Accelerating the next technology revolution

Sub-22nm EUV imaging on SEMATECH Albany Micro Exposure Tool

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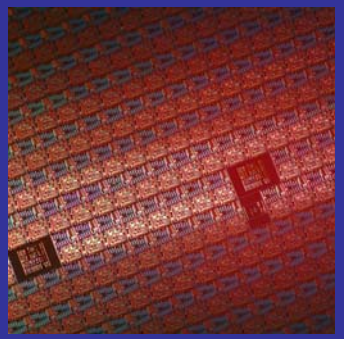
SEMATECH

*Carl Zeiss SMT



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Overview

- Albany MET
  - Tool layout
  - Illuminator Upgrade
- Albany MET Current Imaging Performance
  - Quadrupole and dipole imaging
  - Best in class materials performance
- Albany MET Future Optics Upgrades
  - Illuminator II upgrade
  - High NA Projection Optic Upgrade
- Albany Uptime and availability
- Summary

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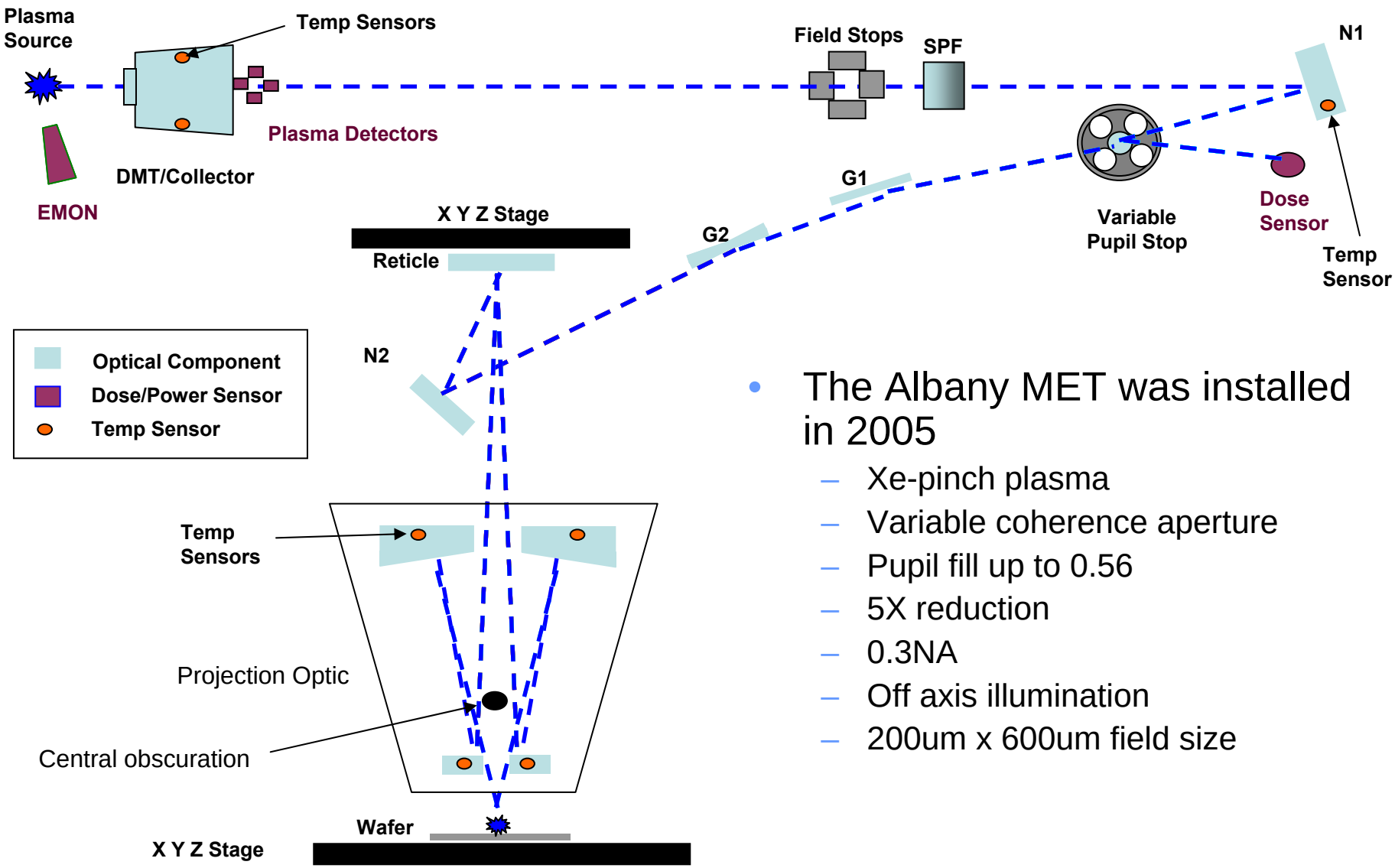
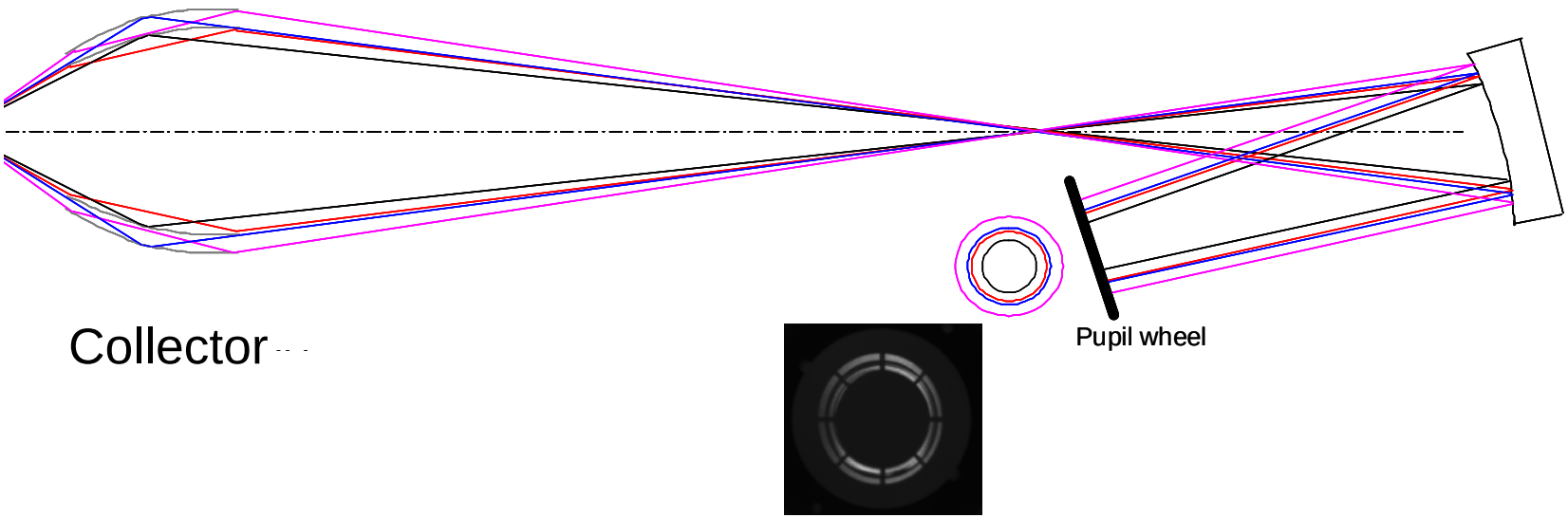
Albany MET Tool Layout



