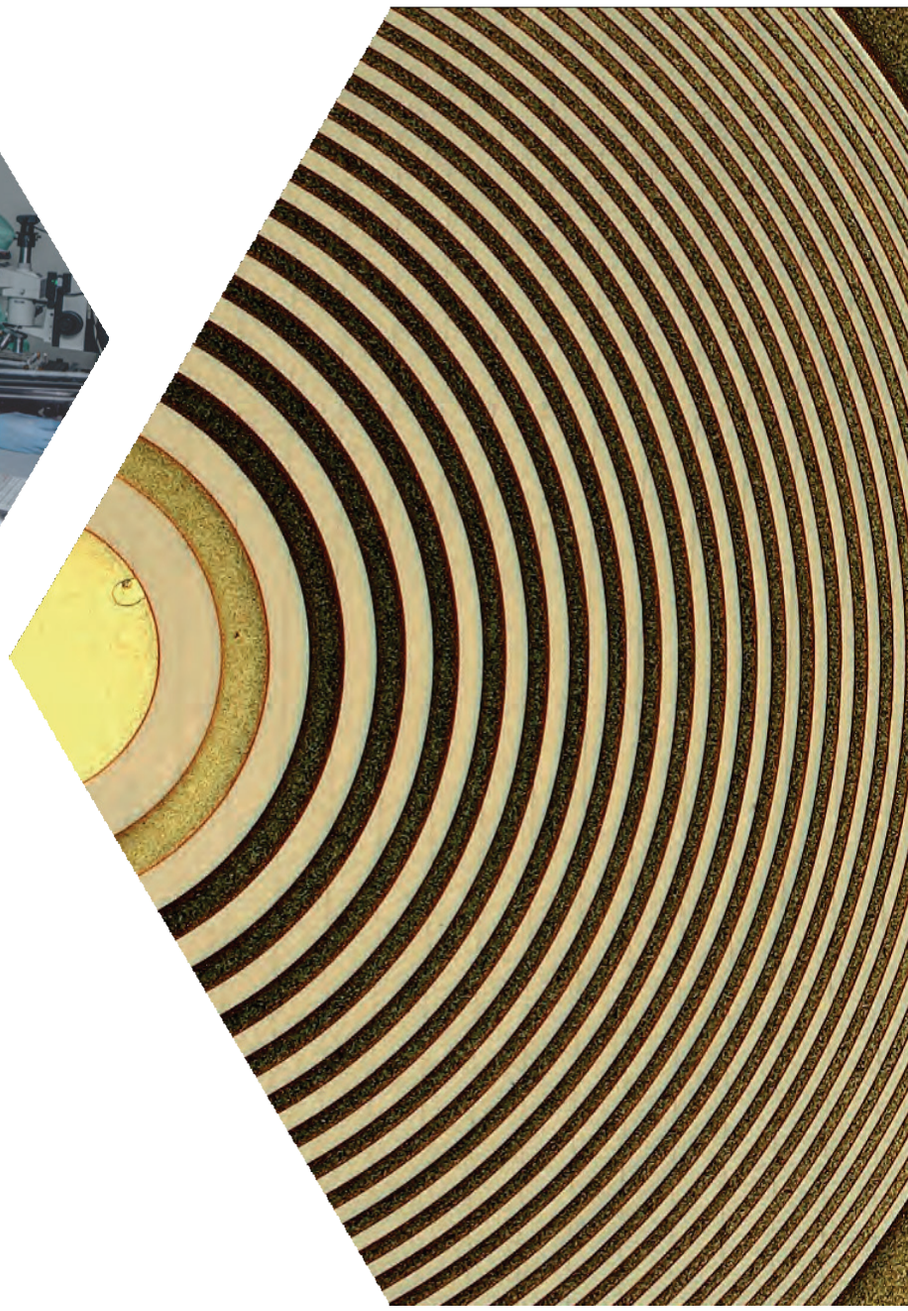
XRnanotech



Established in 2020

Nanostructures & Optics with Swiss Precision

TABLE OF CONTENTS

ABOUT XRNANOTECH

XRnanotech is the leading Swiss manufacturer of the highest-quality nanostructures and optics: from high-aspect-ratio fresnel zone plates with record breaking resolution to ultra-stable diamond optics and custom 3D-nanostructures for a wide range of applications.

XRnanotech is the culmination of more than 10 years of research and development at the world-renown Paul Scherrer Institut in Switzerland. The company was incorporated in 2020 with the goal to bring the newest groundbreaking innovations in nano-optics to market.

Vision

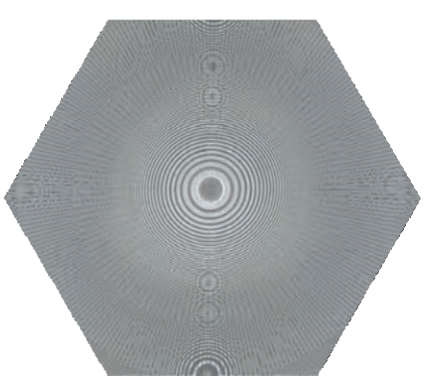
To enable optical instruments around the world to reach their full potential.

