

SPIE 2004

# Validation of the current status of EUV Mask Blank Defectivity levels

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February 23, 2004

 **Lasertec Corporation**

INTERNATIONAL  
**SEMATECH**

# Outline

- **Scope of study**
- ISMT program
- Inspection sensitivity
- Inspection results
- Outlook at 32nm PSL equivalent defect size

# Scope of study

**Using multilayer coated EUV Mask Blanks  
obtained from commercial suppliers:**

- 1. Validate defect density numbers reported**
- 2. Report defect density numbers at highest  
qualified inspection sensitivity**
- 3. Estimate defectivity level at 32nm PSL  
equivalent defect size**

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# **EUV Mask Blank Development Center**

**International SEMATECH North, Albany, NY**

## **Mission:**

### ***Commercial Quality EUV Mask Blanks by 2007***

**In partnership with commercial blank and tool suppliers, develop the equipment, processes and infrastructure to meet industry needs for 45nm technology node.**

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

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# Lasertec M1350 calibration

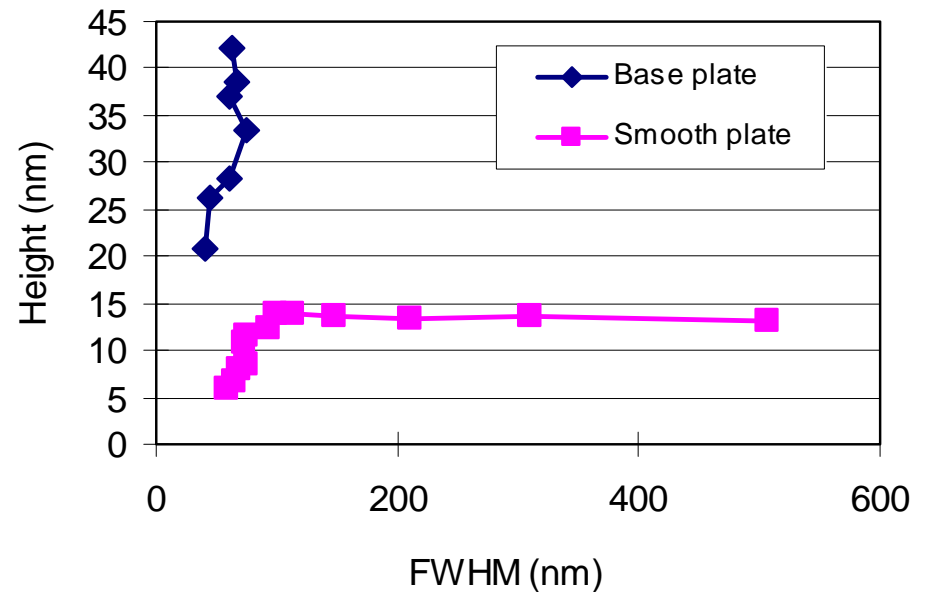
- **Calibration**

1. PSL defects

- on Quartz (range 40 – 500nm)
- on Mo/Si Multilayer (range 60 – 300nm)