- The Albany MET was installed in 2005
  - Xe-pinch plasma
  - Variable coherence aperture
  - Pupil fill up to 0.56
  - 5X reduction
  - 0.3NA
  - Off axis illumination
  - 200um x 600um field size

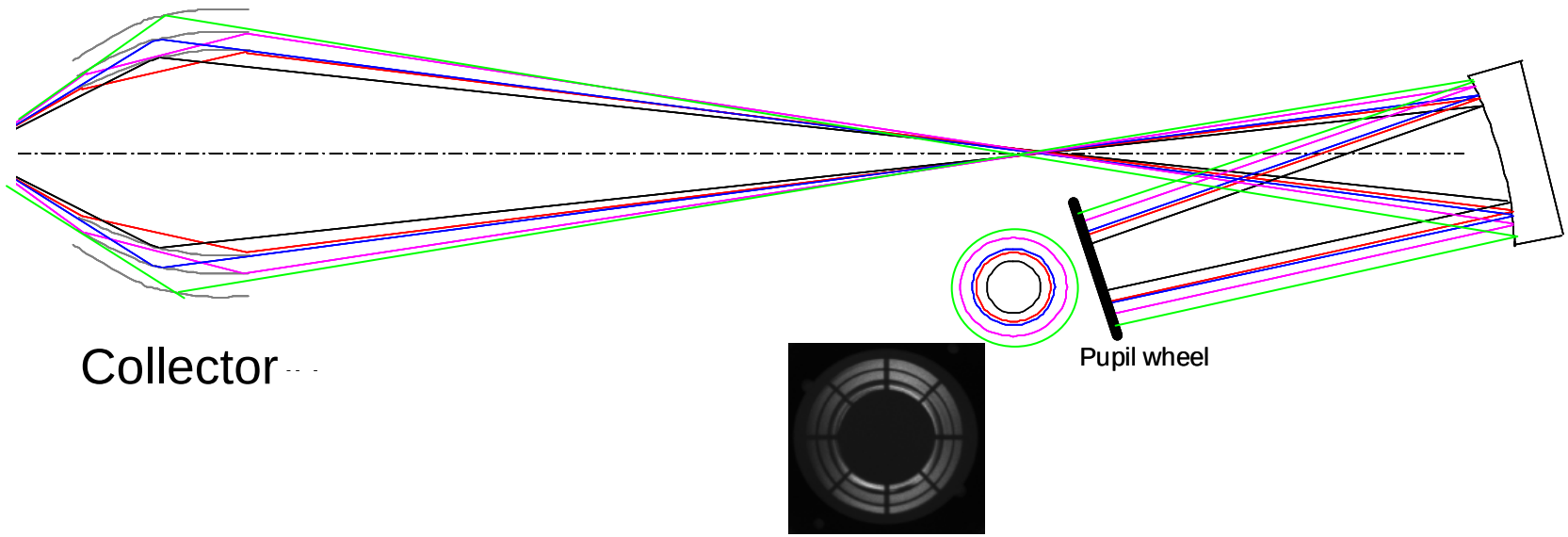
Albany MET Original Illuminator

- The Albany MET optics were designed with a maximum outer sigma at the pupil of 0.56



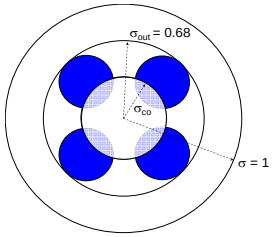
Albany MET Collector Upgrade

- The Albany MET optics were designed with a maximum outer sigma at the pupil of 0.56
- In 2008 an additional outer shell was added to the collector that allowed for a larger illuminated area at the pupil providing an outer fill of 0.68



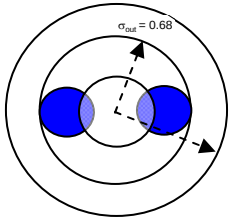
Material Screening Coherence Apertures

- As part of the illuminator upgrade following new coherence apertures were designed to accommodate the larger pupil fill



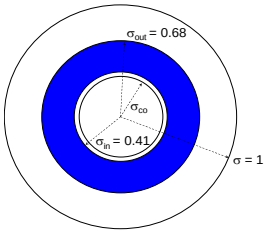
0.22/0.68 Quadrupole

- Standard aperture for L/S resolution screening of new materials



0.22/0.68 Dipole

- L/S UR screening of advanced materials
- 50% transmission reduction*

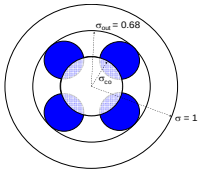


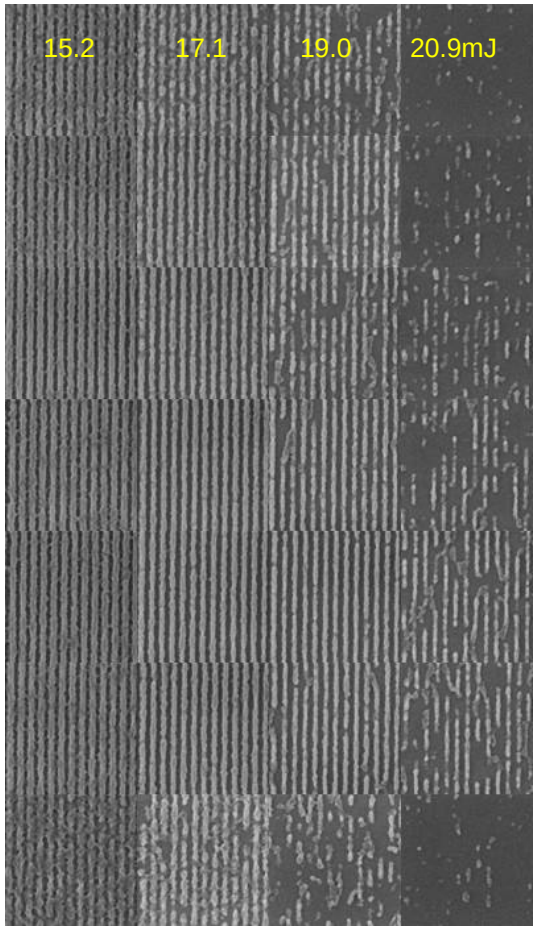
0.4/0.68 Annular

- Standard aperture for CH resolution screening of new materials
- 50% transmission increase*

