



# Mask Considerations for Next Node

February 24, 2015

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Mask



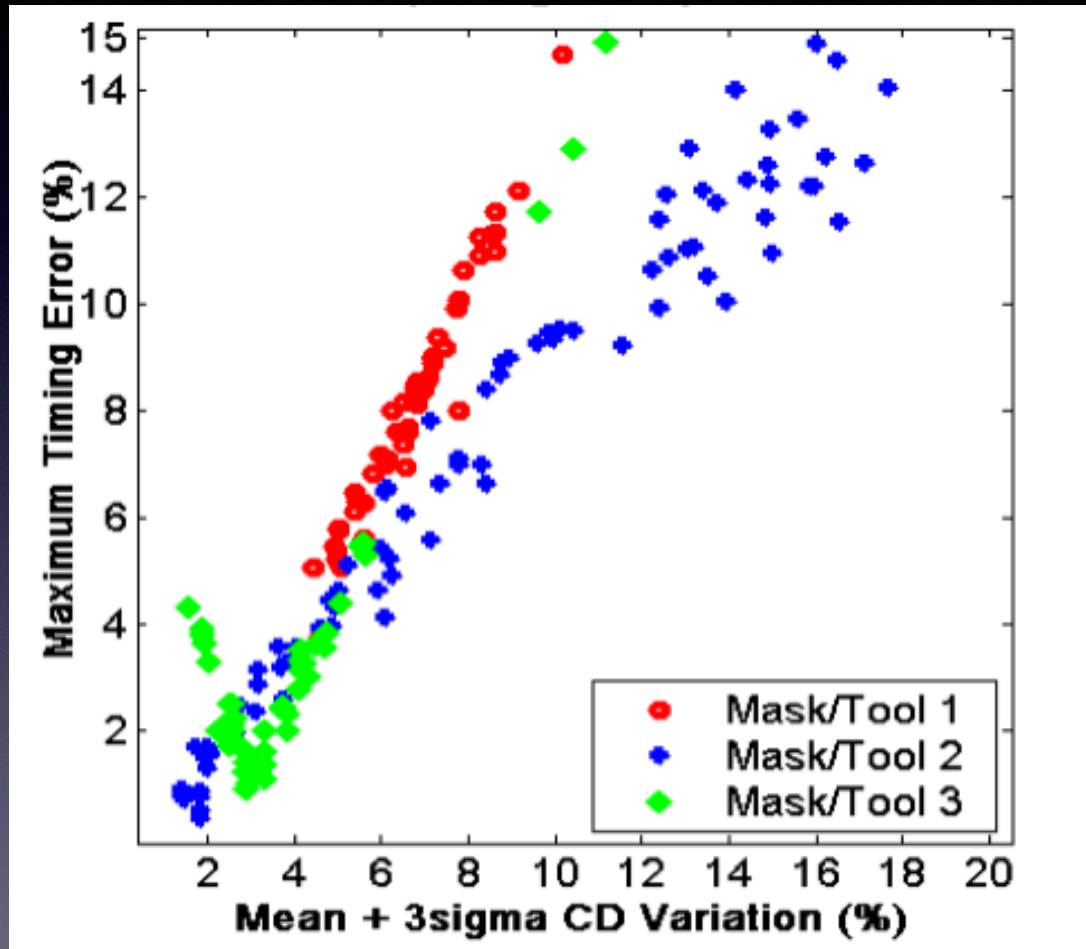
Scanner



Wafer



# Role of Mask/Scanner Signatures on Device Yield





“Does the Flap of a Butterfly’s wings in Brazil  
Set Off a Tornado in Texas?”