Mission

To develop and fabricate the most innovative nano-optics that reach the highest quality in resolution, efficiency, stability and design.

Team

Our team of engineers and scientists works tirelessly to find the ideal solution for our customers.



Fresnel Zone Plates

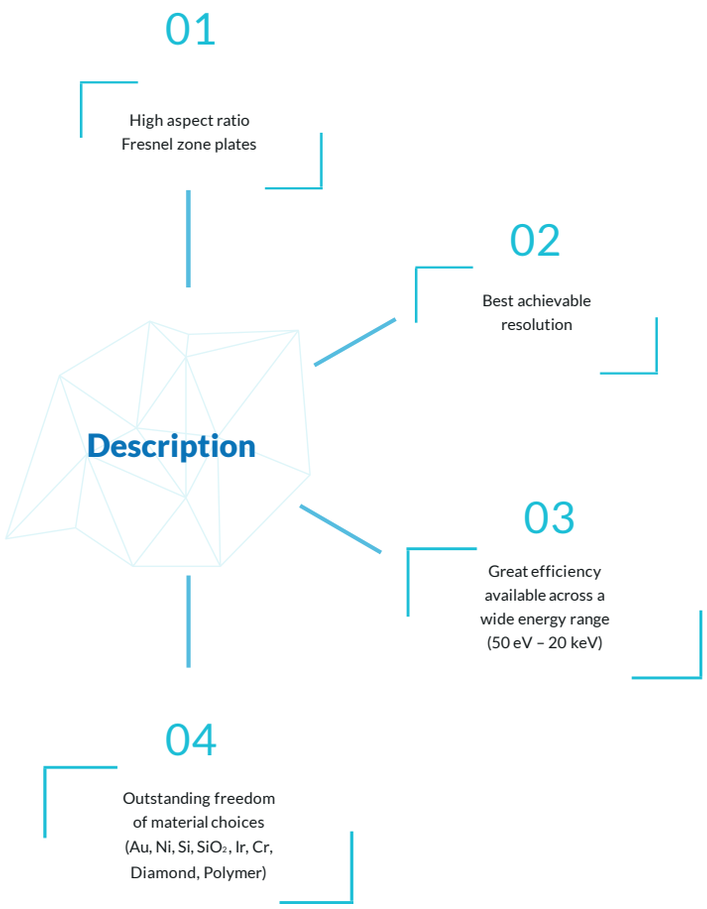
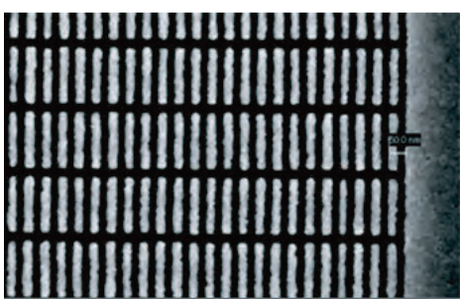


Figure: 1.1
Electroplated gold zone plate for multi-keV X-rays with 50 nm wide and 500 nm high structures

Specifications

Parameter	Typical Value	Achievable limits
Outermost zone width [nm]	50-100	<10
Diameter[µm]	100-500	>4500
Number of Zones	1000-3000	>30000
Aspect Ratio	10	>30

Figure: 1.2
Nickel zone plate for soft X-rays with 25 nm outermost zone width (right).



References

1. S. Gorelick et al. Direct e-beam writing of high aspect ratio nanostructures in PMMA: a tool for diffractive x-ray optics fabrication Microelectronic Engineering 87 (2010) p. 1052
2. Vila-Comamala, Joan, et al. "Zone-doubled Fresnel zone plates for high-resolution hard X-ray full-field transmission microscopy." Journal of Synchrotron Radiation 19.5 (2012): 705-709.

Specialized Zone Plates

Ultra-high Resolution Zone Plates

01
Ultra-high aspect ratio Fresnel zone plates

02
World-record resolution

Description

03
Based on the Ir-line-doubling technique

04
Material: Ir

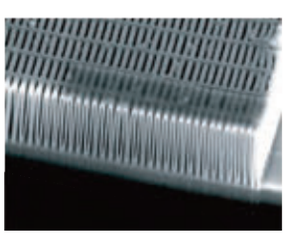


Figure: 2.1
FIB cross-section of 25 nm wide, 550 nm high Ir zone plate

High Efficiency Zone Plates

01
High efficiency with multistep processing

02
Optimized phase shift and low absorption

Description

03
Blazed optics overcome efficiency limitations of binary optics

04
Wide selection of material

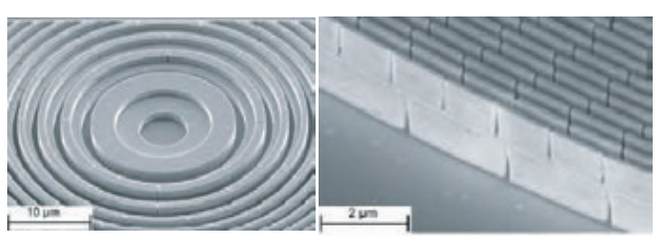


Figure: 2.2
A three-level nickel zone plate with 200 µ m diameter and effective 200 nm smallest zone width

