

Full Wafer-Scale Solution to Thin-Film Metrology for CMP

Scanning Thickness Mapper (STMapper)

**Sangbong Lee
Filmetrics, Inc.
June 5, 2003**

CMPUG Meeting, CEA, Sunnyvale, CA

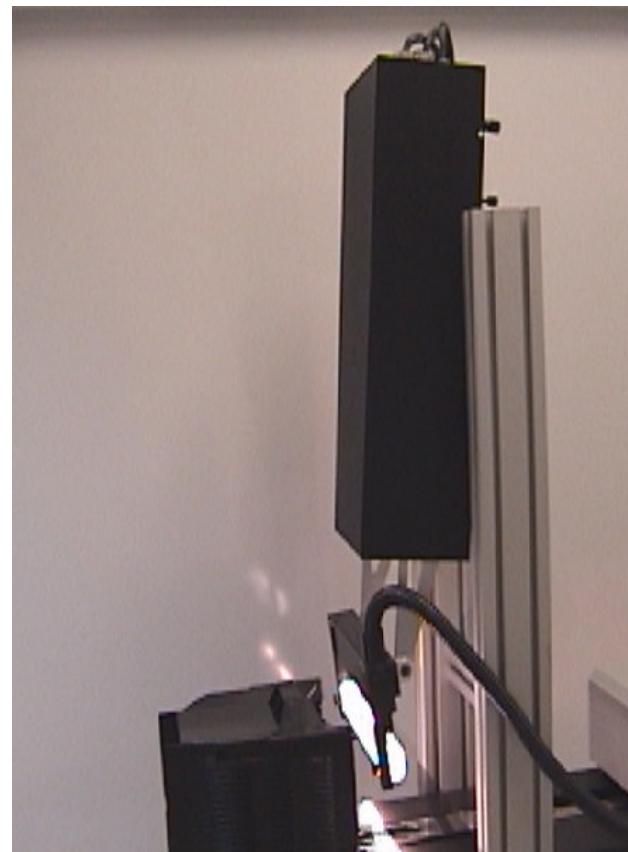
FILMETRICS INC.

