

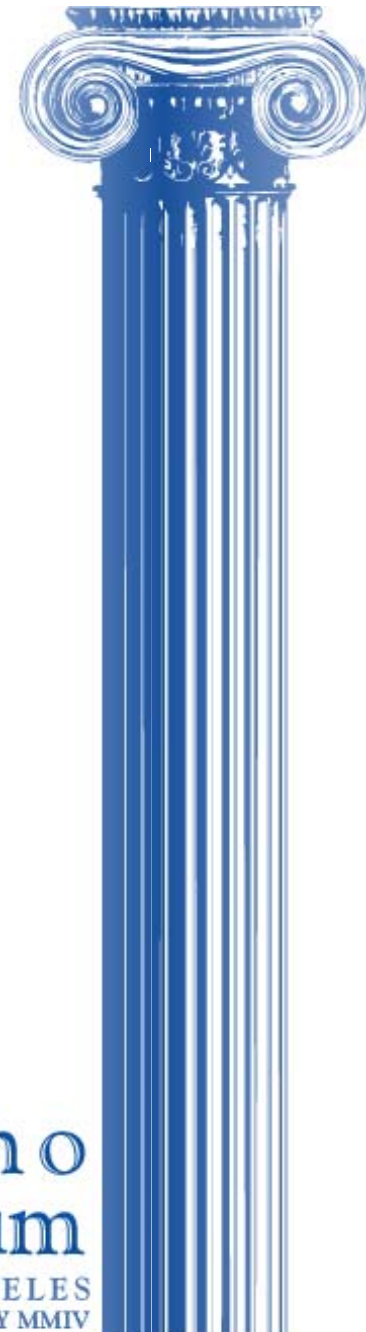
EUV Mask Blanks

Industry Status

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EUV Mask Blank Development

- **Early development proved feasibility of reflective EUV masks**
 - VNL/EUV-LLC, Medea+ Extumask, CEA-LETI, ASET.
- **Commercial blank supplier status:**
 - 2 major suppliers now supplying blanks to preliminary specifications.
 - At least 2 other suppliers developing capability.
- **ISMT program**
 - Developing commercial supplier base through blank purchases, performance evaluation and data feedback.
 - Accelerating equipment infrastructure and process development through EUV Mask Blank Development Center in Albany, N.Y.
- **SEMI Standards**
 - P37 describes substrate form factor and material properties.
 - P38 describes reflector, buffer and absorber layers.