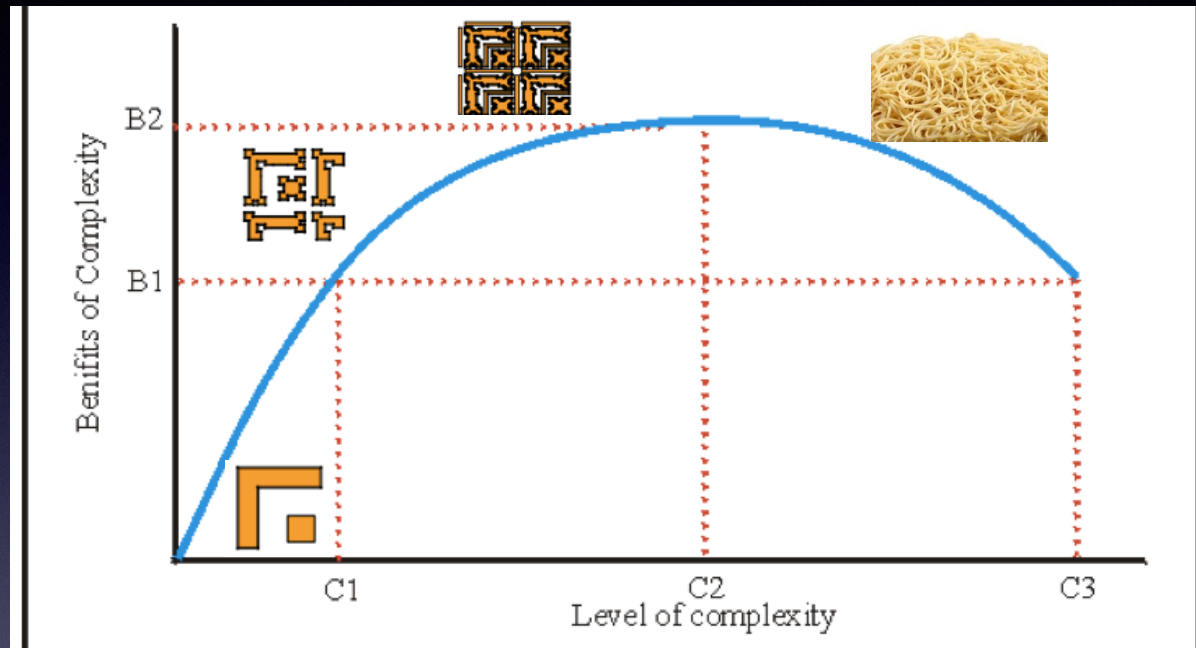
–Edward Lorenz Dec. 29, 1972



“Does the Topple of a Mask SRAF in Taiwan  
Set Off A Crisis in Cupertino?”

