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Engineering

Title

Development of a standalone zoneplate based EUV mask defect review tool

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Peer reviewed

Development of a standalone zoneplate based EUV mask defect review tool

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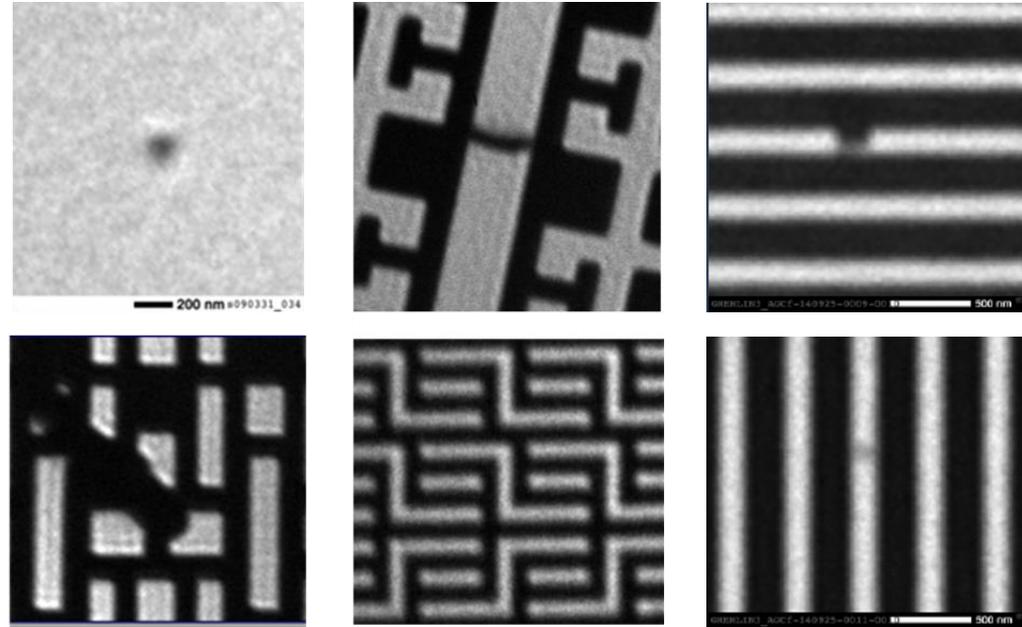


Agenda

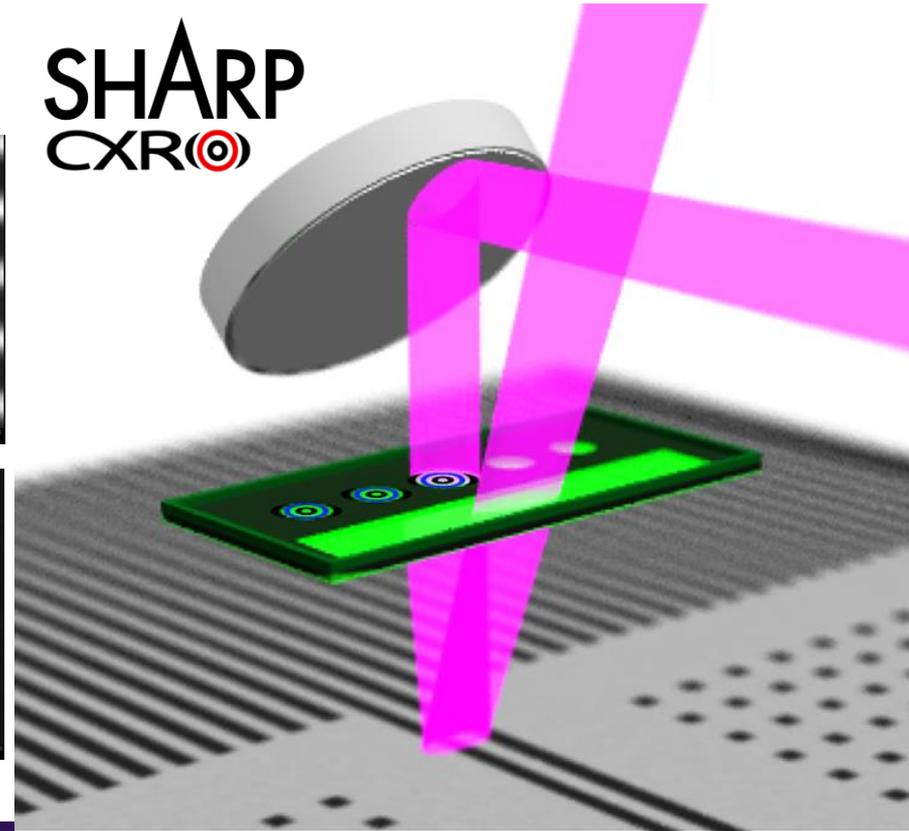
- Background
- System description
- Performance
- Future improvements