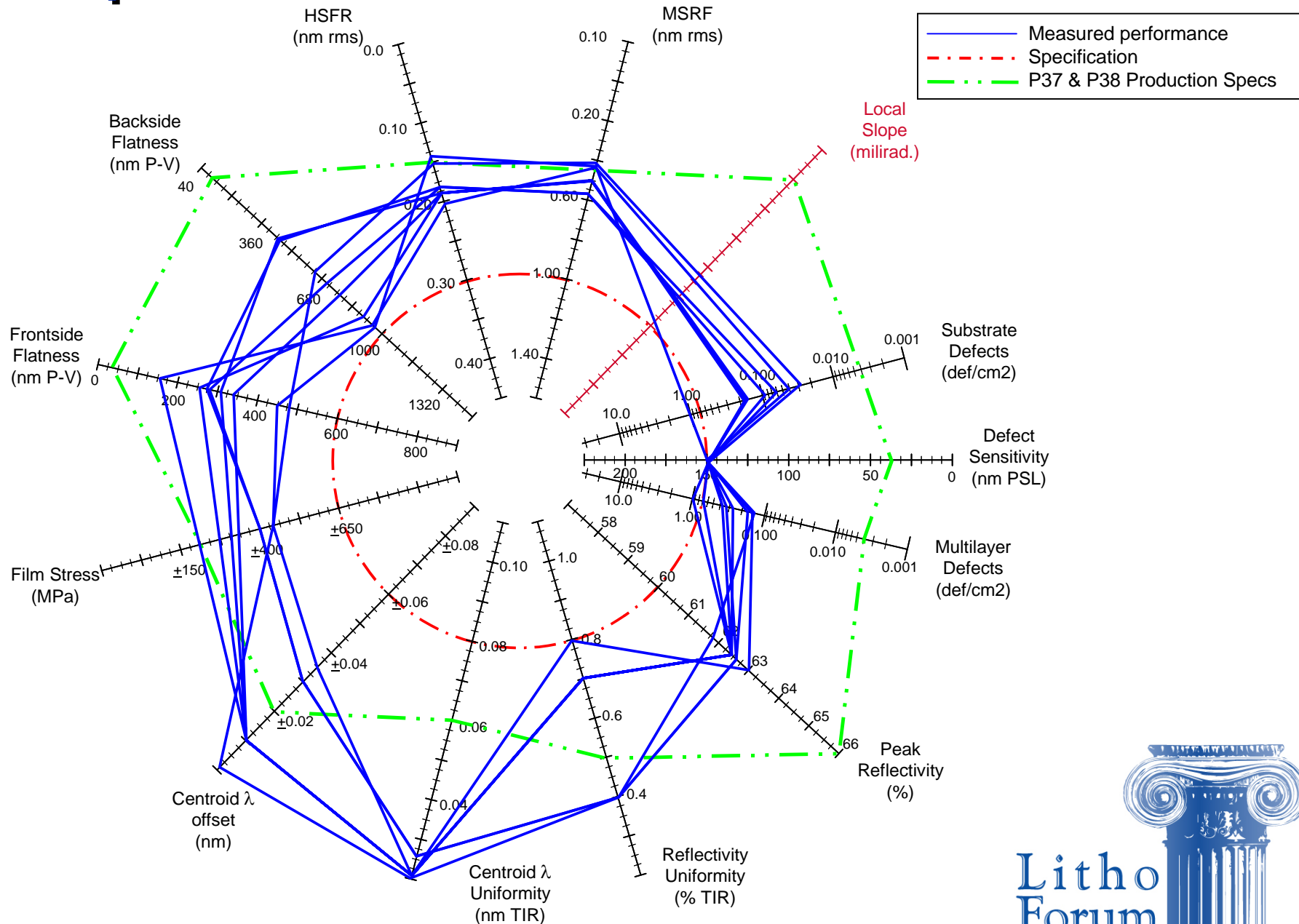


EUV Mask Blank Specification Roadmap

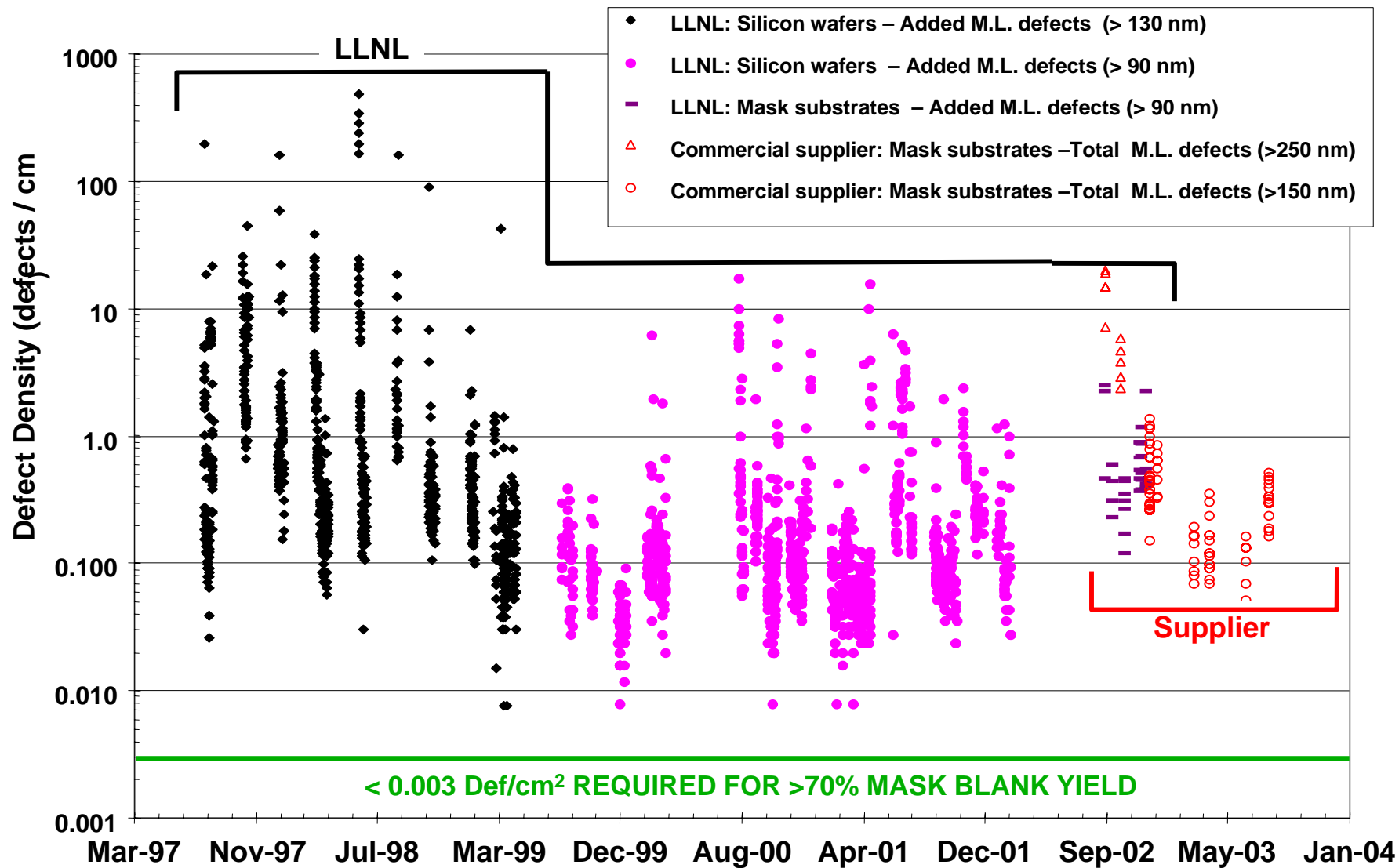
Year	2003	2003	2004	2004	2005	2005	2006	2006	2007	2007	Production
Half	H1	H2	H1	H2	H1	H2	H1	H2	H1	H2	45nm
Phase	Pre-a	Pre-a	alpha	alpha	beta	beta	beta	beta	beta	beta	gamma
Parameter											
Mask Substrate											
Material	LTEM NZTE	LTEM NZTE	LTEM NZTE	LTEM NZTE	LTEM NZTE	LTEM NZTE	LTEM NZTE	LTEM NZTE	LTEM NZTE	LTEM NZTE	LTEM NZTE
Mean CTE (\pm ppb/ deg K)	30	30	25	25	20	20	15	15	10	10	± 5
CTE Spatial Variation (TIR)	10	10	10	10	8	8	8	6	6	6	6
Flatness Front (μm) (P-V)	0.6	0.6	0.5	0.4	0.3	0.3	0.2	0.2	0.1	0.05	0.03
Flatness Back (μm) (P-V)	1.0	1.0	0.8	0.8	0.6	0.5	0.4	0.3	0.2	0.1	0.05
Maximum Wedge Angle ($\mu\text{radians}$)	200	200	200	200	150	150	150	150	100	100	100
Surface Finish											
