Mask Metrology in the ILT World

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D2S, Inc.

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Managing Company Sponsor

A Decade of ILT!

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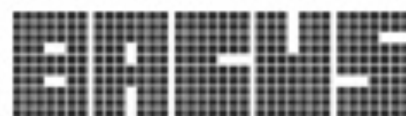
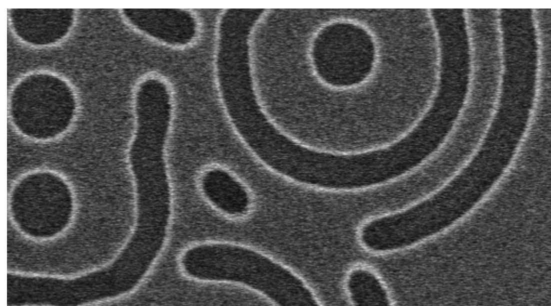


2005

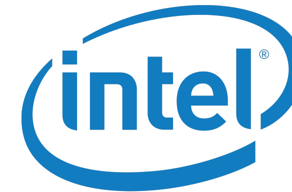


6	2	1	1
Papers	Foundries	Memory	Mask shop

ILT Adopted as the Way Forward

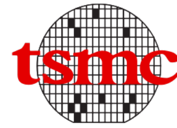
>200

Papers

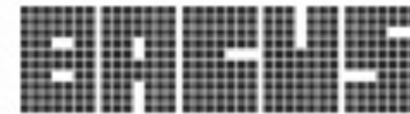


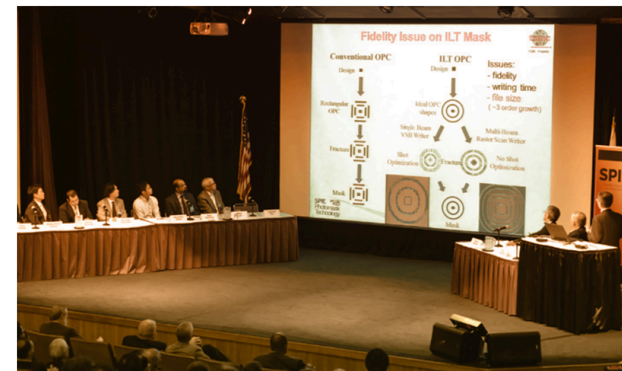
Officially announced

Today



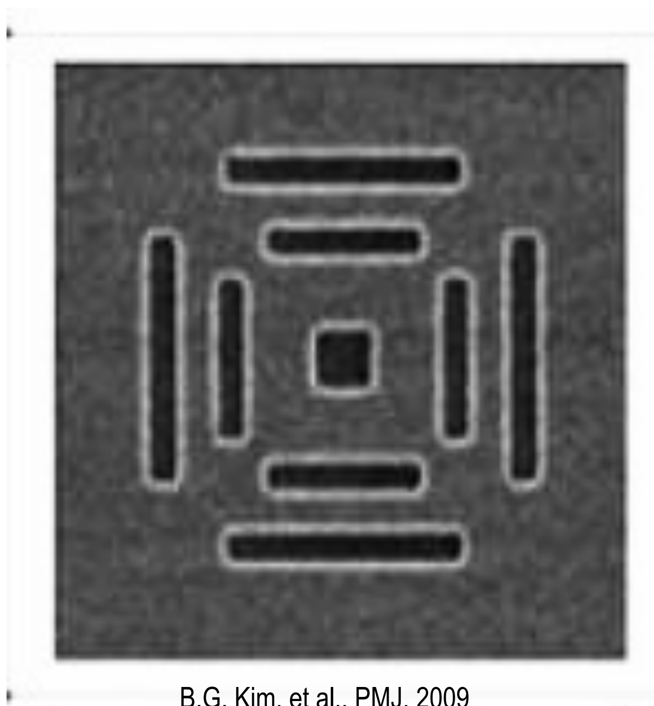
ILT expertise proliferated



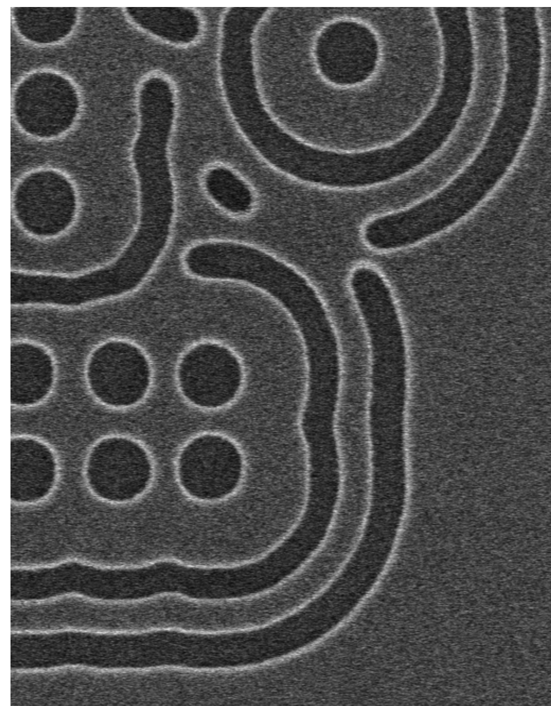


2014 panel

But What About CD Metrology?


B.G. Kim, et al., PMJ, 2009

VS


B.G. Kim, et al., BACUS, 2012

Old World:
Conventional Mask Pattern

New World:
ILT Mask Pattern

What *is* CD In the ILT World?

D2S®

ILT CD is not just line width: it's 2D!

Contour and EPE

What to use as a reference?

