TSMC Property

Progress in EUV Lithography

A Report from the Frontline

Anthony Yen

27 October 2014

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TSMC's sales breakdown by technology

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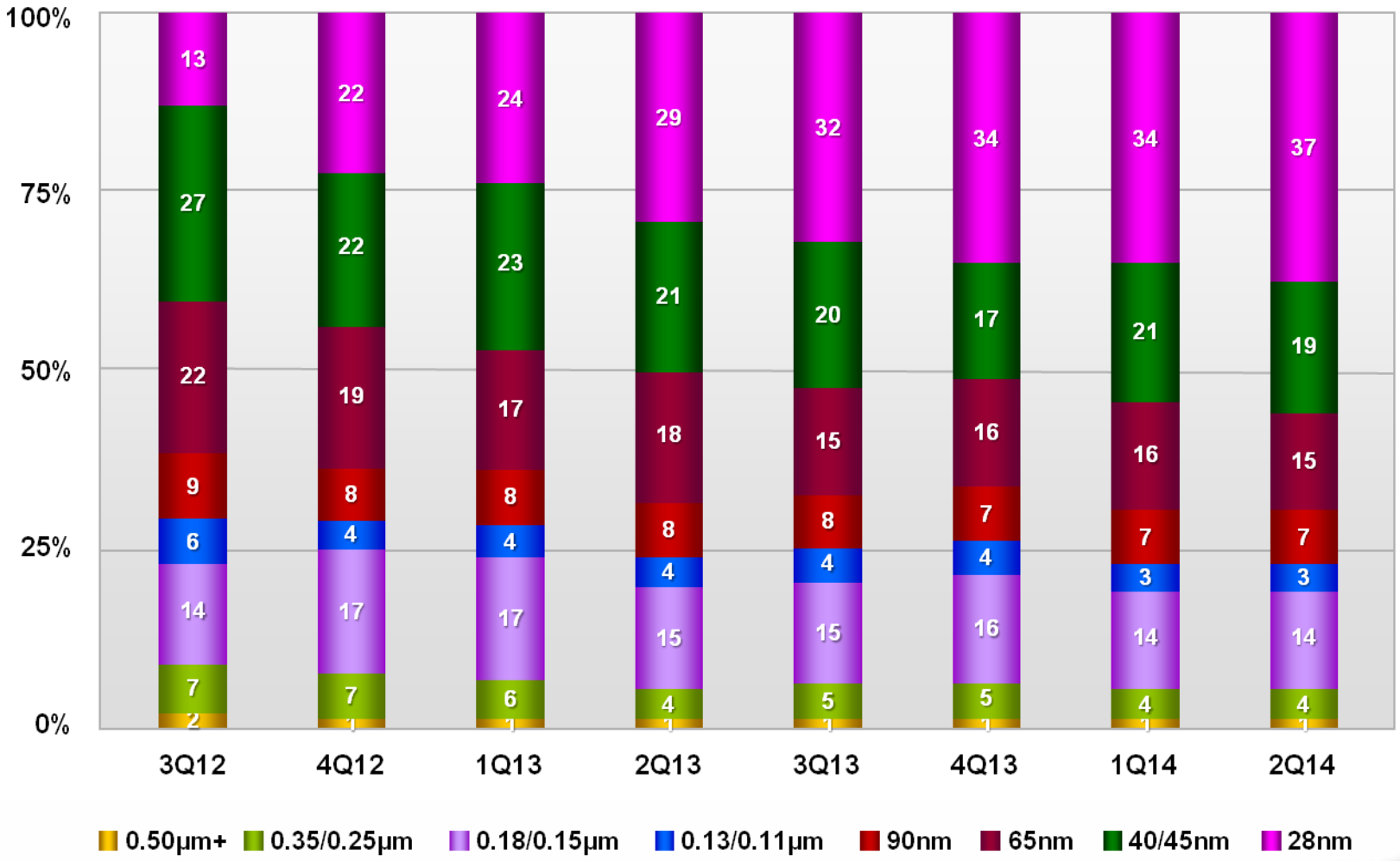

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We are the trusted technology and capacity provider

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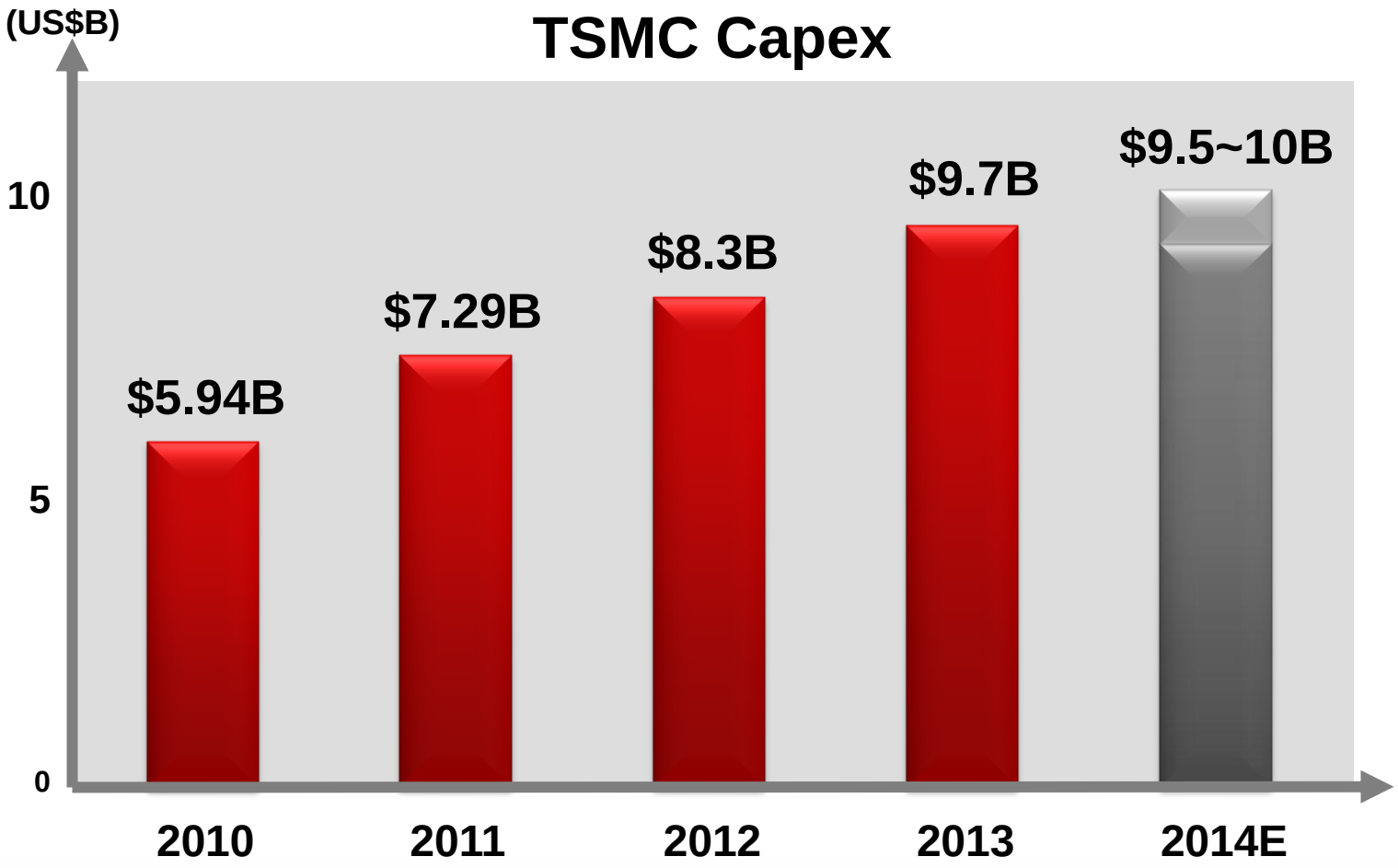

