EUV Micro-Exposure Tool (MET) for Near-Term Development Using a High NA Projection System

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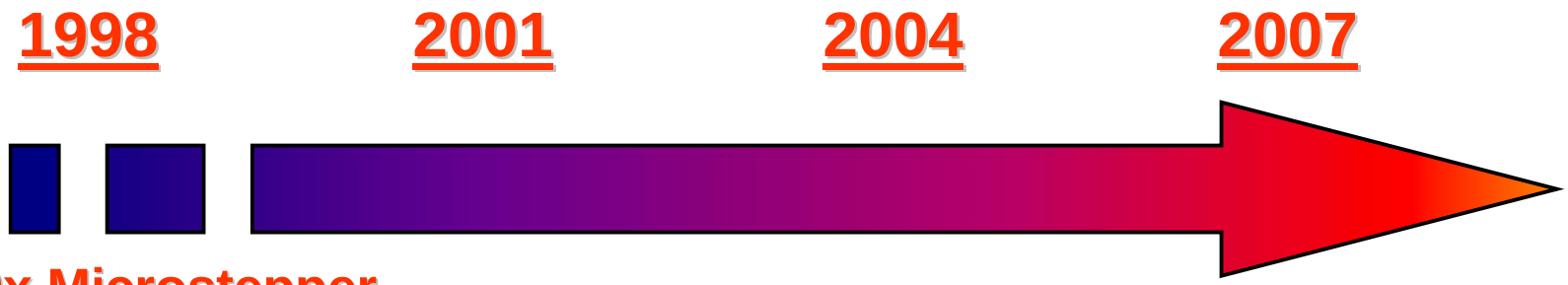
The Micro-Exposure Tool (MET) provides early learning with a high-NA imaging system



10x Microstepper
0.1 NA, small-field

Engineering Test Stand
0.1 NA, full-field

Micro-Exposure Tool
0.30 NA, small-field
30-70 nm imaging

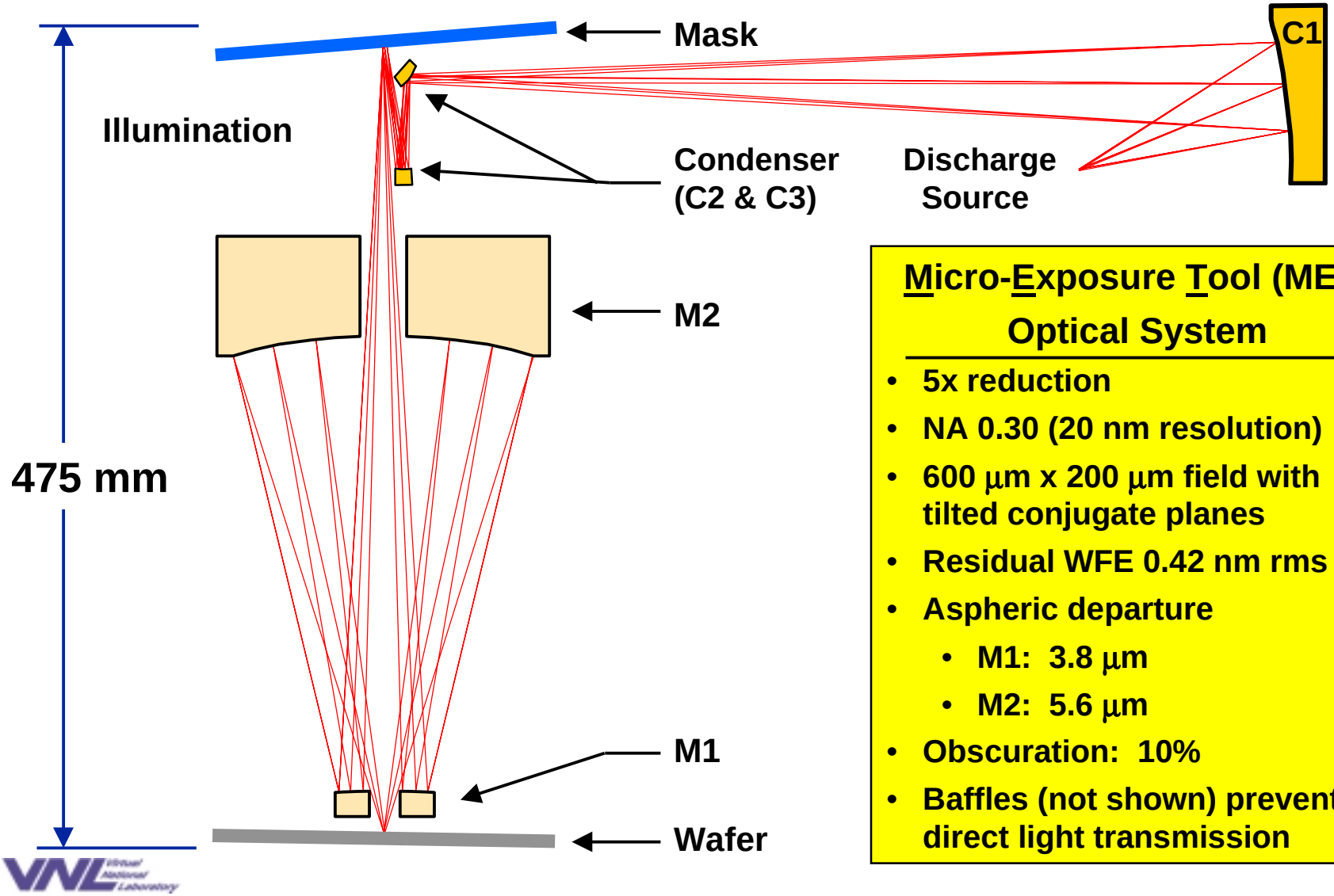
Key early results:

- Resist Development
- Defect Printability
- Process Latitude

Beta-Tools
0.25 NA, full-field

Production Tools
0.25 NA, full-field

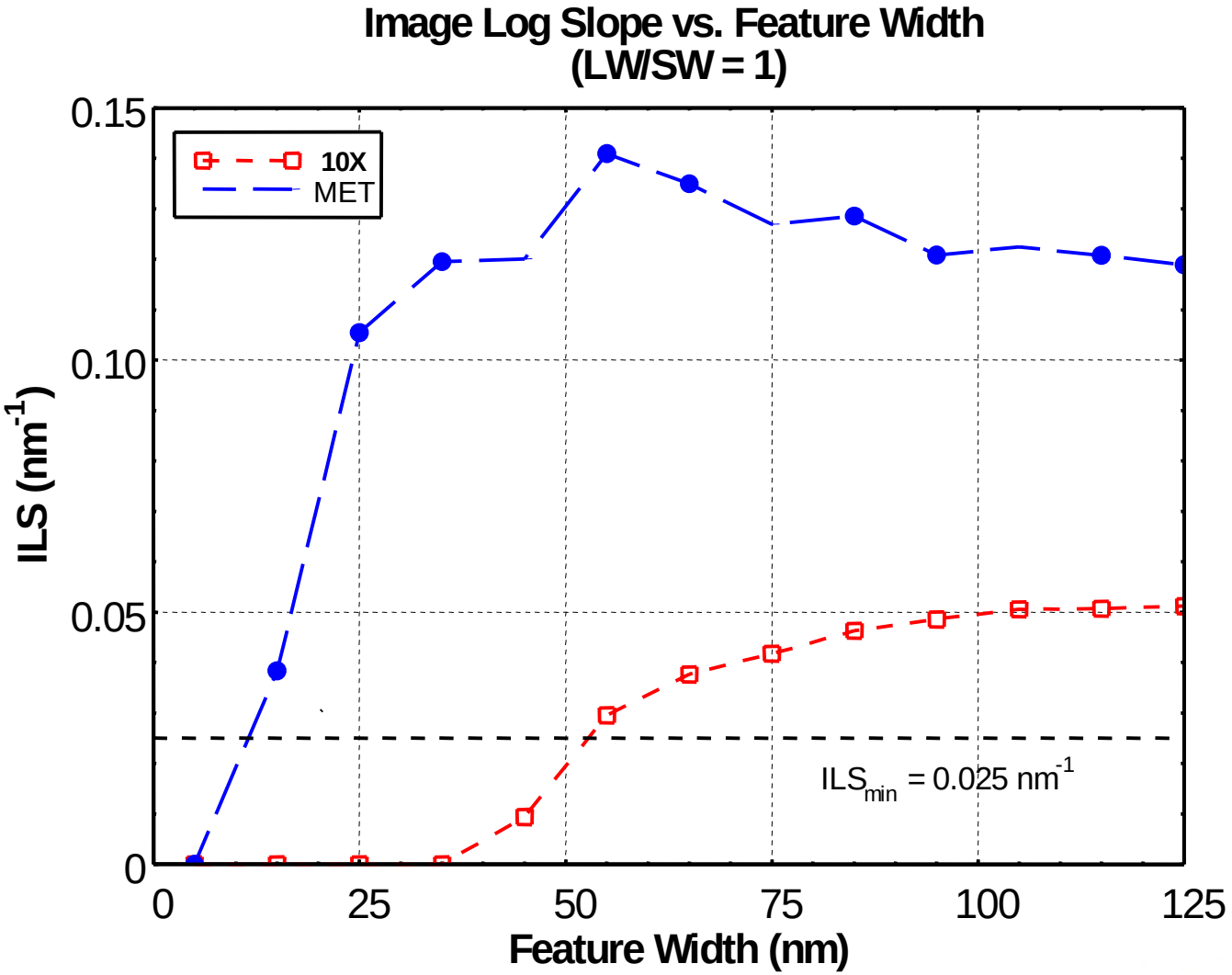
Optical layout of MET camera with condenser concept



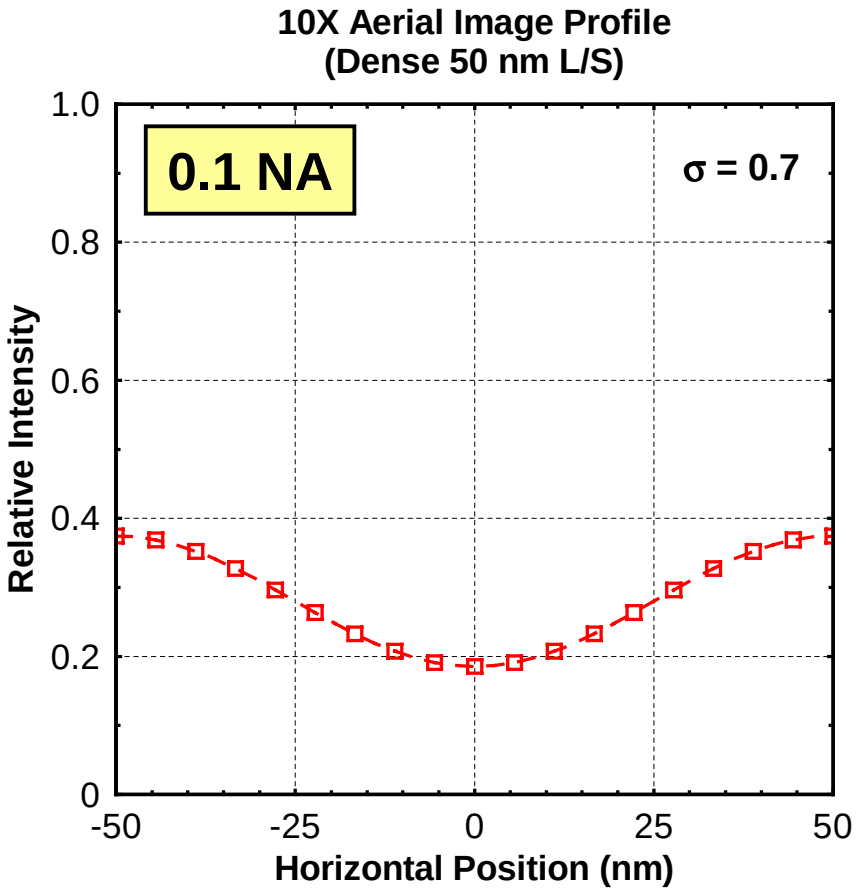
Micro-Exposure Tool (MET) Optical System