**TAKING
THE MYSTERY
OUT OF
THIN-FILM MEASUREMENT**

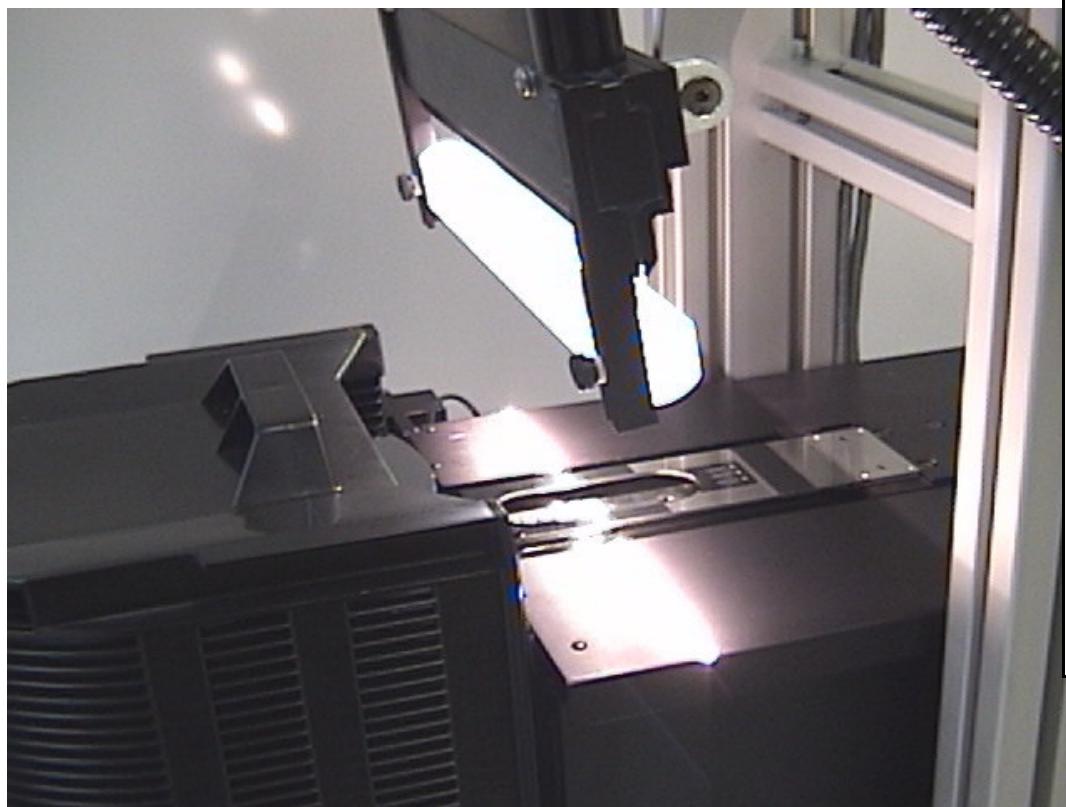
Overview

- **STMapper Introduction**
- **Metal Residue Examples – Wafer-Scale Residue**
 - SKW6-3 & 926AZ
- **Metal Residue Examples – Wafer-Scale TaN thickness**
 - SKW6-3 & 926AZ
- **Copper Erosion Examples (926AZ)**
- **STI Examples (SKW3)**
- **CMP Capability – In-Situ Extension (sample movies)**
- **Brief Specifications – Performance & Throughput**
- **Summary**

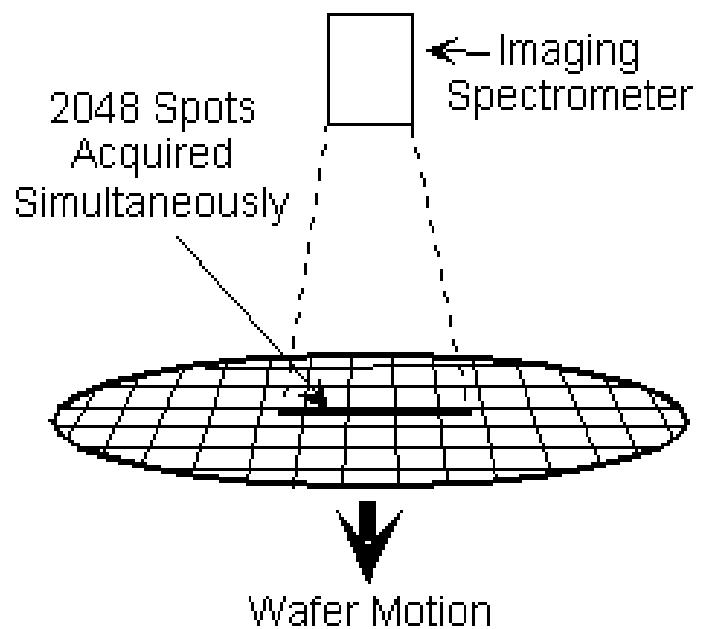
The Look of STMapper (very small footprint)