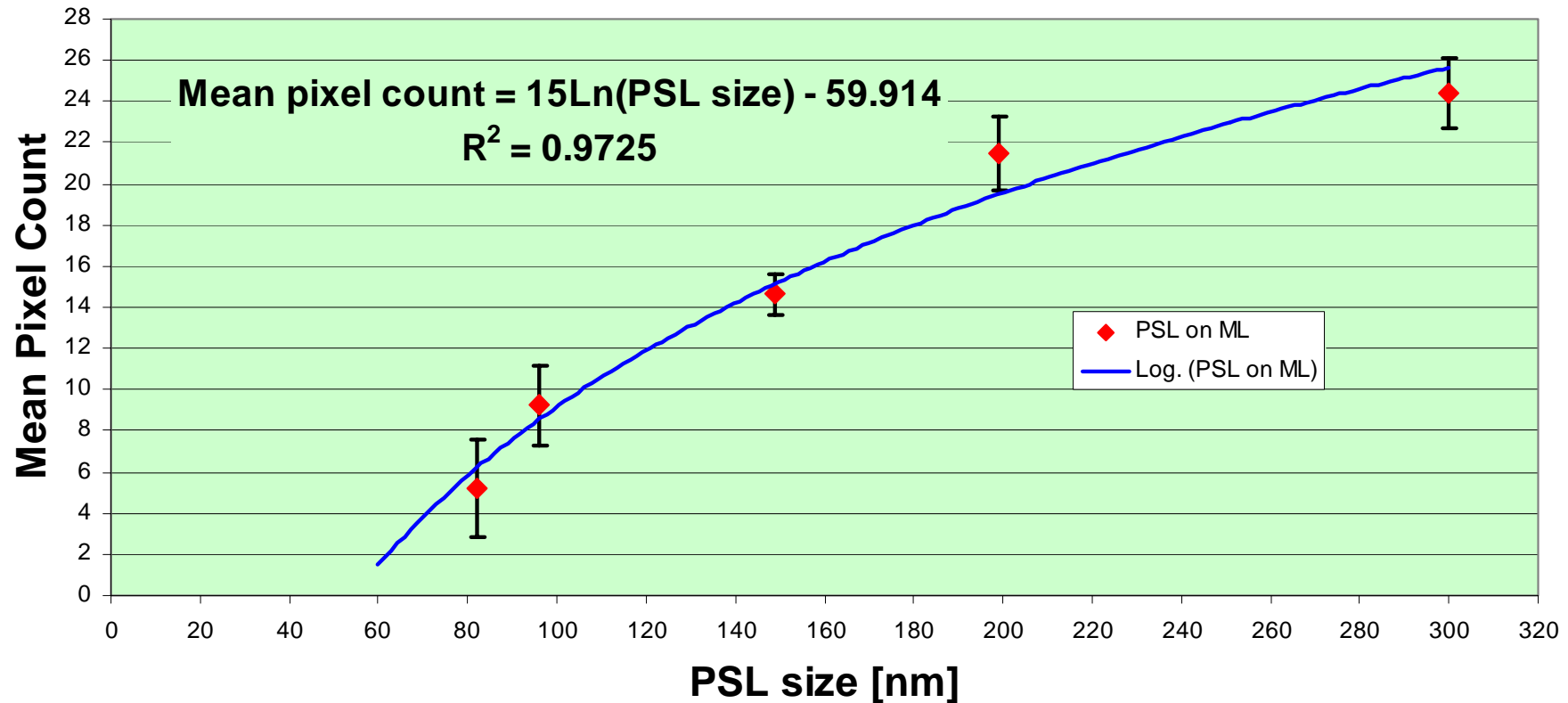
2. Programmed Multilayer (ML) defects

- bumps
  - FWHM 40-500 nm
  - Height 5-40 nm
- pits / scratches



# Lasertec M1350 calibration

Mean Pixel Count calibration of Lasertec M1350  
with PSL spheres on Multilayer coated blanks



Fit model:

Pixel Count response of sphere with radius  $d = A \ln(B \cdot d)$

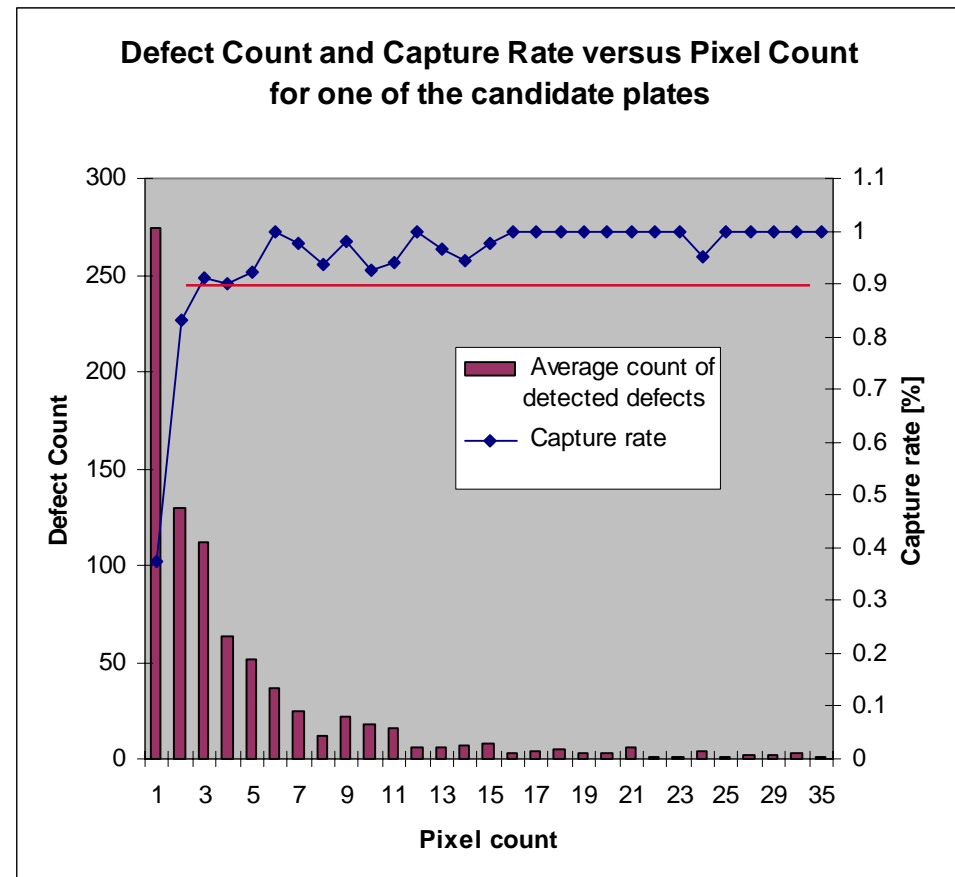
J.P. Urbach  
BACUS 2003

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# Lasertec M1350 Inspection sensitivity

- **Sensitivity optimization**
  - Max 5% false defects in smallest pixels (1,2)
  - Capture Rate > 90%
  - Allowing plates with various levels of roughness to be inspected at equal sensitivity



The system is currently qualified at

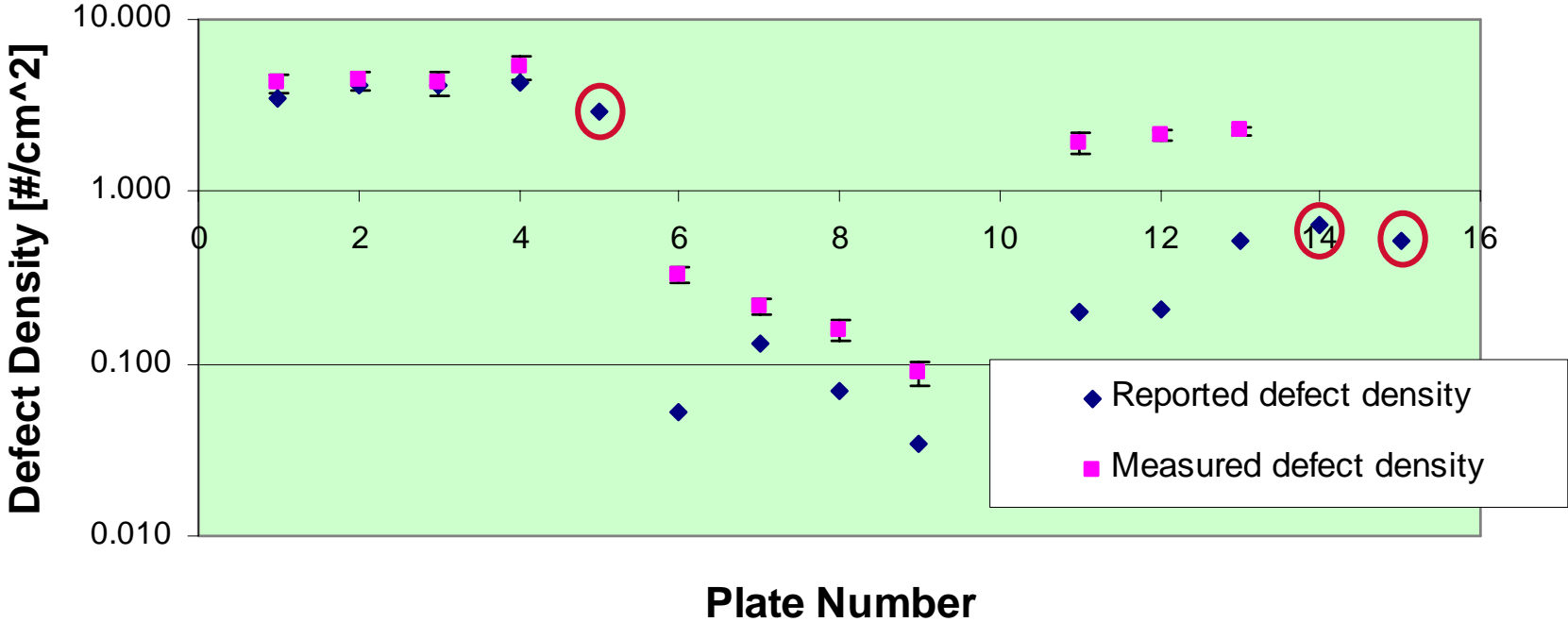
- 80nm PSL sensitivity on Multilayer
- 60nm PSL sensitivity on Quartz