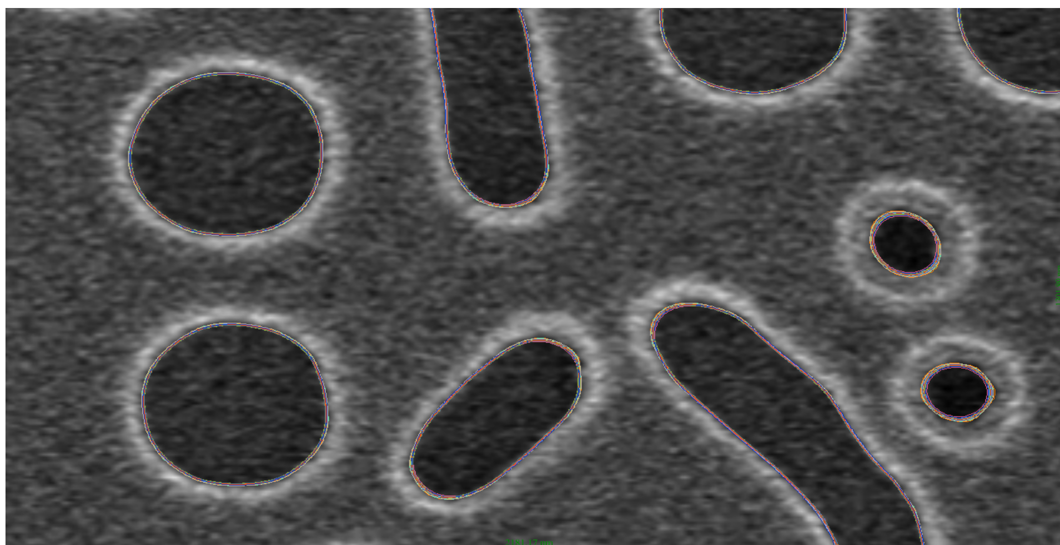
Simulated mask pattern

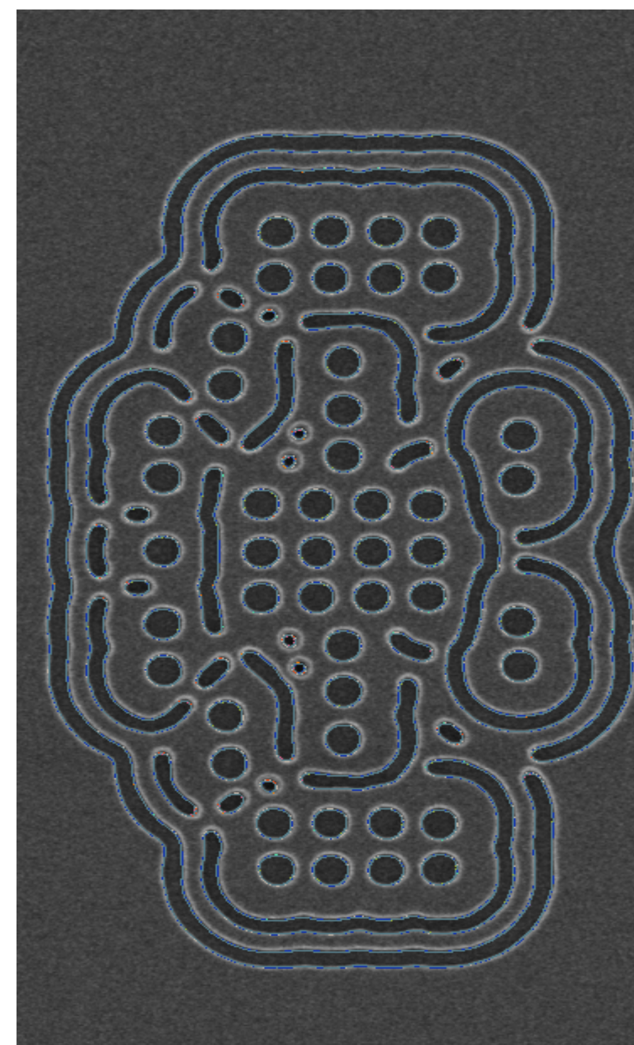
Which mask issues impact the wafer?

Wafer plane analysis

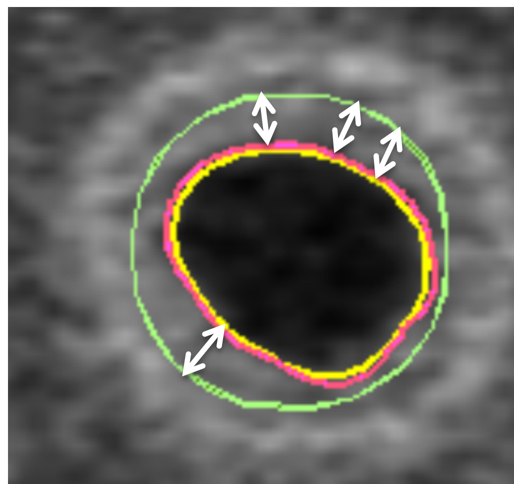
Mask Plane Metrology: Contour and EPE Measurements

