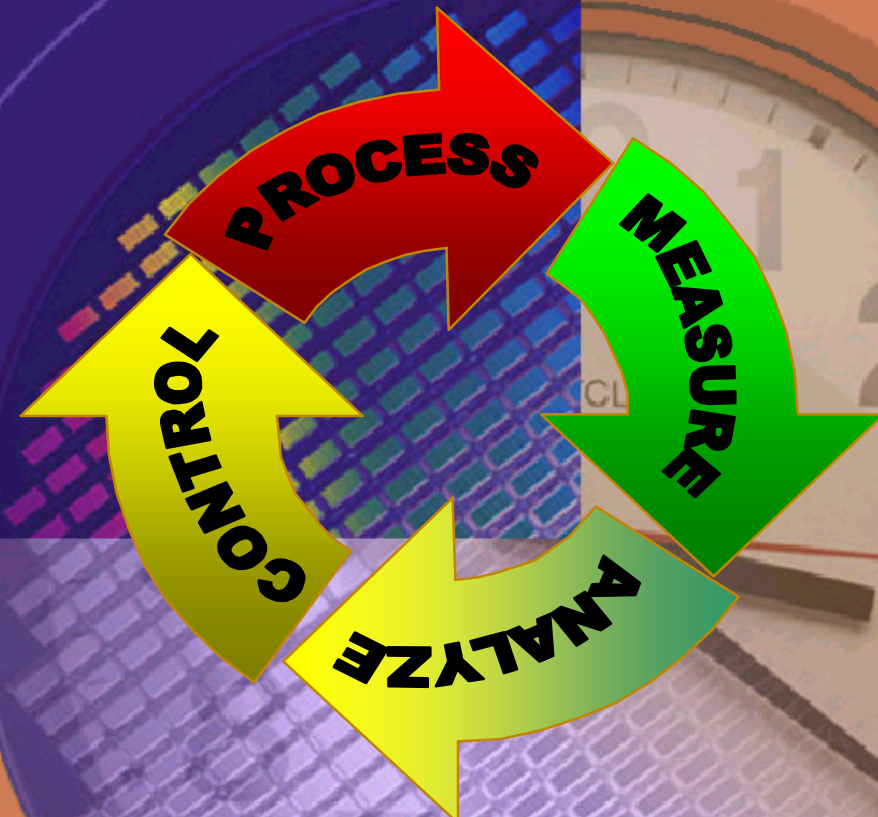




Accelerating Yield

Integrated Metrology
11-October-01

Matt Hankinson, PhD
KLA-Tencor



Agenda

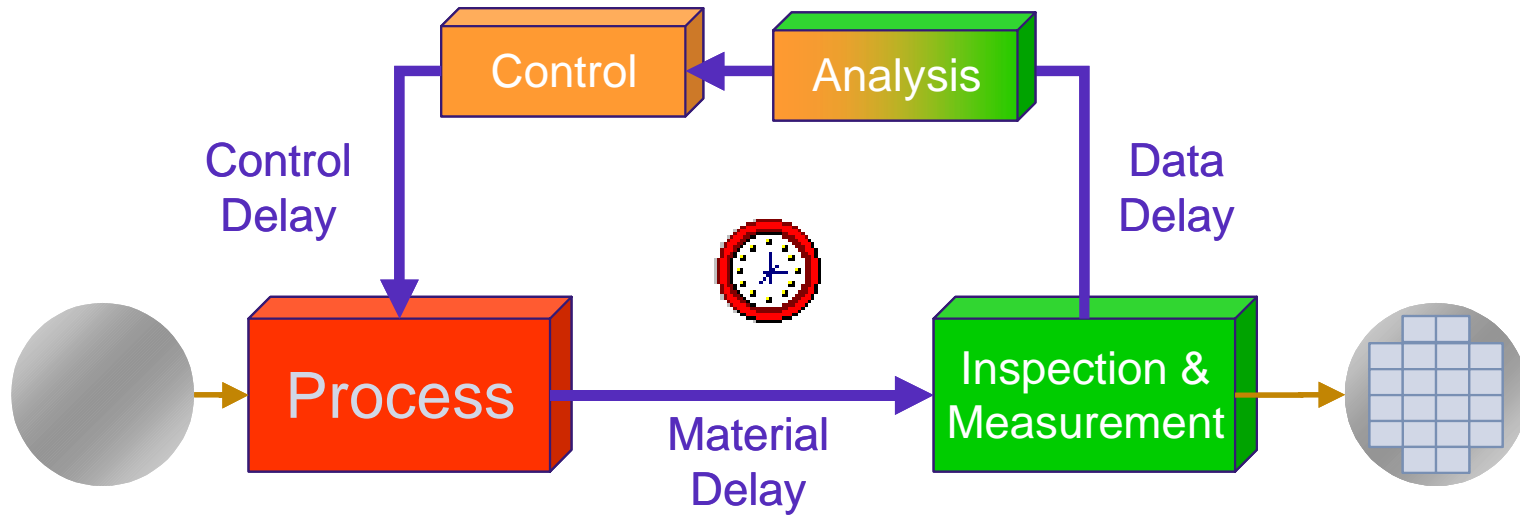
- Integration of CD with Lithography Track and Gate Etch
- Simulated Results
- Limitations of Integrated Inspection
- Standards Requirements

Integrated Metrology Requirements

- To be implemented properly:
 - Reliable
 - High throughput
 - Environmental Robustness
 - Small footprint (tool and on wafer)