MSFR (nm rms)	< 2.0	< 2.0	< 1.5	< 1.0	< 0.5	< 0.5	N.A.	N.A.	N.A.	N.A.	N.A.
HSFR (nm rms)	0.25	0.25	0.25	0.20	0.20	0.20	0.20	0.15	0.15	0.15	< 0.15
Local Slope of Front Surface (mrad)	N.A.	N.A.	≤ 2.0	≤ 2.0	≤ 1.5	≤ 1.5	≤ 1.5	≤ 1.5	≤ 1.0	≤ 1.0	≤ 1.0
Total Blank Defects											
Total ML Defect Density (defects/cm ²)	2.0	1.0	0.8	0.6	0.4	0.20	0.12	0.08	0.03	0.01	0.003
Cut-off Size (PSL equivalent, nm)	150	150	120	120	90	90	60	60	40	40	25
Multilayer Performance											
Peak Reflectivity (%) [j]	>58%	>58%	>60%	>60%	>62%	>62%	>63%	>64%	>65%	>66%	> 67%
Peak Reflectivity Unif. (%P-V) Absol.	0.80	0.80	0.70	0.60	0.60	0.55	0.55	0.50	0.50	0.50	0.50
Mean Centroid λ of Reflectivity (nm) [I]	13.40	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	TBD
Centroid Reflected λ Uniformity (nm P-V)	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07	0.06	0.06	0.06