*Compared to Quadrupole illumination

Albany MET Imaging Performance – 26nm Process Window





0.15um

0.10um

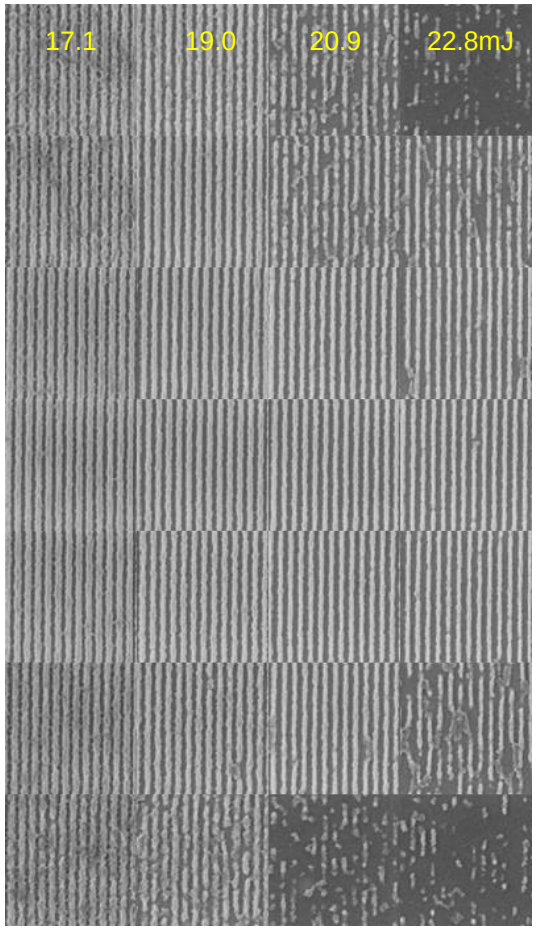
0.05um

0.00um

-0.05um

-0.10um

-0.15um

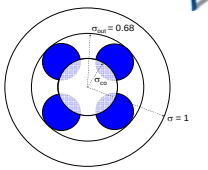


UL/Resist: UL-1(20nm)/STM3 (40nm)
PAB: 110C/90sec
PEB: 100C/60sec
Dev: MF26A / 30sec
Exp: Albany E-MET 0.3NA

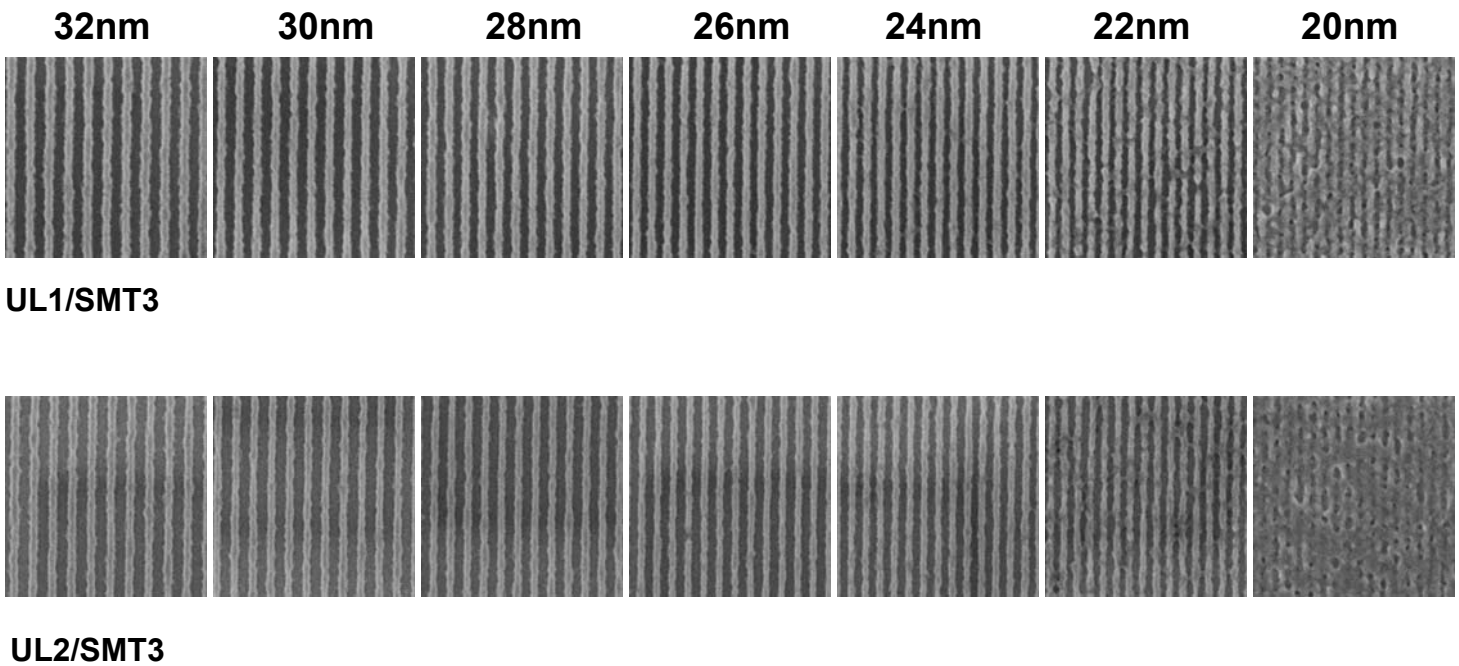
Old Illuminator
0.36/0.56 Annular

New Illuminator 0.36/0.68
Off-axis Quadrupole

Linearity with Quadrupole Illumination using SMT2 & SMT3 Resists



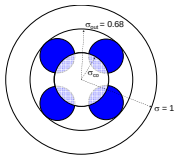
- Post upgrade Albany MET routinely resolves 24nm hp & modulate 22nm hp using Quadrupole illumination

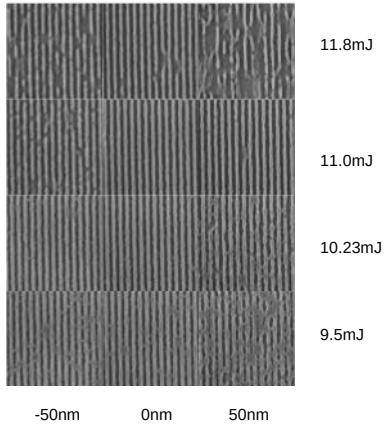


SEMATECH Confidential/ TOK, Fujifilm, and Nissan Chem. Sensitive

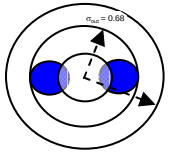
Albany MET Imaging Performance 24nm Resolution