 - High precision and matching
 - Good Correlation with Stand-alone measurements
 - Robust recipe setup and operation
 - Fast Analysis Turn-Around Time

Turn Around Time



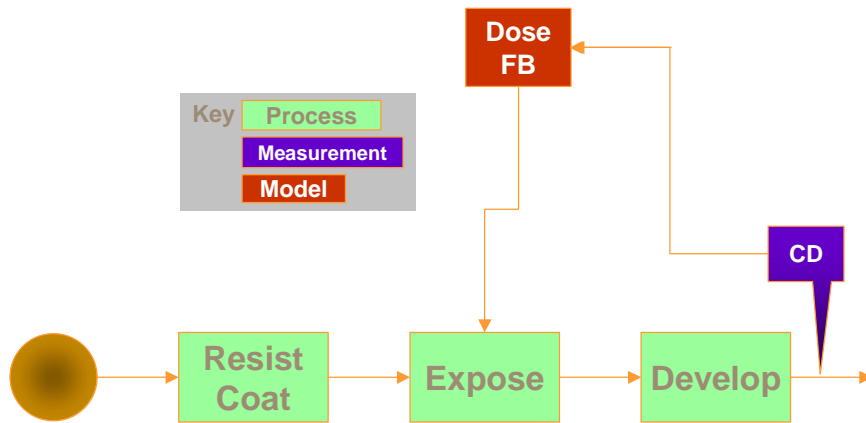
Reducing the total turn-around time allows for tighter control of process variations with higher frequency

Tighter MPU Speed Distribution

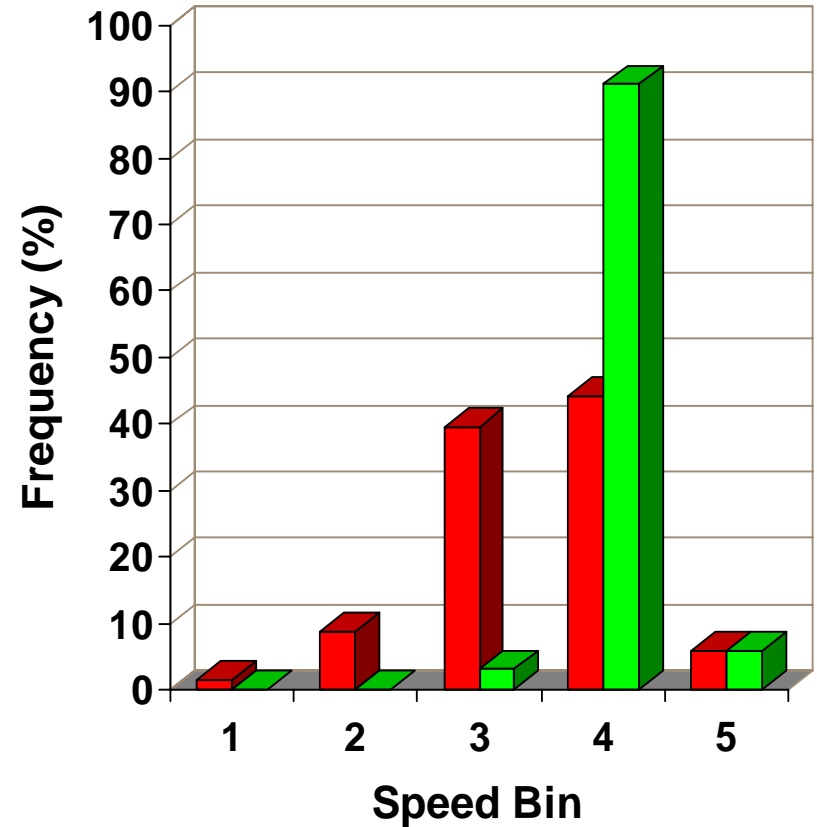
- Stand alone CD-SEM
- Automated analysis and control
- Gate CD control

Results

- Tighter speed distribution allows re-targeting of process
- \$2M / KWSPW Savings