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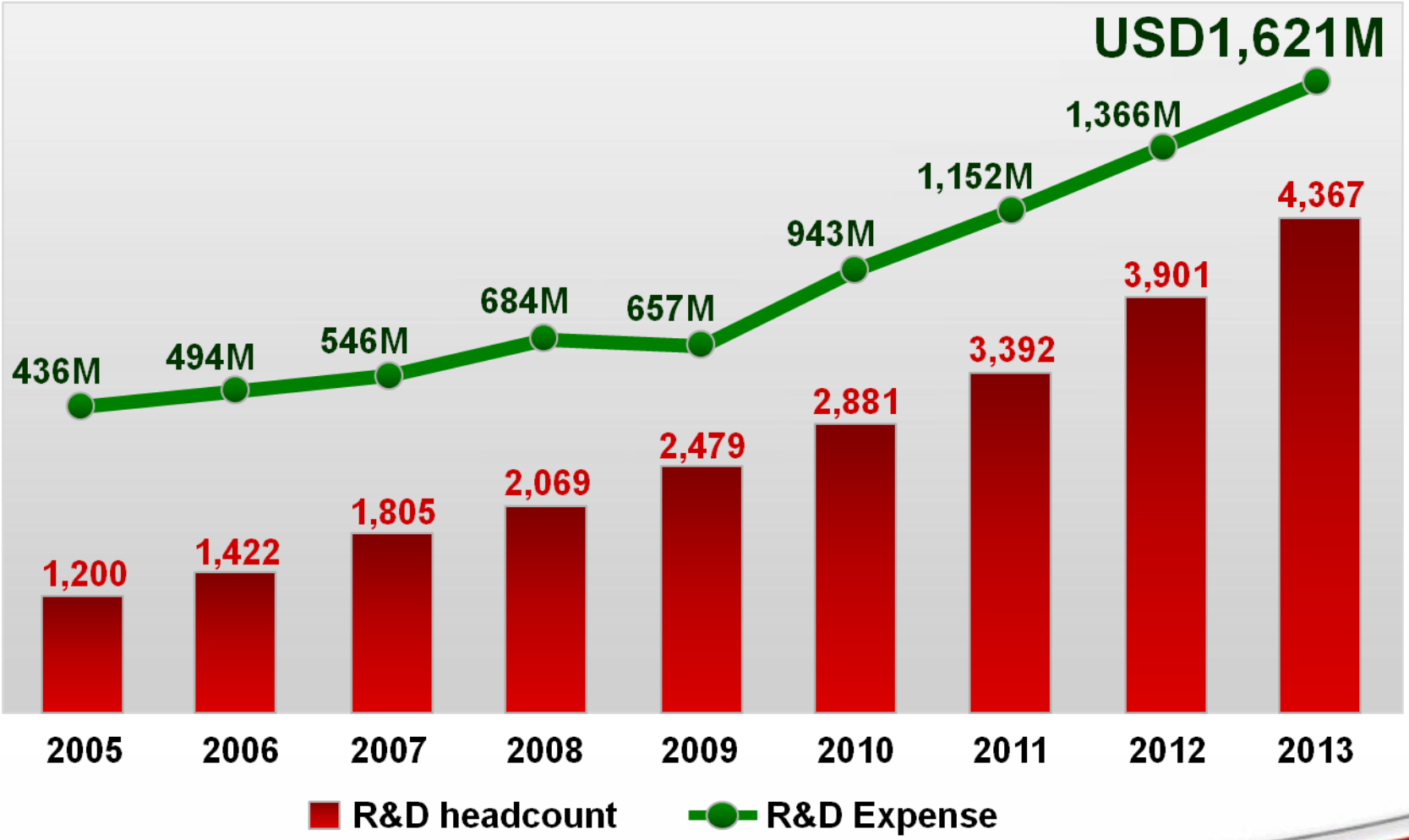
We are committed to invest in technology advancement



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Laser-Produced Plasma EUV Source

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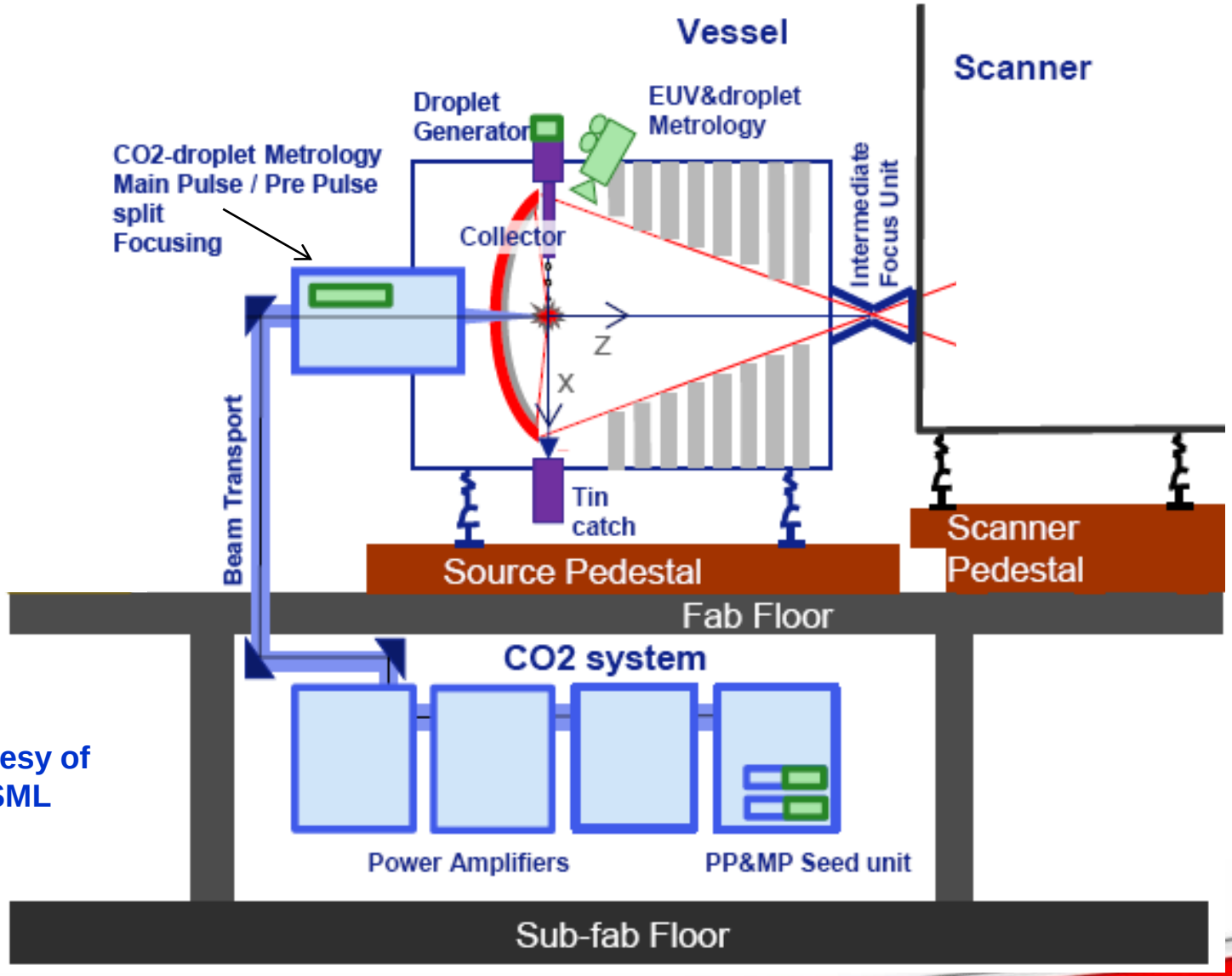

Courtesy of ASML

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Progress has been made on EUV source power

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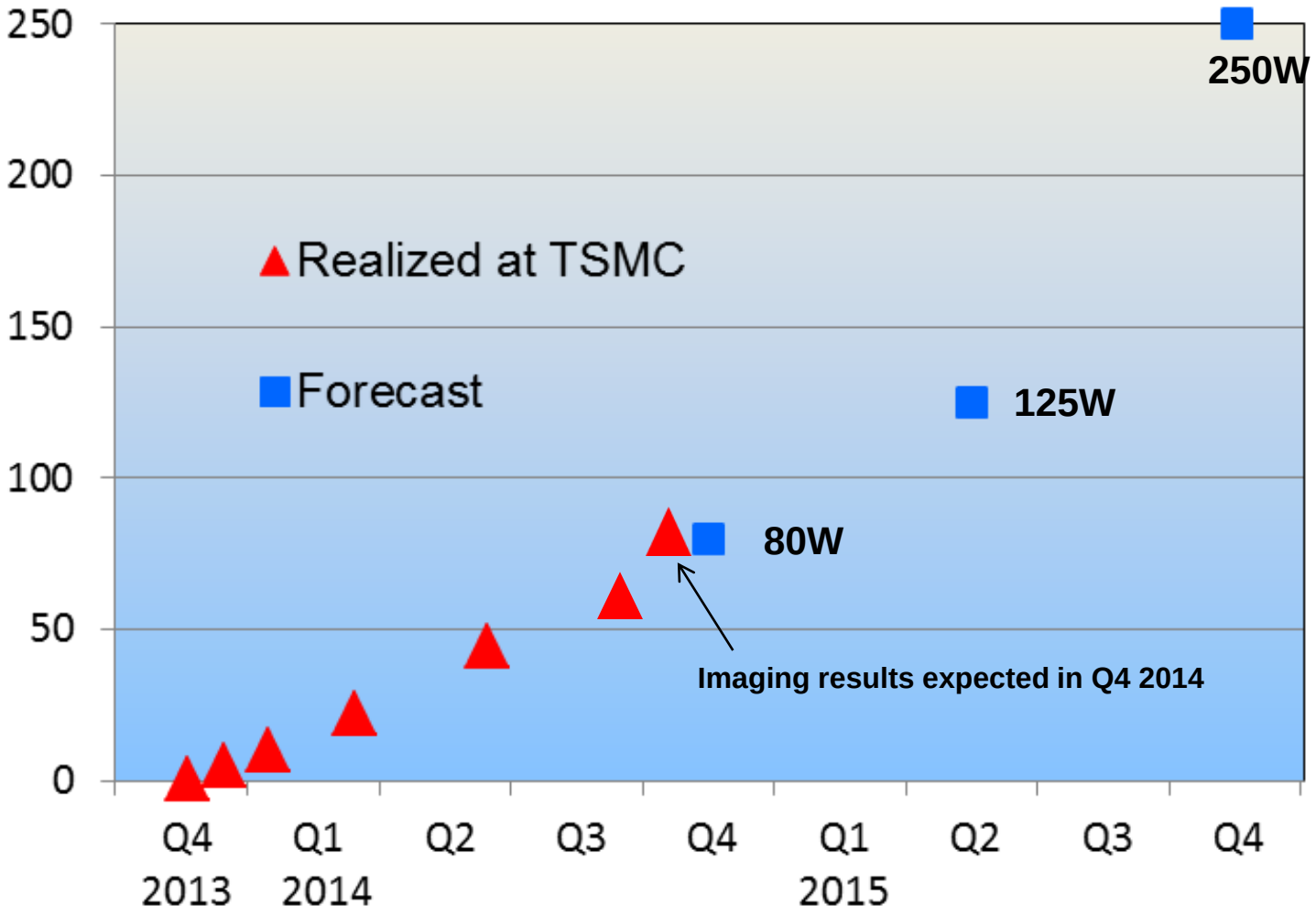