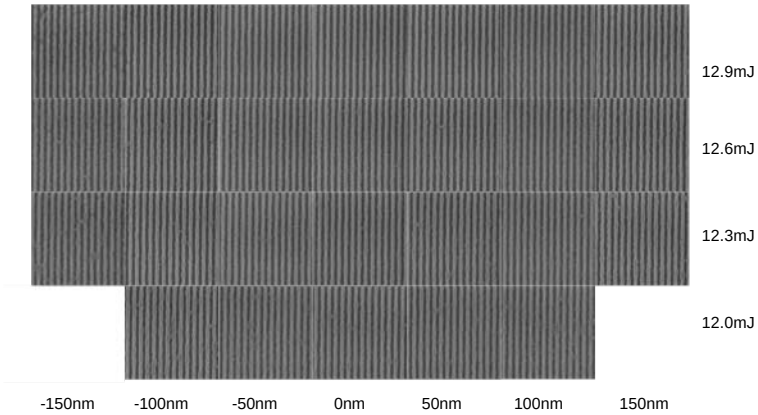
Off-axis Quadrupole

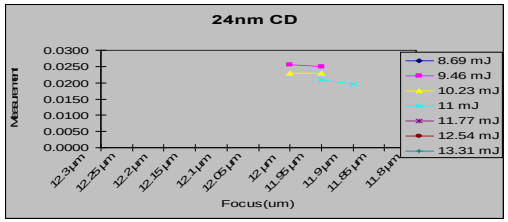


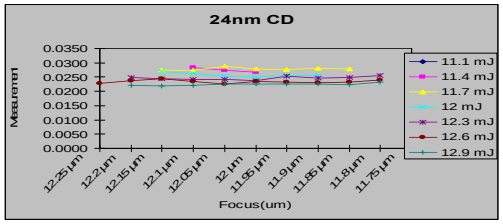


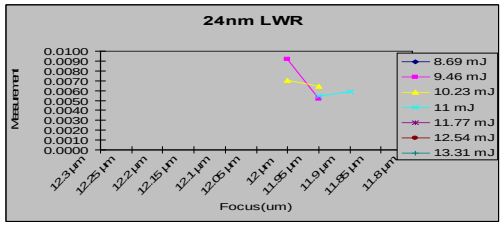
On-axis Dipole

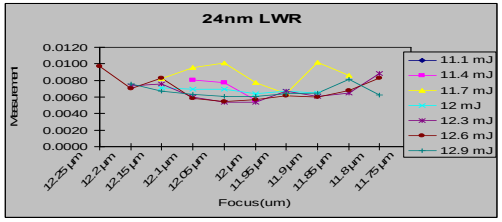






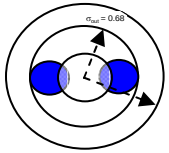




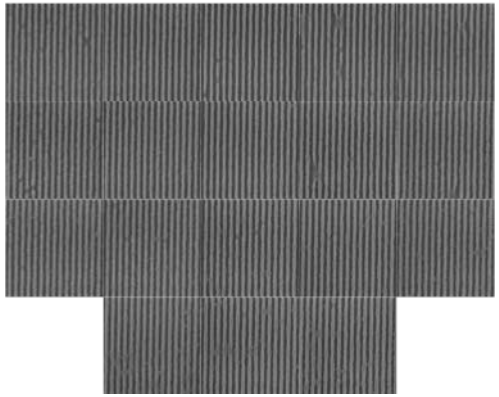


RT 40nm

Albany MET Imaging Performance Dipole 22nm Resolution



Supplier E



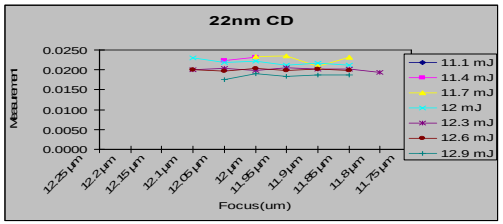
-100nm -50nm 0nm 50nm 100nm

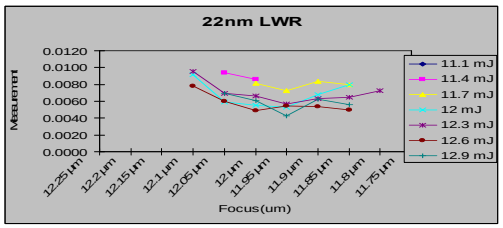
12.9mJ

12.6mJ

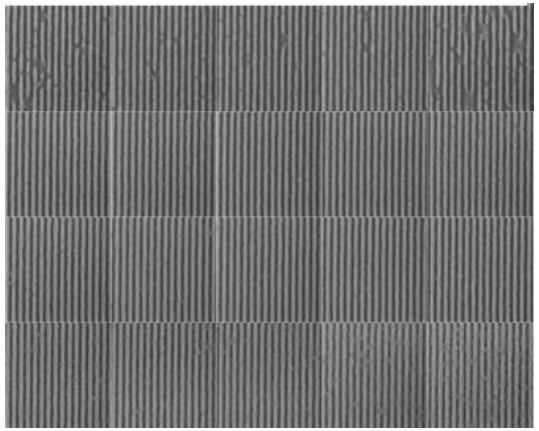
12.3mJ

12.0mJ

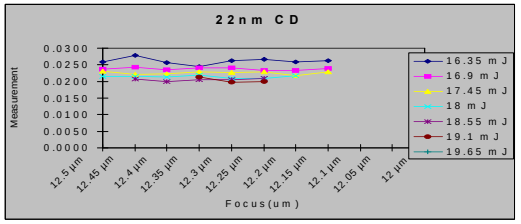


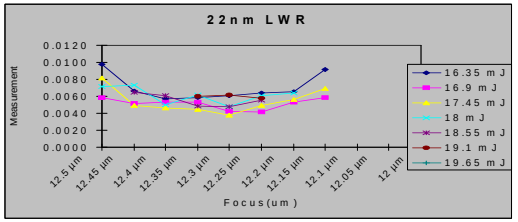


Supplier B



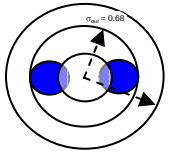
-100nm -50nm 0nm 50nm 100nm





RT 40nm

Albany MET Imaging Performance Dipole 20nm Resolution



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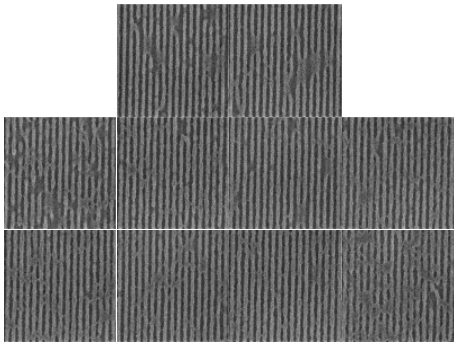
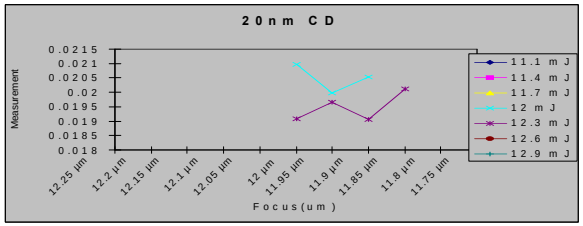
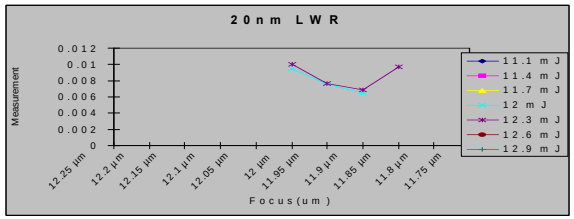