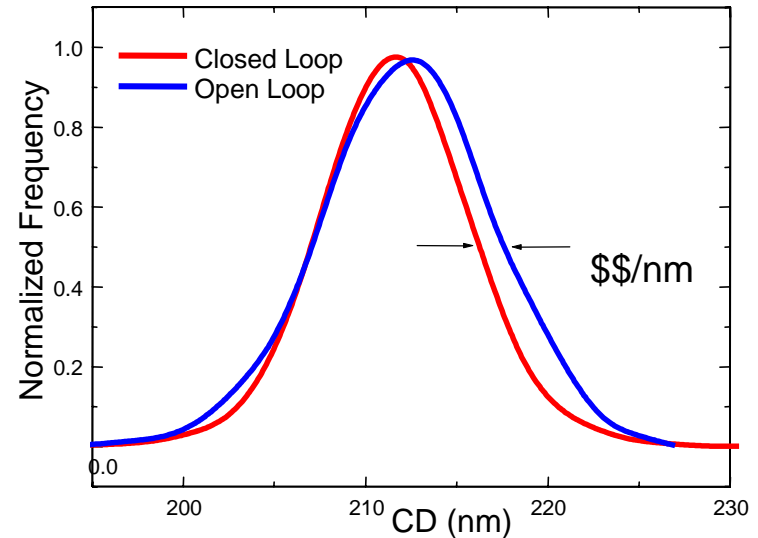
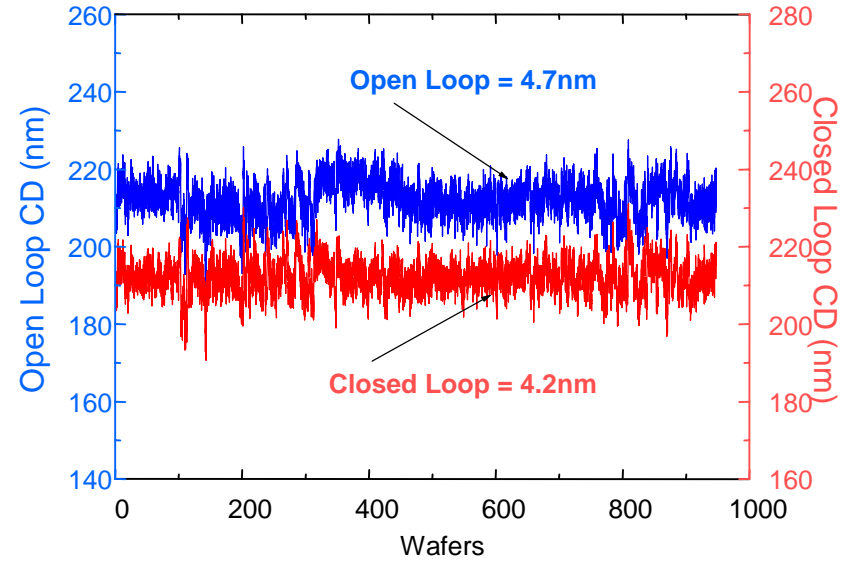
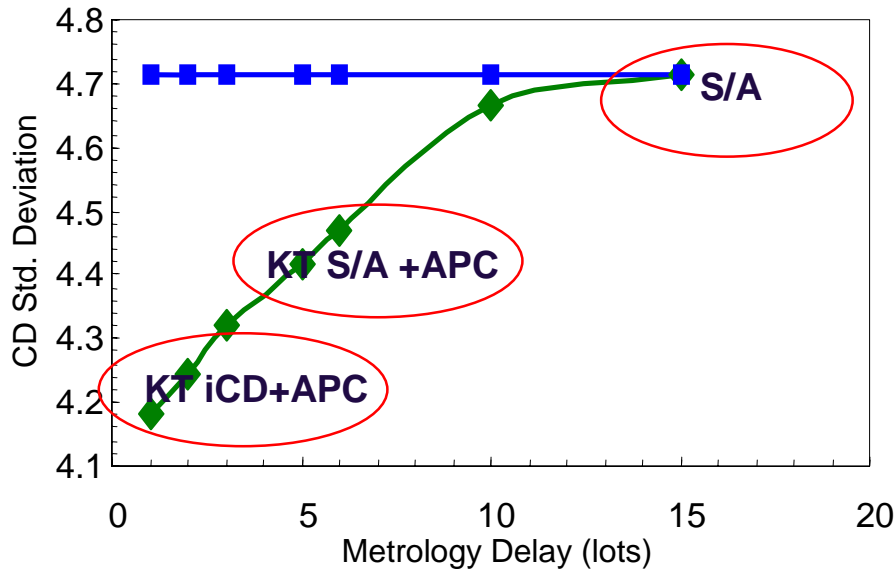


Microprocessor Speed Distribution

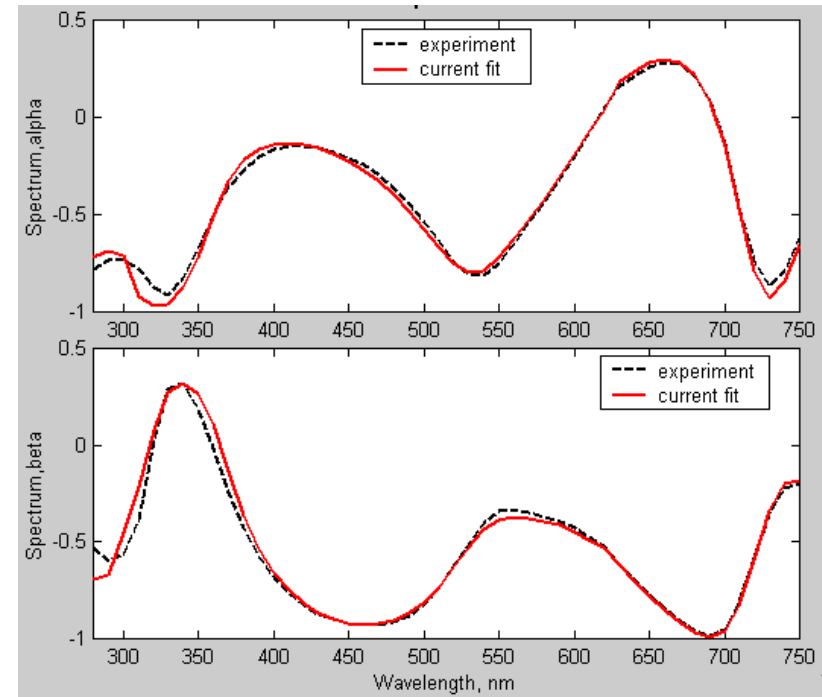
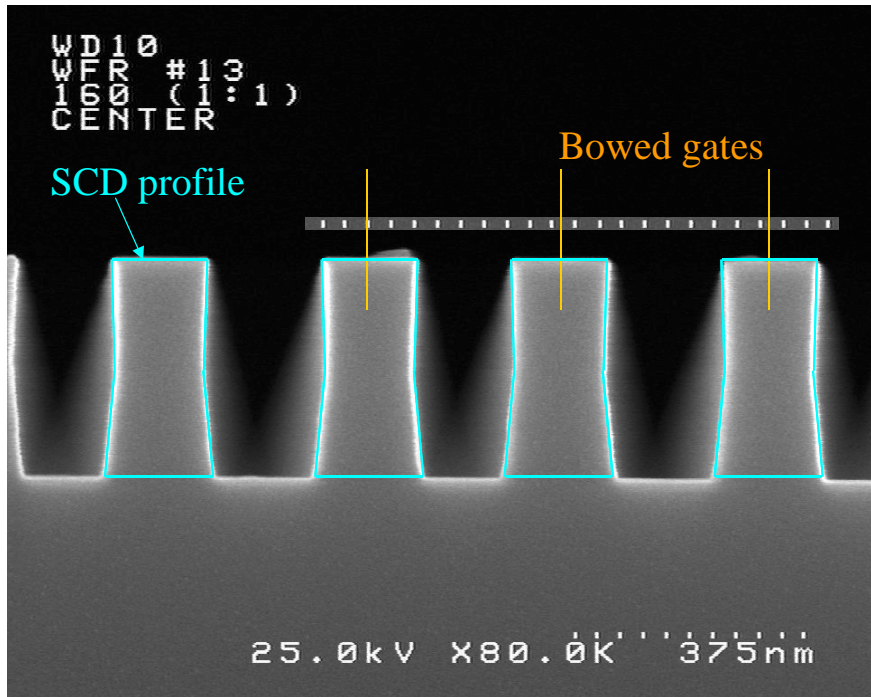