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A 24-hour marathon test was run

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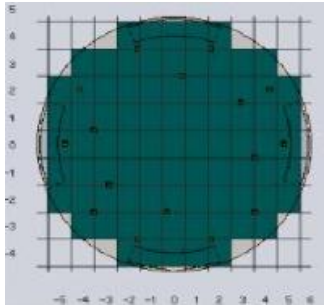
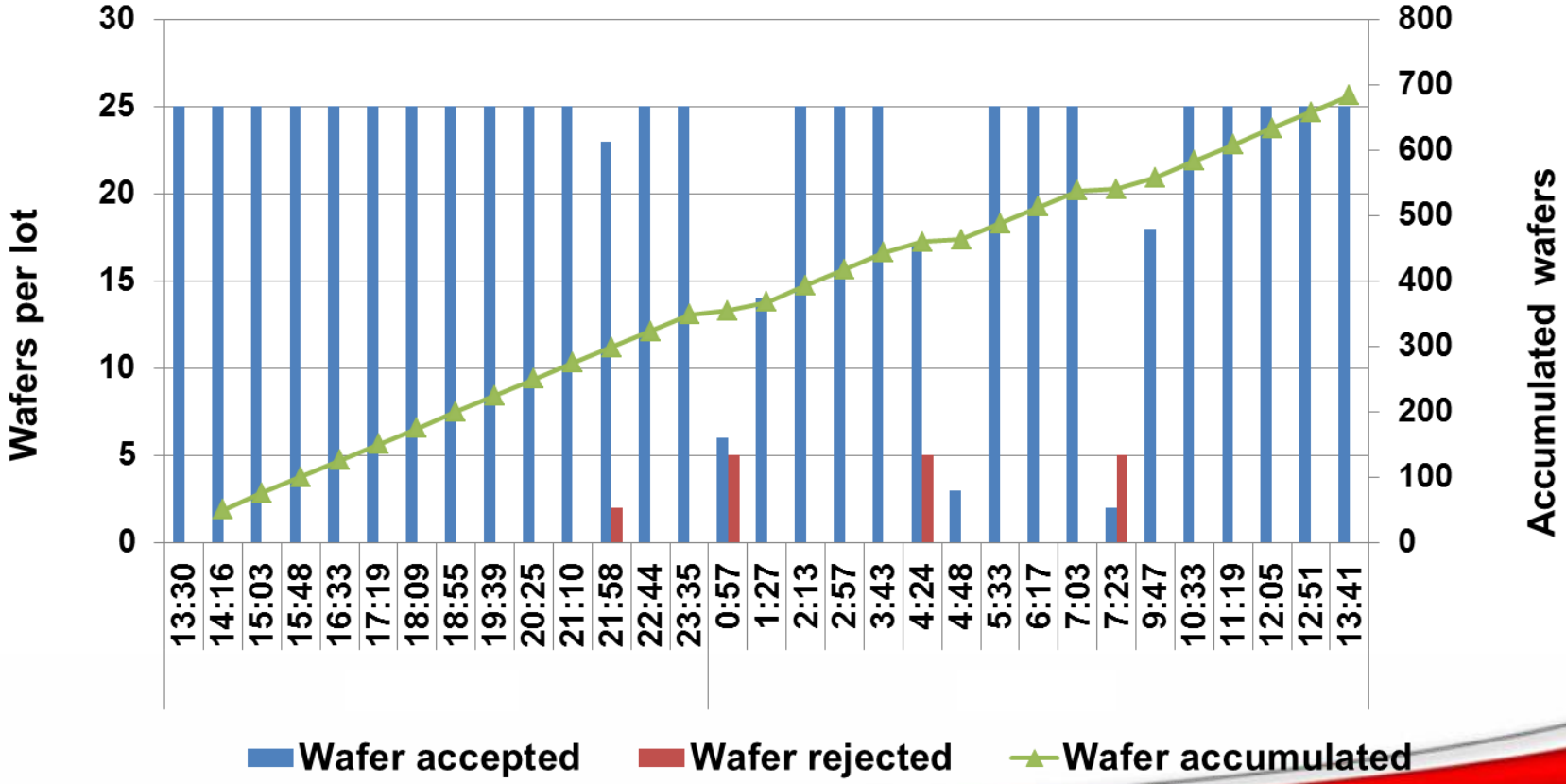
- **Test Conditions**
  - **25x33 mm field size / 83 fields / 20 mJ/cm^2**
- **WPD: 653 wafers**
  - **Actually 683 wafers in a 25-hour continuous run**





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Progress is being made on tool availability

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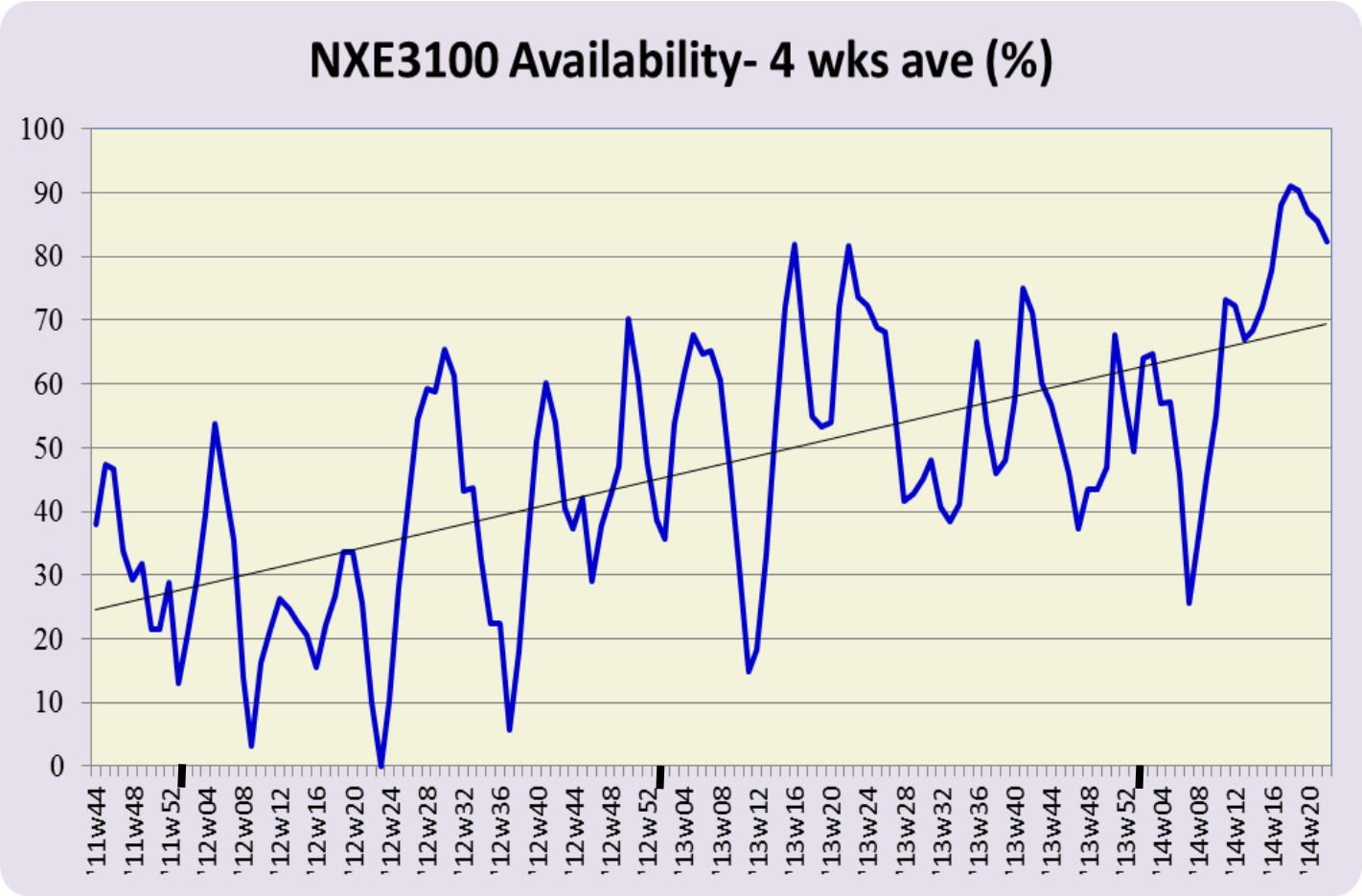

- **NXE3300's one-week availability was 65% at peak, but fluctuated due to frequent tool upgrades**