- EPE measured on entire contour
- Histogram: mean, 3 sigma

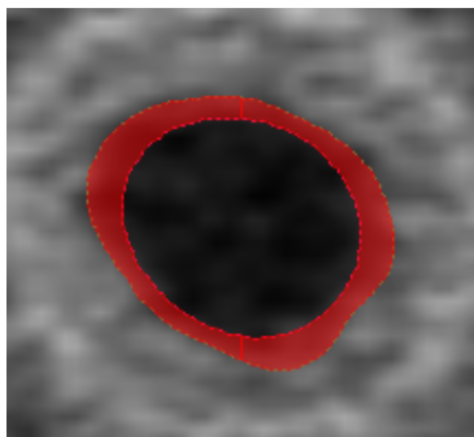




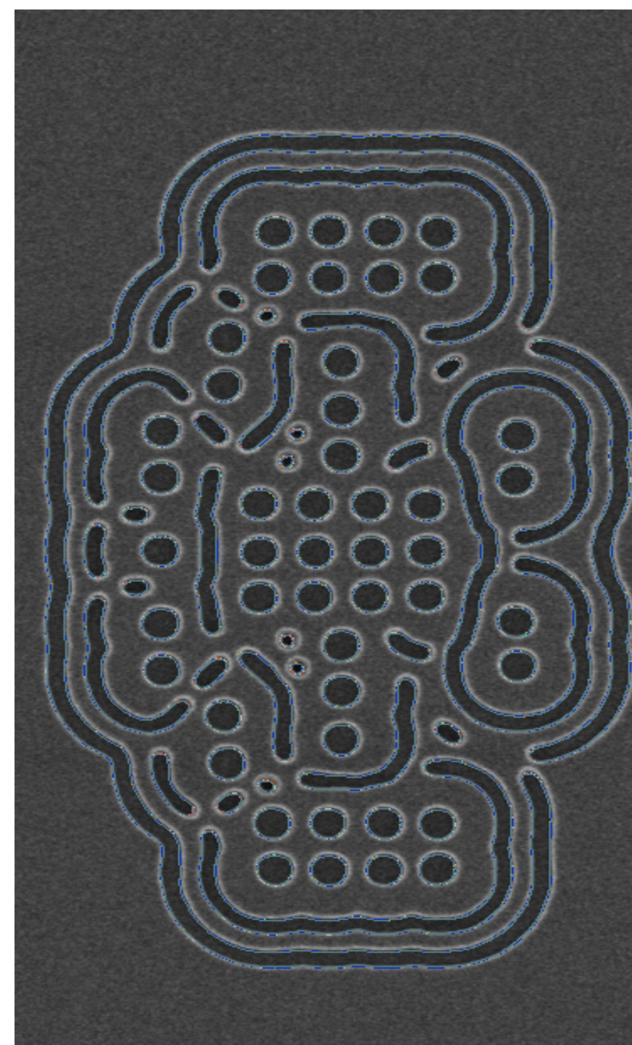
Mask Plane Metrology: Contour and EPE Measurements



EPE measured on entire contour



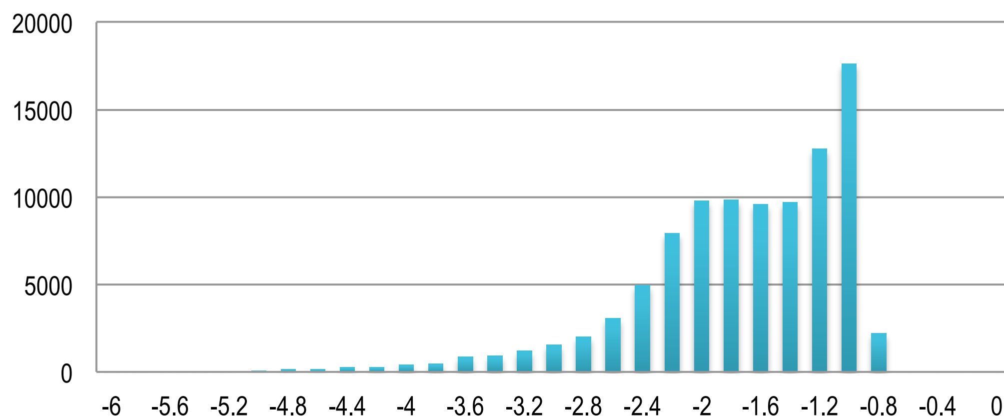
PV band

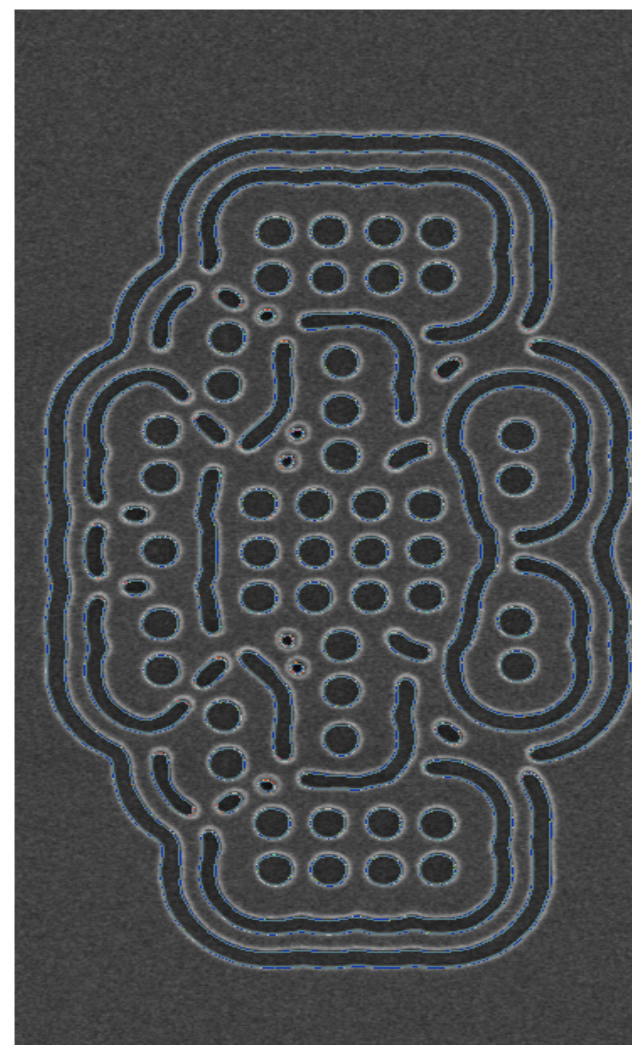


Mask Plane Metrology: Contour and EPE Measurements

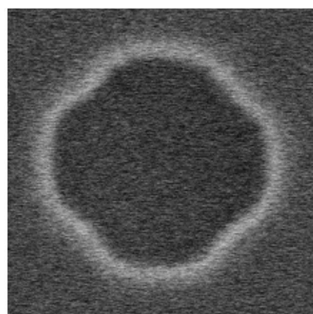
Count	95883
Min (nm)	-6.00
Max (nm)	-0.84
Mean (nm)	-1.83
Median (nm)	-1.71
3 Sigma (nm)	2.14

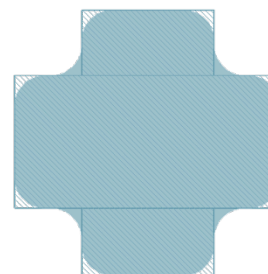
EPE Histogram (Mask)

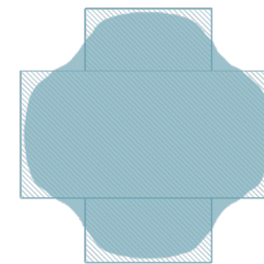




Mask Plane Metrology: What is the Target for EPE?