– Anonymous Feb 24, 2015

# Layout Complexity

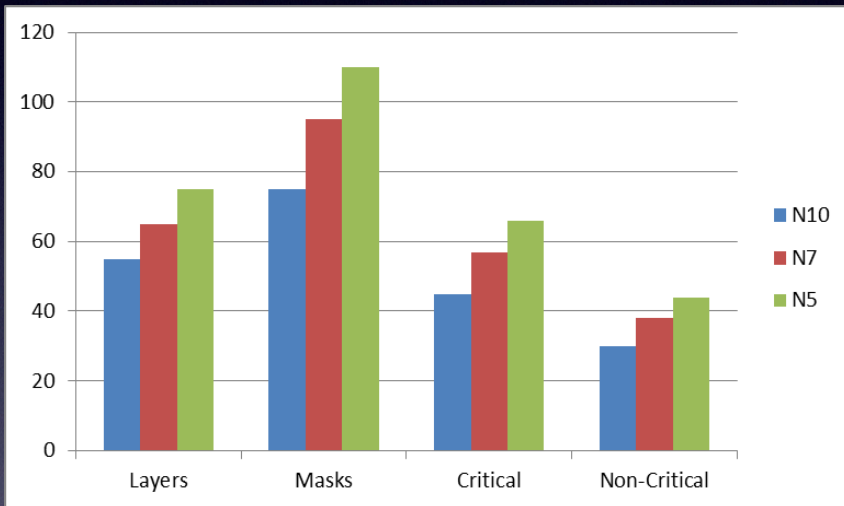


*Joseph Tainter, 1988*  
*The Collapse of Complex Societies*

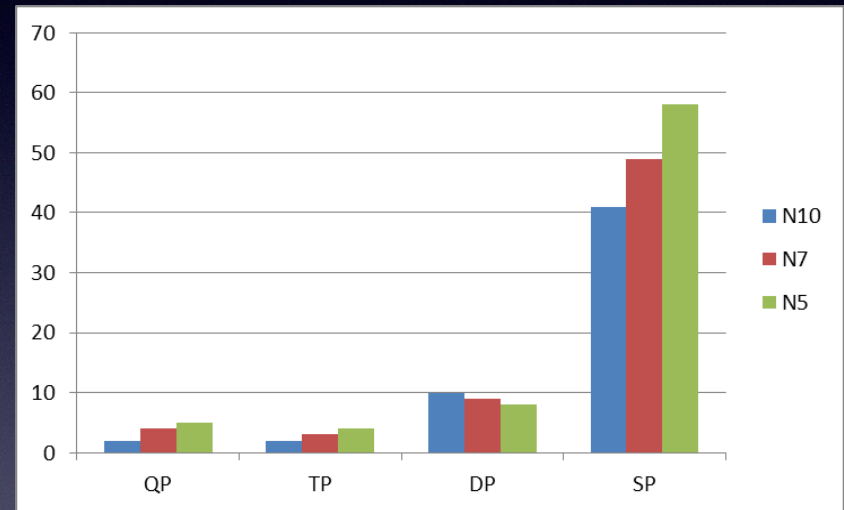


# Level Count Complexity

## Mask Counts Per Node

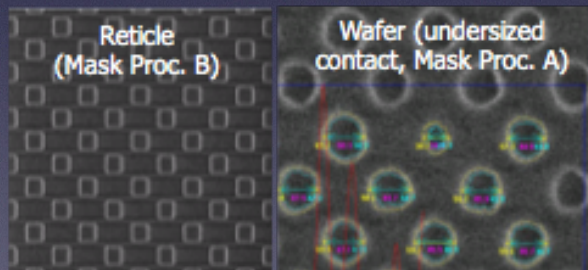
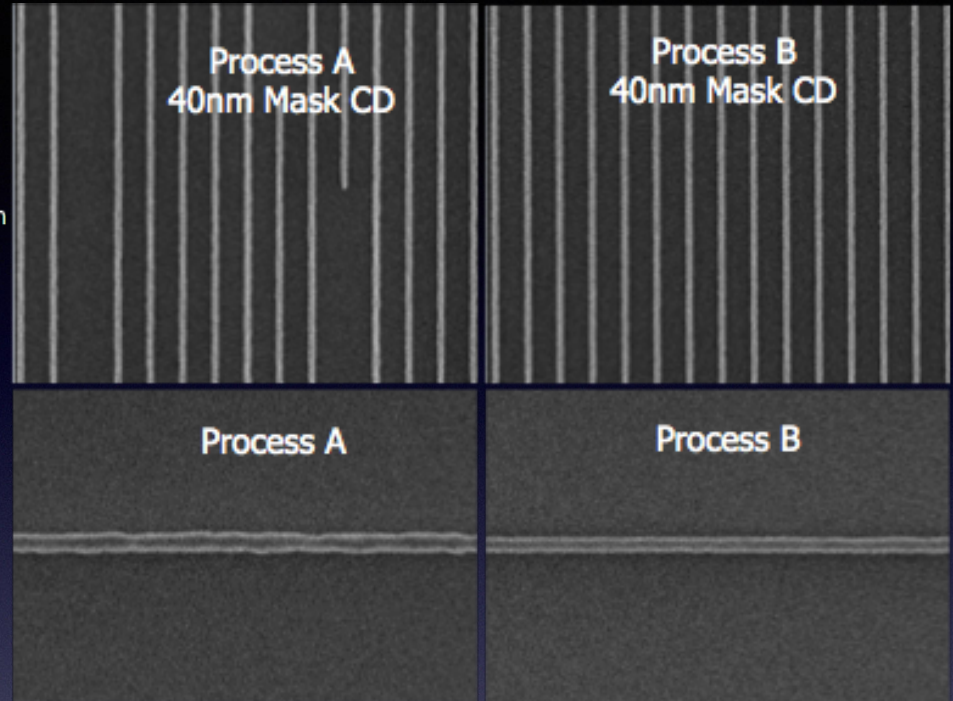


