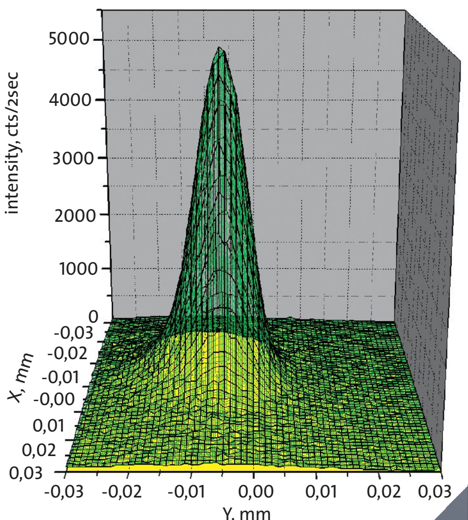
# CAPILLARY X-RAY OPTICS


Glass capillary optics can be used for numerous different X-ray analytical methods such as XRF or XRD, or, recently, full field X-ray fluorescence. Improvements in the technology to produce polycapillary optics made it also possible to reach spot sizes of about 10 μm in a broad energy interval at distances between source and sample of 400 mm and more. These lenses are used for XRF application in scanning electron microscopes. For applications in micro X-ray fluorescence analysis a new generation of polycapillary optics was produced with improved physical parameters such as spot sizes of about 10 μm for MoKα.

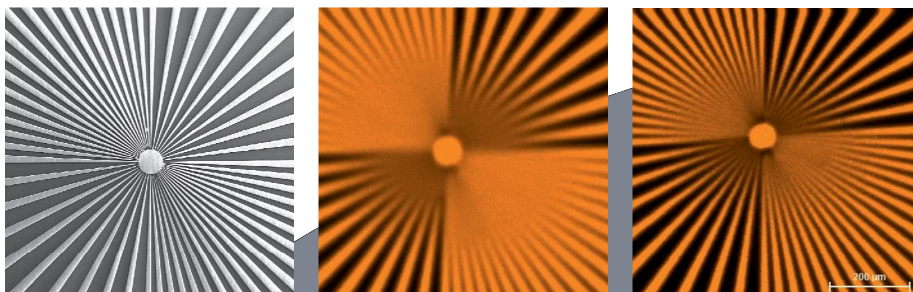
The development in capillary optics is directed to a further decrease of focal spot sizes and an increase of brilliance. Such parameters can be realised if corresponding high brilliant microfocus sources are available and a high quality of the capillary optics is guaranteed. An important task is the realisation of a small focal spot independent of the working distance. To achieve such a result several technological and physical problems must be solved. New developments were carried out for capillary optics by changing the capillary diameters as well as using new glass types to improve the transmission qualities.