BACKGROUND

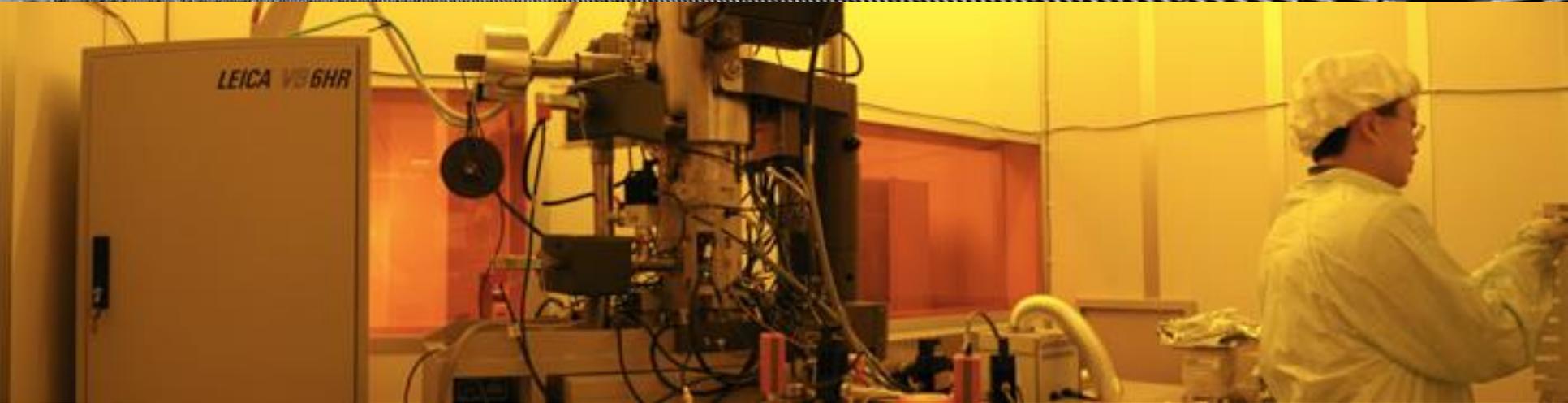
Zoneplate microscopy proven technique for EUV mask review



SHARP
CXRO



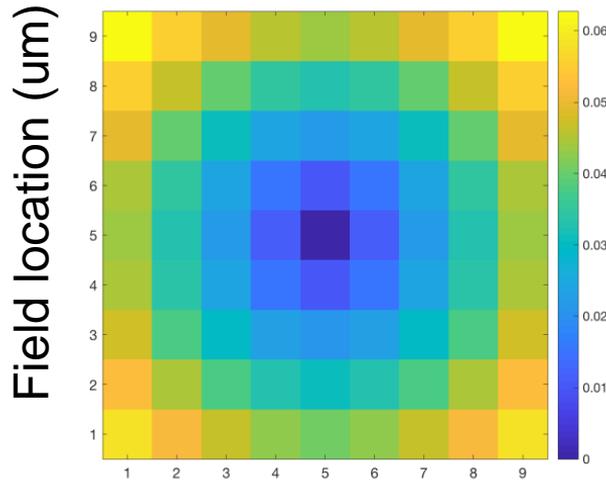
Zoneplates are ultra-compact high wavefront quality diffractive optics



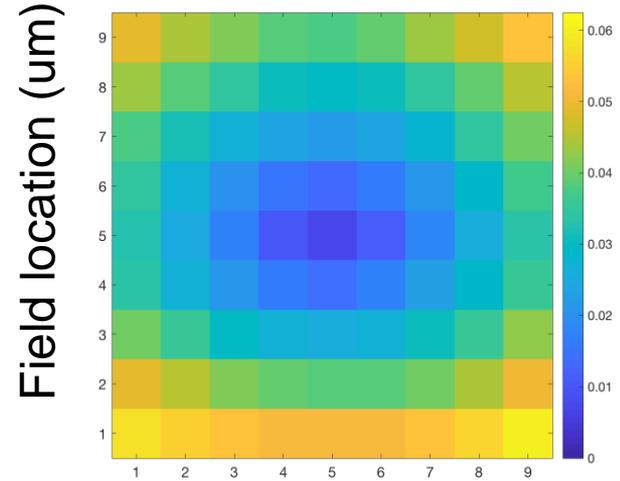
Measurement of zoneplate aberrations in SHARP using in-situ wavefront sensor