Mask Shape

OPC Design

- No corner rounding
- Affected by corner EPE

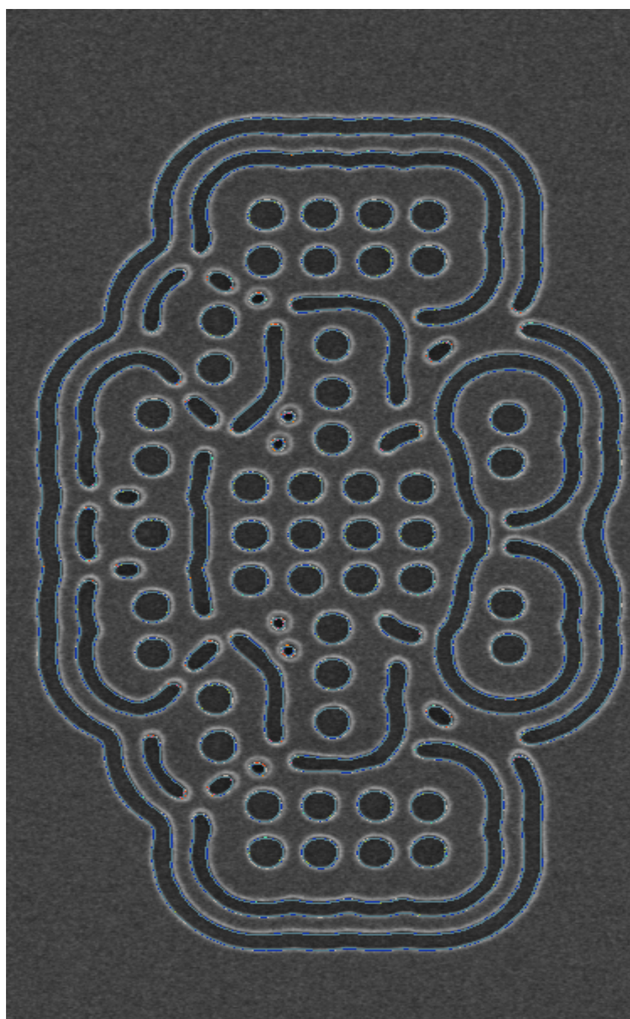
CR + bias

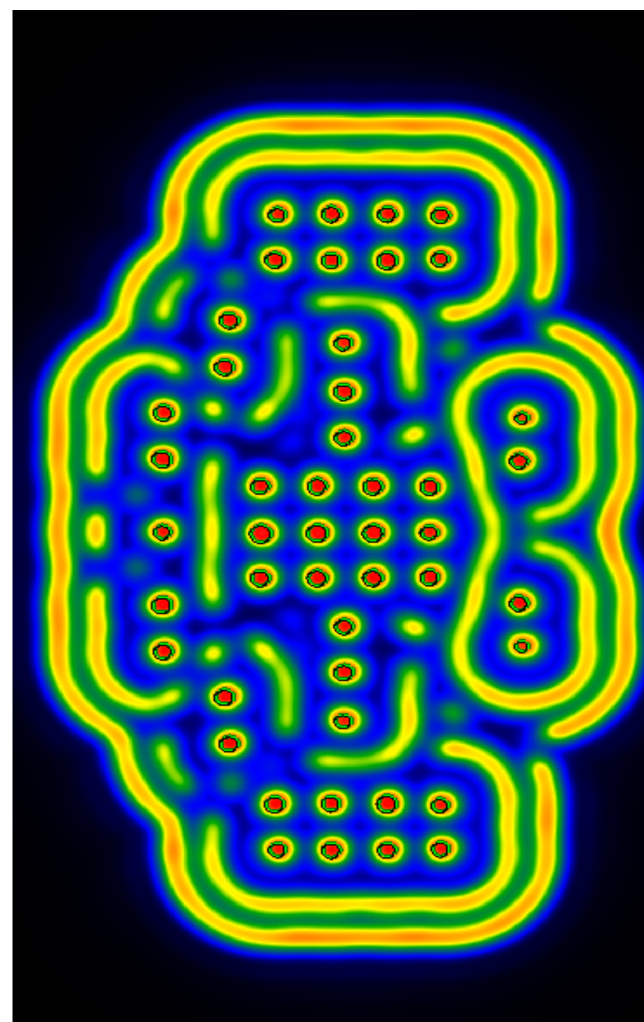
- What OPC thinks the mask shape will be