Both technologies combinable to hybrid zone plates- merging great resolution with high efficiency.

Gratings and Beam Splitters

01

Diffractive gratings on thin membranes or silicon wafers

Description

02

Different use cases:

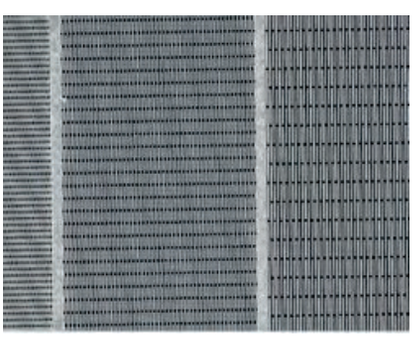
- Beam splitting
- Grating interferometry
- Phase contrast imaging

03

Wide range of material choices (Si, Au, Ni, SiO_2, Ir, Cr, Diamond)

Figure: 3.1
Si grating (p=1800 nm)

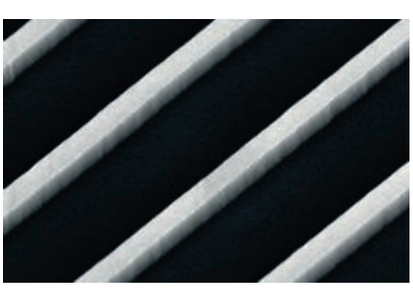
Figure: 3.2
Au grating (p=100-200 nm)



Specifications

- Gratings can be designed according to customers' needs using various fabrication approaches.

Figure: 3.3
SiO_2 grating (p=500nm)



References

1. **S. Marathe etal. Development of synchrotron pink beam x-ray grating interferometer at the Diamond Light source I13-2 beamline Developments in X-Ray Tomography XII 11113 (2019) p. 1111319**
2. **.S. Rutishauser et al. Exploring the wavefront of hard x-ray free electron laser radiation Nature Communications 3(2012), p. 947**

