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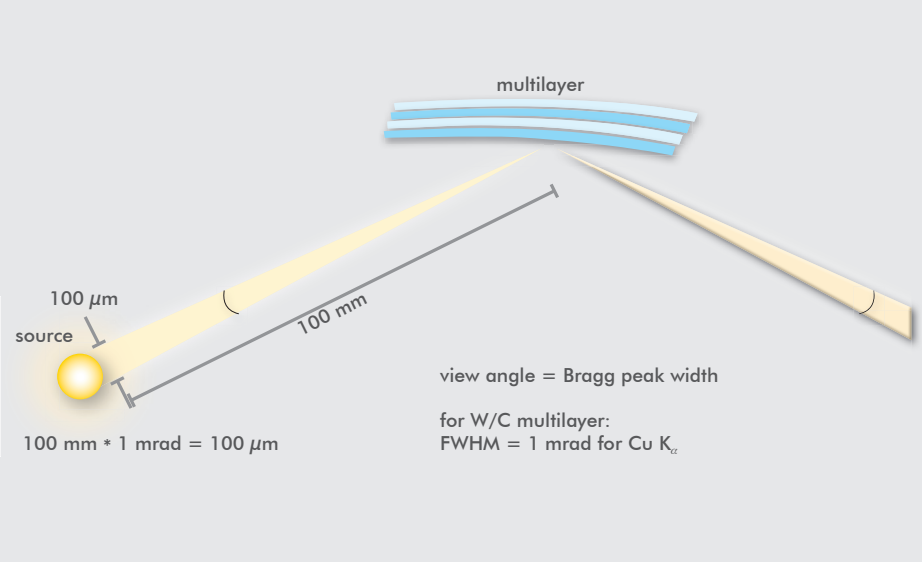
Montel Optics

2D Multilayer Mirrors for X-ray Diffractometry



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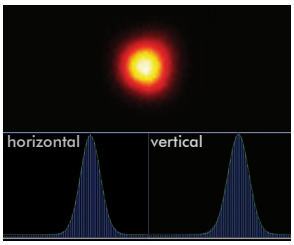

2D beam shaping

Multilayer mirrors consist of high quality optical surfaces that are coated with a multilayer structure and are best suited for beam shaping and monochromatization of X-rays. Applying Bragg's law, the X-rays are collected in a solid angle by the multilayers (~ 1 mrad for W/C multilayers and Cu radiation), monochromatized with a K suppression of less than 0.5% and reflected to the sample position with a reflectivity up to 80%. To take account for the varying incident angles, the multilayer requires a lateral gradient in the thickness of the layers. In order to focus the reflected beam, the multilayers are deposited on an elliptically shaped substrate, while a collimated beam is formed with a parabolically shaped substrate. A shaping of the beam in 2 dimensions is achieved by combining two mirrors side-by-side in an L-shape orientation. This assembly is called Montel optics. In this configuration, the beams are doubly reflected and thus the monochromatization effect is squared. Due to the fixed solid angle, multilayer optics are an ideal combination for X-ray sources with a diameter of the anode spot of well below 100 µm. For sources with larger anode spot diameters, however, the range of incident angles increases. Therefore, the multilayer optics only "collects" a portion of the anode spot and thus reflects a small amount of X-rays as some of the emitted X-rays do not fulfill Bragg's law. Multilayer optics are designed to meet customer's needs. Hence, there are optics exhibiting e.g. low divergency or high flux density with spots on the sample varying from some 10 µm up to the mm range.