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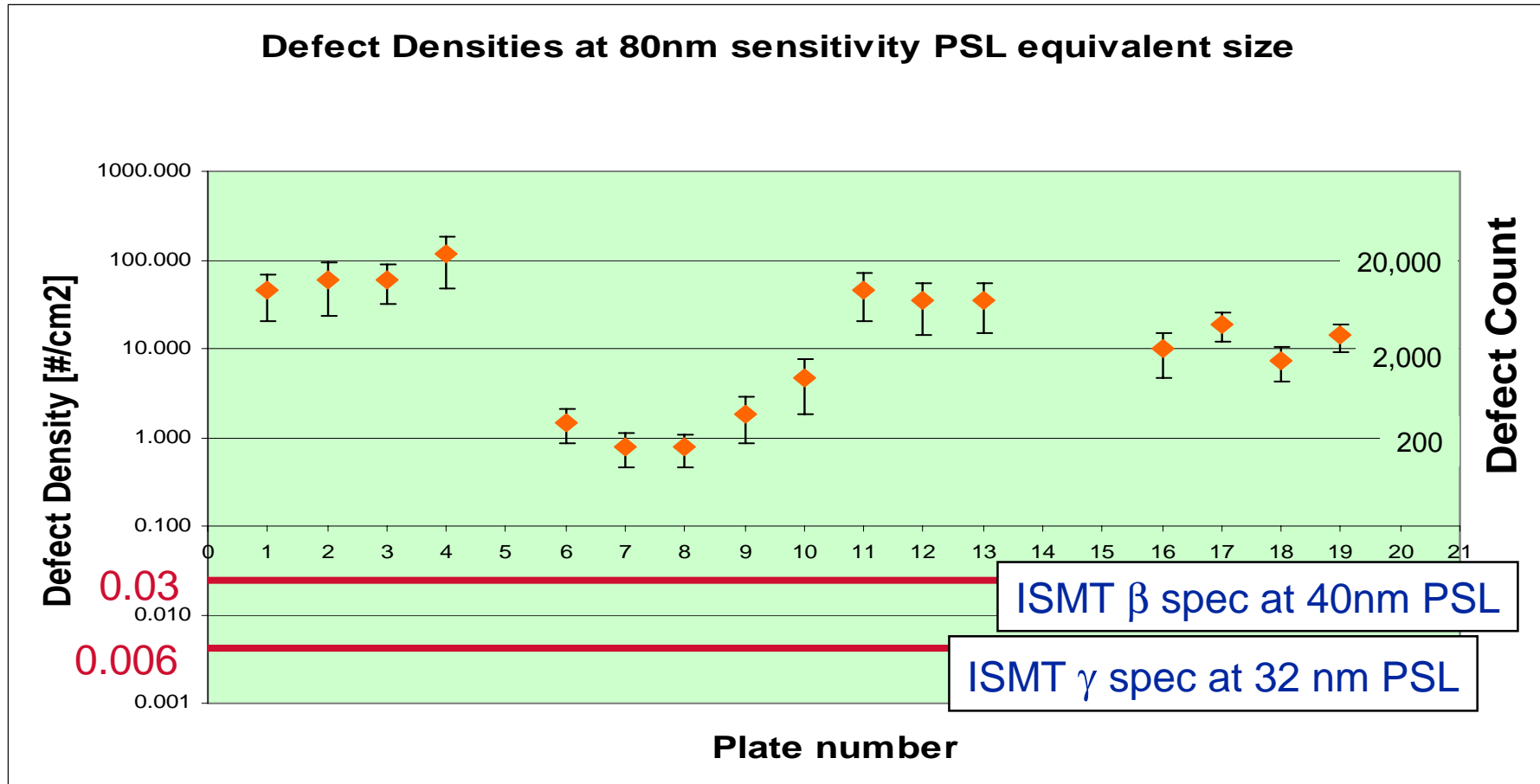
# Comparing Lasertec with supplier reported data

Reported versus measured defect density  
(sensitivity and inspected area matched to supplier)



○ 3 plates defect overflow (>100.000 counts)