## Degree of Multi-Pattern

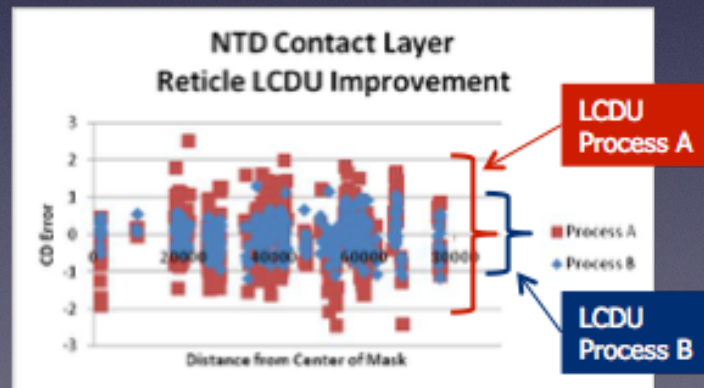


► Critical process characterization items

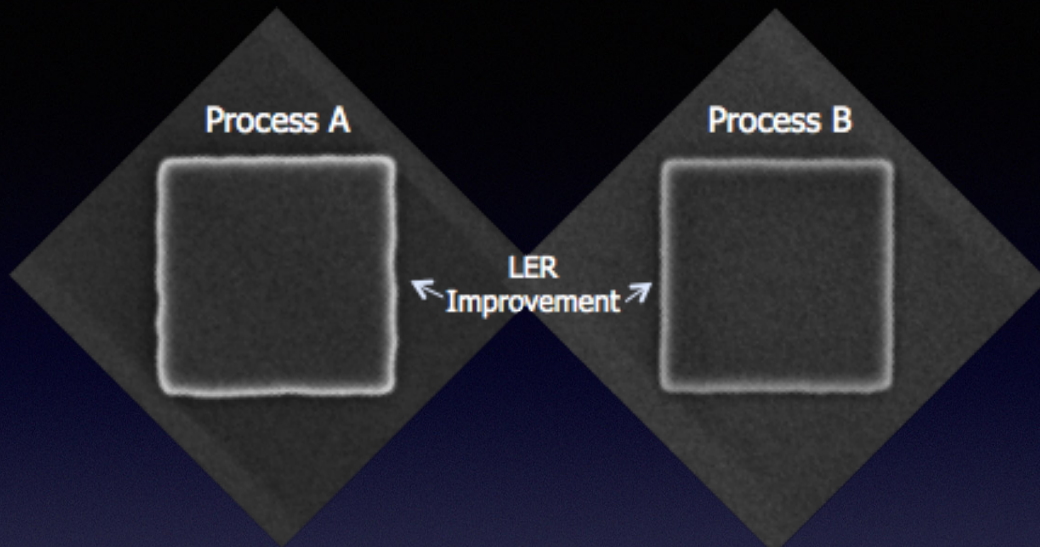
- Min Resolution
- PEC (thru-pitch) and global positional dose correction
- CDU, global and local
- LWR thru density and dose
- CD linearity
- CD thru-pitch
- Corner Rounding



Process B vs. A:  
33% reticle local CDU improvement translated to 35% on-wafer LCDU improvement and reduction of undersized contacts.