■ Current & expected performance
 ■ Meet w/ upgraded tooling & process
 ■ New tooling / process needed
■ New Tooling & Process innovation needed

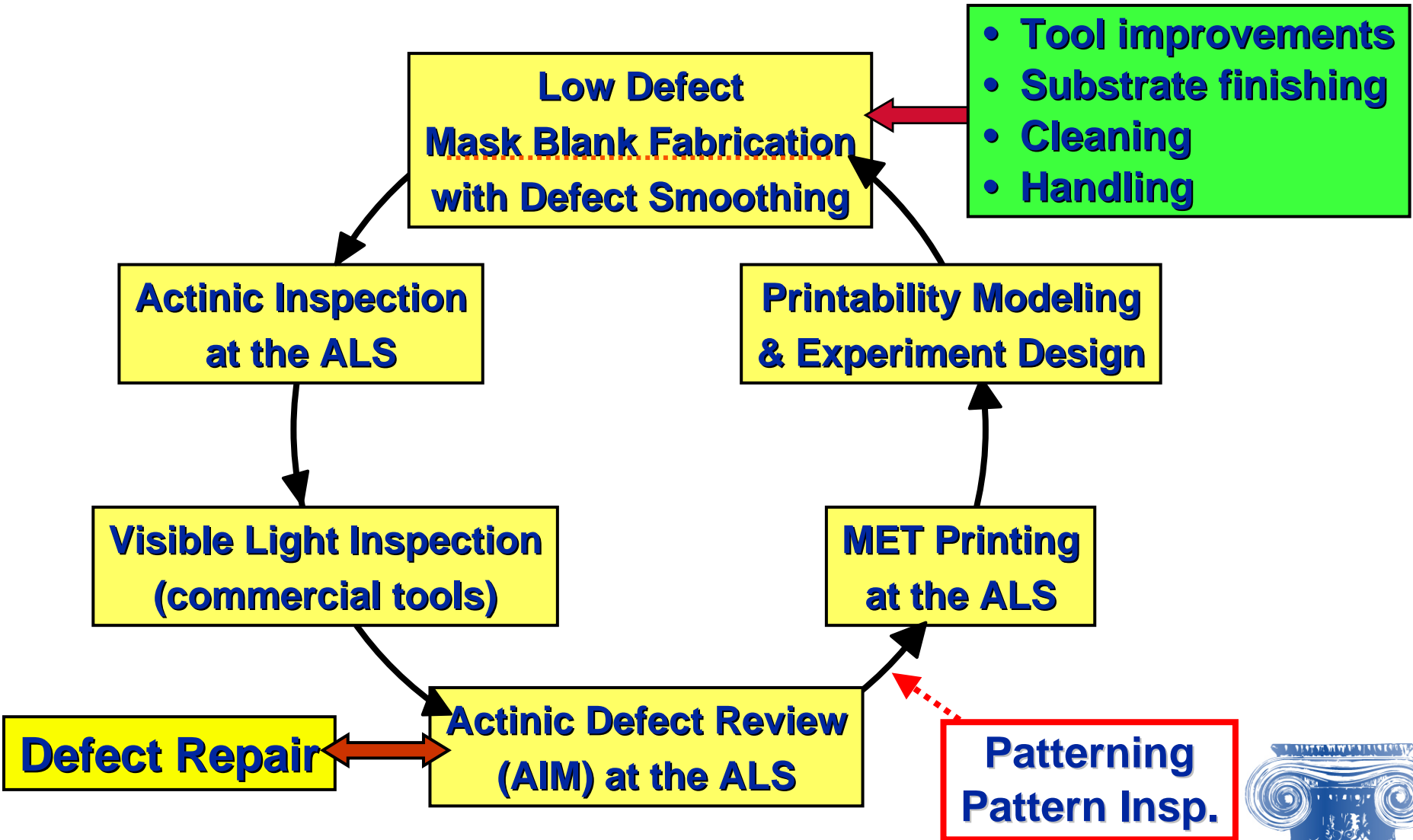