Diamond Optics

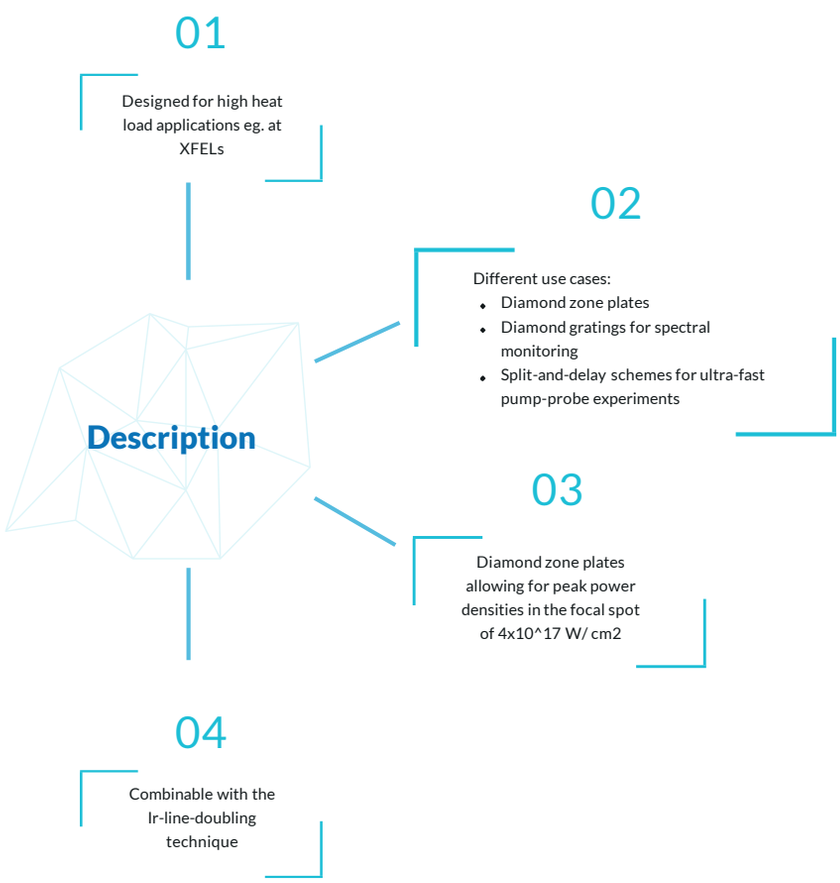


Figure: 4.1
Diamond checkerboard grating

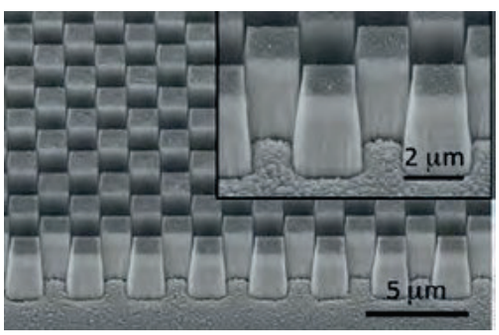
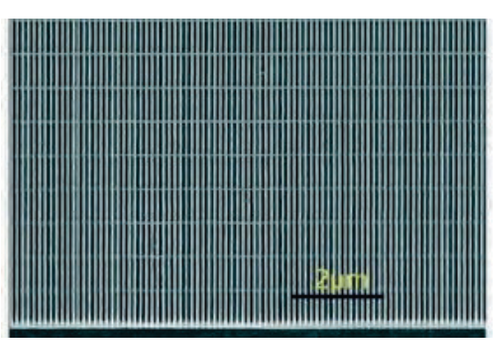


Figure: 4.2
Diamond grating (pitch:150 nm, height: 1200 nm)



Specifications

Parameter	Typical Value	Achievable limits
△Rn [nm]	50-100	<10
D [µm]	100-500	>4500
N	1000-3000	>30000
Aspect Ratio	10	>30

References

1. C. David et al.Nanofocusing ofhard X-ray free electron laser pulses using diamond based Fresnel zone plates Scientific Reports 1 (2011) p. 57
2. M. Makita etal. Diamond diffraction gratings for experiments with intense hard x-rays microelectronic Engineering 176 (2017)p. 75

Custom Design Optics

01

Designed to enable unique applications at synchrotrons and XFELs

Description

02

Different use cases:

- Focusing
- Beam splitting
- Generating beams with orbital angular momentum

03

Wide range of material choices (Au, Ni, Si, SiO_2, Ir, Cr, Diamond)

Figure: 5.1
Multi-focus zone plate

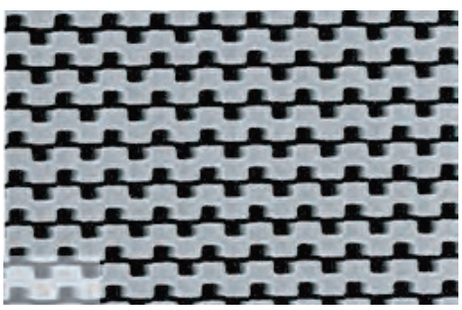
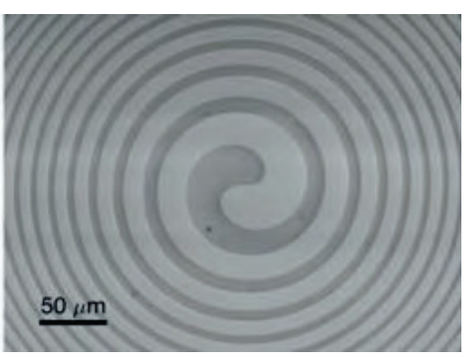