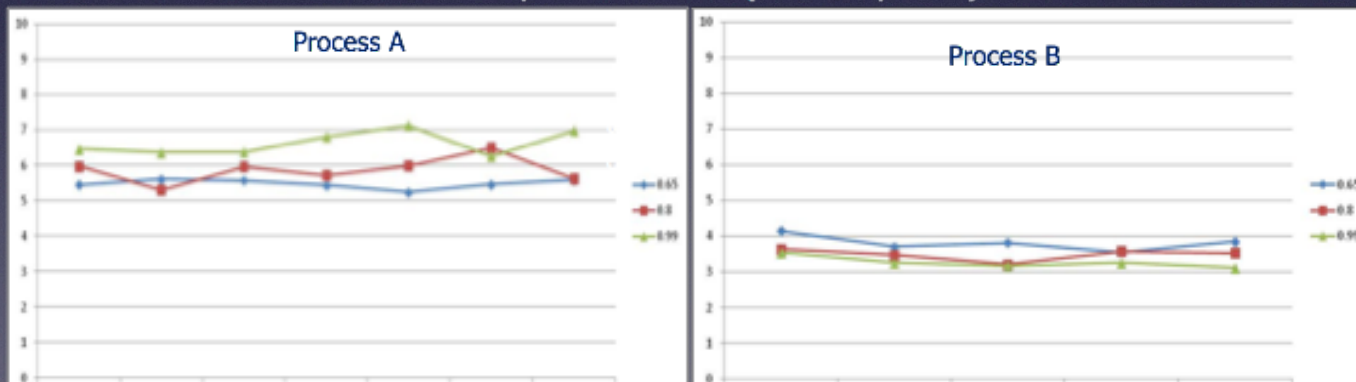




## Corner Rounding

- 22% improvement in corner rounding radius (Process B vs. Process A)

## LWR Improvement (Line/Space):

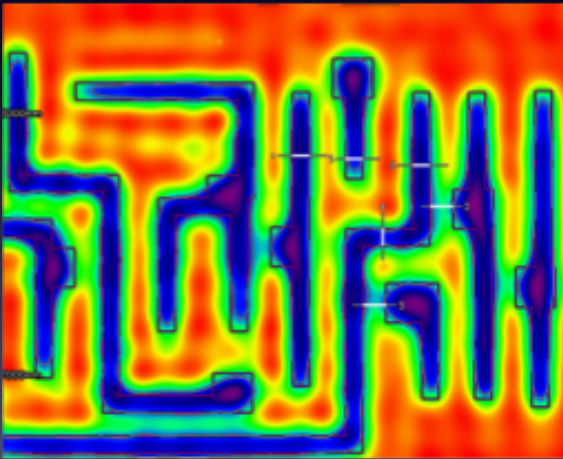


Increasing Dose →

Increasing Dose →

# Hunting for Hot Spots

## Mask Sensitivity Matrix

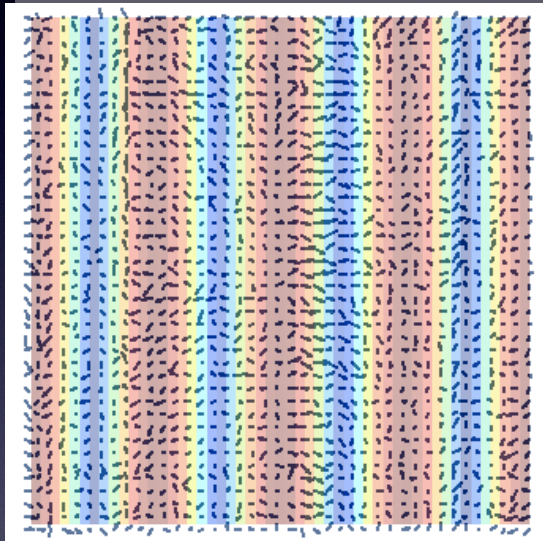


	1	2	3	4	5	Avg
Roughness	0.052	0.022	0.155	0.076	0.023	0.057
Rounding	0.000	0.008	0.001	0.008	0.006	0.004
Transparency	0.003	0.007	0.004	0.002	0.003	0.003
Resize	0.007	0.091	0.317	0.030	0.082	0.089
PhaseShift	0.001	0.004	0.003	0.001	0.001	0.002
Shift	0.018	0.119	0.331	0.113	0.067	0.110



