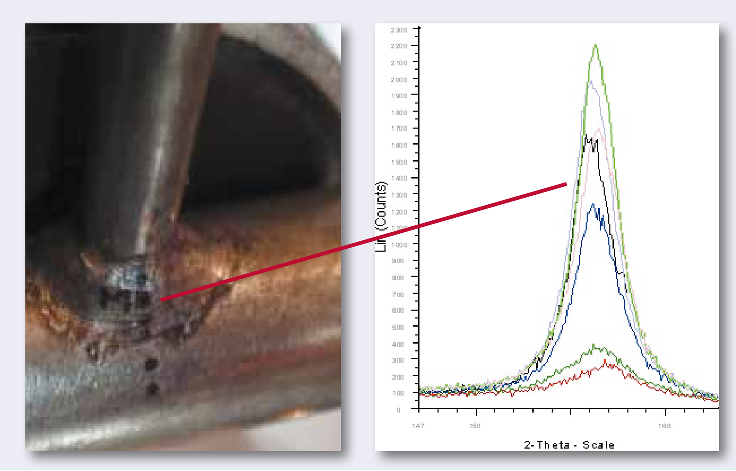


Setup for the measurements in transmission geometry (right) and book painting with indicated colors and diffraction pattern of green and red colored regions respectively (left, Mo-IμS, 30 s exposure time each).

IμS for Cr Radiation: Best for Position Sensitive Stress Analysis

Measurements of samples containing iron are possible by using a 14W Cr-IμS 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. The stress profile from this measurement shows the expected characteristics for a weld. (data from H. and U. Göbel, LabXA, Munich, Germany)

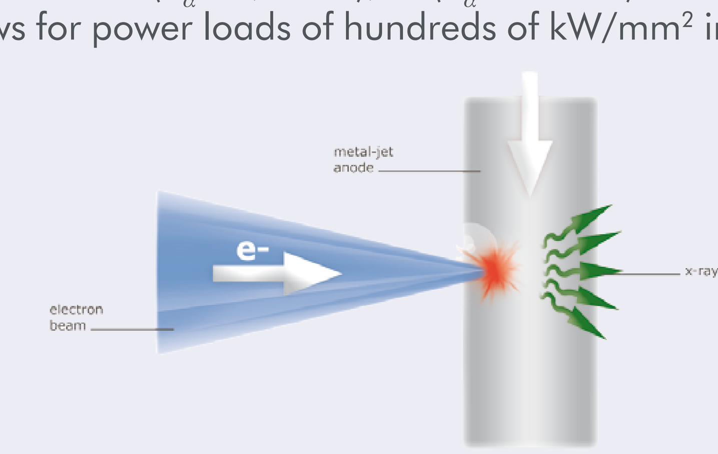




Integration of the IμS in Different Systems

Liquid Metal Jet X-ray Source

Liquid metal jet sources use a new technology and have already shown intensities superior to the best microfocus rotating anodes. The maximum power load that can be applied to standard solid metal anodes is in the first instance limited by the thermal properties of the anode material and by the heat dissipation mechanism. In liquid metal jet X-ray sources, however, X-rays are generated by an electron beam that is focused on a jet of a liquid metal melt, such as Ga (K_α=9,2 keV), In (K_α=24 keV) or Sn (K_α=25,3 keV, see schematics). Such a liquid target allows for power loads of hundreds of kW/mm² in a spot size of < 20 μm. In order to preserve the extreme source brightness, a dedicated synchrotron-class optic was designed for Ga-Ka radiation (9.25 keV). With this optics, the METALJET source is the brightest home-lab X-ray source, delivering intensities of > 4x10¹¹ photons/(s mm²) for a focused beam (FWHM = 70 μm). With a parallel beam Montel optics, a flux of > 3x10⁹ ph/s has been observed, giving a superb performance for small angle X-ray scattering.



Working principle of a liquid metal jet anode.

SAXS scattering plot of a very thin fiber from a rat tail tendon, measured with a Bruker AXS NANOSTAR equipped with the METALJET X-ray source (200 W at 70 kV) and the new rotating anode TXS (2.5 W at 50 kV). The METALJET delivers 3x higher intensity.

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