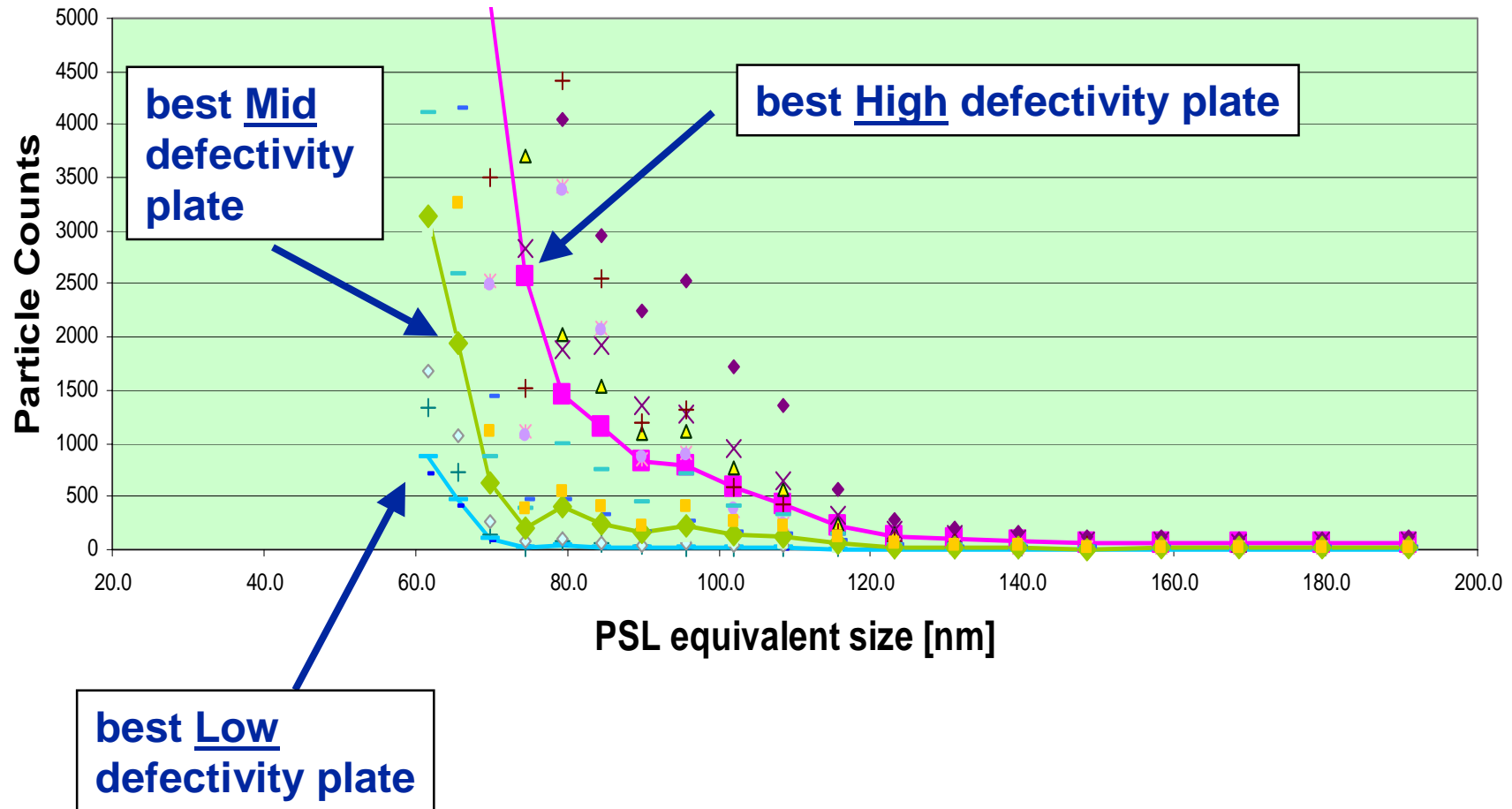
# Current status of EUV Mask Blanks



- ISMT beta total defect density spec for pilot line: 0.03 at 40nm PSL (2007)
- ISMT's EUV technology mapping roadmap and 2003 ITRS gamma specifications for introduction 45nm HP node: 0.006 at 32nm PSL