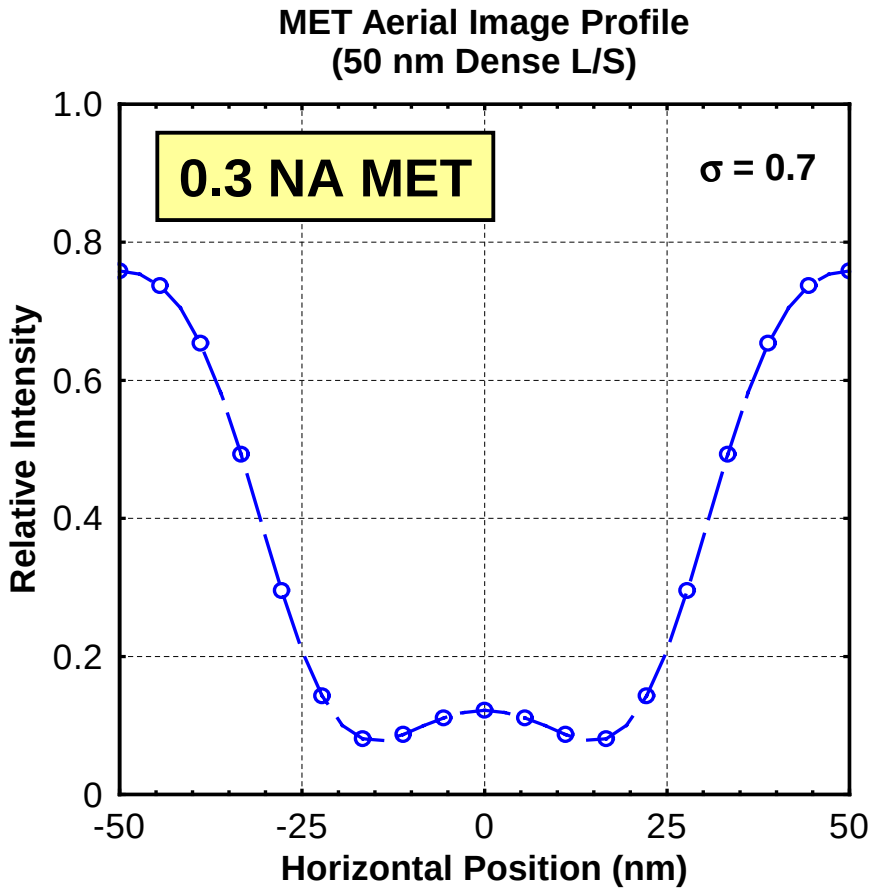
- 5x reduction
- NA 0.30 (20 nm resolution)
- 600 μm x 200 μm field with tilted conjugate planes
- Residual WFE 0.42 nm rms
- Aspheric departure
  - M1: 3.8 μm
  - M2: 5.6 μm
- Obscuration: 10%
- Baffles (not shown) prevent direct light transmission

MET provides ILS > 0.025 nm^{-1} to 20 nm, providing capability beyond that of 0.1 NA 10x microstepper



Superior contrast below 70 nm will support printable defect experiments and resist screening