Simulated mask pattern

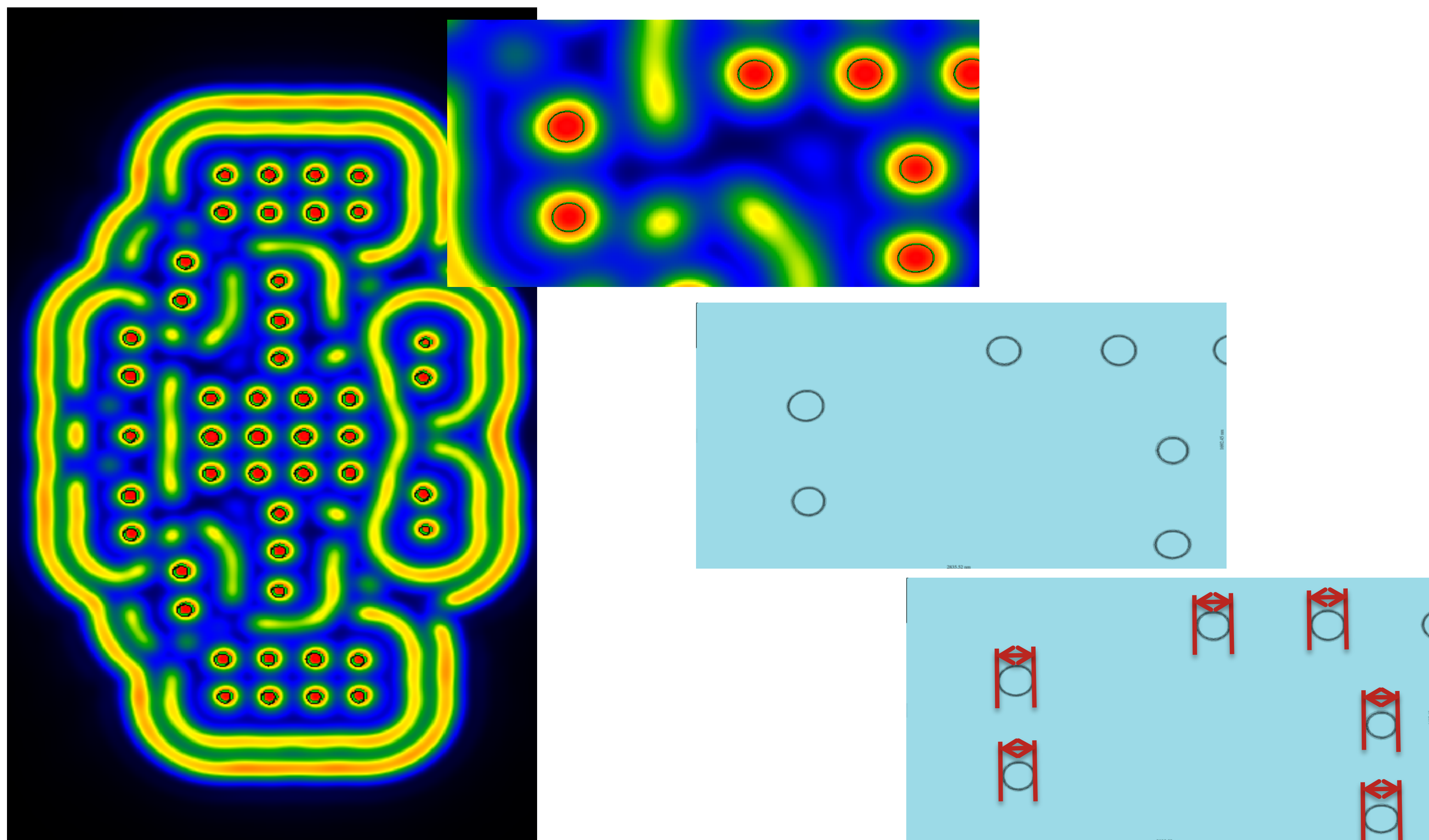
- Model of actual mask shape

Wafer Plane Metrology: Traditional CD and Wafer Impact in One Simulation

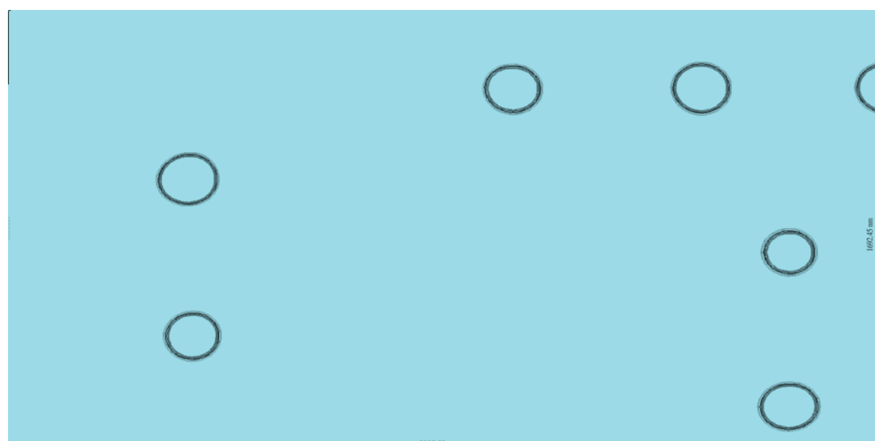




Wafer Plane Metrology: Traditional CD and Wafer Impact in One Simulation