# Defect Count distribution

Particle counts versus PSL equivalent size for all material

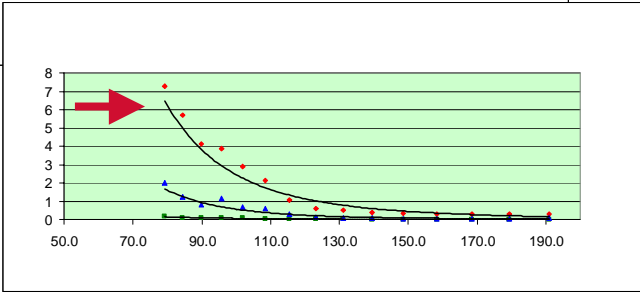
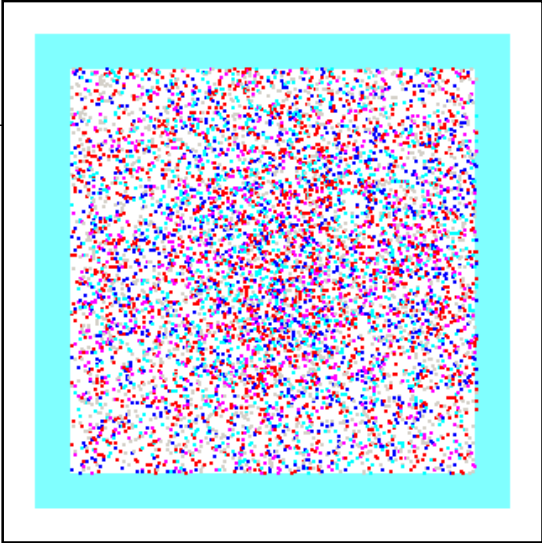
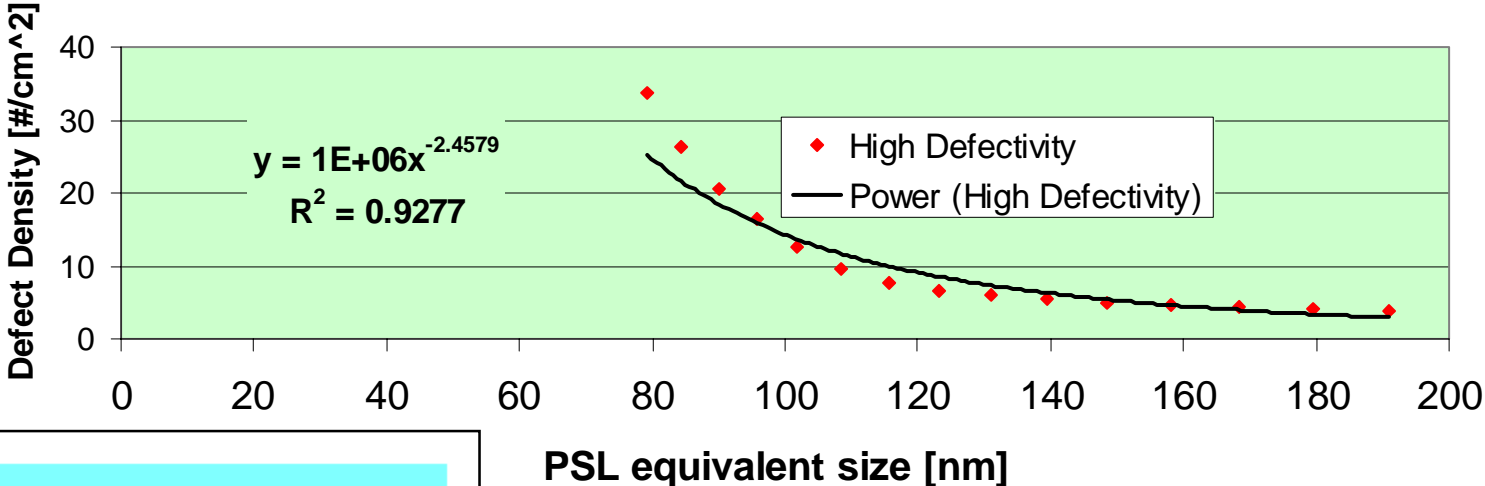