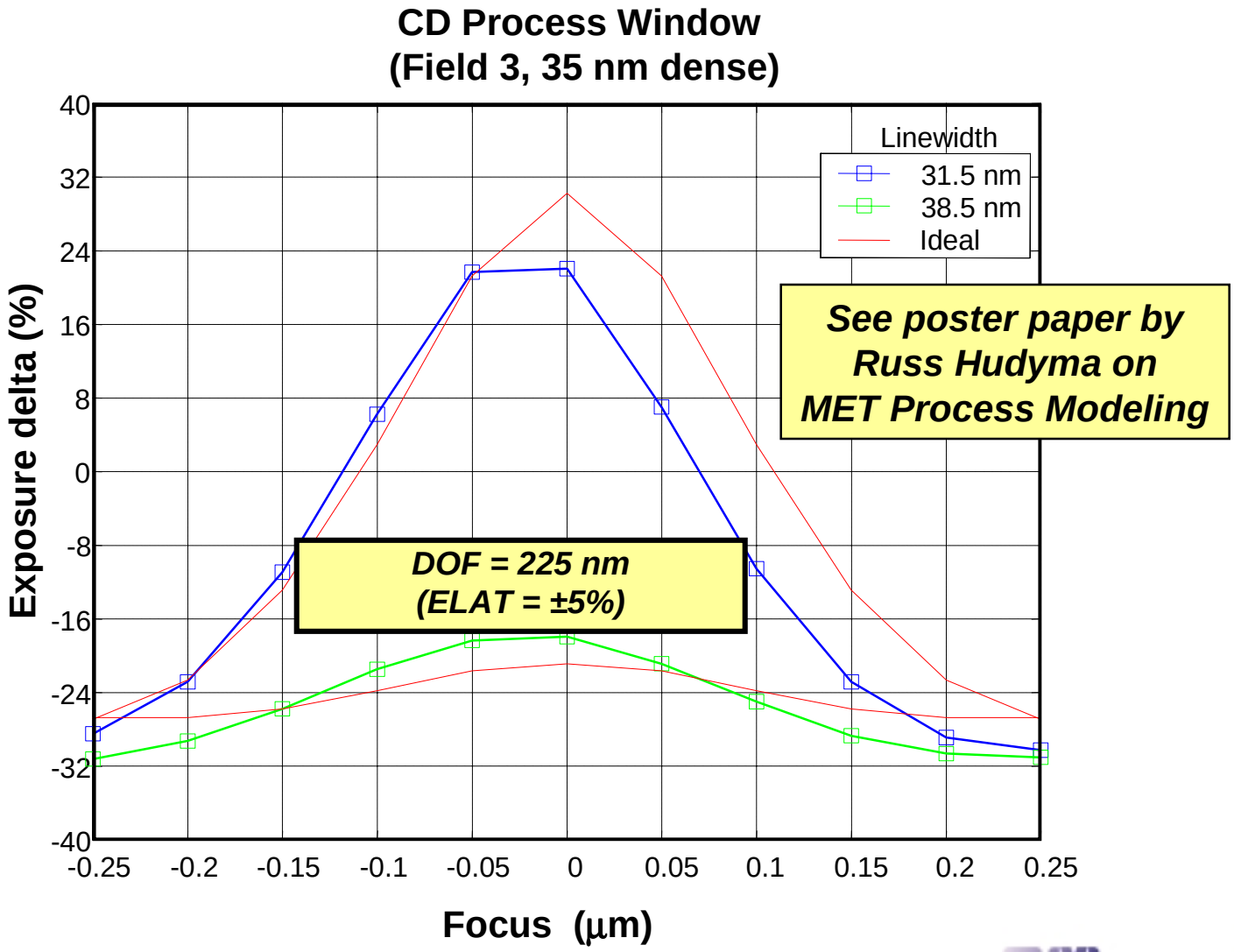


Contrast ~ 0.34

Contrast ~ 0.81

Simulations predict that the MET has a DOF = 225 nm for 35 nm dense L/S

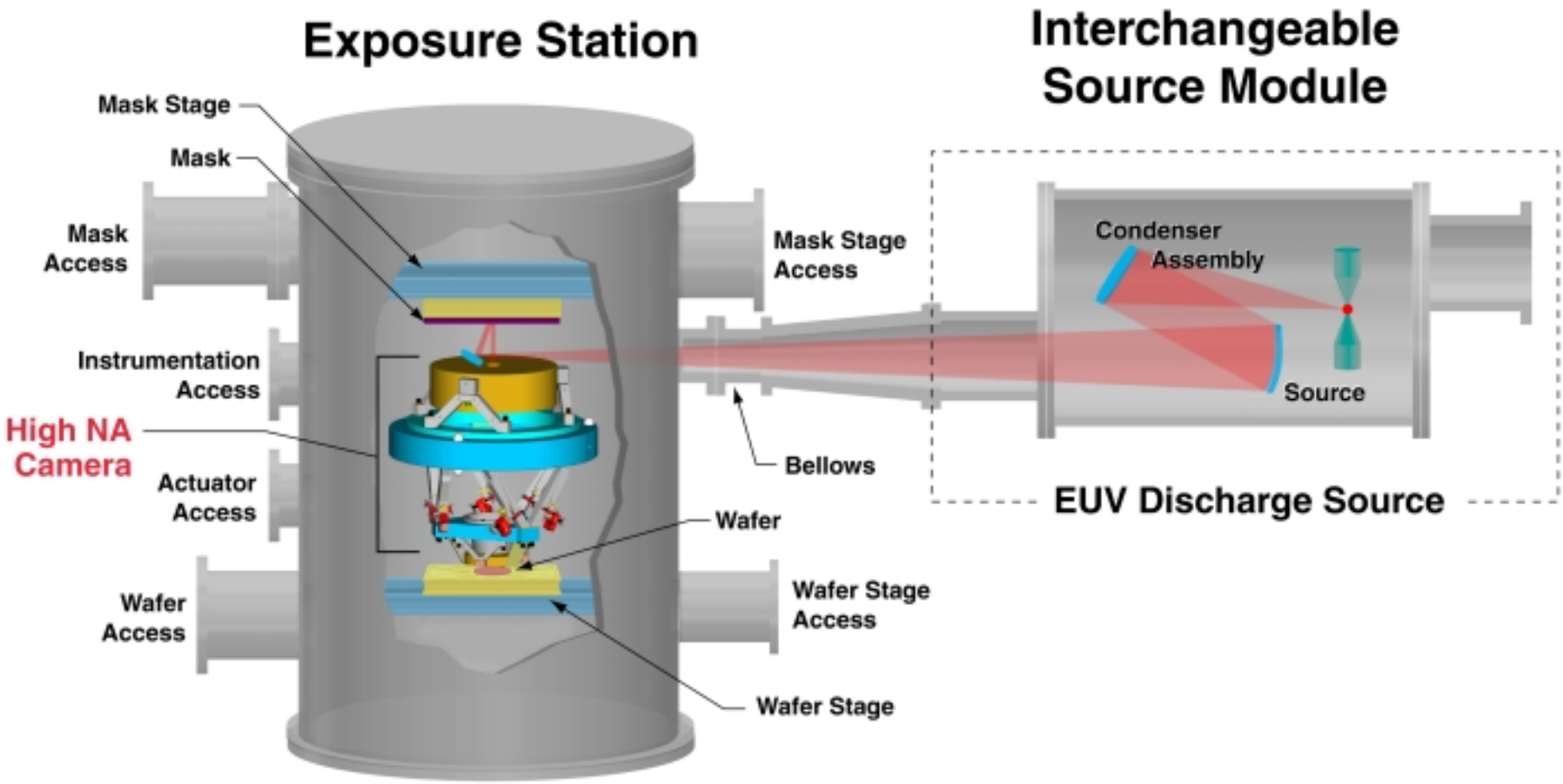
ED Window Dense
(NA 0.30, σ = .7, λ = 13.4 nm)



The High-NA MET enables EUV technology at the 70nm, 50nm, and 35nm nodes

- Resist development
- Printability of mask defects
- Line Edge Roughness
- EUVL extendability to 35 nm node
- Exposure-Defocus process window
- Experience with discharge source
- Development of focus system

Conceptual exposure tool



The Micro-Exposure Tool (MET) is envisioned as a flexible printing test-bed

Imaging System (funded in FY99-00 by Int'l SEMATECH)