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Within-lot CD uniformity

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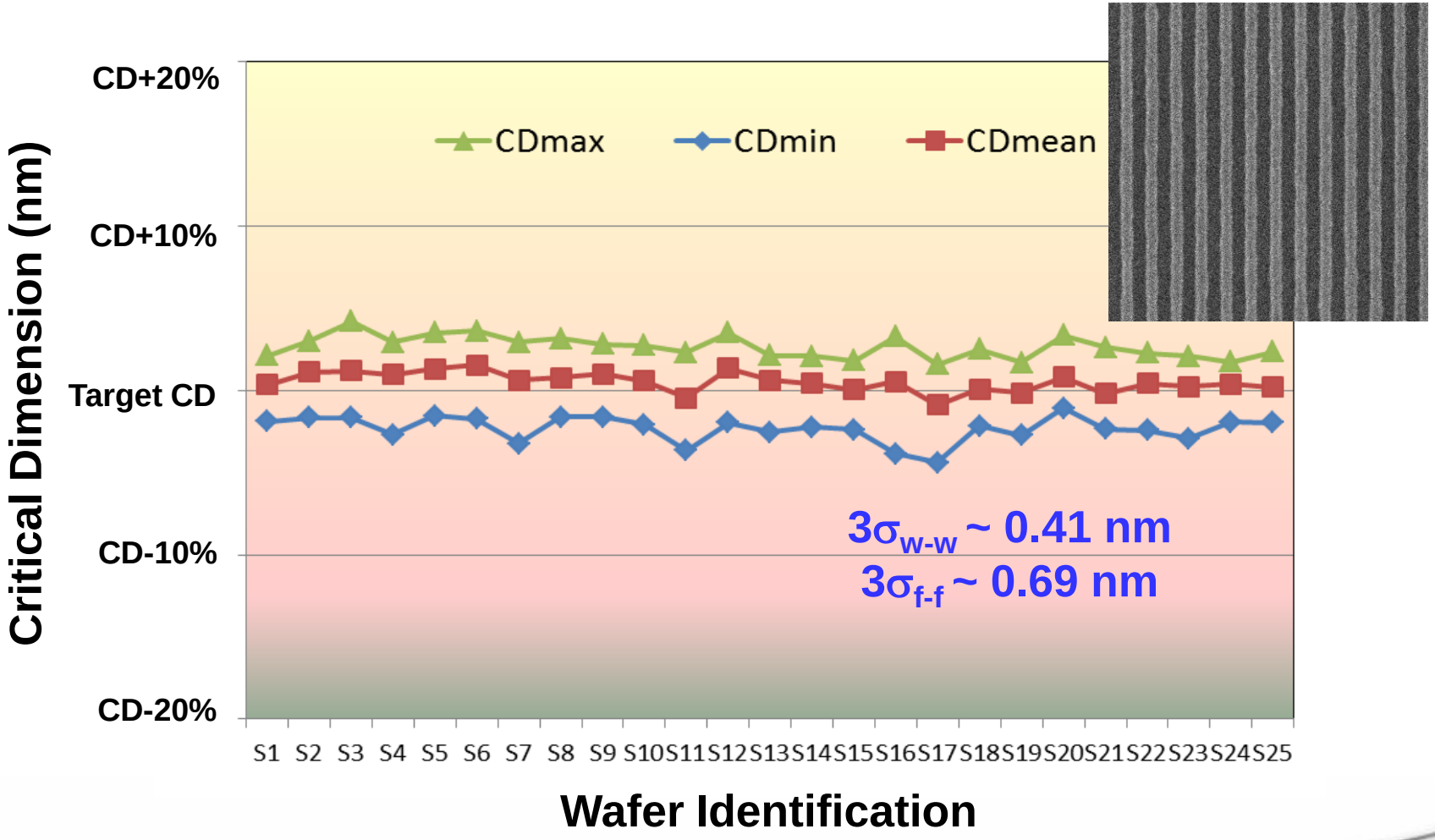

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Mix-and-match overlay performance

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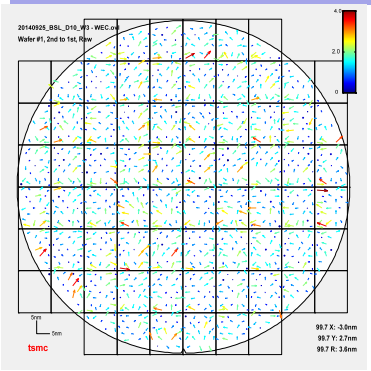
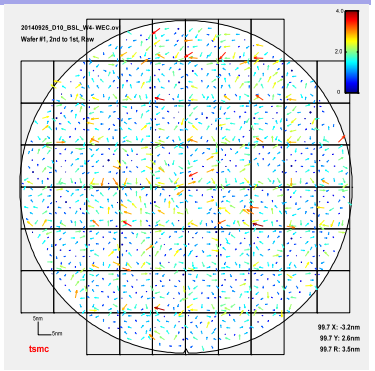
Chuck #1

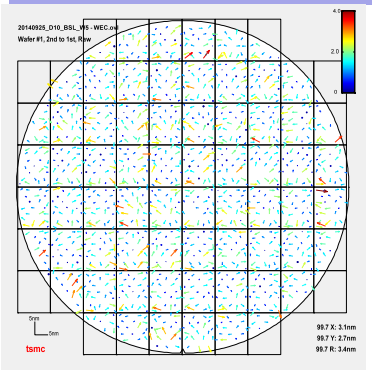


(3.0nm, 2.7nm)

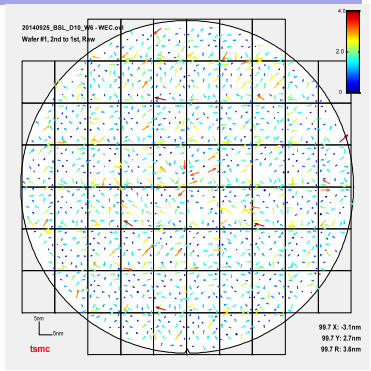


(3.2nm, 2.6nm)

Chuck #2



(3.1nm, 2.7nm)



(3.1nm, 2.7nm)

Measurement on 68 fields; 25 points per field

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Resolution Limit of NXE3100

with dipole illumination

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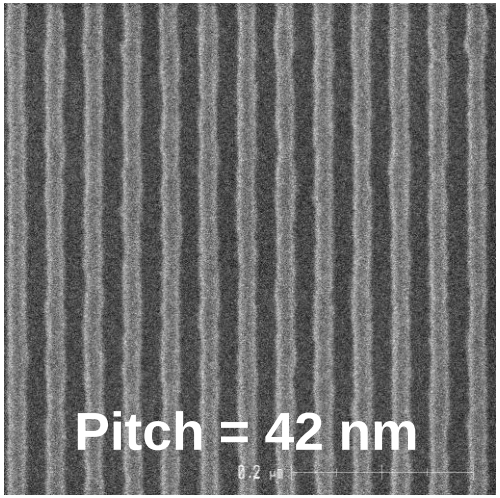