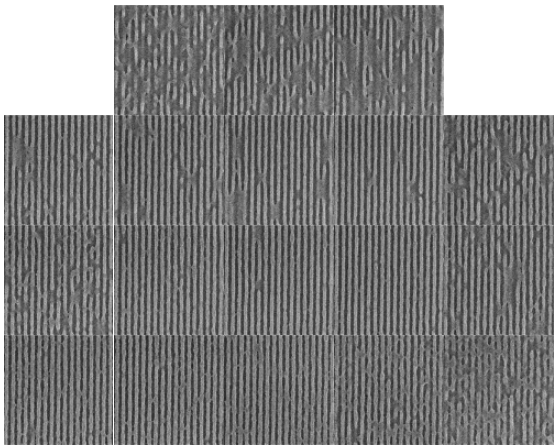
12.9mJ

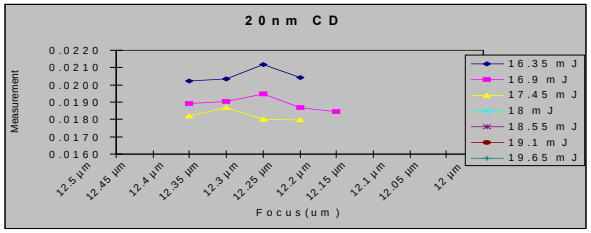
12.6mJ

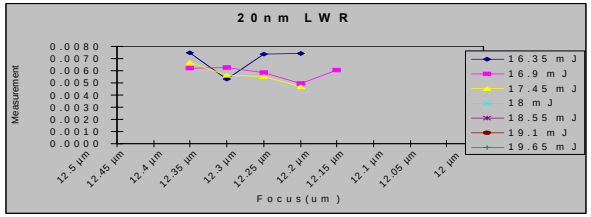
12.3mJ

12.0mJ

Supplier B

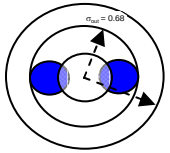


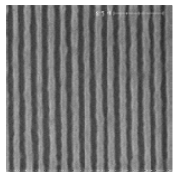
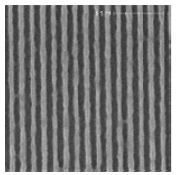
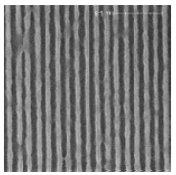
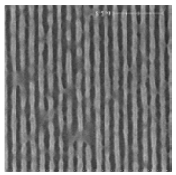
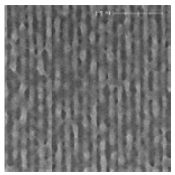
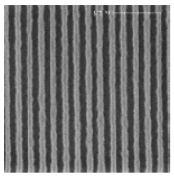
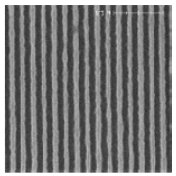
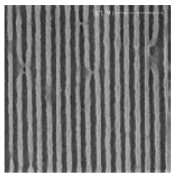
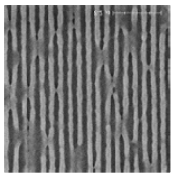
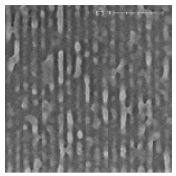
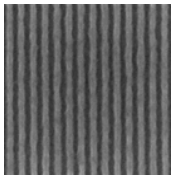
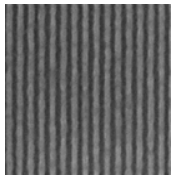
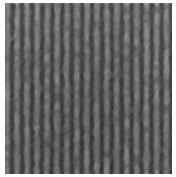
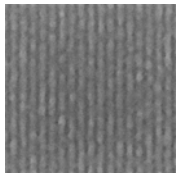
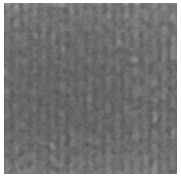
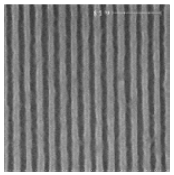
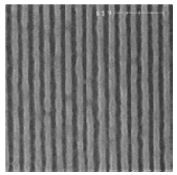
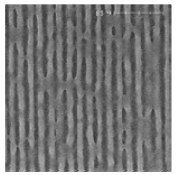
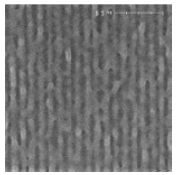
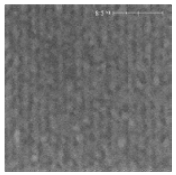
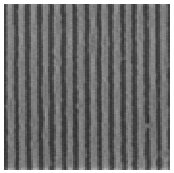
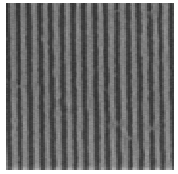
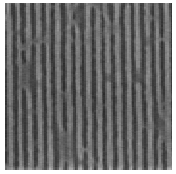
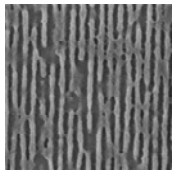
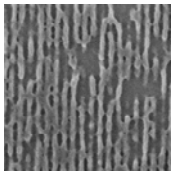




RT 40nm

Material Linearity - Dipole Illumination



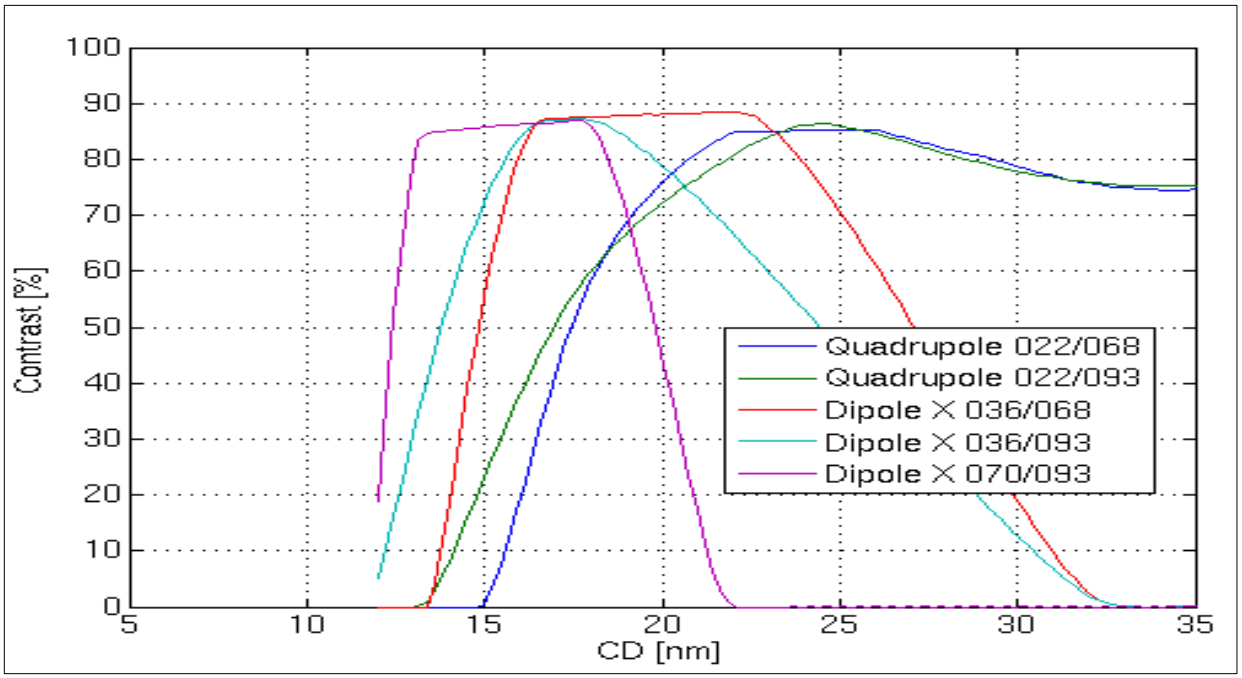
Vendor	24nm	22nm	20nm	19nm	18nm	Dose
A						12.2mJ
B						17.4mJ
C						17.9mJ
D						12.7mJ
E						12.3mJ

RT 40nm

- Albany MET
  - Tool layout
  - Illuminator Upgrade
  - Variable apertures
- Albany MET Current Imaging Performance
  - Quadrupole and dipole imaging
  - Best in class materials performance
- Albany MET Future Optics Upgrades
- High NA Projection Optic Upgrade
  - Integration timeline
- Albany Uptime and availability
- Summary