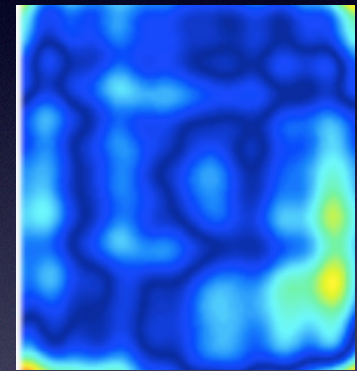
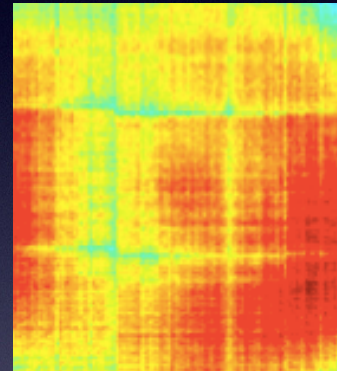
# Hunting for Nanometers

Extraction of Periodic Registration Effect



□ Writer/resist interaction

Isolation and Modeling of CD Systematics

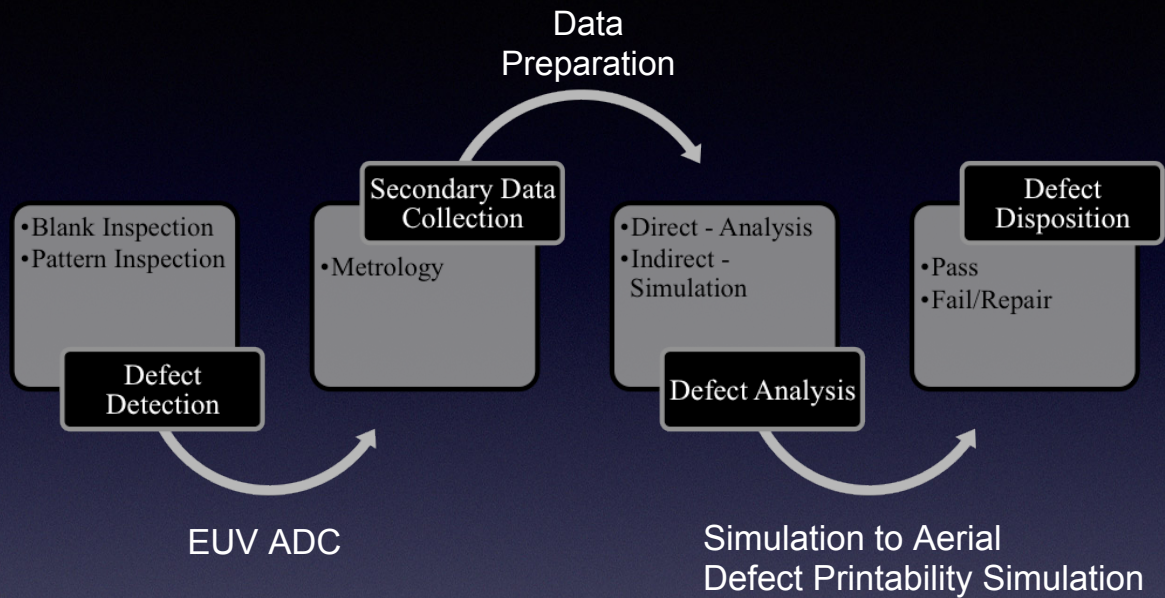


□ Supplements higher order polynomial fitting