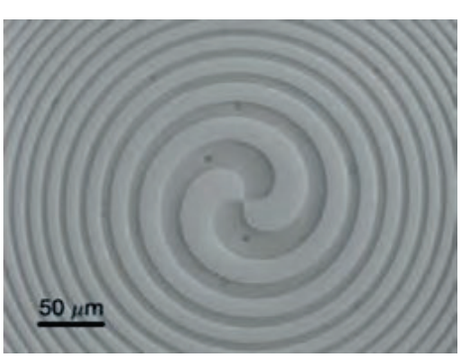
Figure: 5.2
Spiral zone plate



References

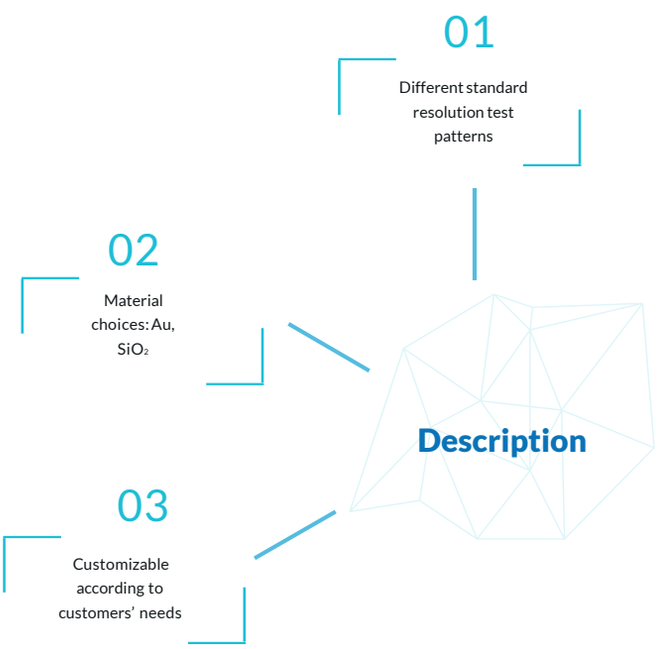
1. **F. Döring et al. Multifocus off-axis zone plates for x-ray free-electron laser experiments Optica 7 (8) p. 1007**
2. **P. R. Ribic et al. Extreme-Ultraviolet Vortices at a Free-Electron Laser Phys. Rev. X 8.3 (2018)**
3. **B. Rösner et al. High resolution beam profiling of X-ray free electron laser radiation by polymer imprint development Optics express 25 (24), p. 30686**

Figure: 5.3
Spiral zone plate

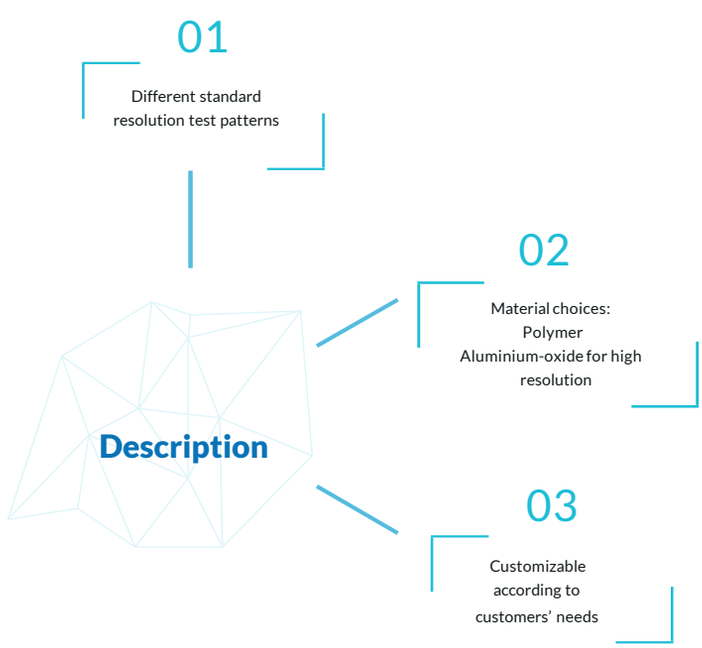


2D and 3D Test Targets

2D Resolution Test Samples



3D Resolution Test Samples



Specifications

Parameter	Typical Value	Achievable limits
Smallest feature [nm]	50-100	<10
Area	1mm x 1mm	3mm x 3mm
Aspect Ratio	10	>30

Specifications

Parameter	Typical Value	Achievable limits
Smallest feature [nm]	<200	<50
Diameter[µm]	100	---
Height of structures [µm]	200	---
Overall height [µm]	250	---

Figure: 6.1
USAF 1951 test target in nm

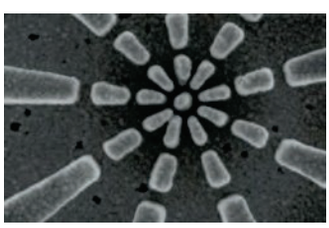


Figure: 6.2
Siemens stars resolution down to 10 nm

Figure: 6.3
Test pattern
"3D Siemens Star"