Integration of CD Metrology - Significant value (Simulated Data)

- 11% improvement in DI CD distribution w/ lot to lot iCD simulated control
- Up to 19% w/ closed loop true lot to lot control

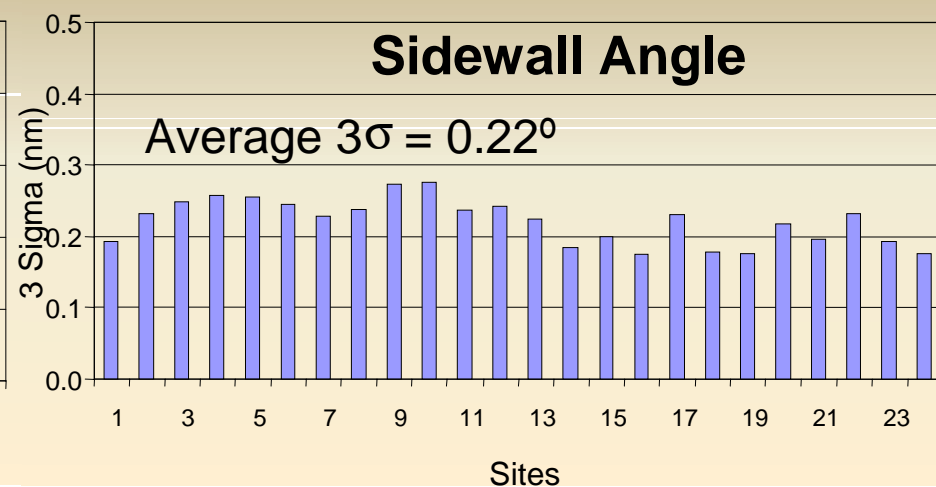
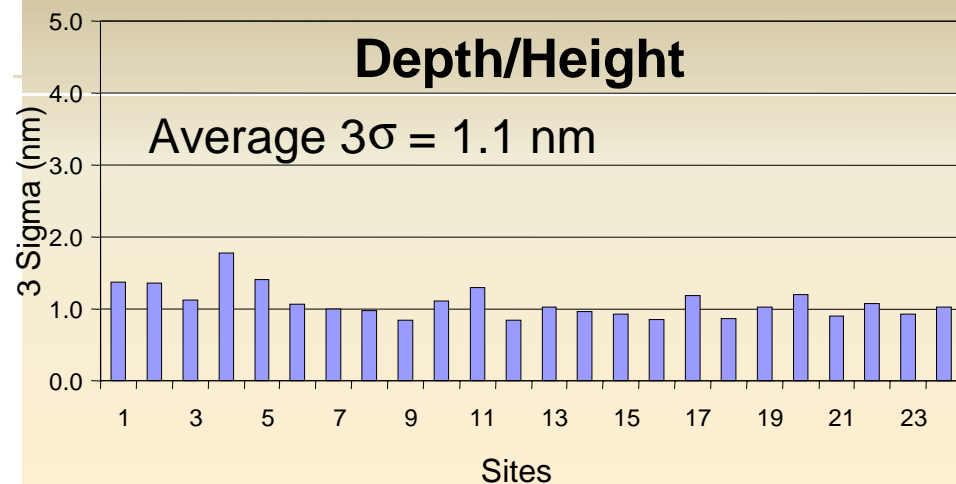
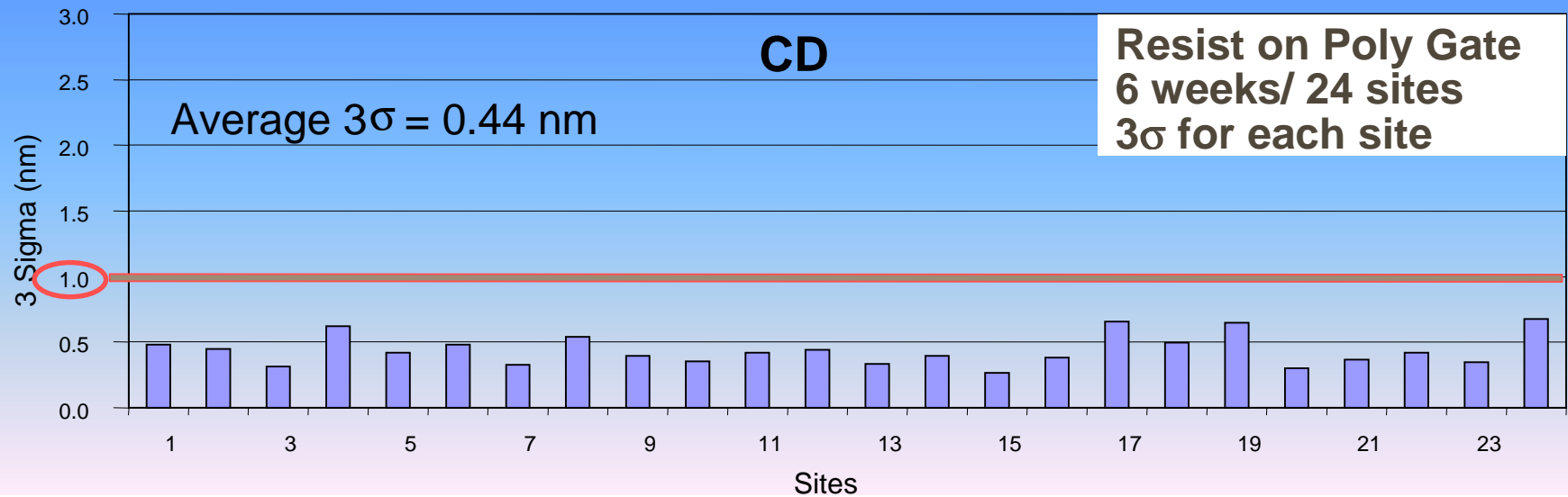