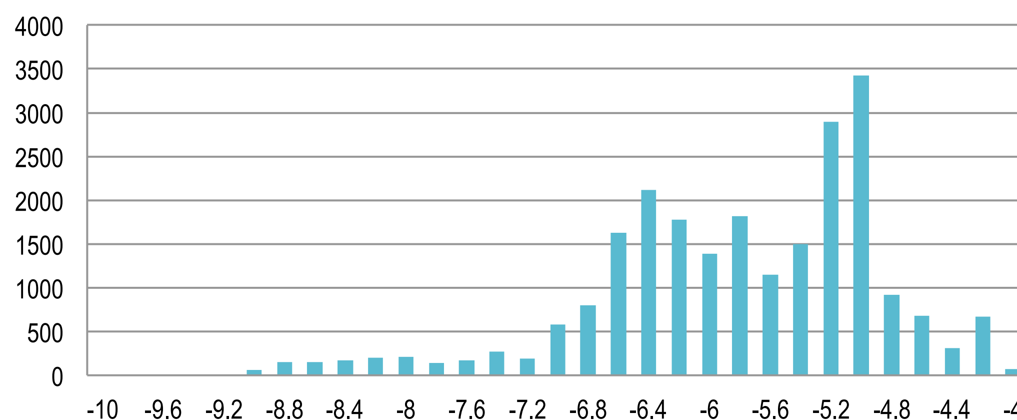


Wafer Plane Metrology: Traditional CD and Wafer Impact in One Simulation

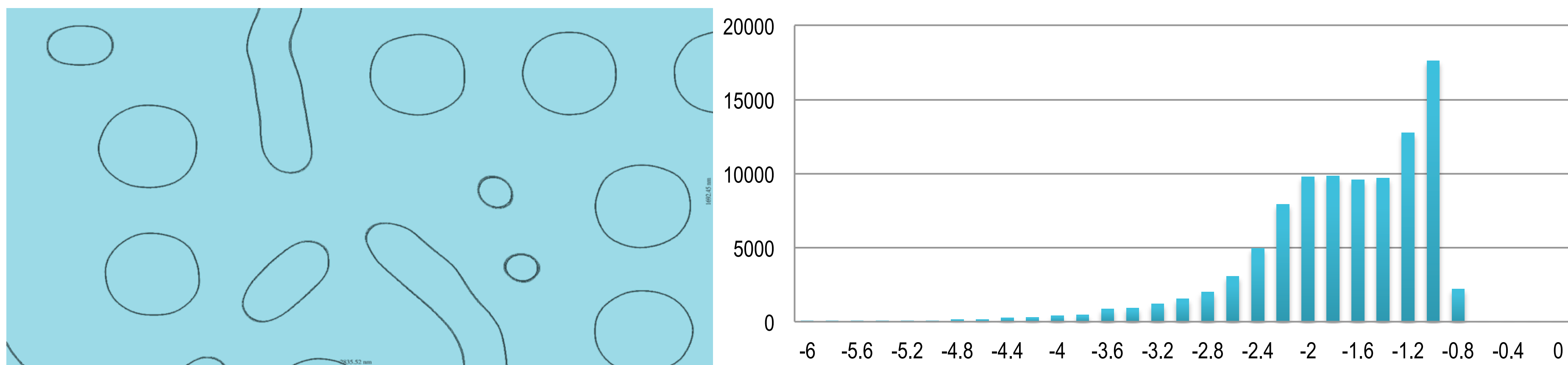


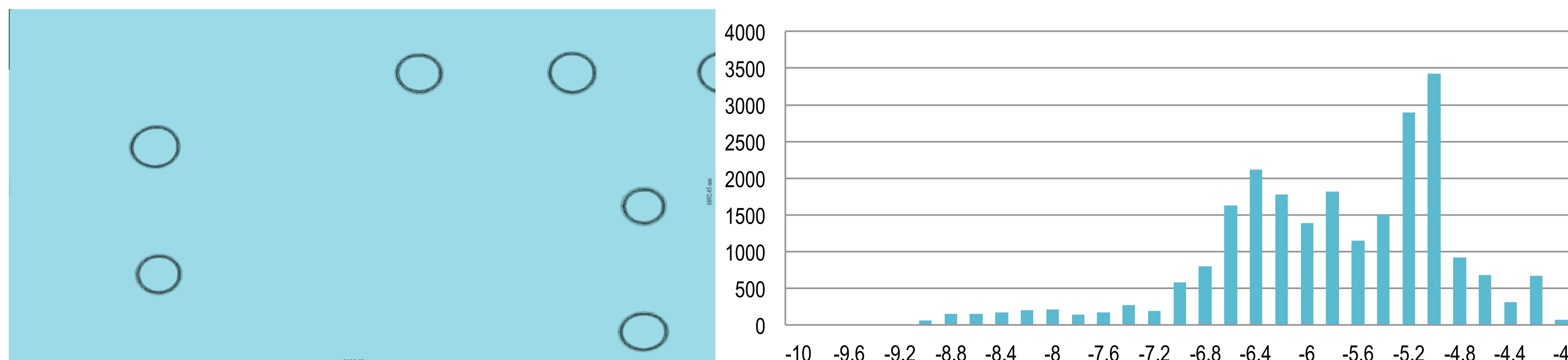
Count	23468
Min (nm)	-9.14
Max (nm)	-4.12
Mean (nm)	-5.91
Median (nm)	-5.81
3 Sigma (nm)	2.80

EPE Histogram (Wafer)