Advantages of Montel optics

- best for preserving the brightness of X-ray sources
- symmetrical beam properties (size, divergence) in 2D
- very clean spectrum due to twofold monochromatization (double-bounce optics)
- easy to align
- best for microfocus, synchrotron, laser plasma and liquid metal jet sources

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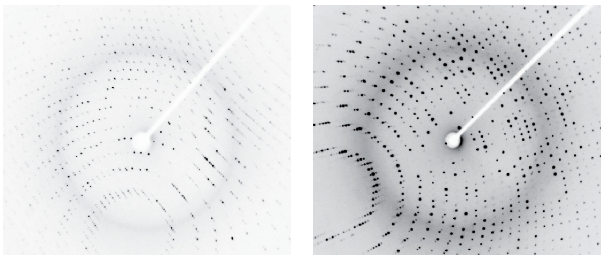
Incoatec offers Montel optics for

- 2D focusing, collimating and hybrid beam shaping
- Cr, Fe, Co, Cu, Ga, Mo, Ag, In radiation, others on request
- More than 30 types of standard mirror designs, others on request
- Optics of various focal distances, magnification ratios and divergences

Single Crystal Diffraction

Protein single crystals are usually very small and only show a poor diffraction. Our Montel optics for protein crystallography deliver more than 4 times the intensity of classic multilayer optics resulting in a superb gain in performance. Our MX optics are designed to deliver the highest intensity with a diameter of 100 µm (FWHM) and a moderate divergence of 7.5 mrad. This makes them the optics of choice for small crystals (≤ 0.1 mm).

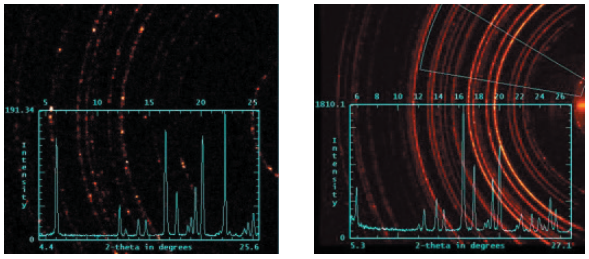


Diffraction patterns of a small thaumatin crystal recorded on a Siemens SRA rotating anode (4 kW, 55 s/°) coupled with Osmic blue optic (left) and Montel multilayer mirror (right) (Courtesy of Prof. G.M. Sheldrick, University of Goettingen).

Our Montel optics for Mo radiation define the standard in small molecule crystallography. One of our customers, Prof. Mike Hursthouse at the University of Southampton, stated: "We have typically 5 times more intensity with a Montel Optics and a Mo target compared to our previous configuration with a graphite monochromator. Now, measurements are possible in our lab that in the past required a trip to the synchrotron."
Higher energy radiation, such as Ag or In radiation, are often used for high pressure crystallography and solid state materials research. Our dedicated Montel optics for high energy radiation deliver superb intensities with beam diameters below 100 µm (FWHM).

Powder Diffractometry

For standard powder diffraction in transmission geometry with a 2D detector, our focusing Montel optics are best suited. When focused on the detector, a larger number of grains is illuminated and the resolution of the diffraction pattern only depends on the point spread function of the detector. When focused to the sample, measurements can be carried out in transmission or reflection geometry with high spatial resolution. This setup is optimal for recording stress profiles.



Ibuprofene measured in transmission geometry. Left: sealed tube with Göbel mirror, 120 s exposure time, right: Microfocus Source IµS with focusing optics, 15 s exposure time.

The hybrid Montel optics combines a focusing and a collimating mirror in the Montel configuration. This optics is ideal when investigating thin films and powders in transmission or gracing incidence geometry as it delivers a high flux in a line shaped spot on the sample.
The collimating Montel mirrors are suitable for SAXS and high resolution XRD measurements due to their very low divergence. For ultra-high resolution SAXS and XRD experiments, our parallel beam Montel optics ensures an excellent performance with a divergence of below 0.5 mrad. Furthermore, the high spectral purity and low temporal broadening of Montel multilayer optics make them the optics to choose for time-resolved diffraction experiments.

Synchrotron Beamlines

3rd Generation Montel optics with slope errors below 2 arcsec are used at Synchrotron beamlines. For inelastic scattering experiments, they are placed between sample and detector and act as analyzer optics (Gene E. Ice et al „Nested mirrors for X-rays and Neutrons").
Montel optics of such quality are also used for high-end lab-instruments such as liquid metal jet sources.