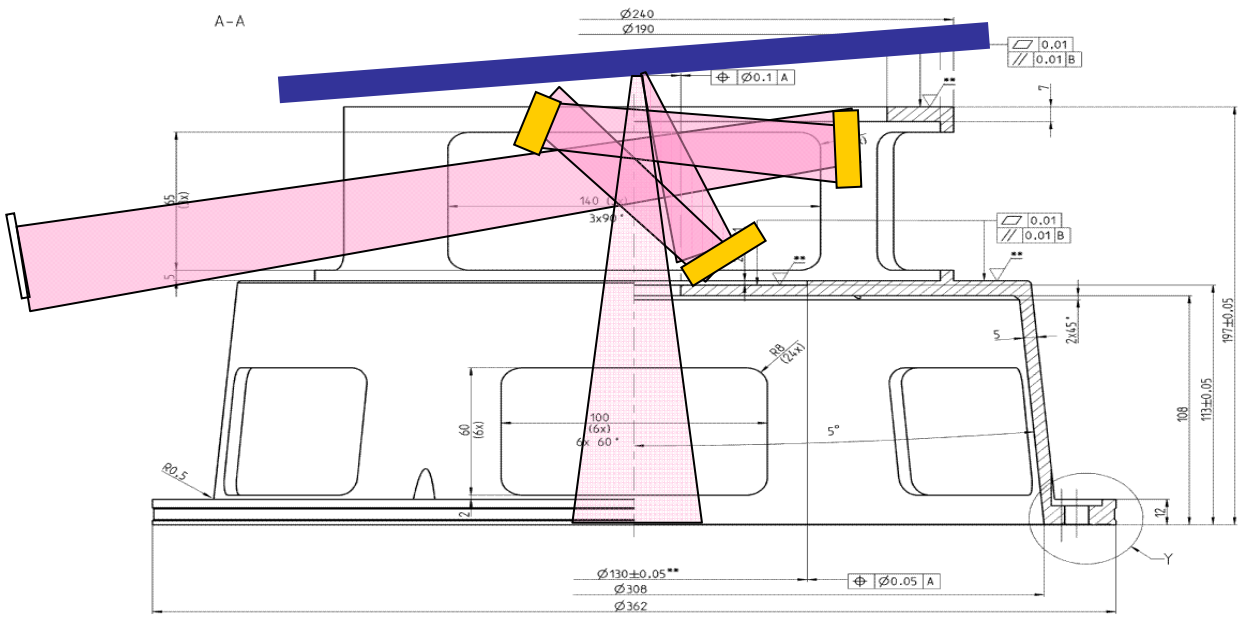
Albany MET Optics Upgrade II
0.9 pupil fill illumination optics

- SEMATECH will further upgrade the illumination to enable a 0.9 fill at the pupil
  - Potentially extend the imaging capabilities of the current 0.3NA lens to < 16nm resolution

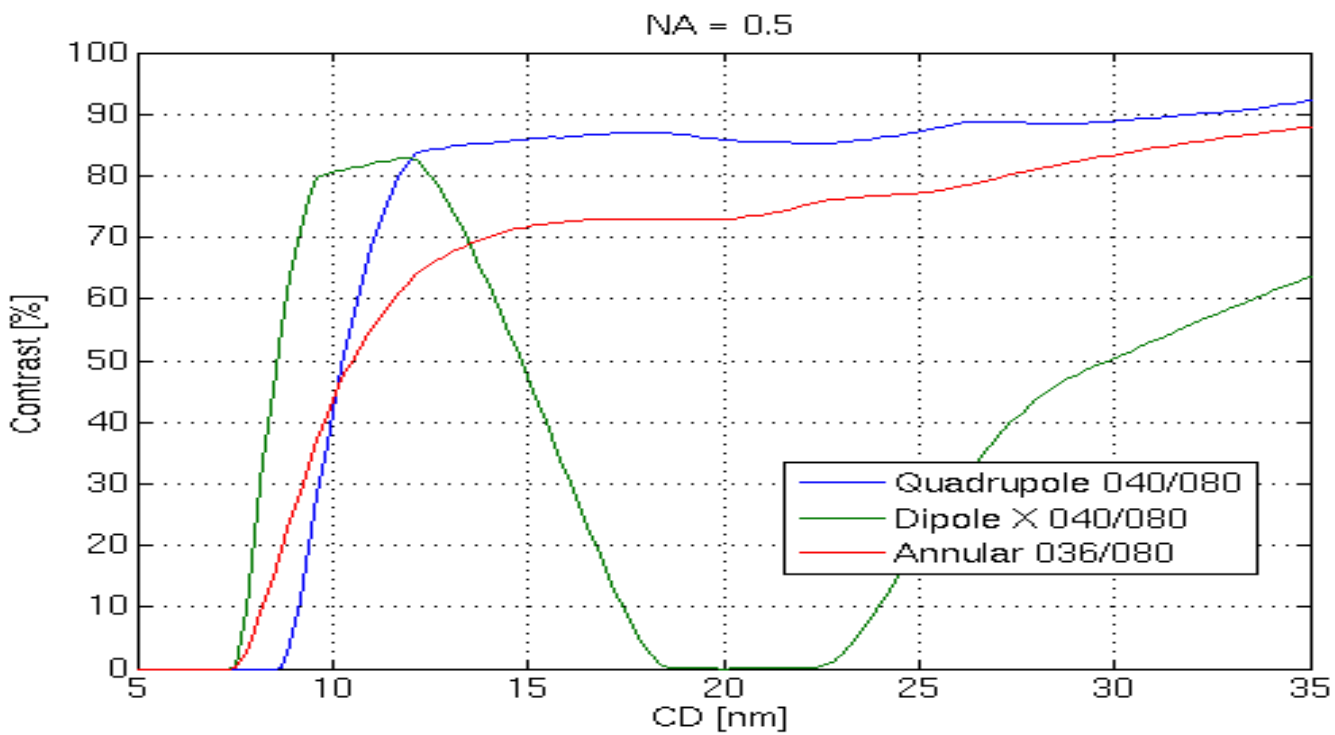


Albany MET Optics Upgrade II
0.9 pupil fill illumination optics

- Adding an additional shell to the collector is not an option due to the design limitations of the system
- The magnification of the illuminator optics will need to be increased to allow for the larger fill