iCD: Gate etch process control



- Sidewall perturbation small – iCD metrology enabled.
- High value add through iCD module + FF/FB control → adoption

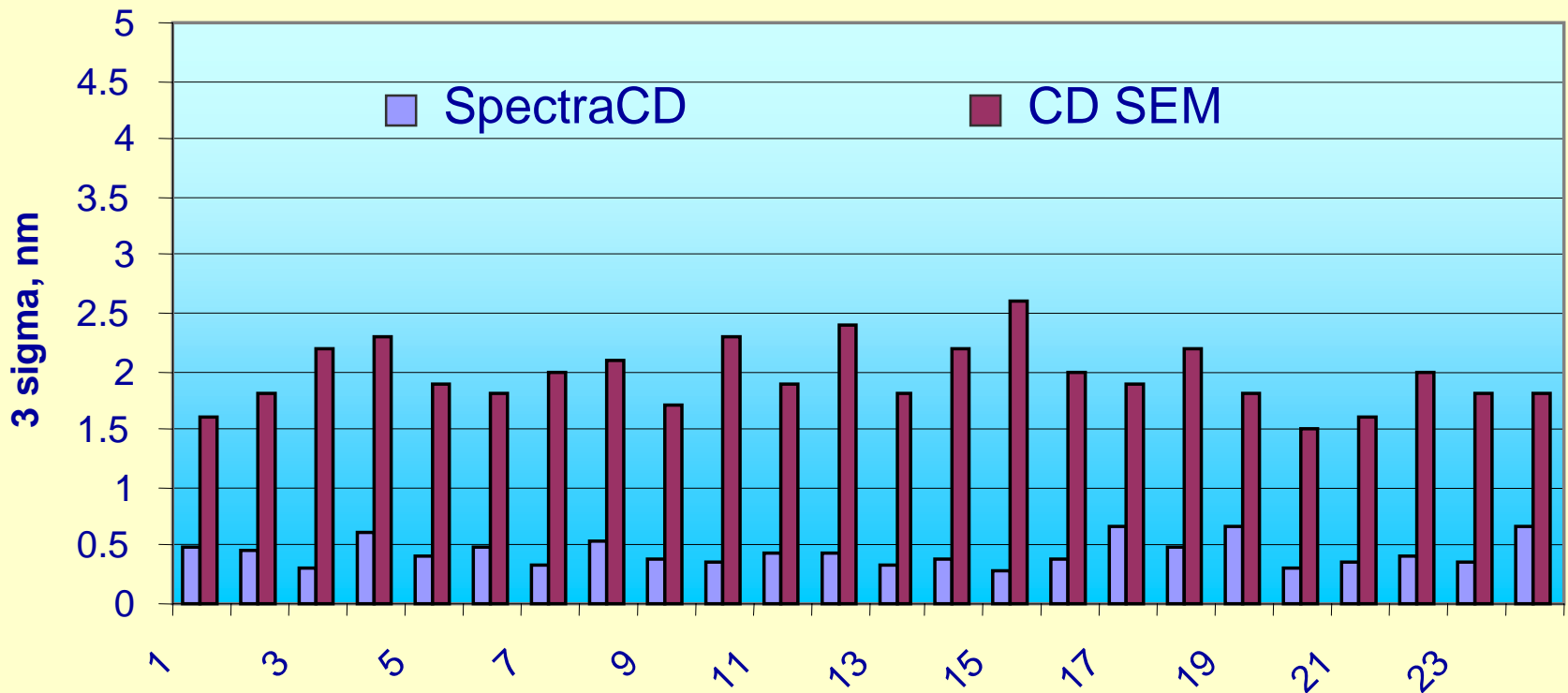
Spectroscopic CD Demonstrated Performance