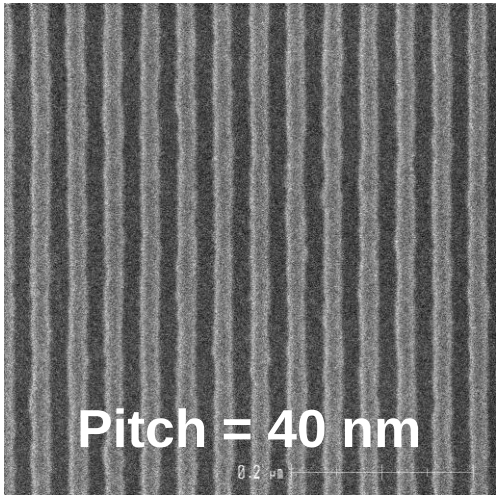

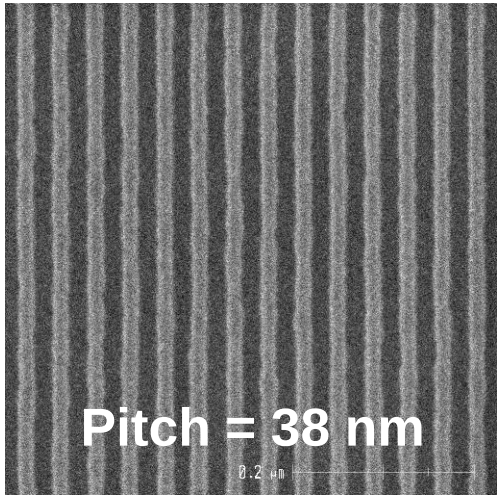

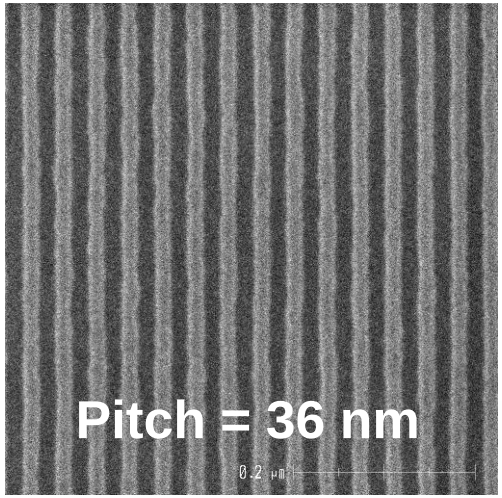

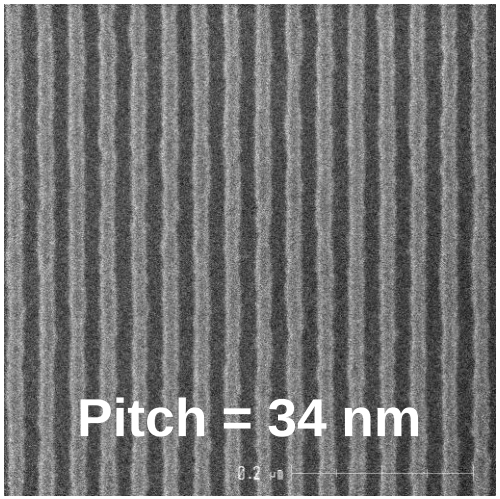

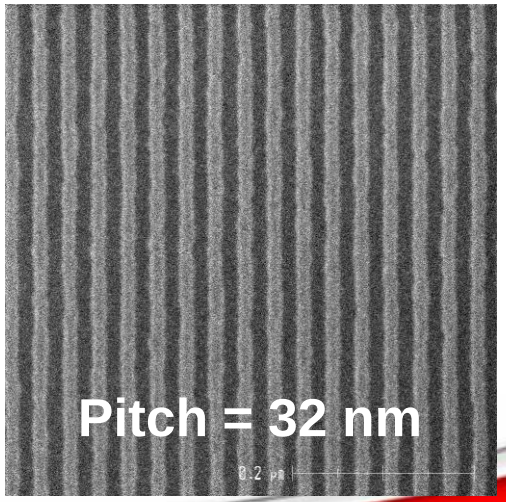

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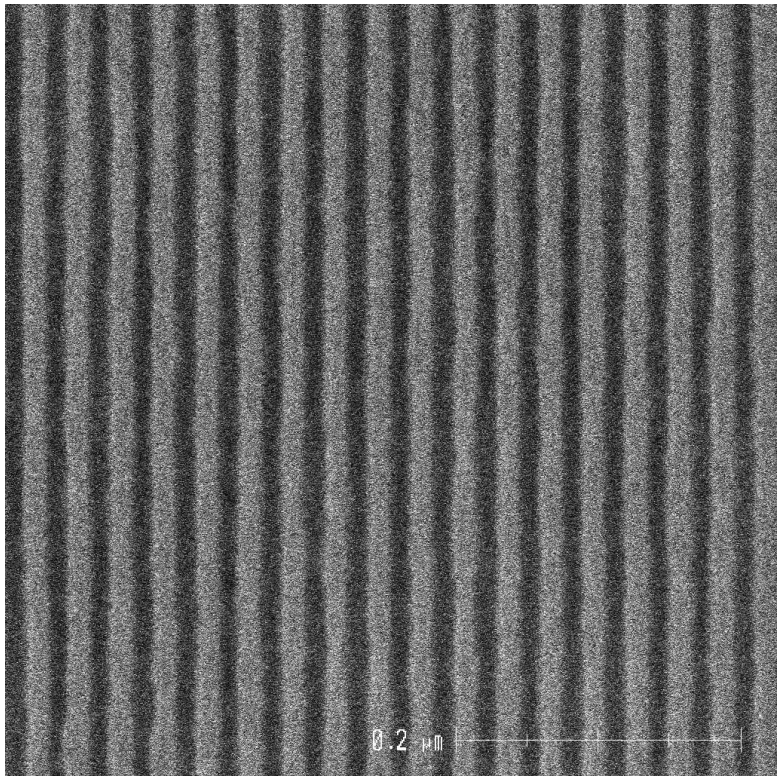
30-nm lines and spaces using chemically amplified resist



0.33 NA; Dipole Illumination; 42 mJ/cm^2

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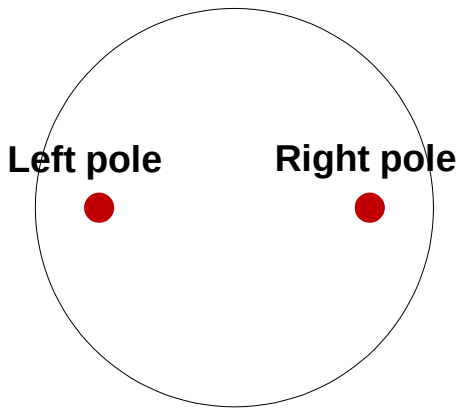
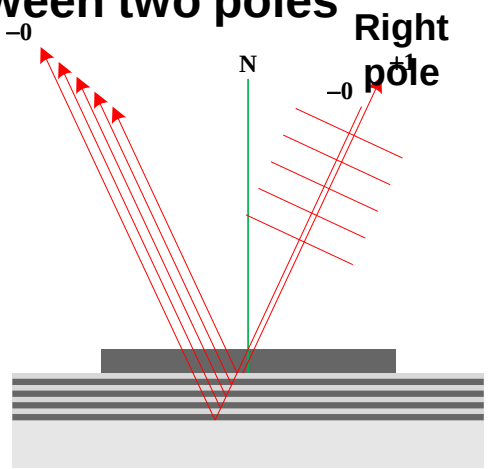
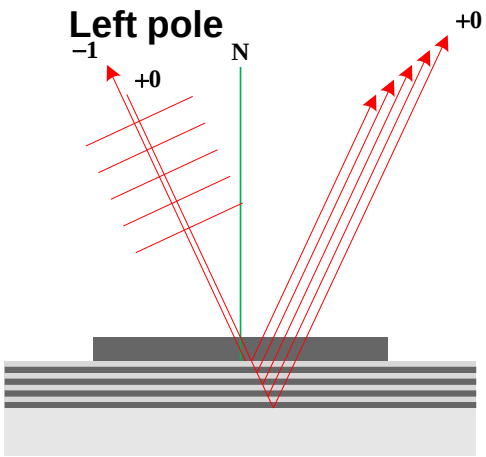
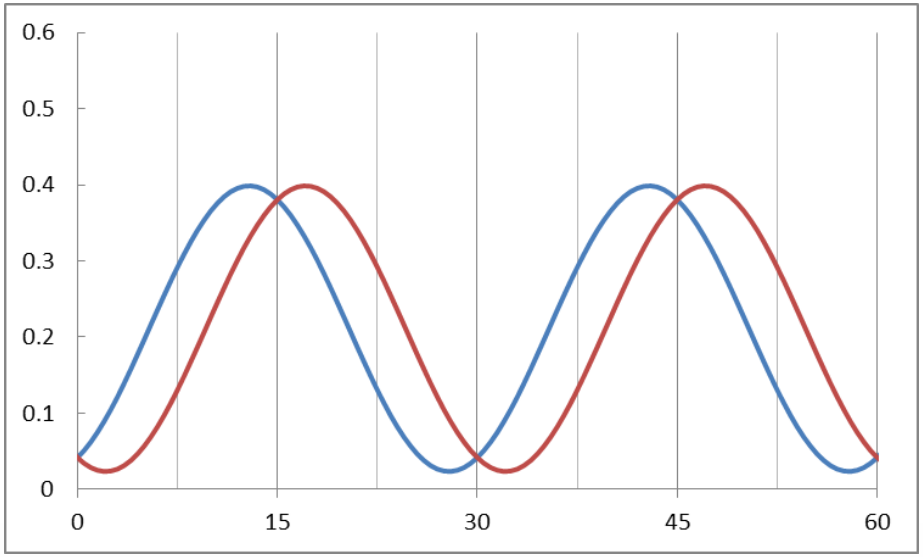
Imaging of vertical 15-nm L/S