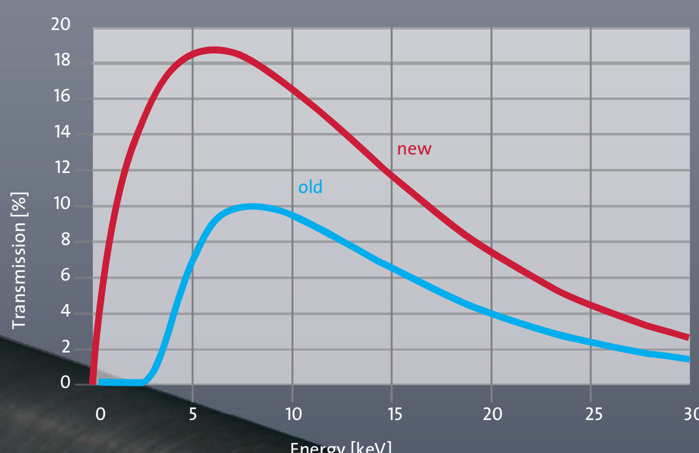
Intensity distribution MoKα

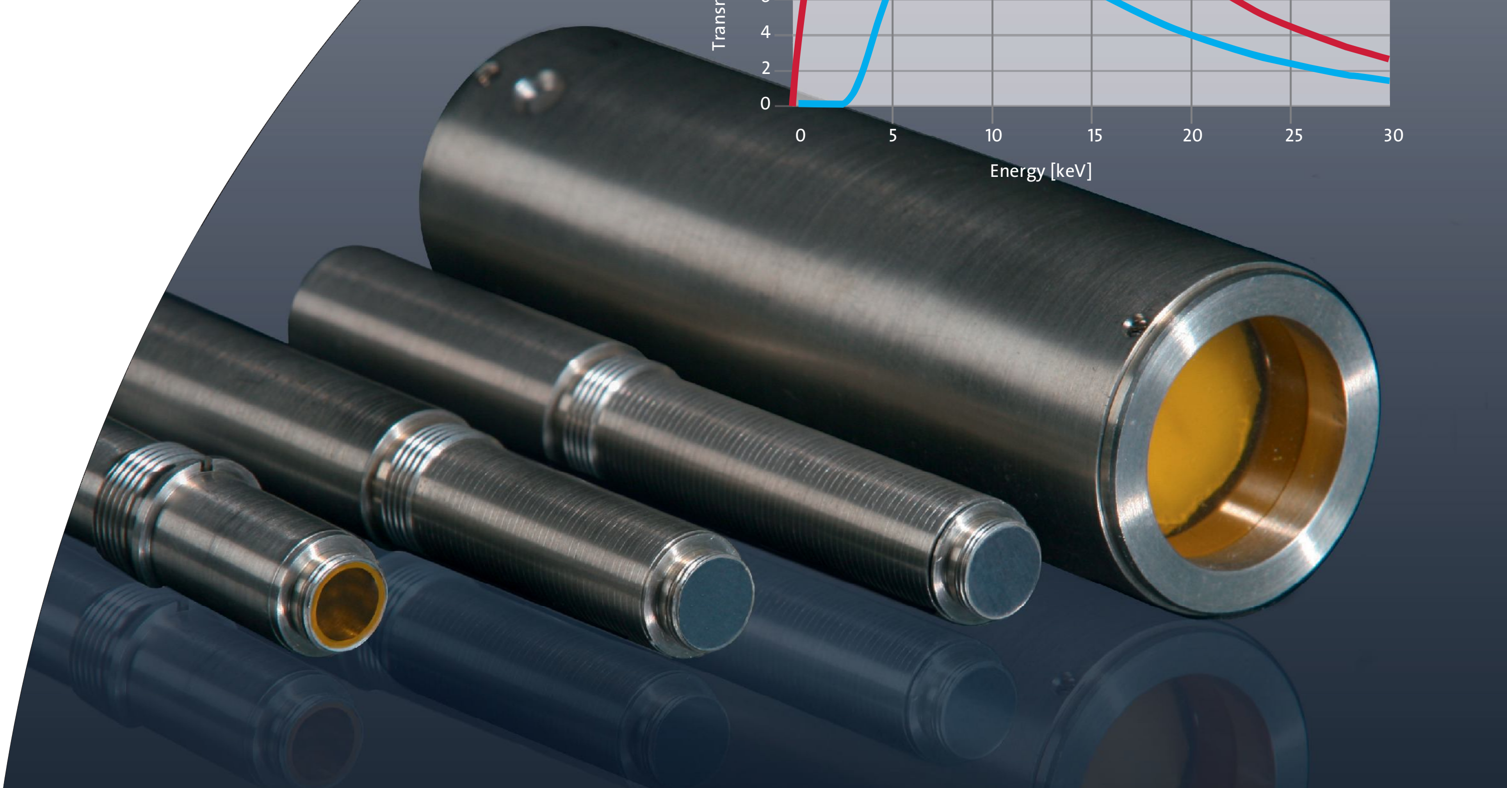



1.5 x 1.5 mm$^2$, 367 x 367 pixel

SEM image | 25 μm lens | 14 μm lens



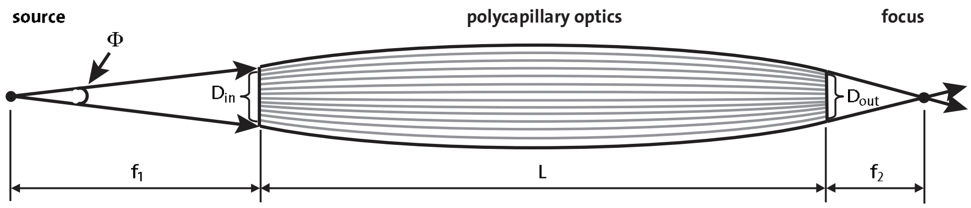


# CAPILLARY X-RAY OPTICS

## Focusing Polycapillaries

Glass capillary optics are used for collimating, focusing or parallelizing X-ray beams. These components utilize multiple total external reflection of X-rays on smooth surfaces. They are comprised of a single or a bundle of mono- or polycapillaries which are specially arranged or bent according to the requirements of X-ray beam formation. These capillary structures are made of special glass with inner surfaces of extremely high quality.