Spectroscopic CD

Twice the Precision on Critical Layers

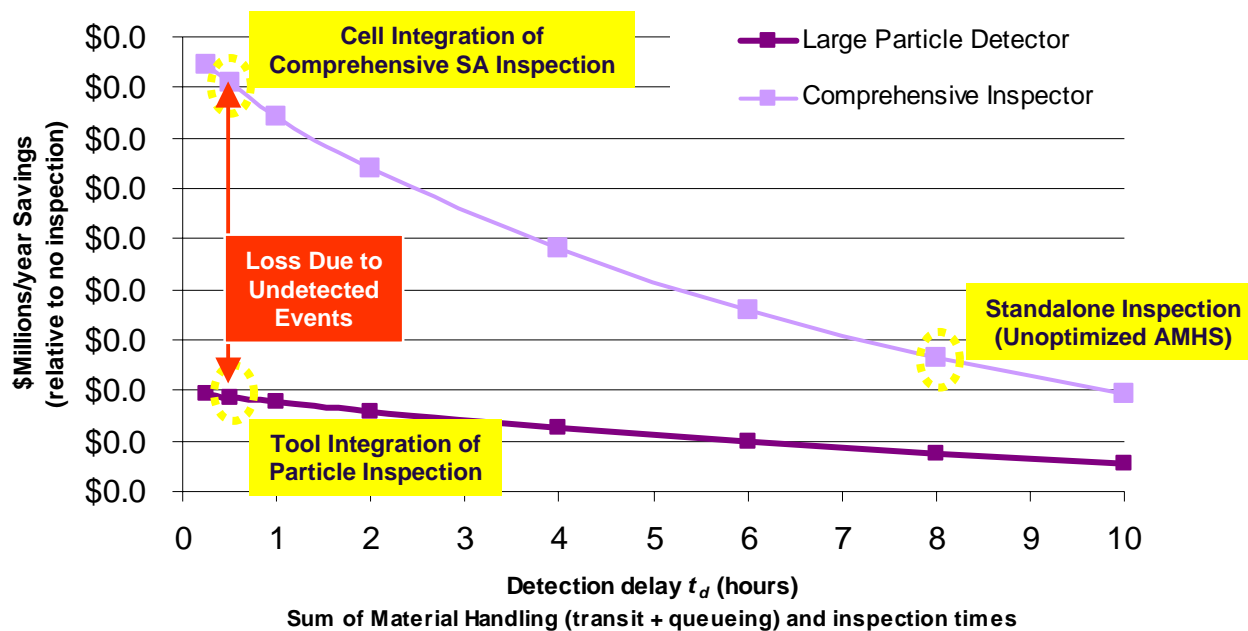
- SCD: 24 sites, average 3s = 0.44 nm
- CD SEM: 5 sites, average 3s = 1.97 nm



Yield Economics of Integrated Inspection

Conclusions:

- $Value_{(\text{standalone comprehensive})} > Value_{(\text{integrated particle detector})}$
- Benefit of shorter time to results is much higher when a comprehensive standalone inspector is used
- Integration adds only small incremental benefit over automation

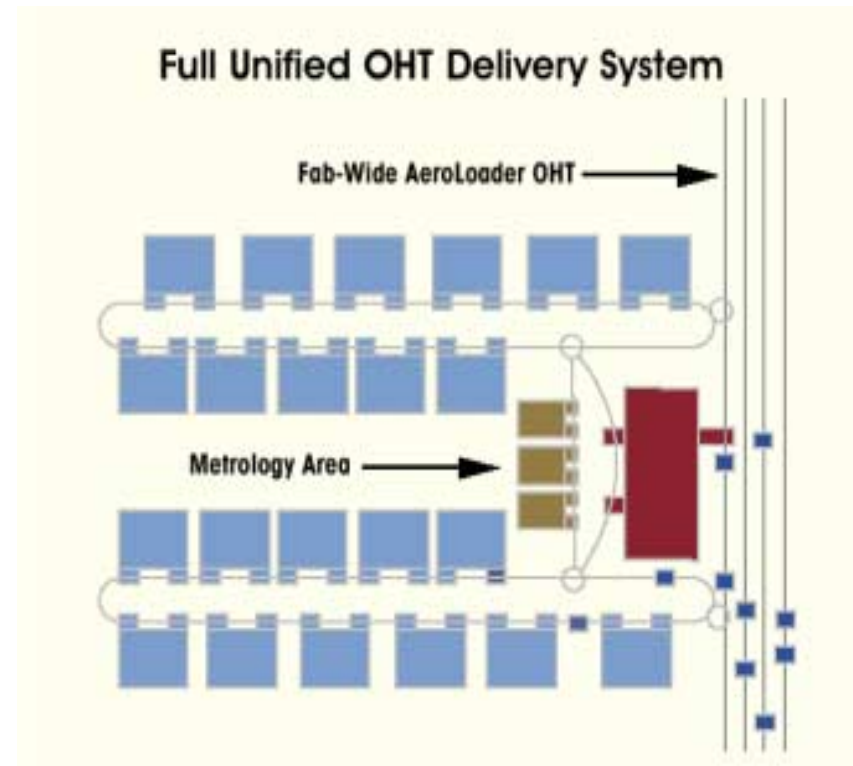


Sample Planner™ example: M3 etch; 5000wspw; logic; yield value only

Source: Spicer, Gudmundsson, Nurani, "Integrated Defect Inspection: Challenges and Considerations" *Solid State Technology* 10/01