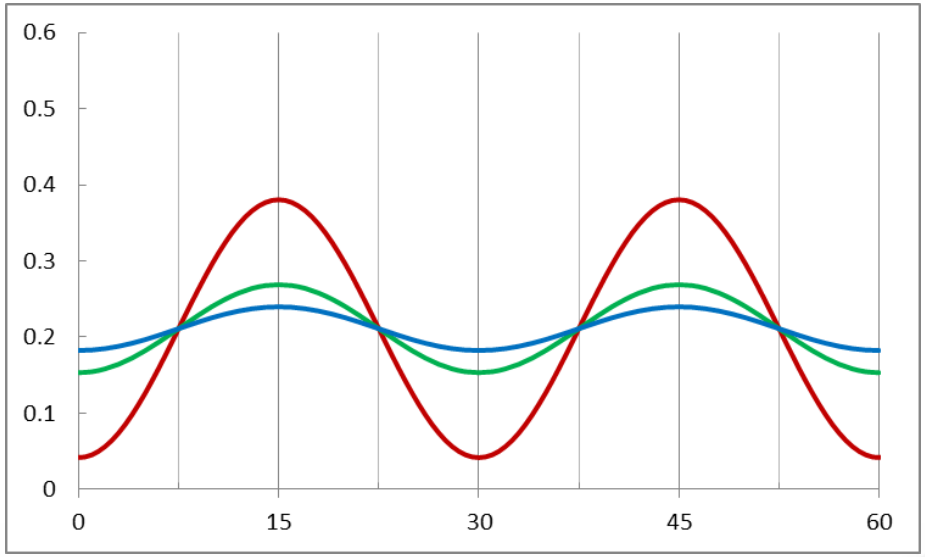
- Phase difference between two poles











L, R

Resist Blur=0

L+R

Resist Blur= 0, 7, 9

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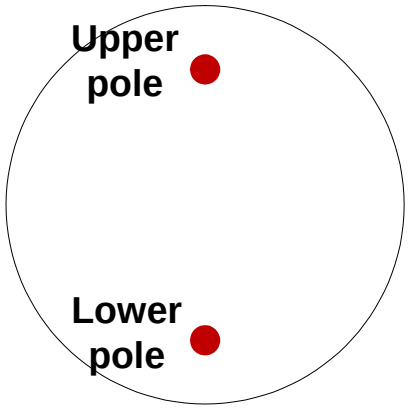
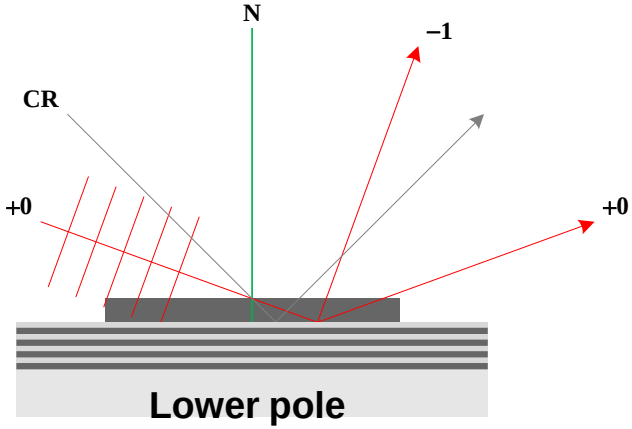
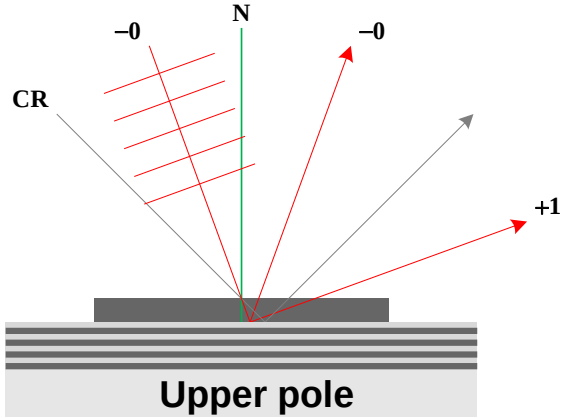
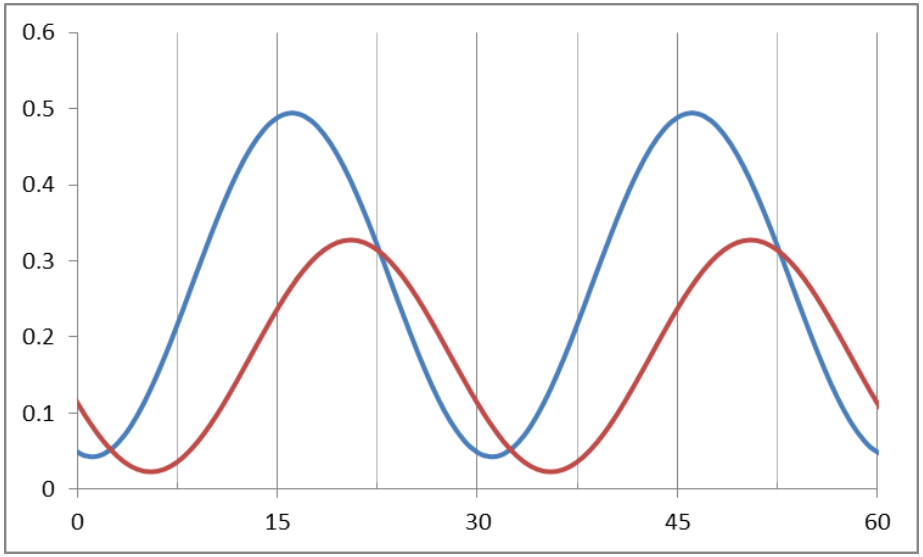
Imaging of horizontal 15-nm L/S

- Intensity imbalance and phase difference between two poles



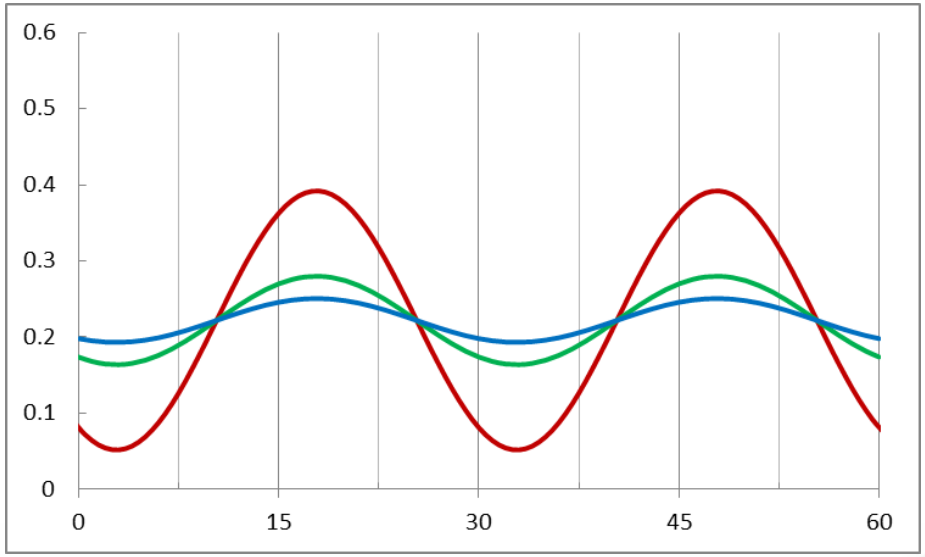






L, U

Resist Blur=0



D+U

Resist Blur=0, 7, 9

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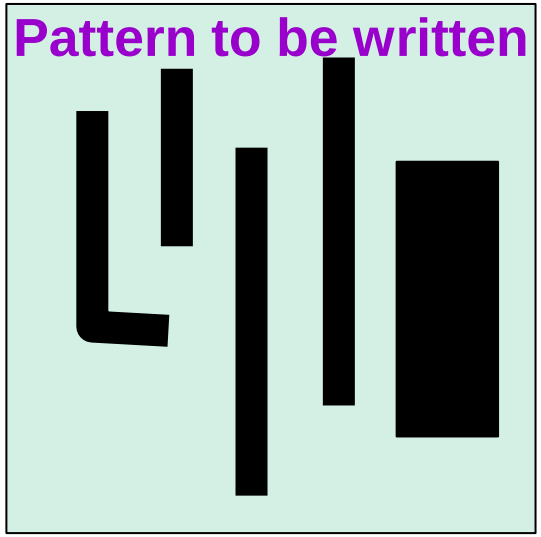
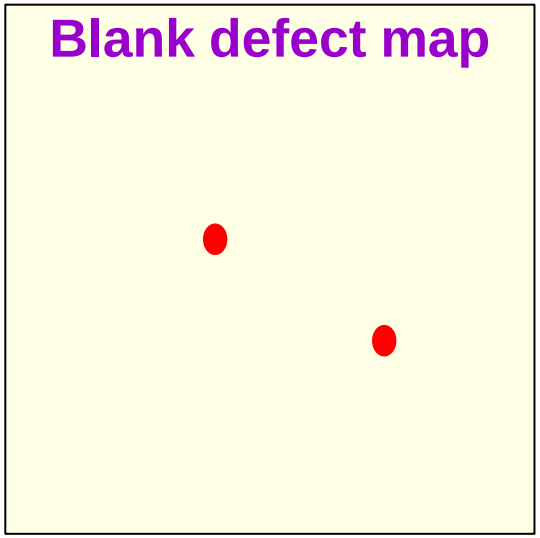
Native defect mitigation is in place





Pre-conditions:

1. Very low blank defect counts
2. Precise blank defect map
3. EBMW alignment capability

Hide defects under absorber!

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Printing of native defects in dense areas

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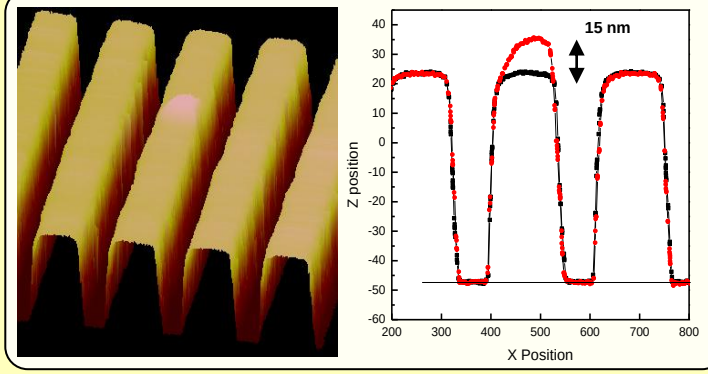
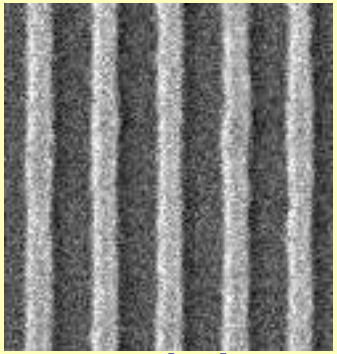
AFM image

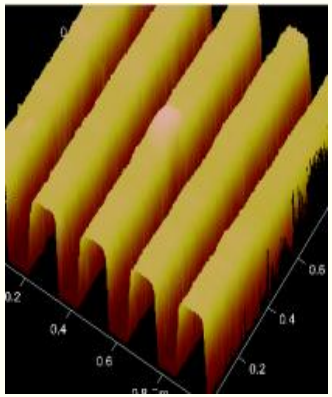


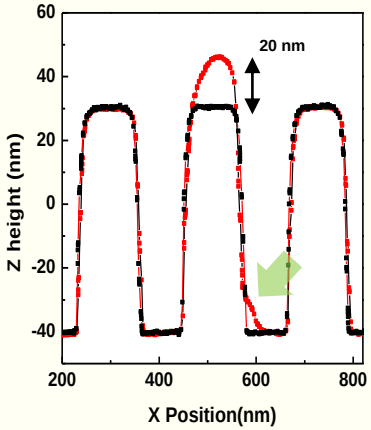
Wafer image



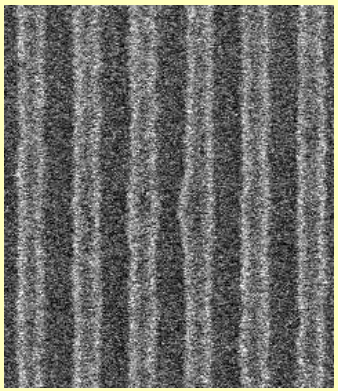
No printing

AFM image





Wafer image



Printing

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Native defect printability in an open area