- 0.30 NA (obsc.) 5x; 2 aspheric mirrors with Mo/Si coating
- Field size: 200 µm x 600 µm, non-scanning
- Stewart-truss PO Box with pico-motor actuation

Source

- Discharge source

Exposure Tool

- Compatible with 6-inch square format masks
- 200 mm wafers
- Focus system
- Visible light microscope for positioning
- Semi-automatic wafer and mask handling

Optional capabilities are under consideration

Imaging System

- Non-tilted conjugate planes with low distortion in extended field

Source

- Interchangeability with other sources with modified collection optics
- Rotating scan mirror to enable variable fill and non-tilted conjugate planes

Exposure Tool

- *In situ* alignment
- Micro-scanning configuration (with non-tilted planes)
- Fully-automated SMIF pod robotics

International SEMATECH is sponsoring the fabrication of the 0.3 NA MET projection optics

The design for the aspheric 2-mirror camera is complete

Carl Zeiss is manufacturing and testing the aspheric substrates

- **"Set 1" substrates will be delivered in Q4 2000**
- **"Set 2" will be delivered in Q1 2001**
- **"Set 1" Specs**
  - **figure: 0.33 nm rms**
  - **MSFR: 0.35 nm rms**
  - **HSFR: 0.40 nm rms**
- **"Set 2" Specs**
  - **figure: 0.25 nm rms**
  - **MSFR: 0.20 nm rms**
  - **HSFR: 0.10 nm rms**

Figure metrology will be validated at LLNL using PSDI

LLNL will ML-coat two sets of optics

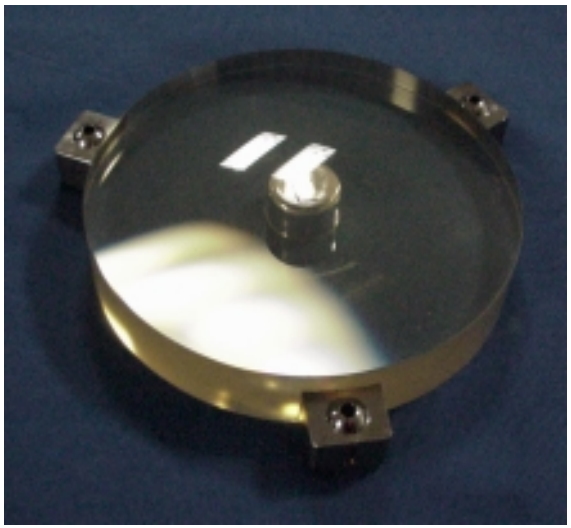
Two PO Boxes have been designed and built at LLNL

Zeiss will perform system alignment using visible light interferometry

PO Box 1 will be shipped to the US; PO Box 2 remains at Zeiss

Carl Zeiss MET primary data demonstrates aspheric convergence to Set 1 requirements

MET Primary In-Process Measurements



Type: Oblate Spheroid
Peak departure: 3.82 μm
Peak slope: -1.18 μm/mm

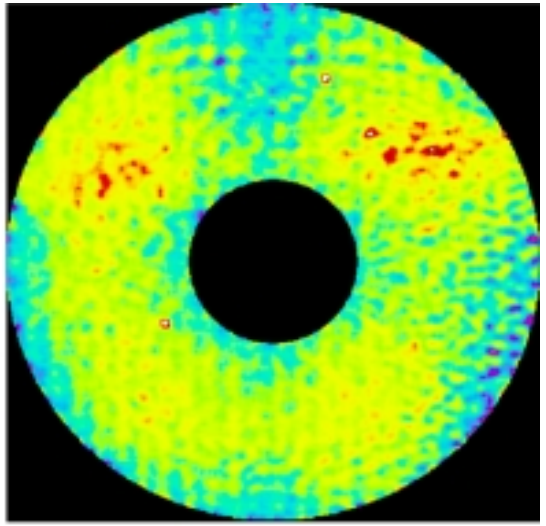
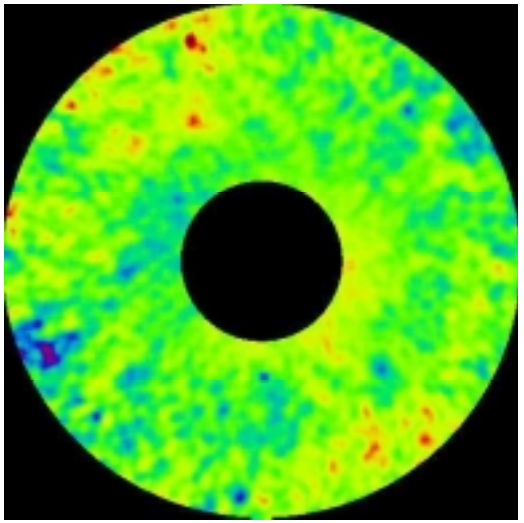
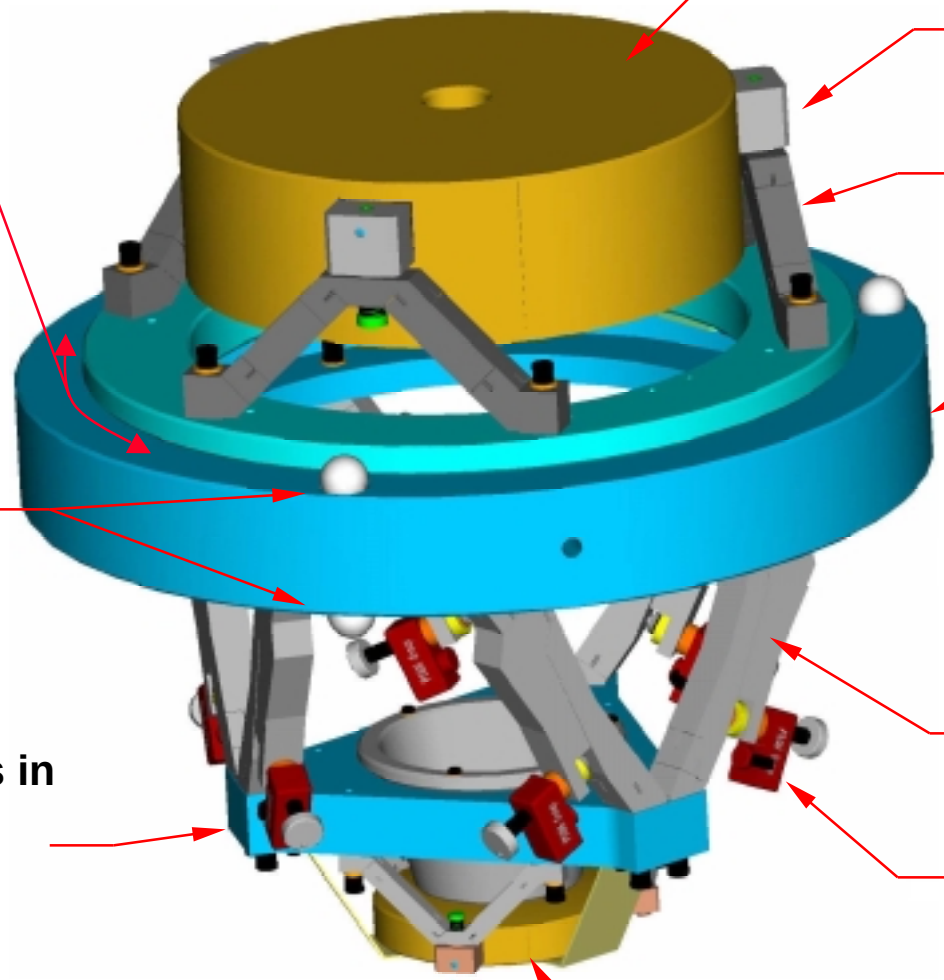