SHARP

Field dependent aberrations



Ideal 0.33 4xNA zoneplate

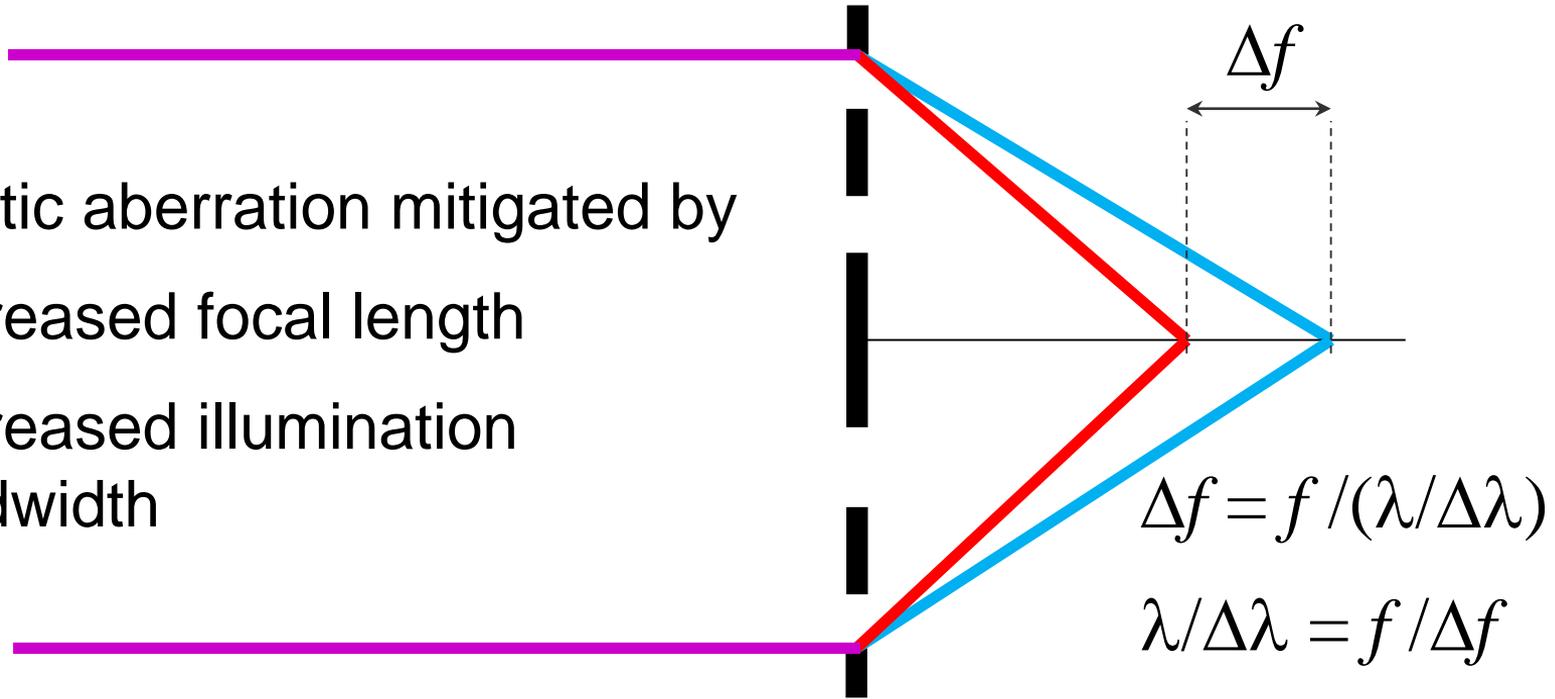


Wavefront measurement

Sweet spot (Z_4 to Z_8) : **7.2 m λ RMS** ($\lambda_{\text{EUV}}/139$)

Primary limitation of diffractive optics is chromatic aberration

- Chromatic aberration mitigated by
 - Decreased focal length
 - Decreased illumination bandwidth