Figure: 6.4
Tomography of test pattern

Micro-CT Test Targets

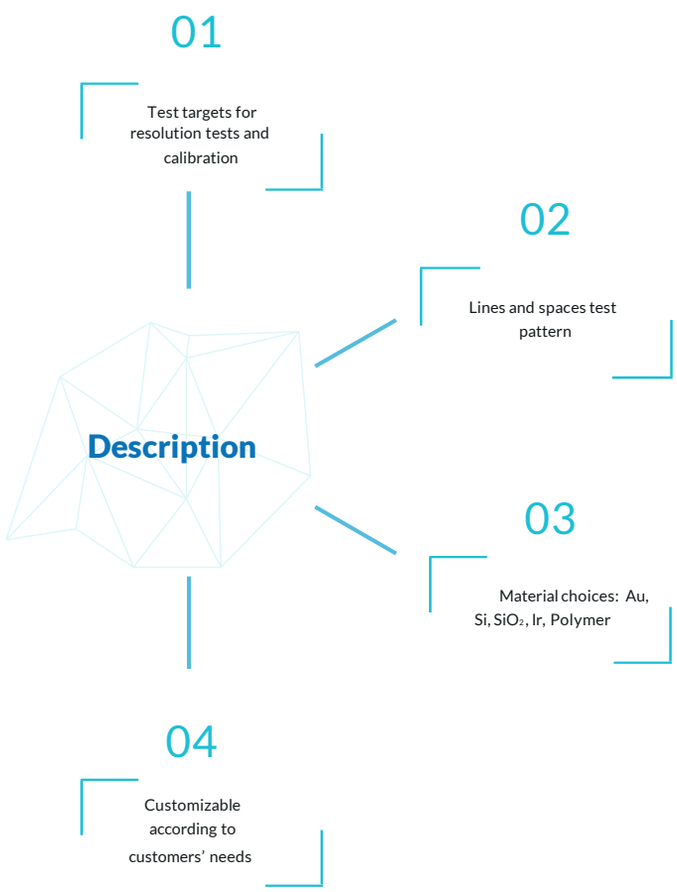


Figure: 7.1
Lines and dots down to 200 nm

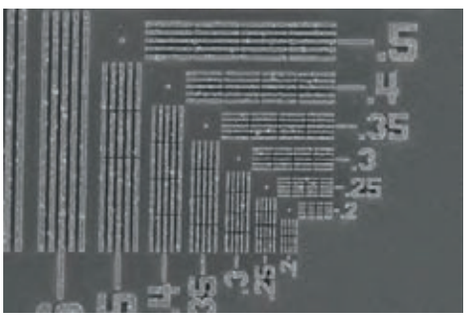
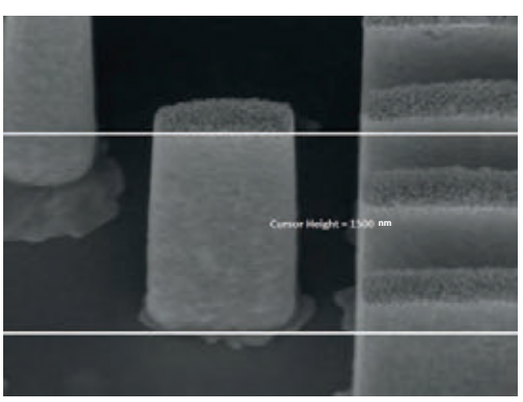


Figure: 7.2
1500 nm tall structures for high contrast



Specifications

Parameter	Typical Value	Achievable limits
Smallest feature [nm]	200	<10
Area	1mm x 1mm	5mm x 5mm
Aspect Ratio	10	>30

3D Nanostructures

01

3D nanoprinting allows unique nanostructures

02

Material:
Polymer(C14 H18 O7)

Description

03

Custom design structures are possible

04

Possible applications:

- Phase corrector plates for Be CRLs
- 3D Siemens star as resolution test patterns for tomography
- Kinoform lenses and lens arrays

Figure: 8.1
Kinoform lens

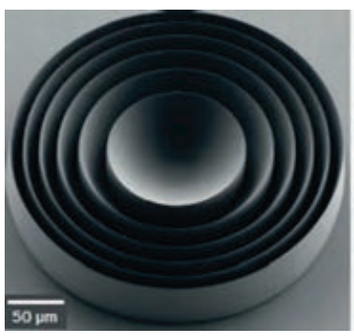
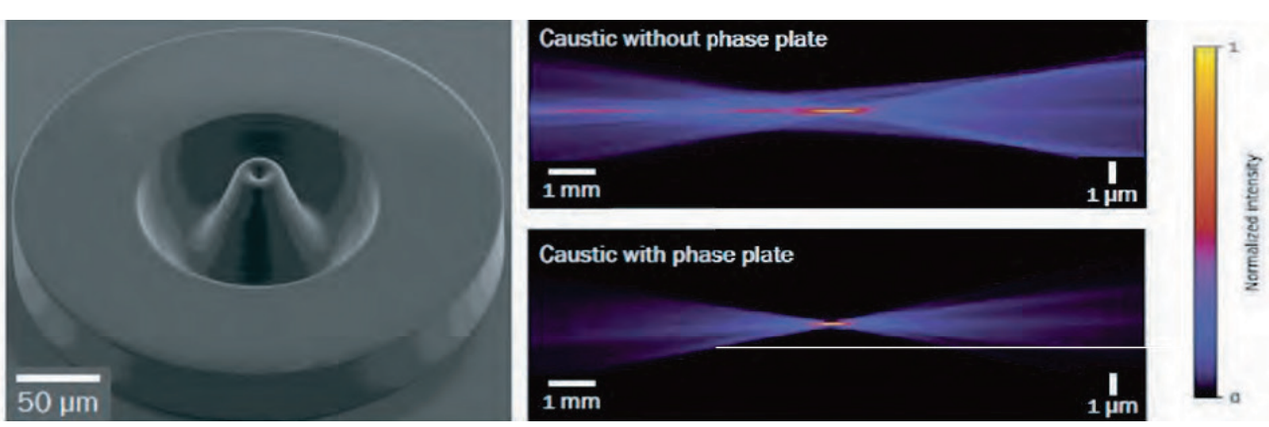