Figure
$f_{spatial} \leq 1\ mm^{-1}$
0.34 nm rms

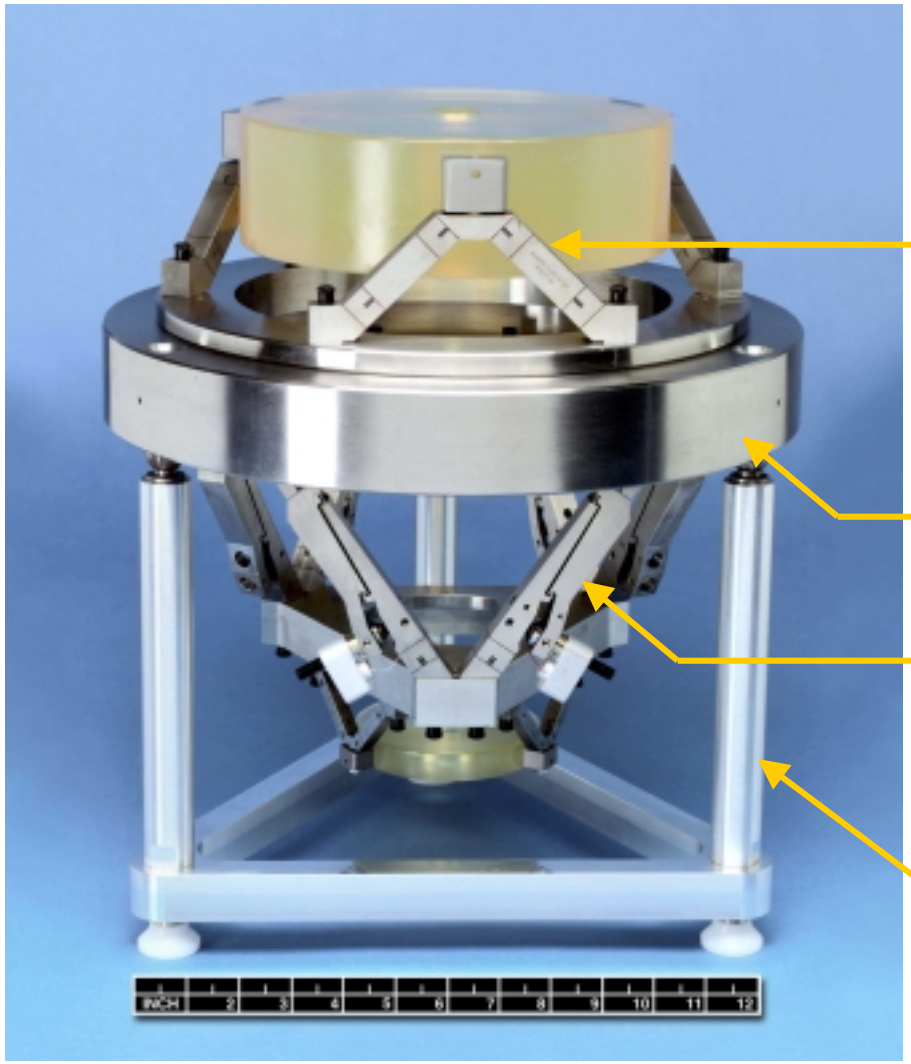


Metrology
Reproducibility
0.056nm rms

The PO Box provides rigid support for the optics, an interface to the system, and alignment control