SYSTEM DESCRIPTION

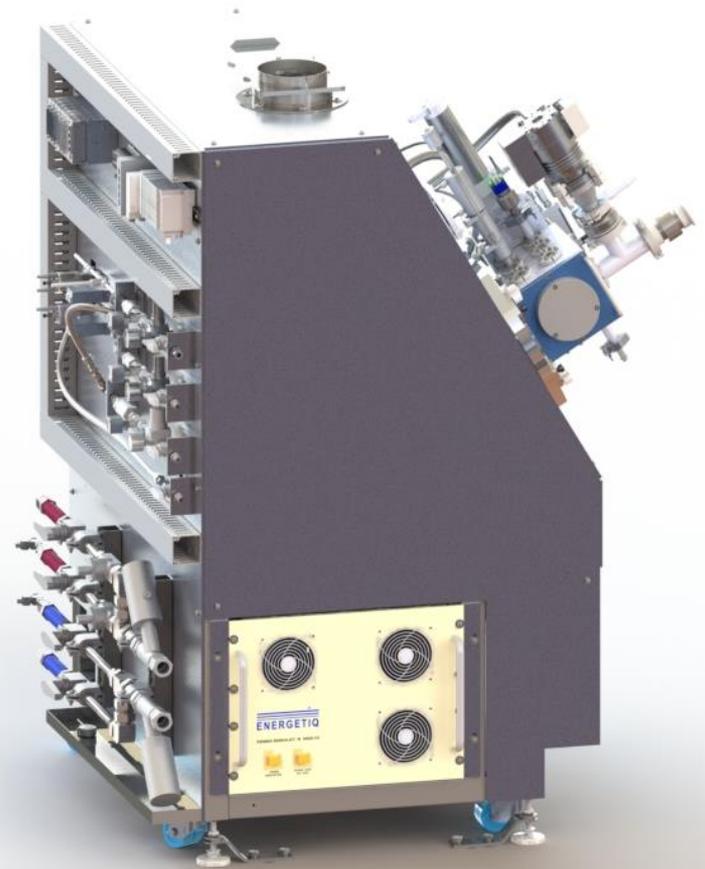
AIRES - ACTINIC IMAGE REVIEW SYSTEM

- Compact plasma-source zoneplate review system
- Incorporates EUV Tech's proven ultraclean mask transfer system
- Low capital cost and low cost of ownership
- Short install time
 - Roll into fab to first EUV images in < 1 month



Source module

- POC tool uses Energetiq EQ10-HP DPP light source
- EUV source, vacuum system, and control system integrated into one upgradable module
- Easy access for source consumables replacements



Process module

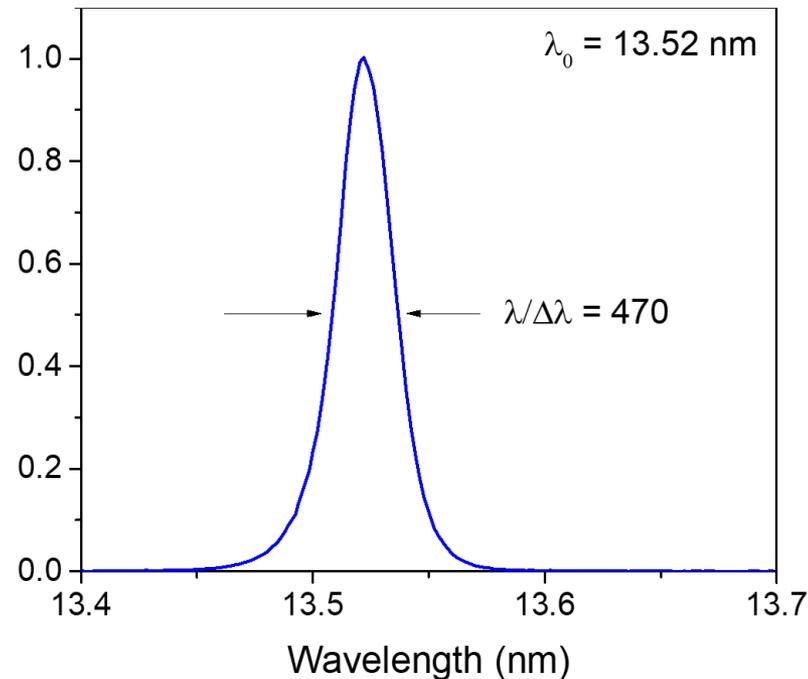
- EUV optical system consisting of collector, monochromator, illuminator, and diffractive optics
- 1200x mag direct EUV imaging
- Active vibration cancellation system
- Automated sample registration, site navigation, autofocus, and image collection
- Full diagnostics and in-situ plasma cleaning



Monochromator module

- Full multilayer mirror bandwidth of 2% not suitable for high quality diffractive imaging
- High efficiency, high resolution monochromator essential to plasma source application
- Measured monochromator resolution $(\lambda/\Delta\lambda) = 470$
 - Design-limited performance achieved