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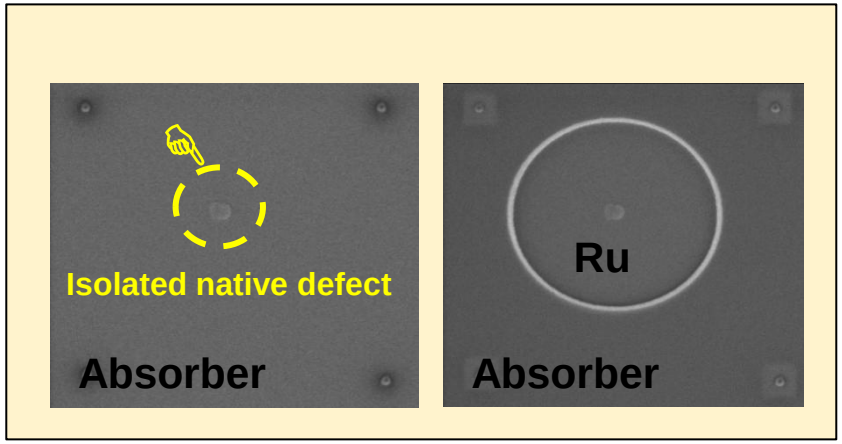
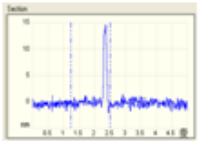
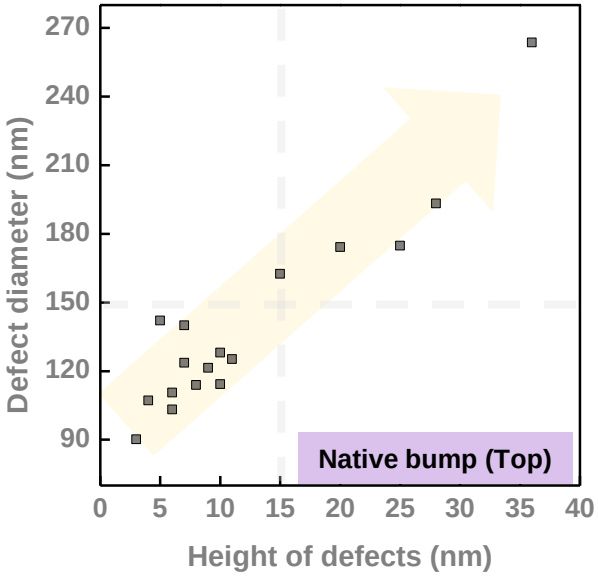


AFM





- **Native defects are "exposed" using mask repair tool to study their printability**
- **Native defects smaller than 120 nm, lower than 20 nm, and > 500 nm from the main pattern are not printable**

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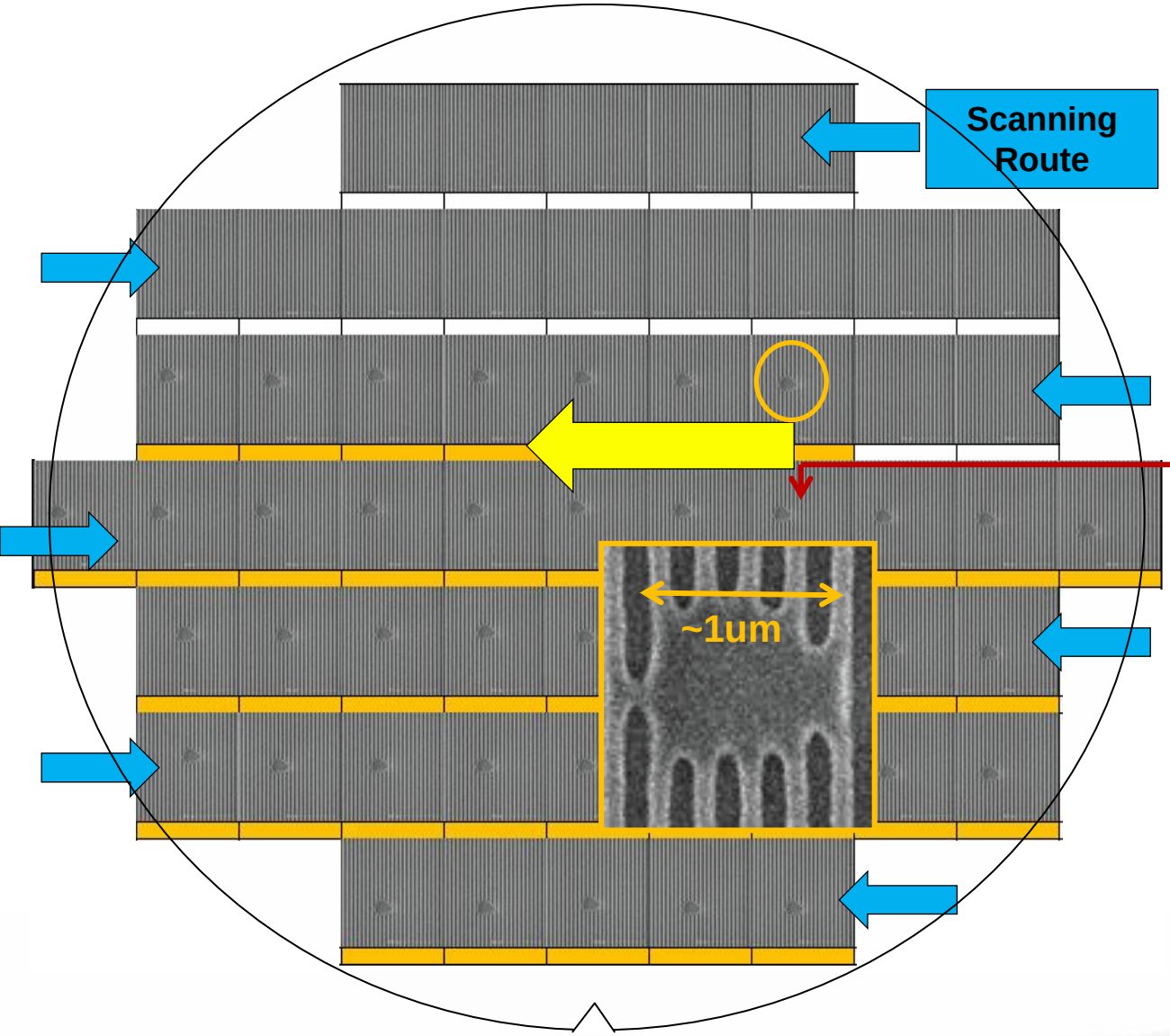
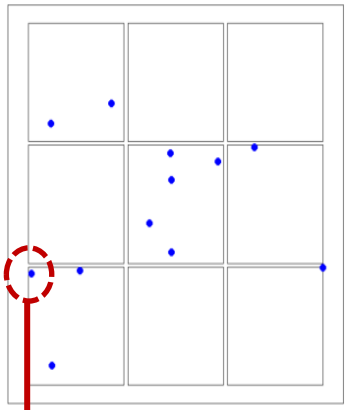
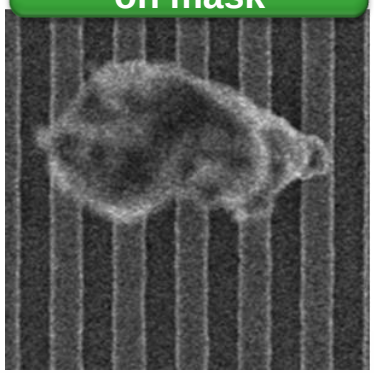
Fall-on particle during exposure in NXE3100





- Repeaters from wafer defect inspection

Fall on particle on mask



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Fall-on defect analysis of NXE3300

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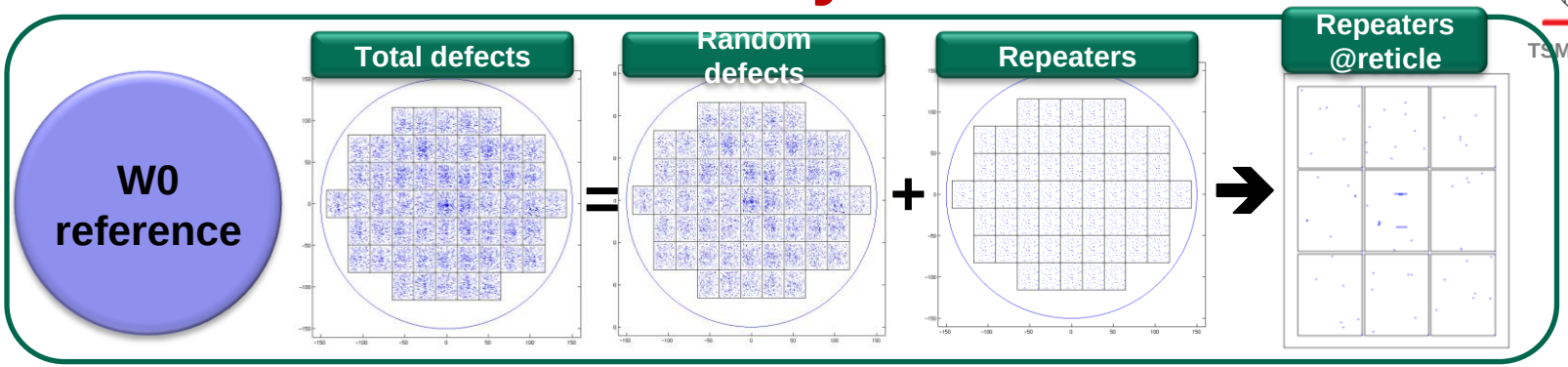