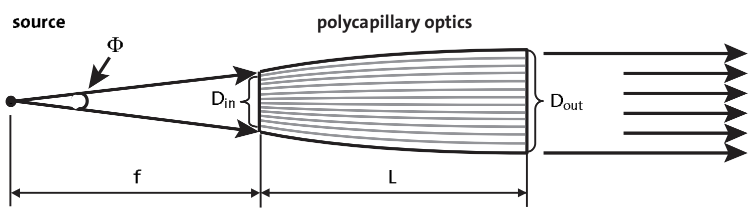



| Parameter | polycapillary SEM-lens | polycapillary minilens | polycapillary microlens |
|---|---|---|---|
| Source-entrance distance $f_1$, mm | > 30 | > 30 | > 25 |
| Length L, mm | > 100 | 50 – 100 | 20 – 50 |
| Exit-focus distance $f_2$, mm | > 2 | > 2 | > 1 |
| Capture angle $\Phi$, rad | 0.05 – 0.2 | 0.04 – 0.2 | 0.02 – 0.1 |
| Energy range, keV | 1 – 30 | 3 – 30 | 3 – 30 |
| Optimal source size, µm | 50 – 100 | 30 – 100 | 30 – 50 |
| Focal spot size, µm | > 10 | > 10 | > 10 |
| Intensity gain | > 1000 | > 1000 | > 100 |
| **Applications** | **µ-XRF-module – iMOXS-SEM** | **micro-XRF, micro-XRD and micro-XPS** | **micro-XRF, micro-XRD and micro-XPS** |

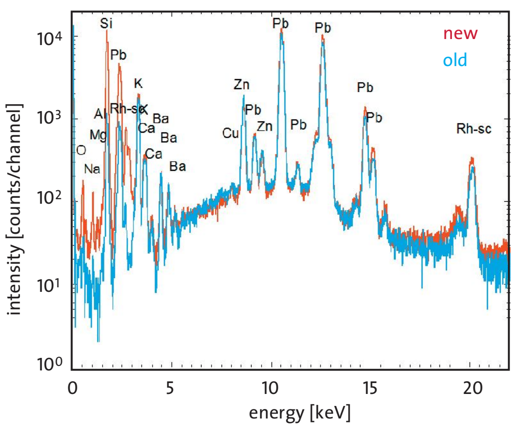
## Collimating Polycapillaries

This type of optics parallelizes and collimates divergent radiation. The divergent beam entering the optical module is transformed into a quasi parallel outgoing beam with a very low divergence. Such collimating polycapillary optics are applied in XRD.

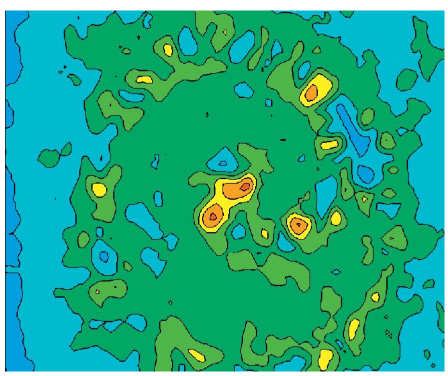
| | |
|---|---|
| f, mm | > 30 |
| L, mm | > 40 |
| $D_{in}$, mm | > 3 |
| $D_{out}$, mm | > 3 |
| $\Phi$, degr. | > 2 |
| $\Delta\theta$, degr. (exit divergence – CuK$\alpha$) | > 0.20 |
| K$\alpha$ % ( CuK$\alpha$) | 10 – 70 |

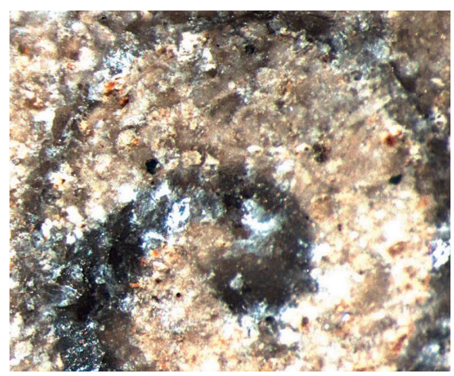



BCR CRM 126A (lead glass)




SrK$\alpha$-distribution





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