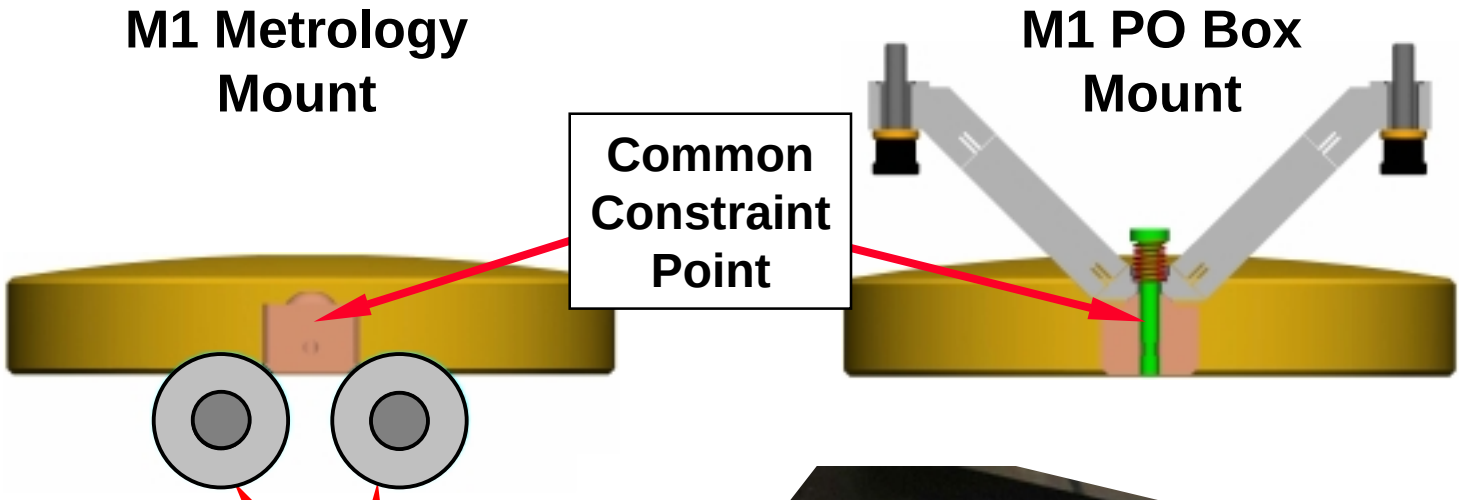


The MET PO Box is ready for installation of optics

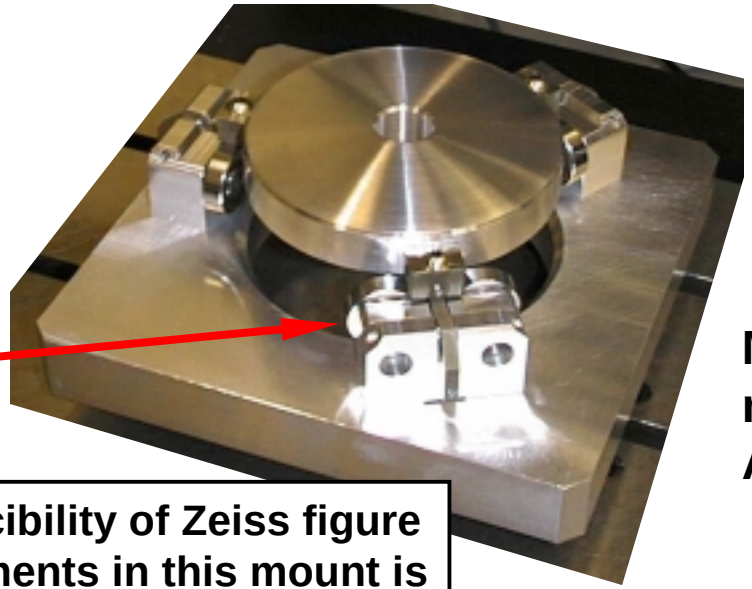


Shown with surrogate optics

Common kinematic constraints enable the use of different mounts for metrology and installation