*We know both signature magnitude and shape are Important*



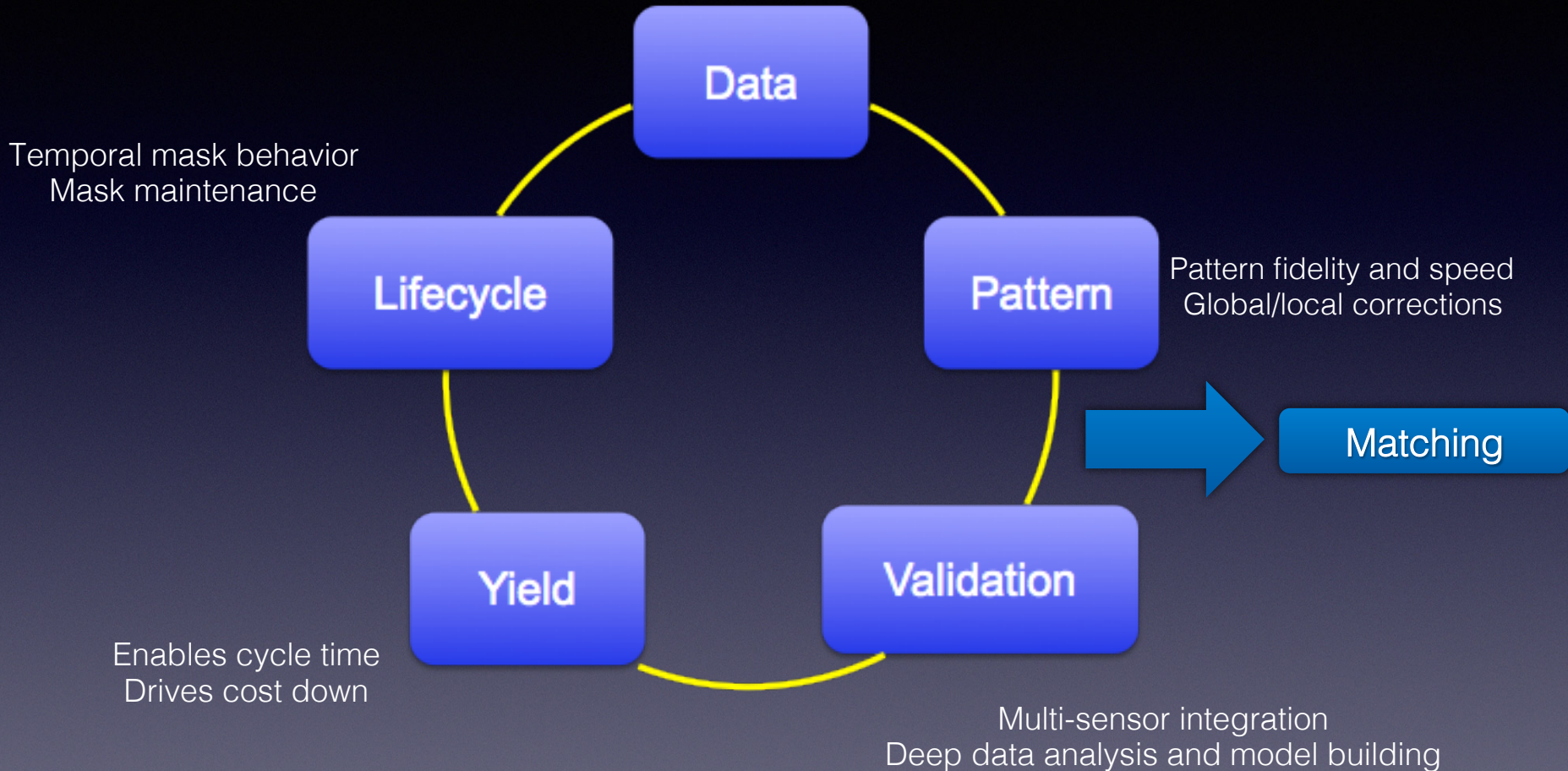
# Applying Multiple Sensors to Characterize Masks



Defect	AFM image	3D AFM image	SEM image	GDS Clip	DPS Image
1					
364					



2D/3D mask process correction  
Feed forward models









Mask



Scanner



Wafer