Figure: 8.2
Lens array

Figure: 8.3
Achromat

Figure: 8.4
Phase corrector plates for Be CRLs



References

1. **A. Kubec et al. An achromatic X-ray lens. Nat. Commun. 13 (2022), p. 1305**
2. **F. Seiboth et al. Hard X-ray wavefront correction via refractive phase plates made by additive and subtractive fabrication techniques in J. Synchrotron Rad. 27, 1121-1130.**

TXM Optical System

02

Combinations of beam shaping condensers, Fresnel zone plates and Zernike phase rings

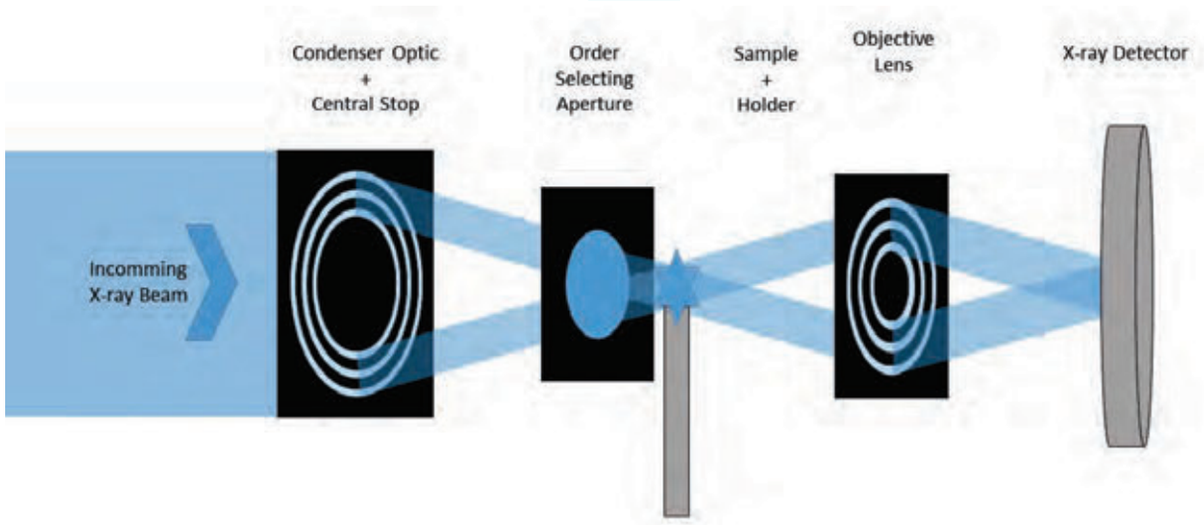
01

Full field transmission X-ray microscopy optics

03

Wide range of material choices

Description



References

1. **I. Vartiainen et al. Halo suppression in full field X-ray Zernike phase contrast microscopy Optics Letters 39 (2014) p. 1601**
2. **M. Stampanoni et al. Hard X-ray 3D phase-contrast nanoimaging Physical Review B 81 (2010) p. 140105**
3. **I. Vartiainen et al. Artifact characterization and reduction in scanning X-ray Zernike phase contrast microscopy Optics Express 23 (2015) p. 13278**
4. **I. Vartiainen et al. Zernike X-rayPtychography Optics Letters41 (2016) p. 721**
5. **M. Storm et al. The Diamond I13 full-field transmission X-ray microscope: a Zernike phase-contrast setup for material sciences Powder Diffraction (2020) p. 1**

Beamline Supplies

01

Contact us with your needs regarding instrumentation at your beamline.

04

Wide range of materials:

- Au
- W
- Pt
- and others

Description

02

- Pinholes and pinhole arrays
- Central stops
- Sample delivery systems
- Mounts for optical components
- X-ray optical components

03

Possible applications:
From NIR to X-Ray energies

Figure 10.1 Mounted Pinholes

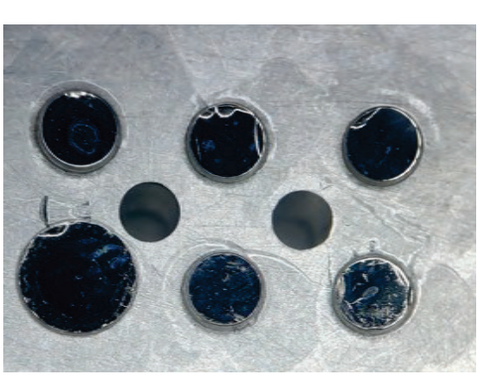
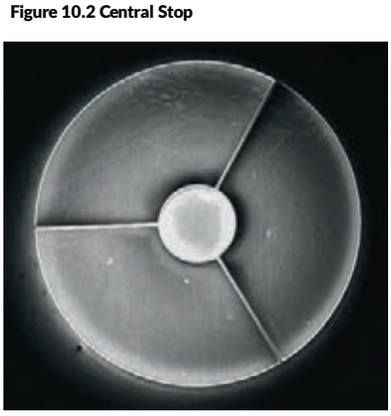