Example data: 8 Commercial Blanks



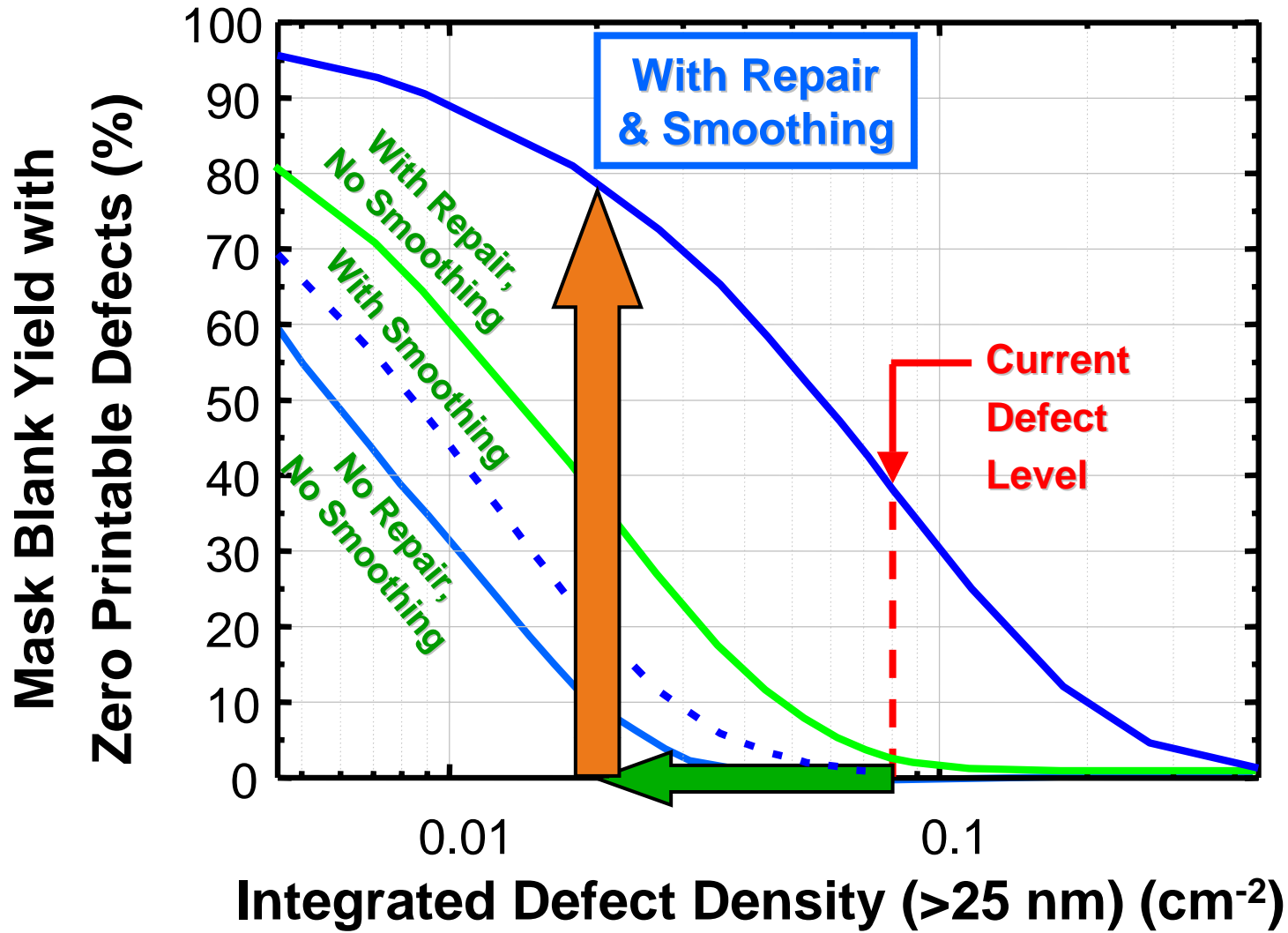
EUV Mask Blank Defect Trend



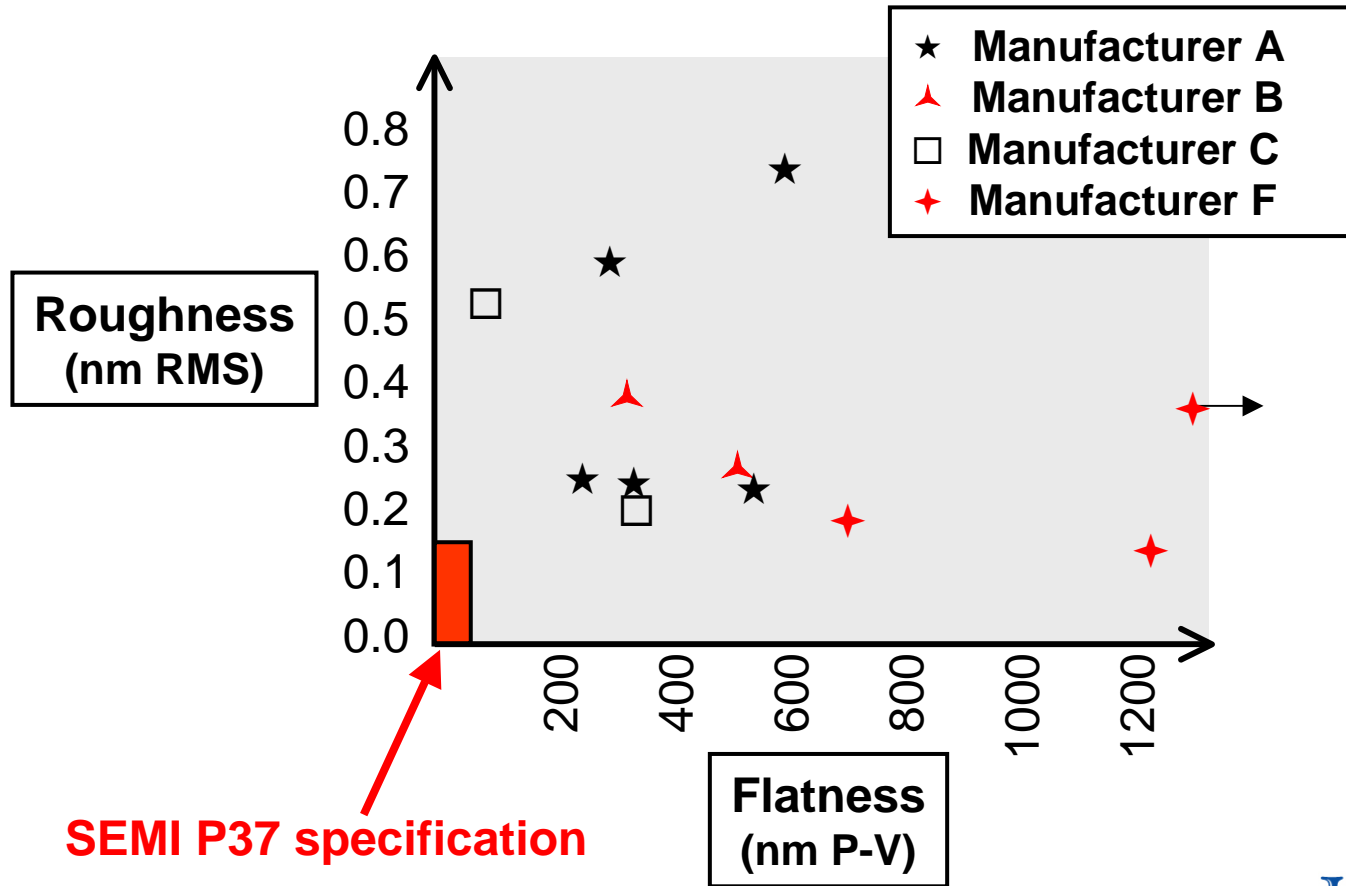
Integrated projects to address defects



Defect repair, smoothing, and defect reduction are being pursued to achieve acceptable yields



Flatness and Roughness



EUV Mask Blank Development Center - Albany N.Y.