Tool Integration vs Cell Integration

- Modeled tradeoffs:
 - Cell vs. tool integration
 - Yield considerations
 - Operational considerations
- Results:
 - Tool integration for inspection is not likely to be the best strategy for fabs
 - yield loss issues / required sensitivity
 - capital cost
 - operations flexibility
 - Effective automation and fab layout (cell integration) is a more effective approach
 - time-to-results comparable with integrated
 - operational flexibility preserved
 - lower capital cost



Cell Integration is Preferred

Integrated Inspection vs Metrology

- Inspection and metrology support different applications
- Different production strategies are required

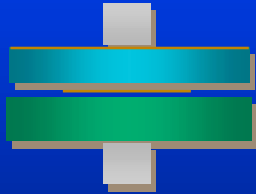
	Supported Fab Applications				Technology	
	Tool Go/Nogo	Wafer Pass/Scrap / Rework	Tool Feedforward / Feedback	Process Development Feedback	Target/Area	Technology Maturity vs Standalone
Metrology (CD, Film Thickness, Overlay)	Yes	Yes	Yes	Yes	Target	Medium
Defect Inspection	Yes	Yes	No	No	Full Wafer	Low
Particle Detection	Limited	Limited	No	No	Full Wafer	Low

Integrated Metrology and Inspection



Diffusion

- *Film Thickness*



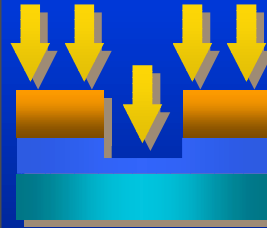
CVD/
Thin Films

- *Film Thickness*



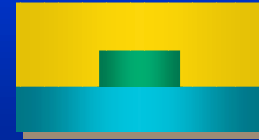
Photo

- *CD*
- *Overlay*
- *Defect*
- *Film Thickness*



Etch

- *CD*
- *Film Thickness*



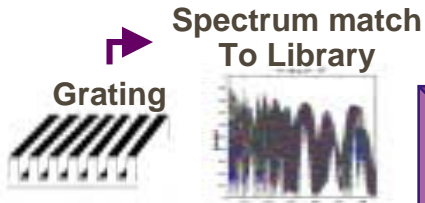
CMP

- *Film Thickness*

- **Covering all critical areas for integrated metrology and inspection**

Example: Integrated CD Technology

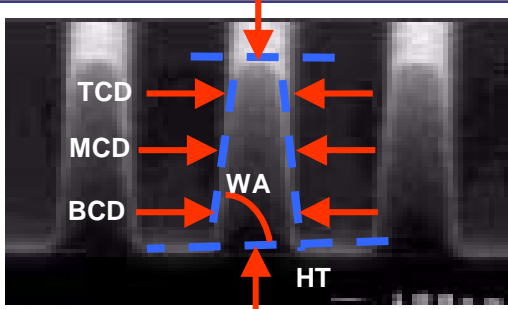
New SpectraCD™ Metrology Tool



CD, Height,
Side-wall angle

Technology driving to smaller features – tighter windows:
Precision exceeds ITRS

Shape of the feature is critical to performance:
Profile information:
CD, sidewall angle, height,
(X-Z dimensions)



SpectraCD
Film Thickness
& CD Metrology

More complex processes demand higher sampling:
high throughput

Not prone to charge issues:
No side effects with 193nm resists or low K dielectrics

New materials
Thickness, n and k monitoring simultaneous with CD

From Standalone to Integrated

- Lithography and Etch are the most critical and expensive processes
 - Tight CD control key to success
 - KT offers industry most complete CD control solution
- New integrated product: iCD/iTF – Profile and thin film measurements based on KT spectroscopic ellipsometry and CD technology