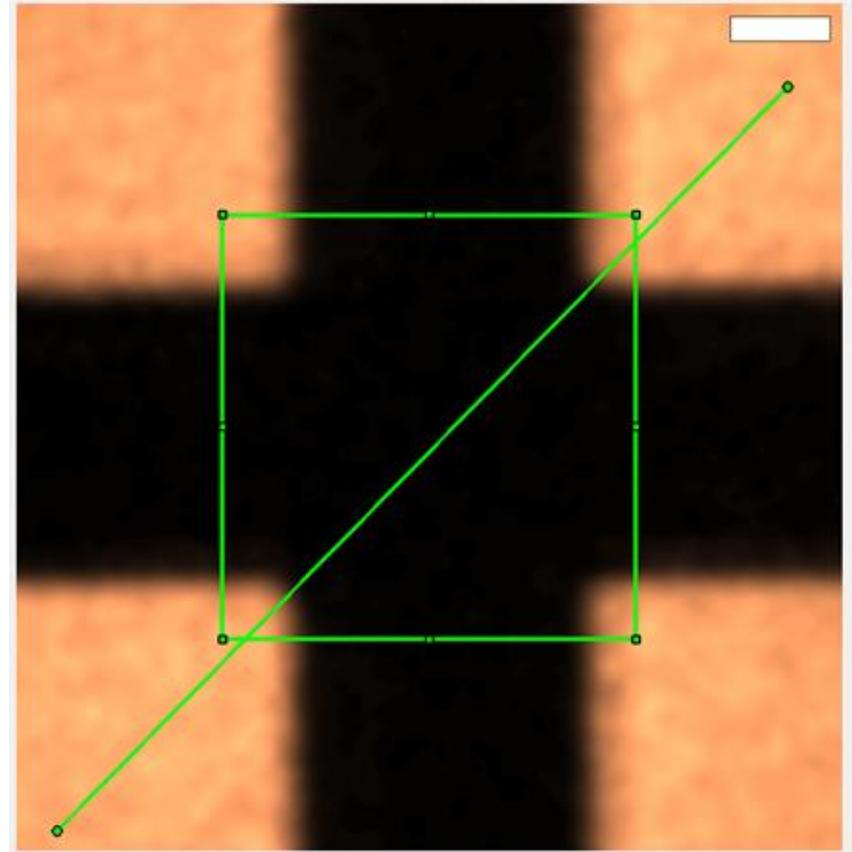
Mono performance measured at CXRO



PERFORMANCE

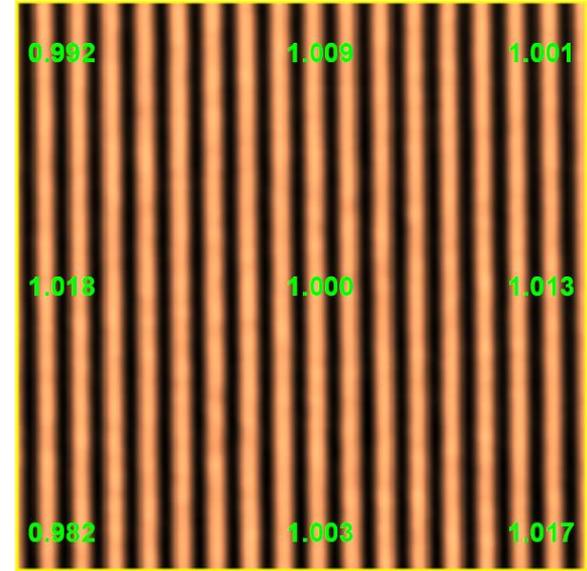
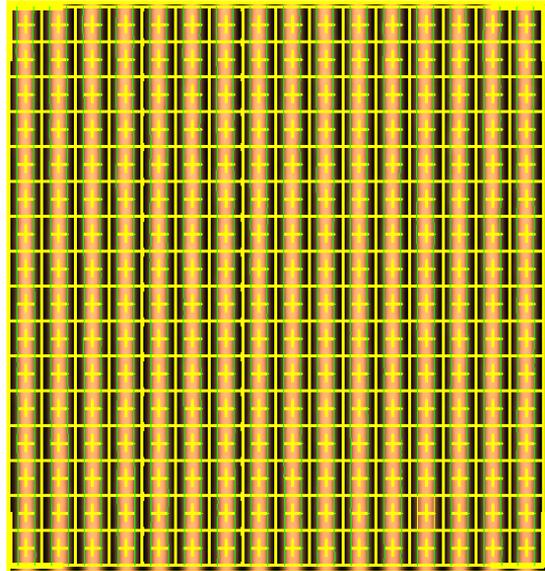
Flare

- Flare often raised as a concern for diffractive optical systems
- Kirk type flare test performed with 800-nm cross
- Direct measured flare = 3.1%
 - System flare < 2% after accounting for mask absorber contrast