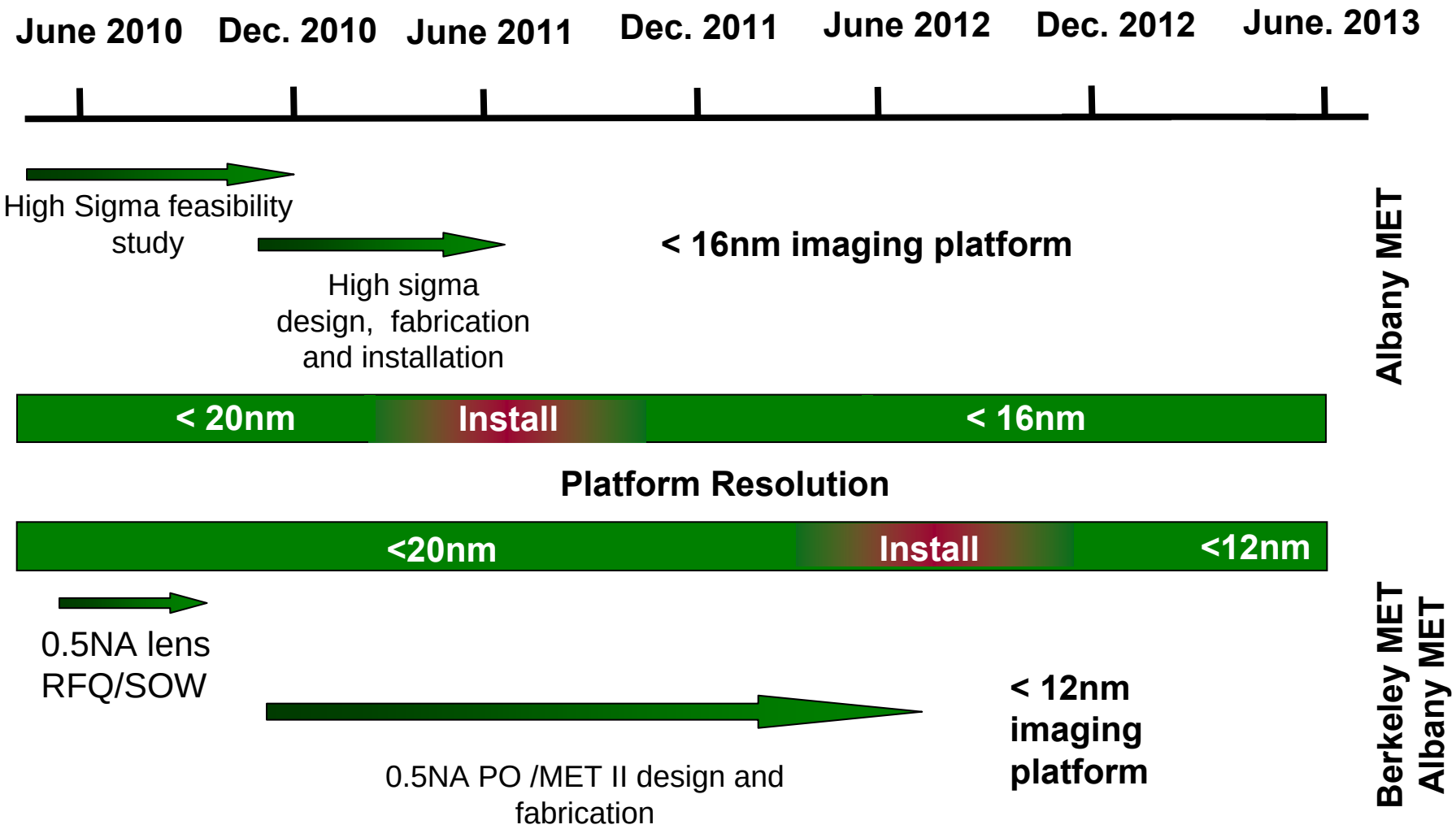
Albany MET Optics Upgrade III 0.5NA Projection Optic



Attribute	Exiting Optic	New Optic
NA	0.3	0.5
Field Size	200umx600um	30um x 200um
Pupil Fill*	0.9	0.8
Magnification	5	5
Off-axis Illuminaiton	Yes	Yes
Variable coherence aperture	Yes	Yes

* With Illuminator II Upgrade

Proposed Integration Timeline



Resist & Materials Development Center

2010 | 2011 | 2012 | 2013 | 2014

Development | Pilot Line | HVM

Exposure Tools

NXE 3100 — G2 HVM

Provide world-best EUV exposure capability to member companies

- *0.3 NA/0.68σ Albany MET (<22nm hp)*
- *0.3 NA/0.9σ (16nm hp)*
- *0.5 NA/0.8σ (12nm hp)*
- *0.3 NA Berkeley MET (<22 nm hp)*
- *0.5 NA Berkeley MET (16-10 nm hp)*
- *0.25 ASML Albany ADT (28-32 nm hp)*
- **ADT repurposed (CNSE)*
- *Access to ASML 3300? (22nm hp)*

Pioneer resist and materials development to enable ≤ 22 nm hp pattern transfer technology and supplier R&D infrastructure

- ***Enable breakthrough Materials Development***
- ***Identifying and Characterizing high performance materials and processes***
- ***Discovering solutions for HVM patterning with < 10 nm hp & atomically smooth sidewalls***
- ***RMDC will continue to be a leader in resist and materials development with strong supplier membership & process development linked to the best researchers world-wide.***

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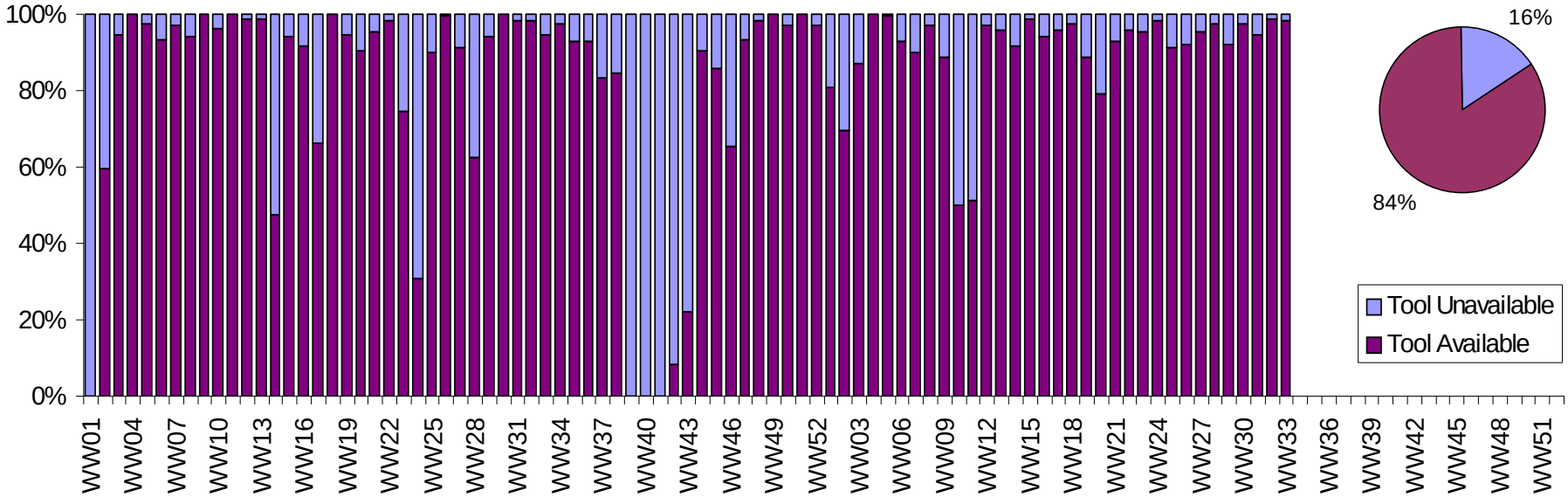
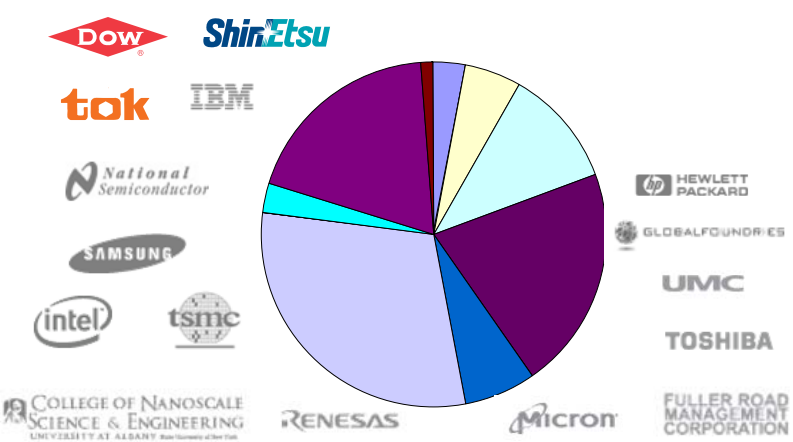
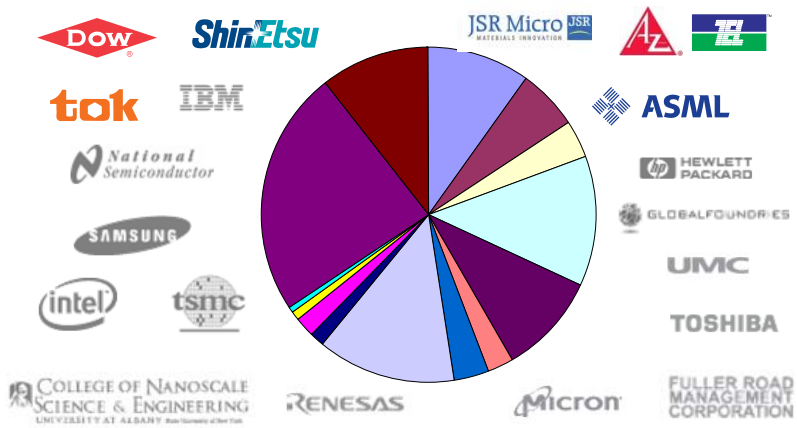
Albany MET Uptime and Utilization 2009 to date