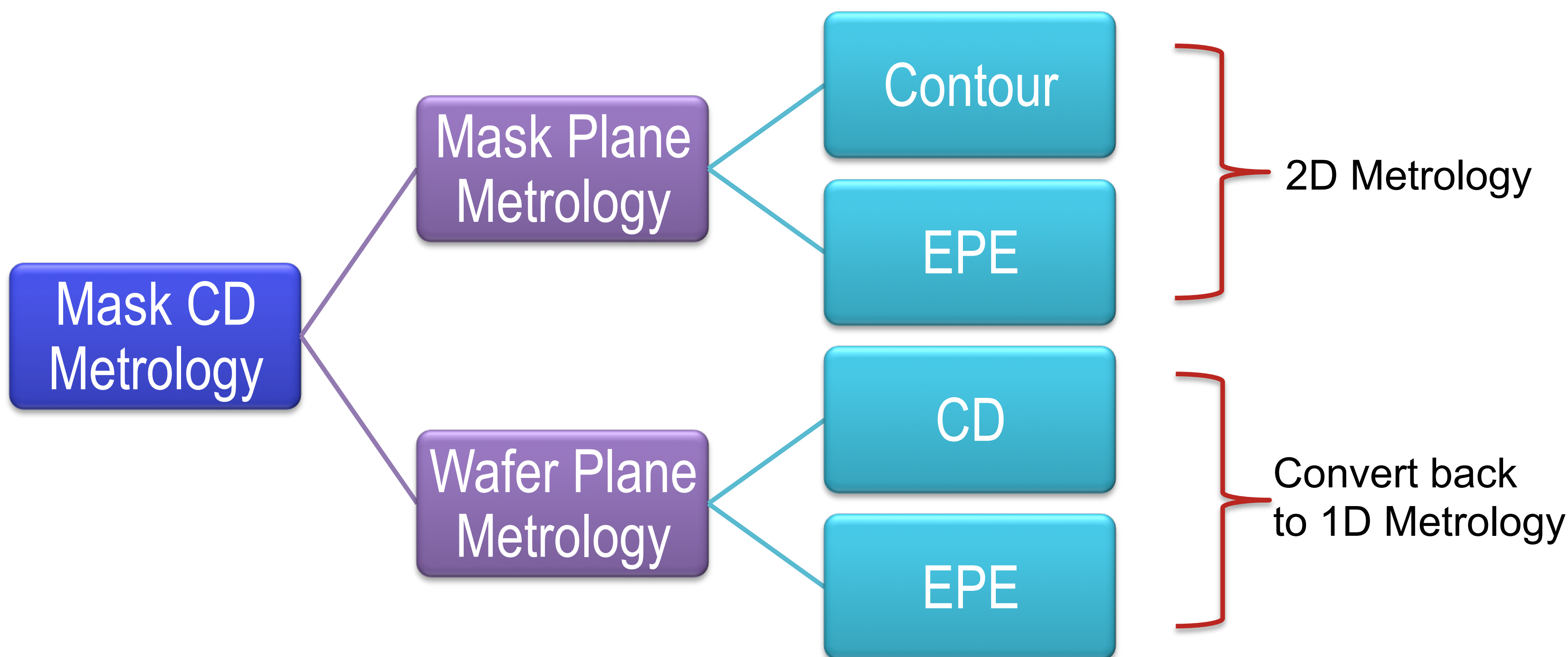


Mask CDU ≠ Wafer CDU: Wafer Metrology is Required

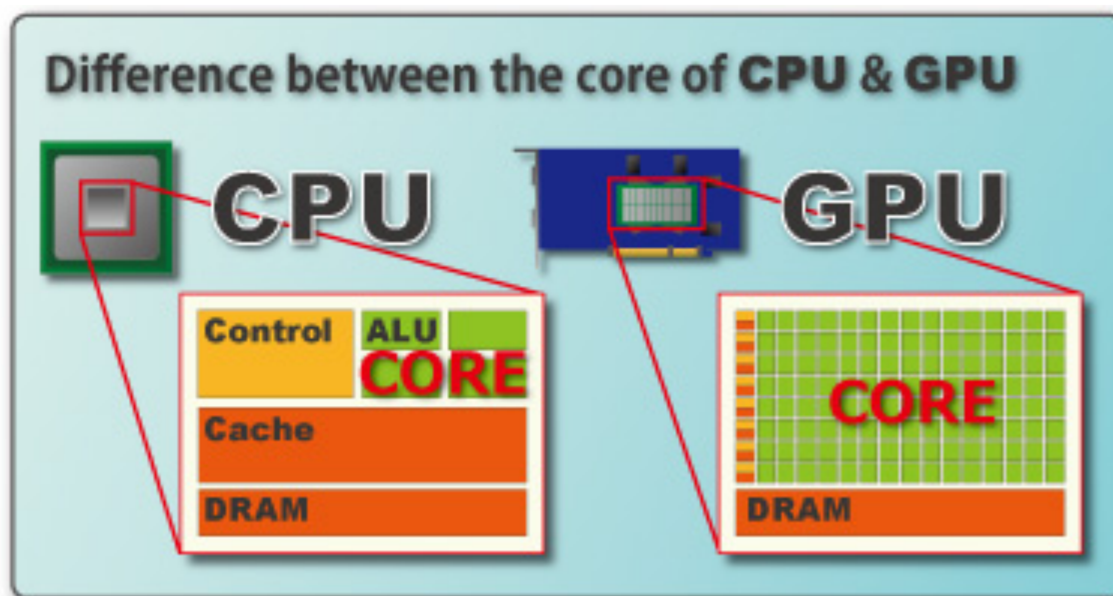




Old World: Mask CD Only
ILT World: Mask and Wafer

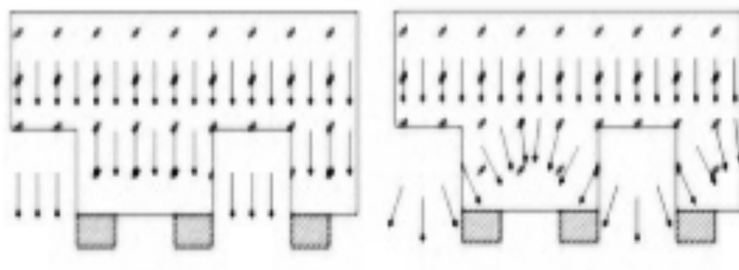


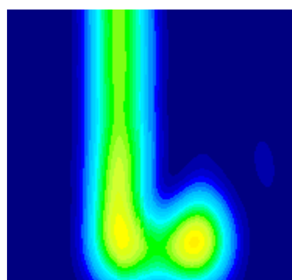
With GPU, the Simulation-based Wafer Plane Metrology is Real Time