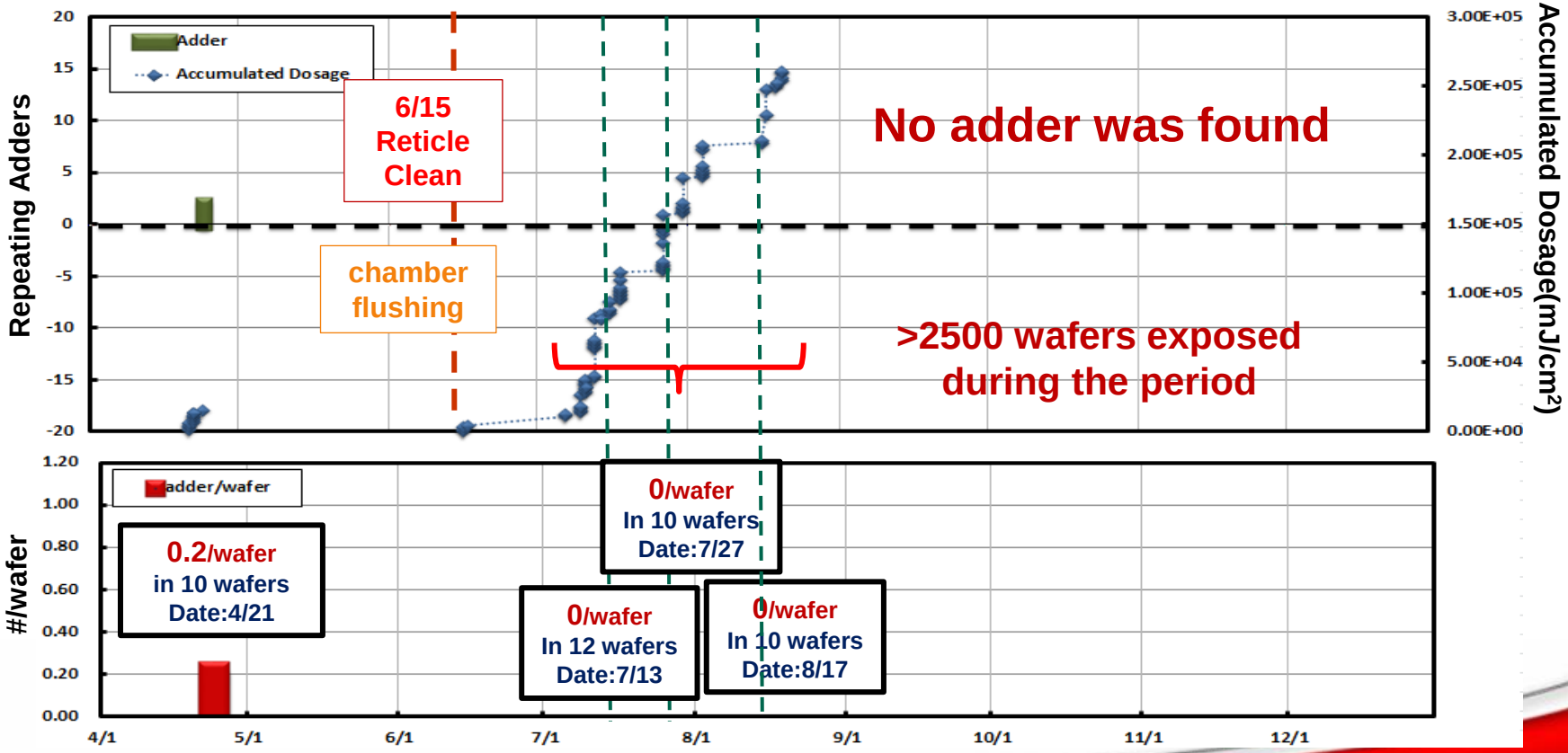

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Progress has been made on EUV pellicles

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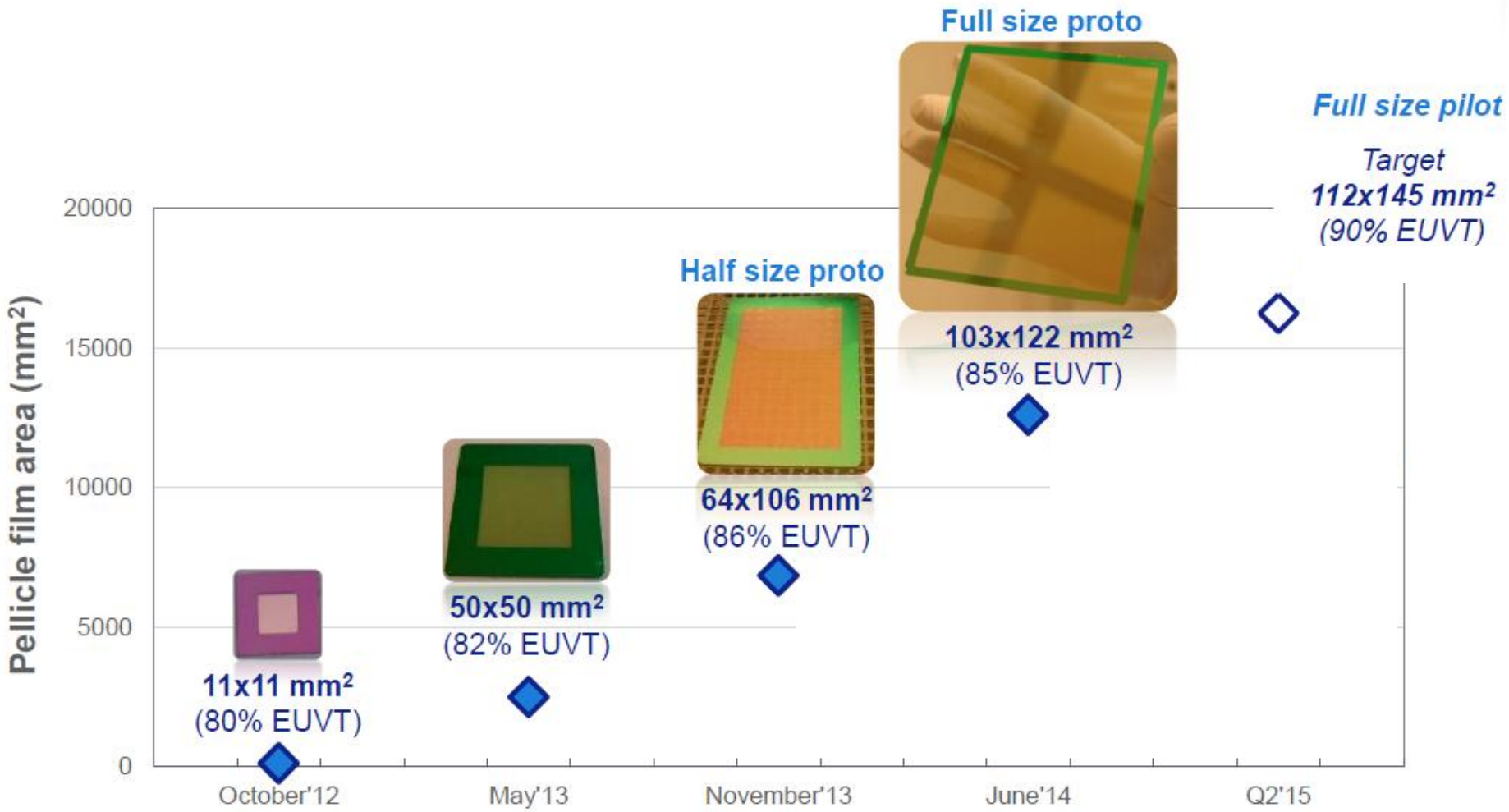

Courtesy of ASML

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A prototype pellicle was tested in NXE3100

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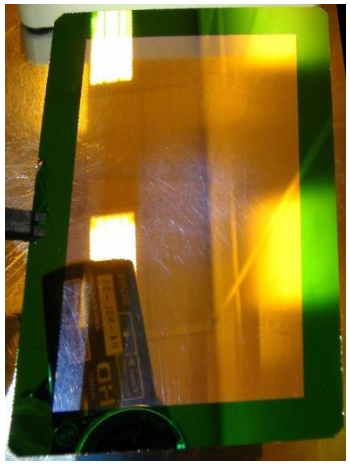
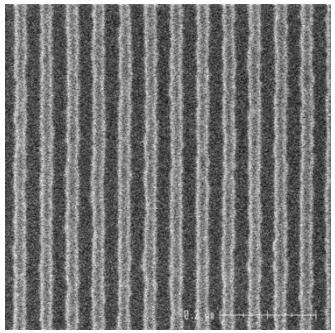
Half-sized Si membrane



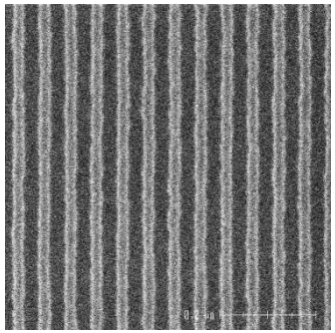
w/o pellicle



LWR: 4.0 nm

Best Energy = 21.7 mJ/cm^2

with pellicle



LWR: 3.7 nm

Best Energy = 30.2 mJ/cm^2

$$Thickness = 55nm$$

$$Transmission = \sqrt{\frac{21.7}{30.2}} = 85.5\%$$

Joint work with ASML

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Summary

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- Productivity
  - LPP EUV sources have been operating with power > 50 W
    - High probability of running the tool at 80 W in Q4 2014
  - Tool availability is improving
    - Recent batches of droplet generators perform well
    - Many upgrades are still to be carried out
  - Progress on CAR resist in extending to <16-nm half-pitch has been limited
    - New metal resists may provide opportunity for high sensitivity and low LWR
- Mask defect management
  - Defect mitigation solution has been demonstrated
    - Defect printability study has been carried out
  - Progress has been made on pellicle development but the pace must increase
    - No fall-on particles were found on masks in >2500 wafer exposures

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