Spectra CD

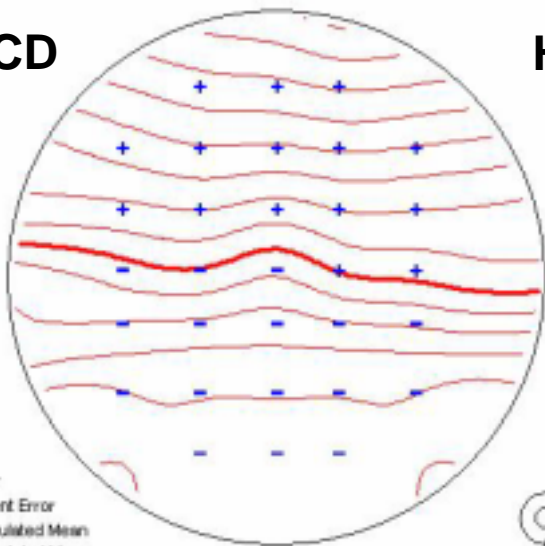


iCD/iTF

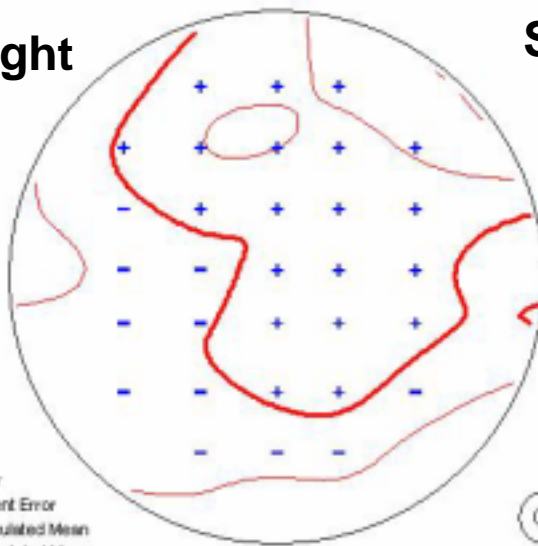


Fast Analysis

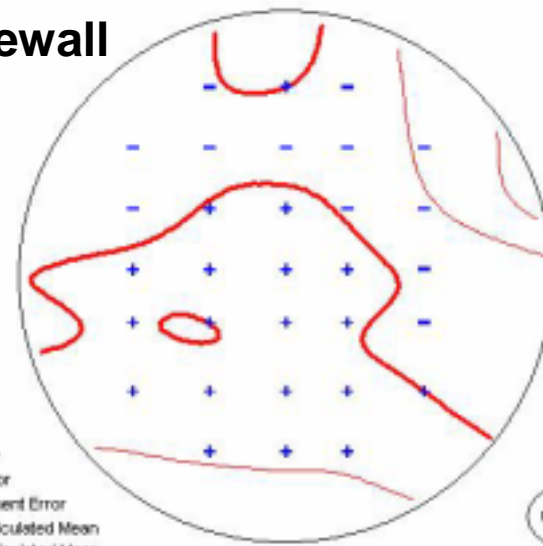
CD



Height



Sidewall

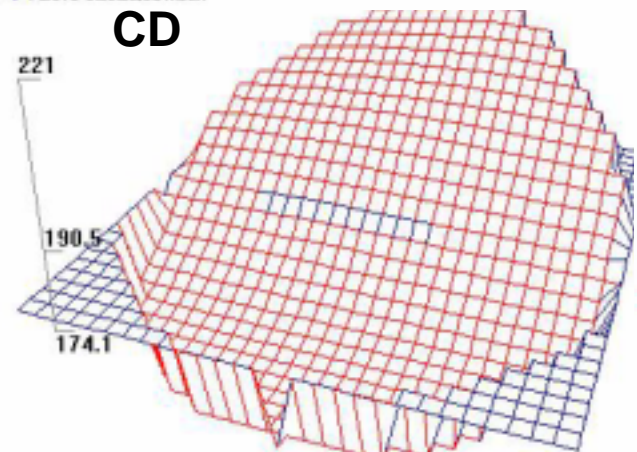


- GOF Error
- ▲ Sigma Error
- Measurement Error
- Below Calculated Mean
- + Above Calculated Mean

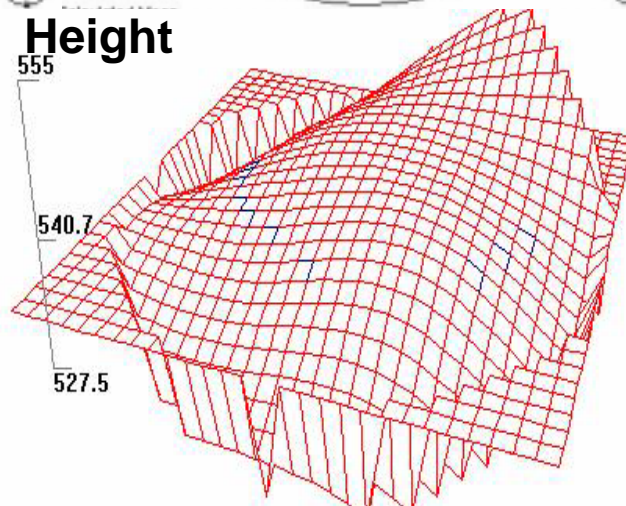
○ Error
○ Inherent Error
○ Calculated Mean

○ Error
○ Measurement Error
○ Calculated Mean
○ Calculated Mean

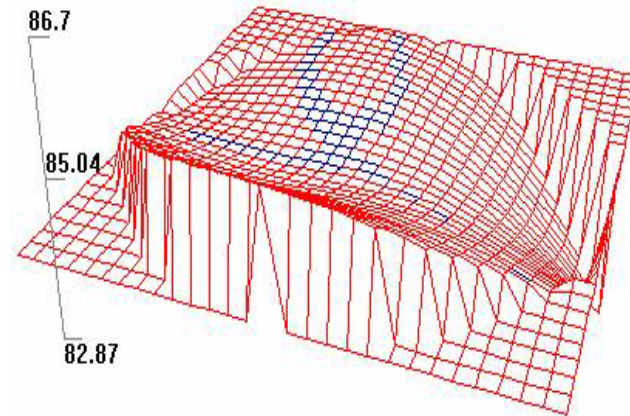
CD



Height



Sidewall



Where IMA can help?

- Automation
 - Drive fab layout and automation guidelines to reduce process to metrology delay time.
- Open Standards
 - Drive process tool / integrated metrology hardware interface standards
 - Drive process tool / integrated metrology software interface standards
- Demonstrate Spectroscopic CD technology
 - Determine best practice for Spectroscopic CD Control
 - Expand SIA Roadmap to include additional control parameters
 - Support extension to new applications

SEMI Standards Integrated Measurement Task Force

- 2 SEMI standards currently in progress to define requirements for IM (1 lilac, 1 yellow)
 - Process tool and WSMI (Wafer State Metrology Instrumentation)
 - Define physical, communication and WSMI specific equipment model requirements
- 2 Task forces created
 - I&C : Information and Control committee
 - Communication
 - Specific Equipment Model
 - PIC : Physical Interfaces & Carrier committee
 - Targeted at Integration onto 300mm EFEM (atmospheric)
 - Re-use SEMI E63 (BOLTS-M plane – 300 mm Box Opener/Loader to Tool Standard)