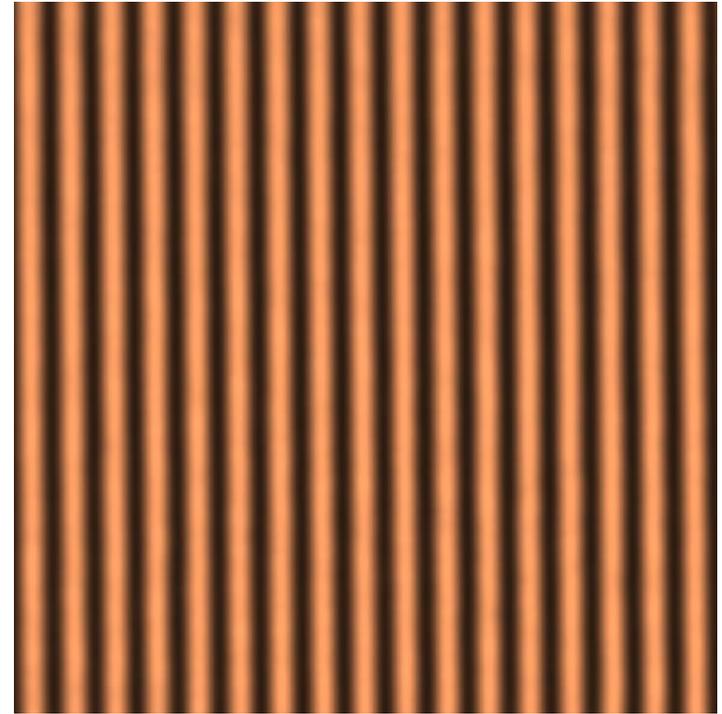
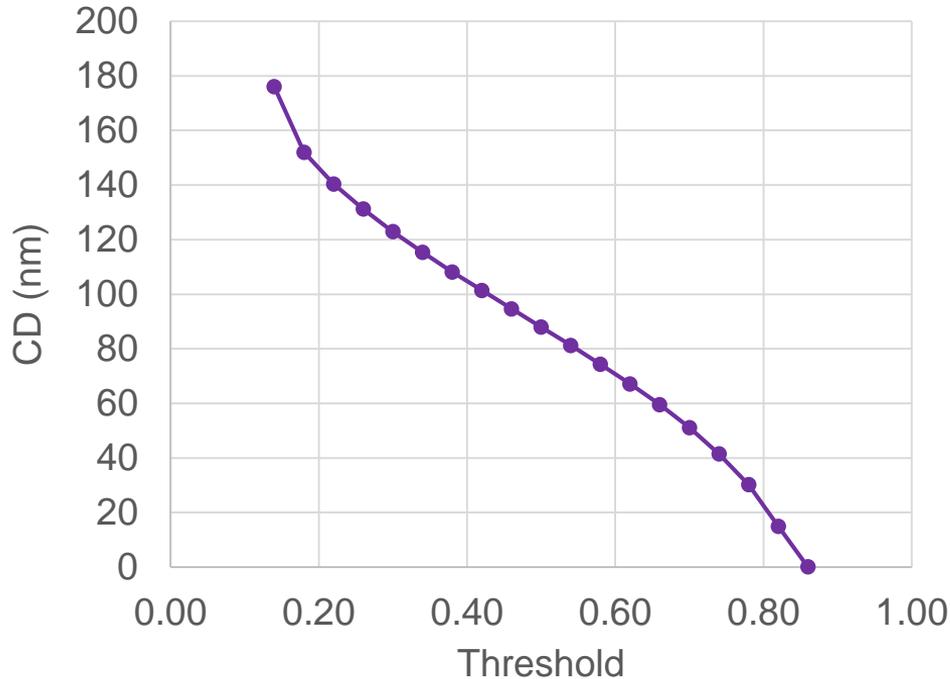
Uniformity

- 88-nm lines across 3-um field
- CD uniformity +/- 1.3%
- Illumination uniformity +/- 1.8%



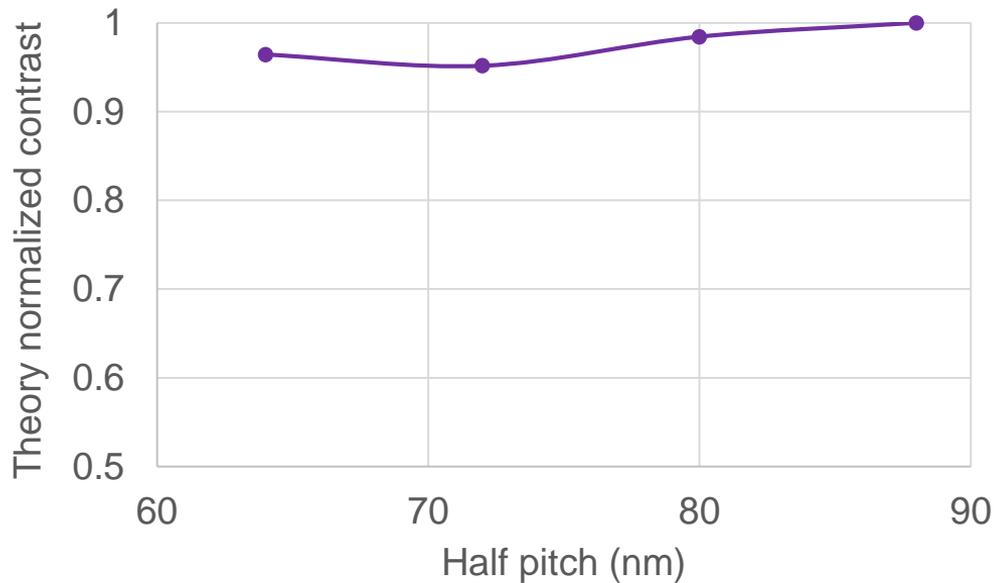
Threshold response indicates diffraction limited performance