Rolling-element bearings minimize non-repeatability due to friction

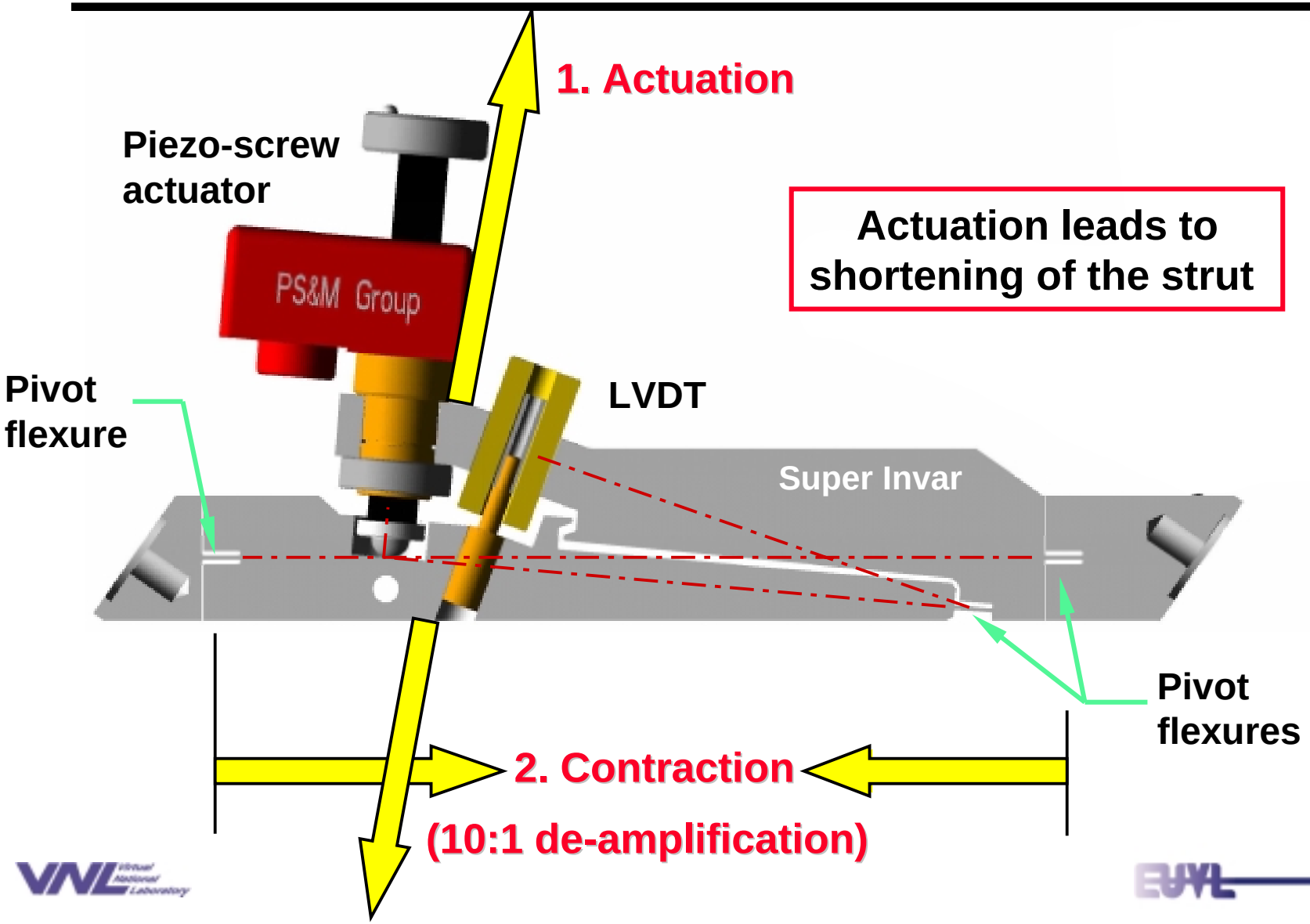


M1 metrology mount with Al surrogate

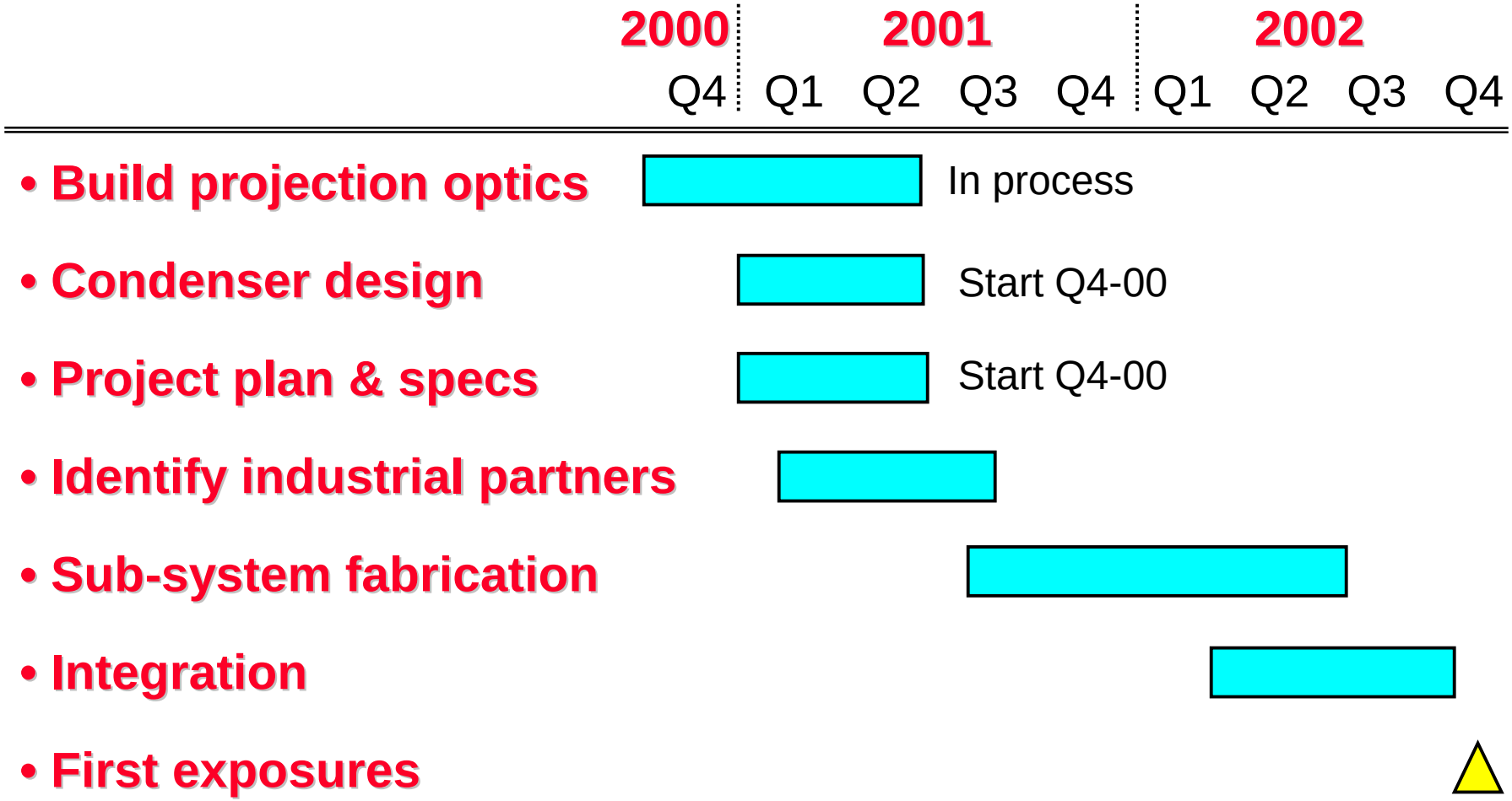
Reproducibility of Zeiss figure measurements in this mount is 0.056 nm rms

Strut arm length has sensitive control using pivot flexure design

See Layton Hale's Poster Paper



A key challenge is to identify a plan that supports high-NA EUV exposures in 2 years



Conclusions

A proposal for a High-NA EUV Micro-Exposure Tool (MET) has been endorsed by the I-SEMATECH Project Advisory Group (PAG) to provide early learning in resist development and defect printability

I-SEMATECH has funded the construction of 0.3 NA projection optics suitable for the MET

System planning is underway to assess specifications, schedule, and cost

Potential industrial partners are invited to participate in system planning

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