- 655 m² ballroom area with Class 10 clean bays.
- RSP (SMIF) interface used for all defect-critical process and metrology tools.

Technical Objectives:

- ❑ Accelerate equipment and process development for low defectivity EUV mask blank manufacturing.
- ❑ Establish user facility for metrology and evaluation of EUV mask blanks.
- ❑ Develop commercial supply infrastructure for EUV mask blanks.

Current Status:

- ❑ Critical process and metrology tools installed and qualified.
- ❑ Fully staffed with 7 engineers and 7 technicians on site.
- ❑ Process development and defect reduction tasks in progress.
- ❑ Commercial suppliers are using the facility.

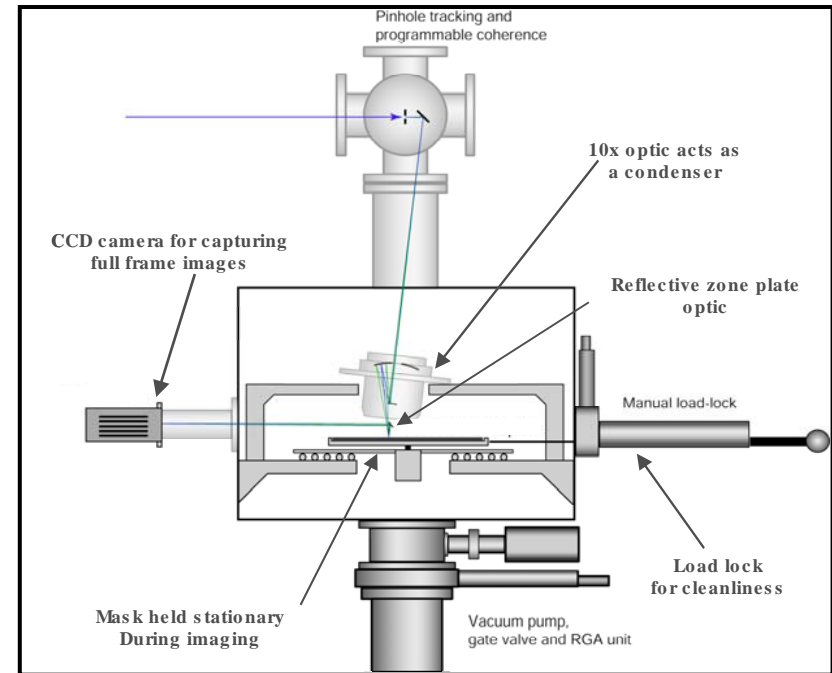
EUV Blank Infrastructure: Defect Inspection

- ❑ A current generation Lasertec Corp. M1350 tool is installed and in use at ISMT-North with demonstrated 60nm defect sensitivity (polystyrene latex sphere equivalent).
- ❑ ISMT has contracted with Lasertec Corp. to develop a next generation defect inspection tool for EUV mask substrates and blanks with 30nm sensitivity.
- ❑ The new tool will be based on the existing M1350 platform and use a shorter illumination wavelength to provide increased resolution.



Actinic Inspection

- ❑ We need to know whether actinic (EUV-wavelength) inspection will be needed to capture all EUV printable mask blank defects.
- ❑ An actinic EUV mask blank inspection station is being constructed at Lawrence Berkeley National Laboratory.
- ❑ Tool will be used to validate the defect sensitivity of optical inspection tools and ultimately to determine if there is a need for a commercial at-wavelength defect inspection tool.
- ❑ A high resolution microscope mode provides at-wavelength imaging of defects, patterned absorbers, repair sites, etc.