limited performance



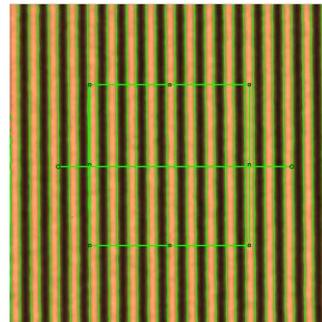
88-nm lines across 3-um field

Near theoretical contrast limit achieved

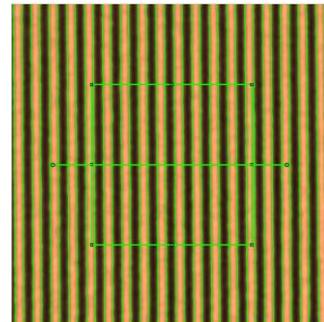


Conventional $\sigma = 0.9$ illumination

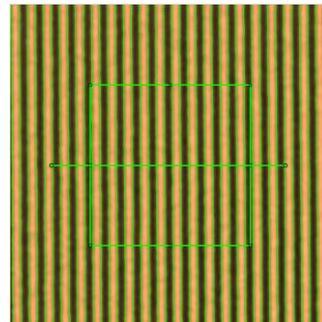
88 nm



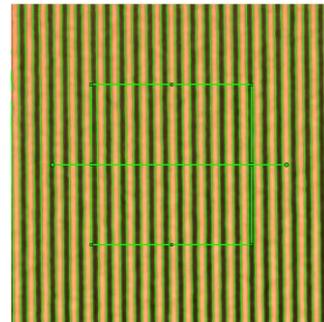
80 nm



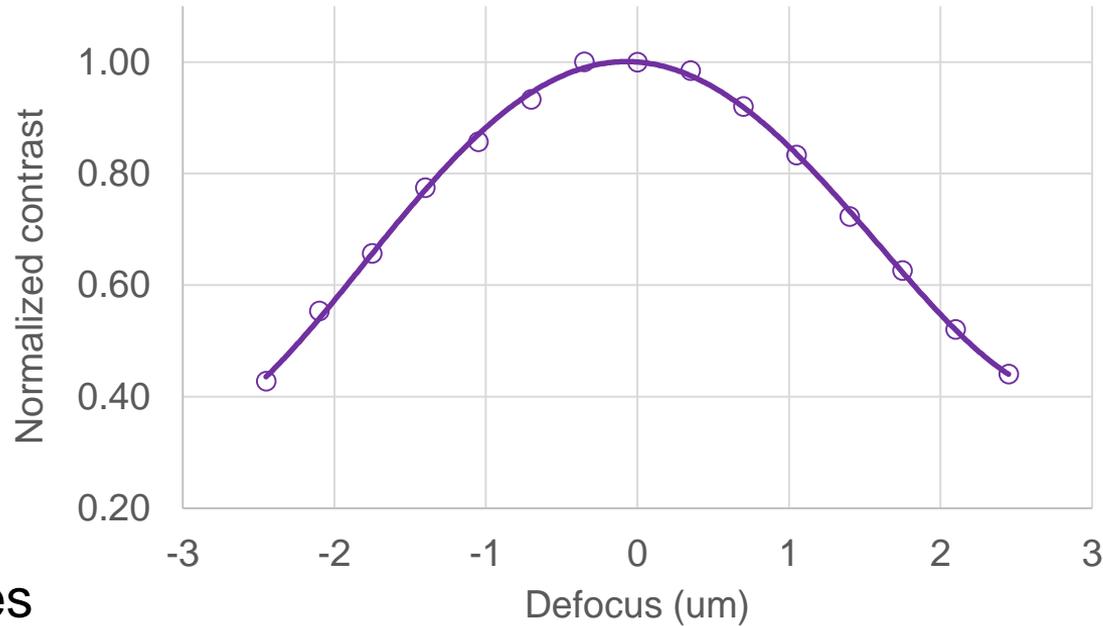
72 nm



64 nm

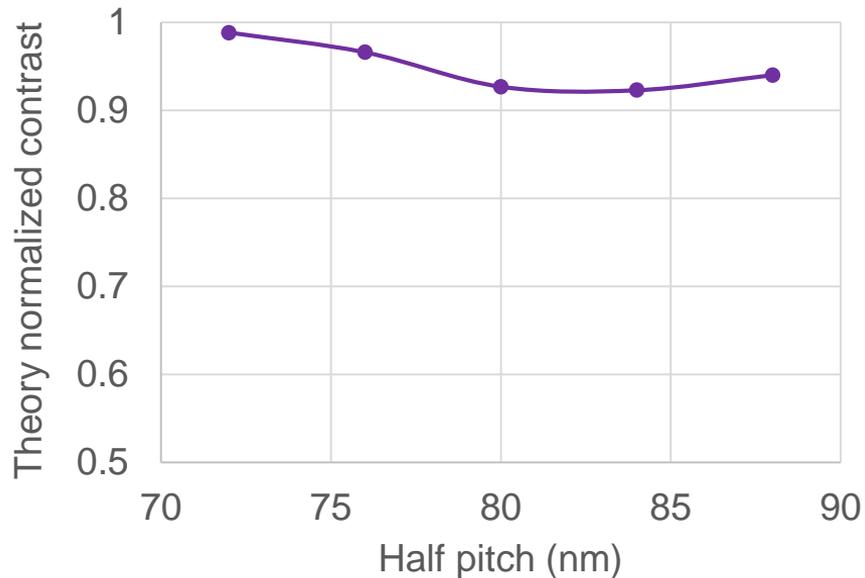


Well-controlled through focus behavior