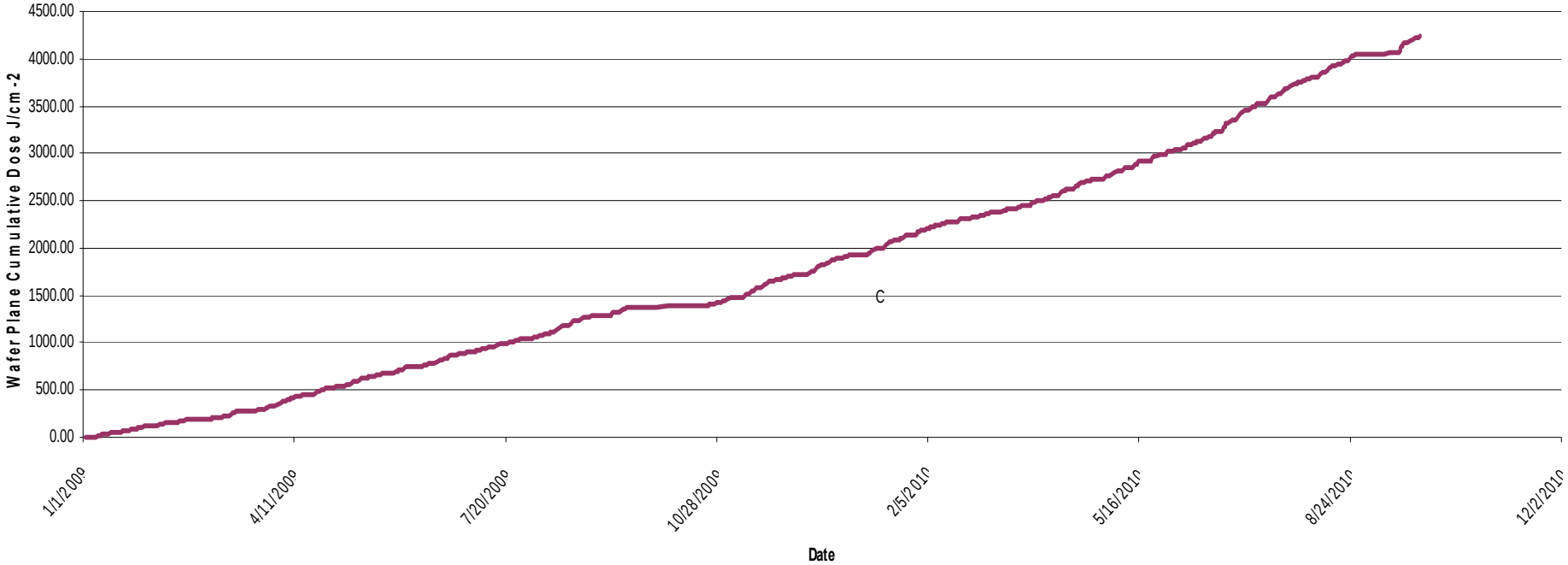


2009 ~ 65hrs / wk



2010 ~ 130hrs / wk

Albany MET Delivered Wafer plane Energy 2009 to date

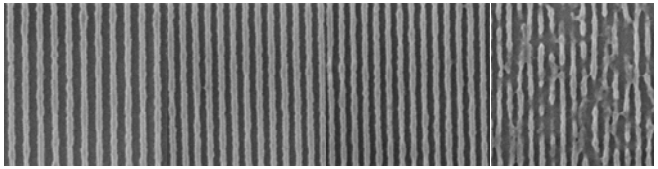


Period	Average Daily Wafer Plane Dose J/cm-2	Number of Wafers Processed	Number of Materials Evaluated
Jan - Sept. 2010	8.5	4325	1025
Jan - Sept. 2009	*5*	*2453*	*603*

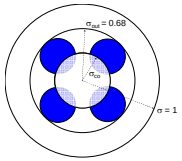
Albany MET Current Imaging Performance

- The Albany MET will continue to support materials evaluation using off-axis quadrupole illumination for coarse material screening

Quadrupole

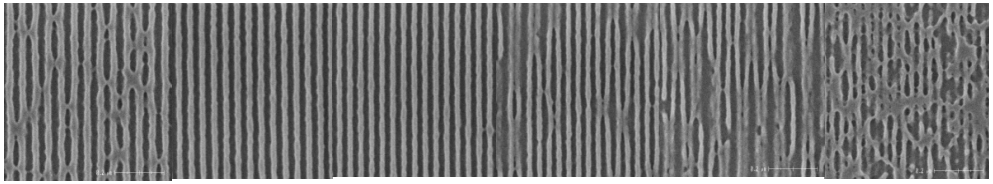


30nm 26nm 24nm 22nm

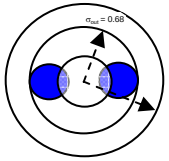


- The on-axis dipole can be used to evaluate materials 22nm and below

Dipole



26nm 24nm 22nm 20nm 19nm 18nm



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Summary

- The Albany MET routinely supports new materials screening down to 24nm and supports advanced materials ultimate resolution screening <20nm
- The Albany MET has demonstrated an average uptime and availability of ~85% over the past two years
  - More than 8000 wafers supporting the evaluation of more than 2000 EUV material formulations
- A planned illuminator upgrade path has been presented that will allow for <16nm optics resolution in 2011
- A planned Projection Optic upgrade path has been presented that will extend optical resolution to <12nm in 2012