Defect Scanning Mode

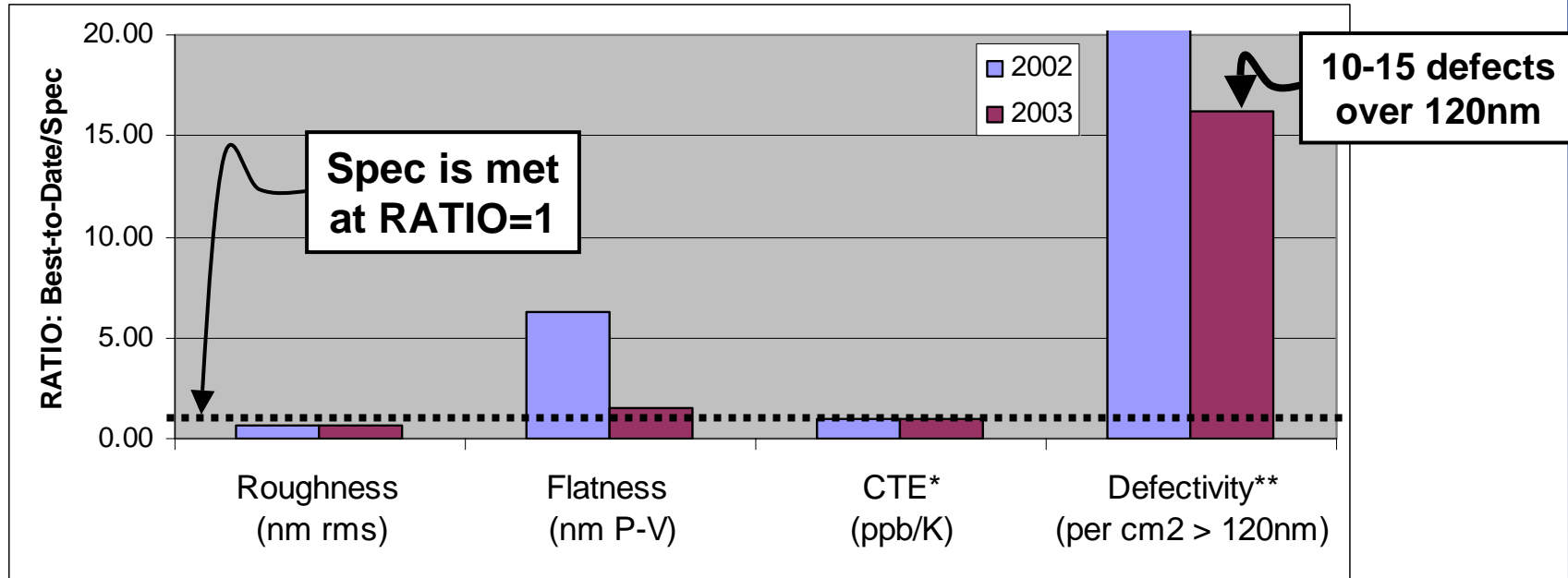
Wavelength:	13.5 nm
Min Spot Size:	~1 μm
Throughput:	2 cm^2/Hr

High Resolution Imaging Mode

Wavelength:	13.5 nm
Angle of Inc:	6°
Resolution:	107 nm
Field Size:	10 x 10 μm
Throughput:	<10 sec

Summary: Supplier best data is within 1.5x of target (except defectivity at 16x)

Comparison of supplier “best to date” capability to specs (P-37 and P-38):



Summary

- Roughness, flatness and CTE capability have been demonstrated separately within 1.5X of specification
- Roughness, flatness, and defectivity not yet available simultaneously.

(Results are best-to-date over all suppliers, from different substrates for all categories)

(*CTE for ULE measured indirectly, through strong correlation to refractive index: Hrdina KE, *Proc. SPIE*, vol.5037, 2003, pp.227-35.)

(**Specification is for >25-60nm size; inspection capability is >120nm)

(**Specification is zero defects; unofficially 1/blank = 0.008cm⁻² usually tolerable)