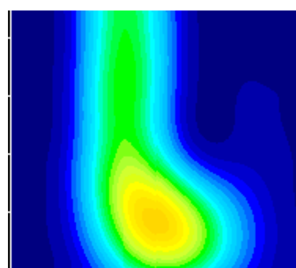


With GPU, the Simulation-based Wafer Plane Metrology is Real Time

Mask



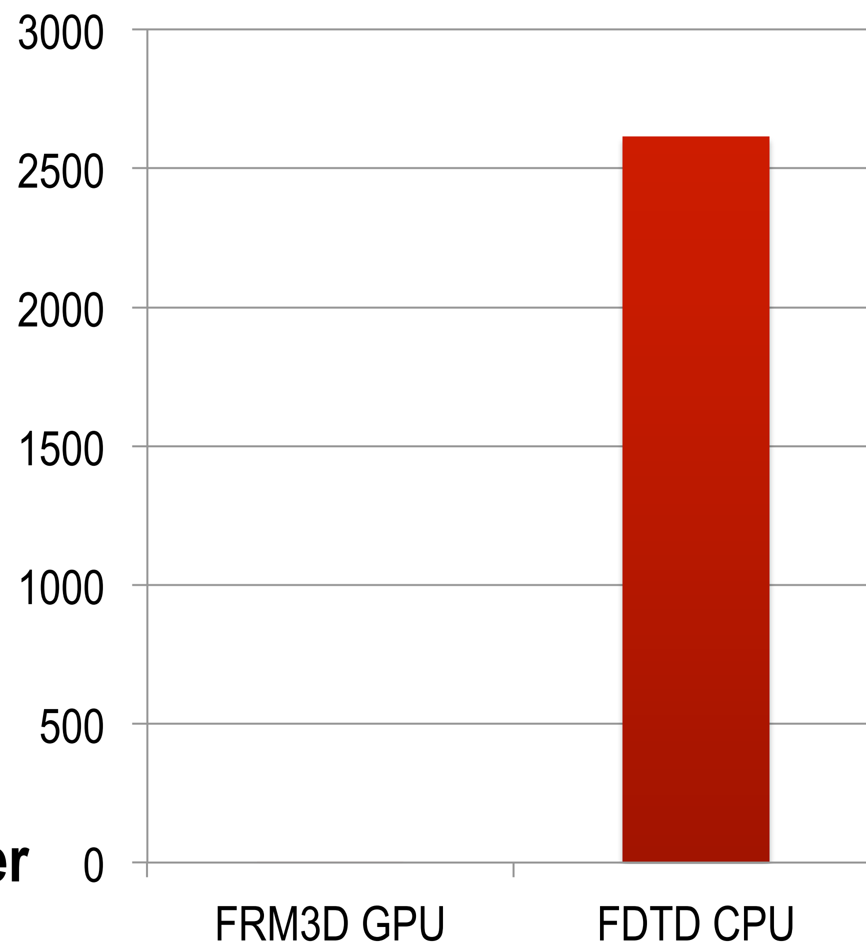




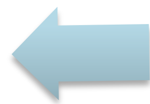
Aerial image

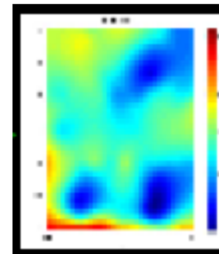
2D 3D

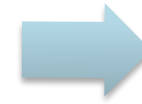
GPU 3D mask sim >1000 times faster



Future: Improve Mask and Wafer Quality





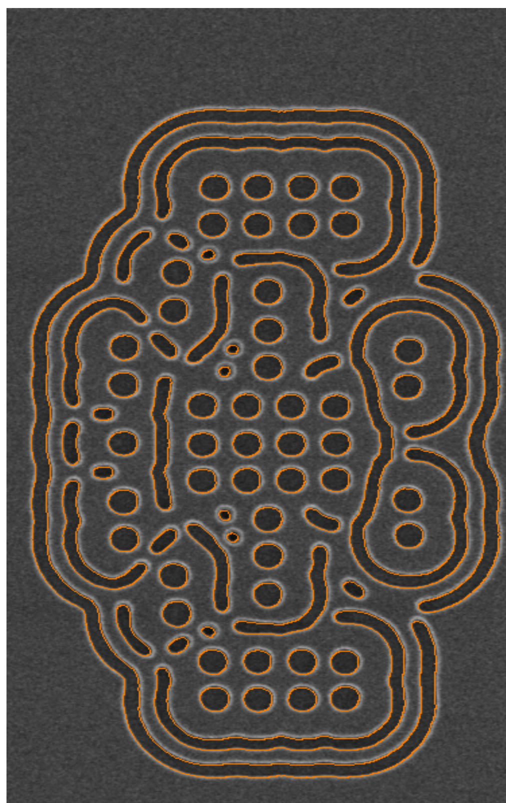


- Improve mask writing

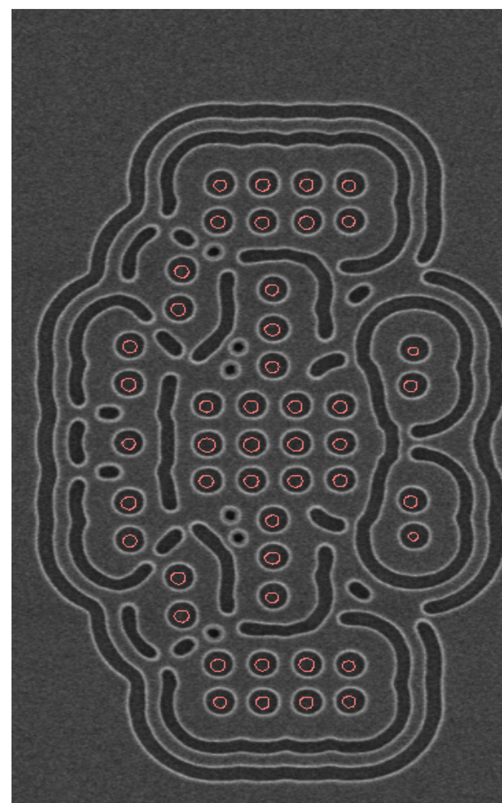
- Shorten time to get wafer CDU map
- Attain SEM-level repeatable accuracy

The New ILT World Calls for New CD Metrology: Mask and Wafer!

Mask

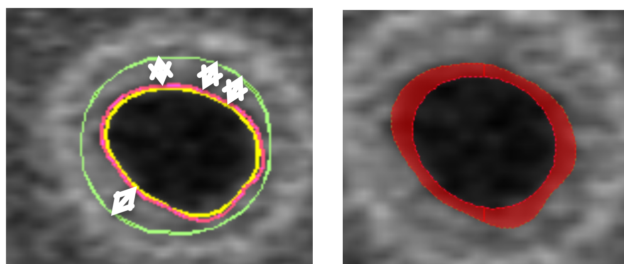


Wafer

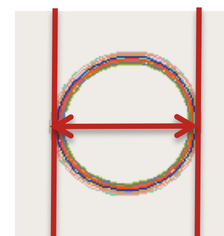


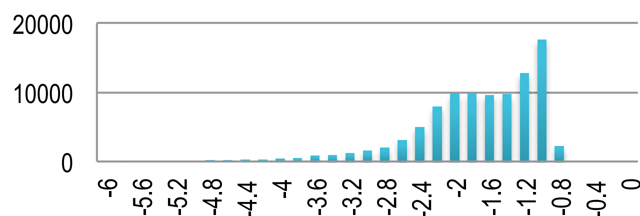
The New ILT World Calls for New CD Metrology: Mask and Wafer!

Mask

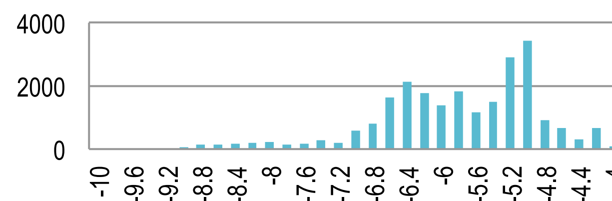


Wafer





Contour, EPE,
PV Band, Histogram



CD, EPE,
PV Band, Histogram

GPU = Real-time for mask + wafer

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