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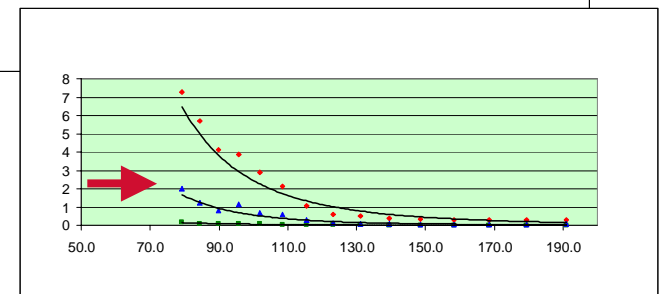
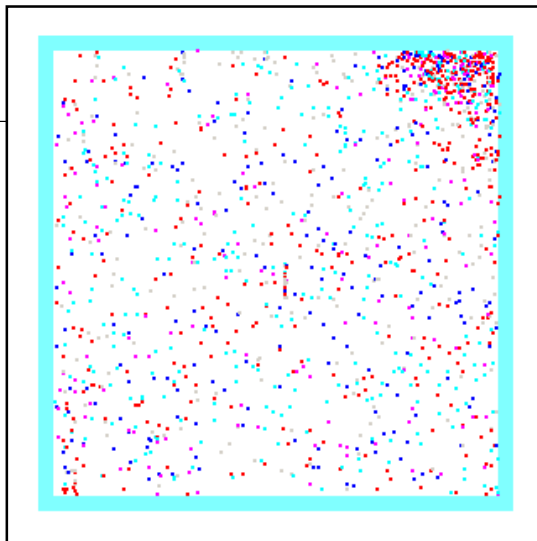
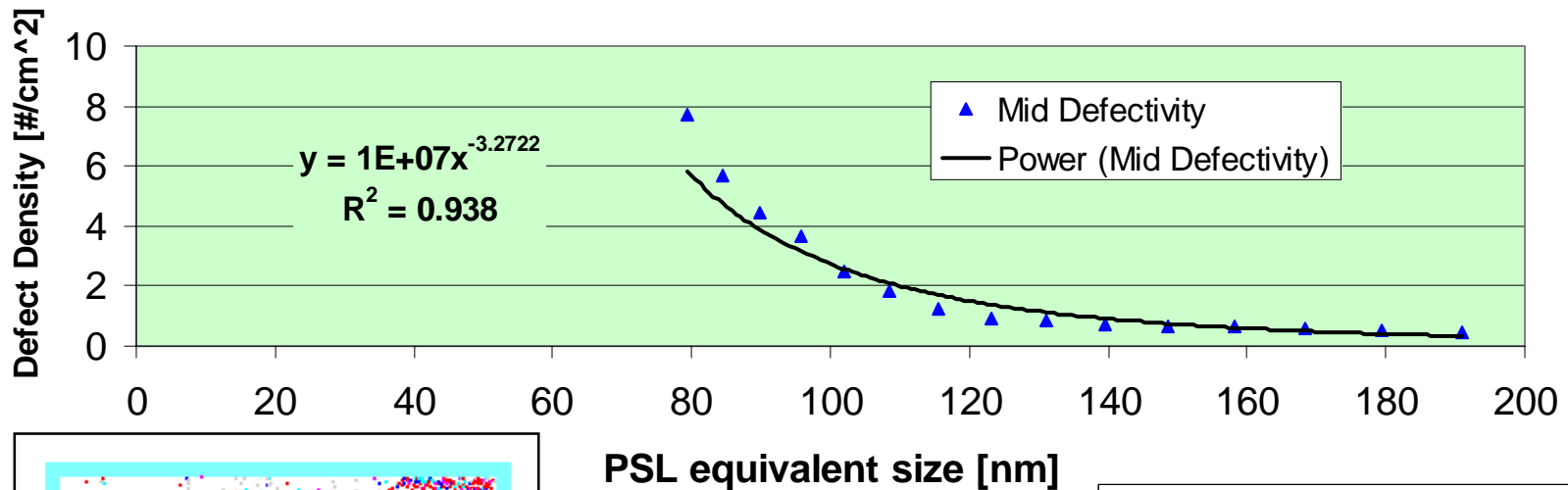
# Power curve fit: high defectivity