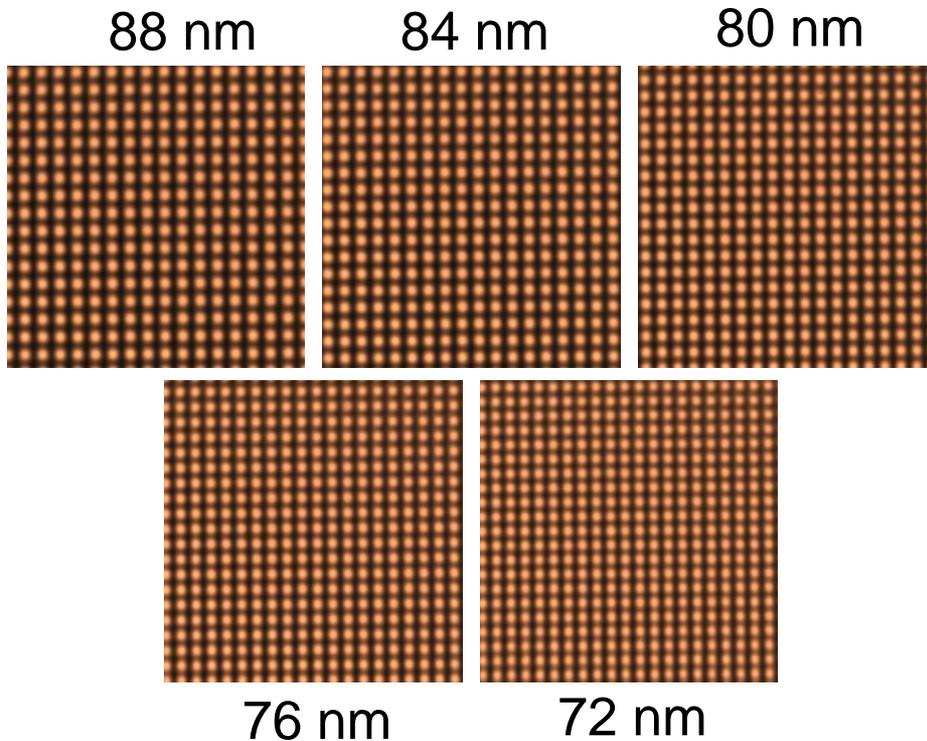


88-nm lines

Near theoretical contrast limit achieved



Conventional $\sigma = 0.9$ illumination



FUTURE IMPROVEMENTS

AIRES+

- The next generation AIRES Tool in fabrication to meet HVM Production requirements
- Increased throughput
 - Improving Optical efficiency
 - Increased source brightness
- Variable illumination
- Upgradeable to High NA
- Customer delivery scheduled Q1 2024



euvi tech



Thank You