Figure 10.2 Central Stop



Membranes

01

SiN membranes with thicknesses 50 - 250 nm

04

From individual chips up to full wafers

Description

02

We can adapt membranes to different sizes and different shapes

03

Further materials, sizes and geometries available upon request

Figure: 11.1
Practical multi-frame arrays that can be cleaved easily into individual membranes

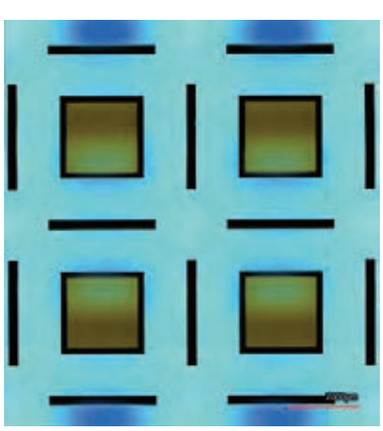
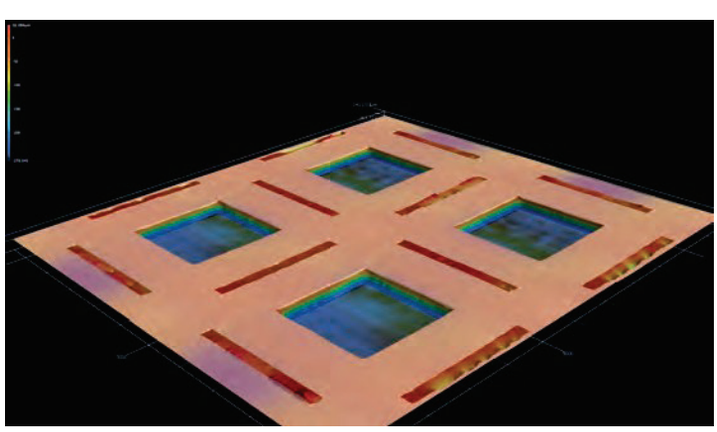


Figure: 11.2
Different roughness classes and various coatings are available



Foundry Service

02

Wide range of lithography technologies available such as Direct Laser Writing (DWL), Electron Beam Lithography (EBL) and Two Photon Polymerization (2PP)

03

Big variety of etching and deposition processes such as (Deep) Reactive Ion Etching (D-/ RIE) and PECVD enabling a wide range of materials
(Si, SiO_2, Ti, Cr and much more)

01

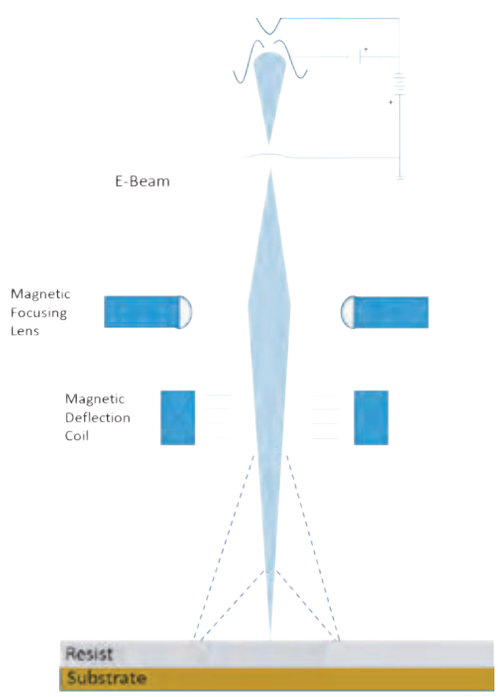
Process and product development for your custom requirements.

04

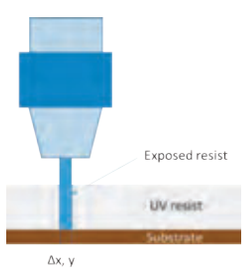
We are at your side from the first sketch to the final product.

Description

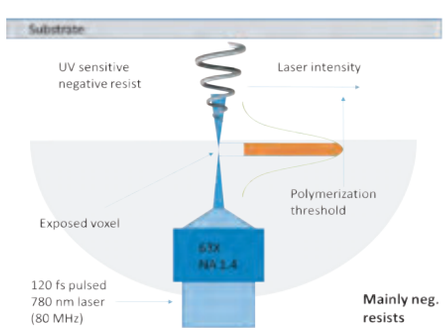
E-Beam lithography



Direct Laser Exposure



2 Photon Polymerization



Contact us now for further information

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