Defect Size distribution for High defectivity material



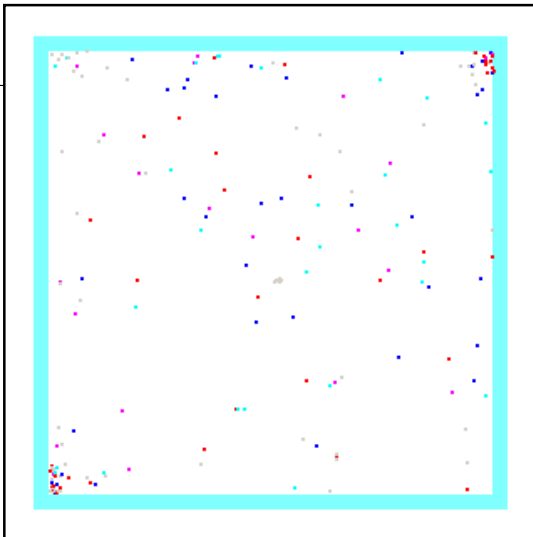
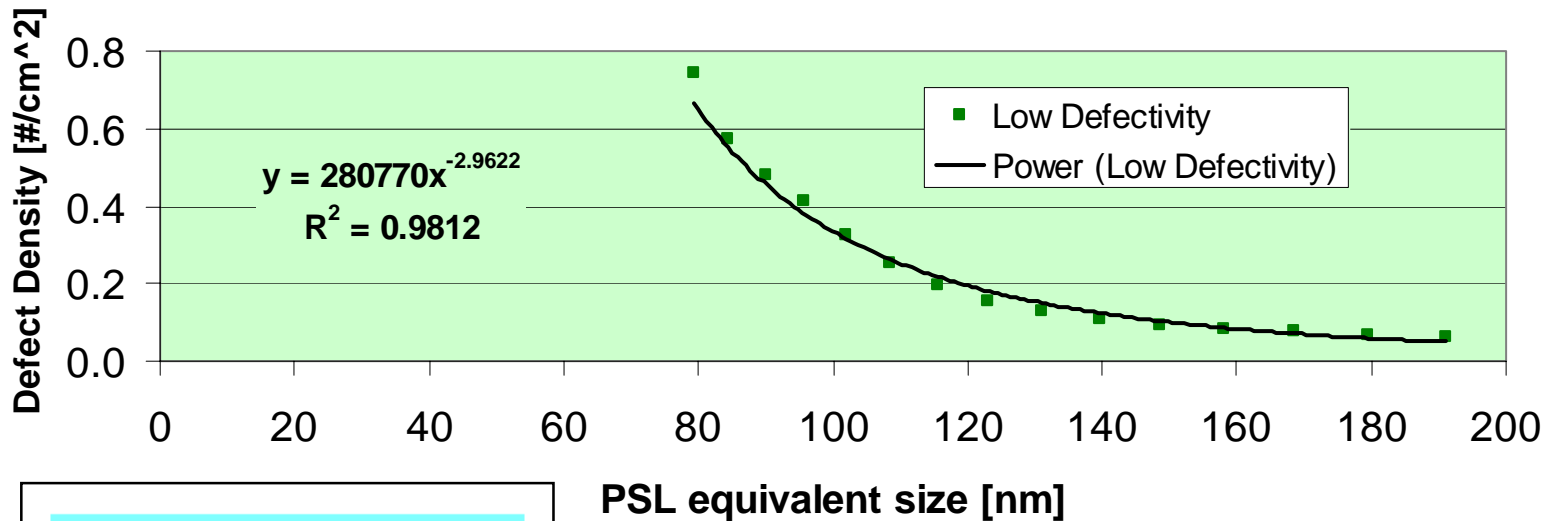
# Power curve fit: mid defectivity

Defect Size distribution for Mid defectivity material

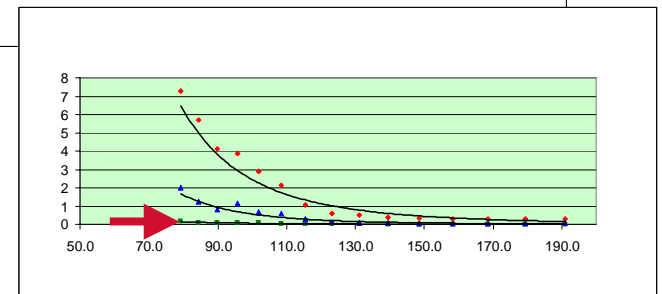


# Power curve fit: low defectivity

Defect Size distribution for Low defectivity material



PSL equivalent size [nm]



# Outlook to Beta and Gamma specs

Defectivity Range	Defect Density *		Required Improvement **	
	40nm	32nm	40nm	32nm
LOW	5.0E+00	9.8E+00	1.7E+02	1.6E+03
MID	5.5E+01	1.1E+02	1.8E+03	1.9E+04
HIGH	1.4E+02	2.3E+02	4.5E+03	3.9E+04
<b>Specification</b>	<b>3.0E-02</b>	<b>6.0E-03</b>		

\* fit data [defects / cm<sup>2</sup>]

\*\* improvement required compared to 80nm performance to meet beta (at 40nm) or gamma spec (at 32nm)

- **Joint development with Lasertec to develop next generation defect inspection tool (MB266) to support reaching Beta and Gamma specs.**

# Conclusions

- **At highest available sensitivity (80nm), defect densities range from 1 – 100 total defects/cm<sup>2</sup>.**
- **Understanding discrepancy between reported and our M1350 results requires defect inspection system cross-calibration and analysis of shipping contribution.**
- **3 to 4 orders of magnitude of defect reduction required to meet ITRS  $\gamma$  specifications at point-of-USE (substrate, deposition, shipping and handling).**

# Acknowledgements

- **Michael Wagner**
- **Jan-Peter Urbach**