The Technology



Scanning Spectral Reflectance

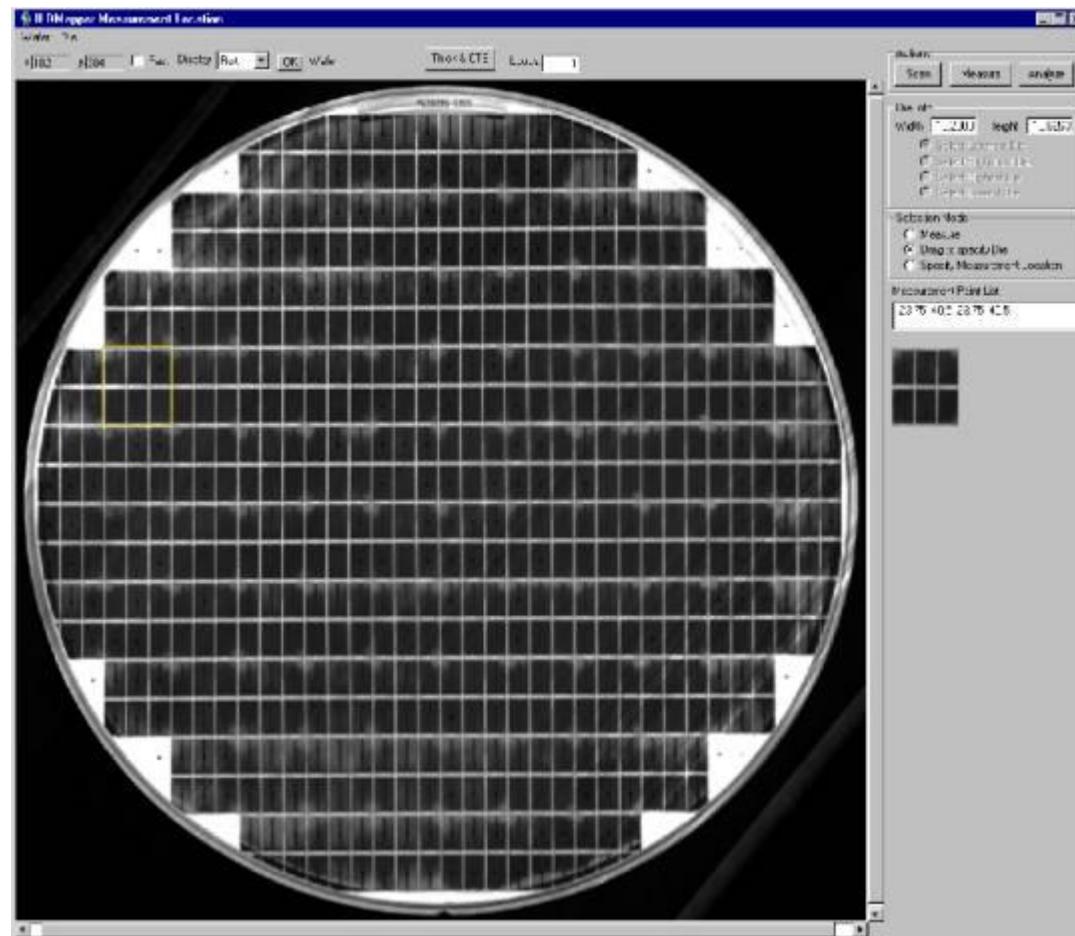


Short Movie STMapper-In-Action

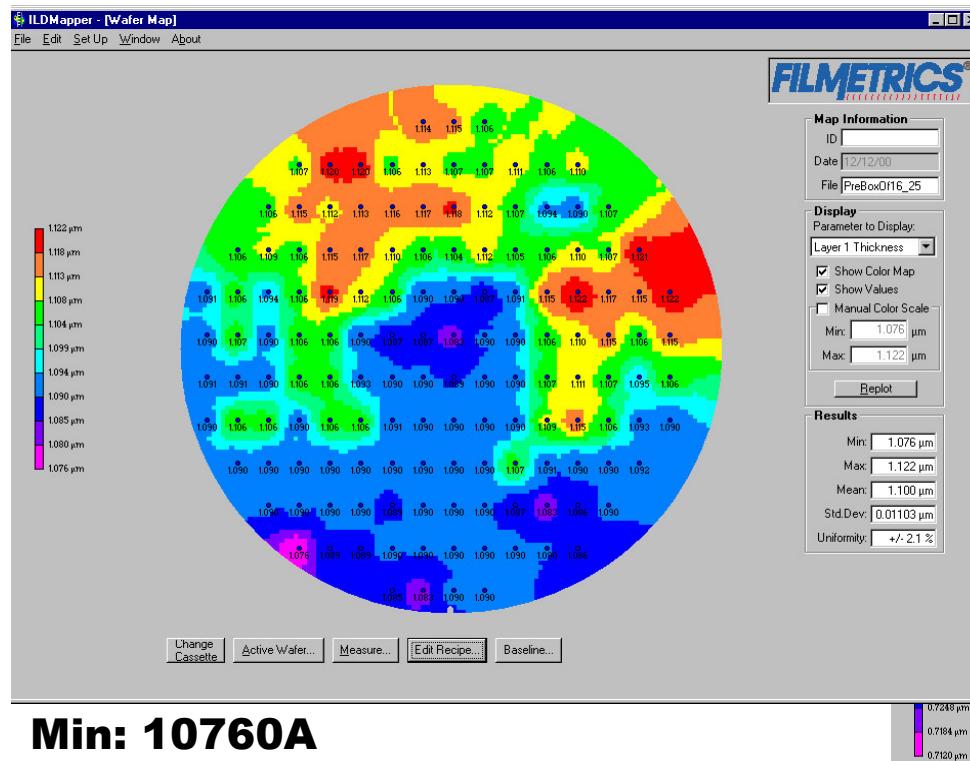
Filmetrics
STMapper In Action

(Real-time movie)

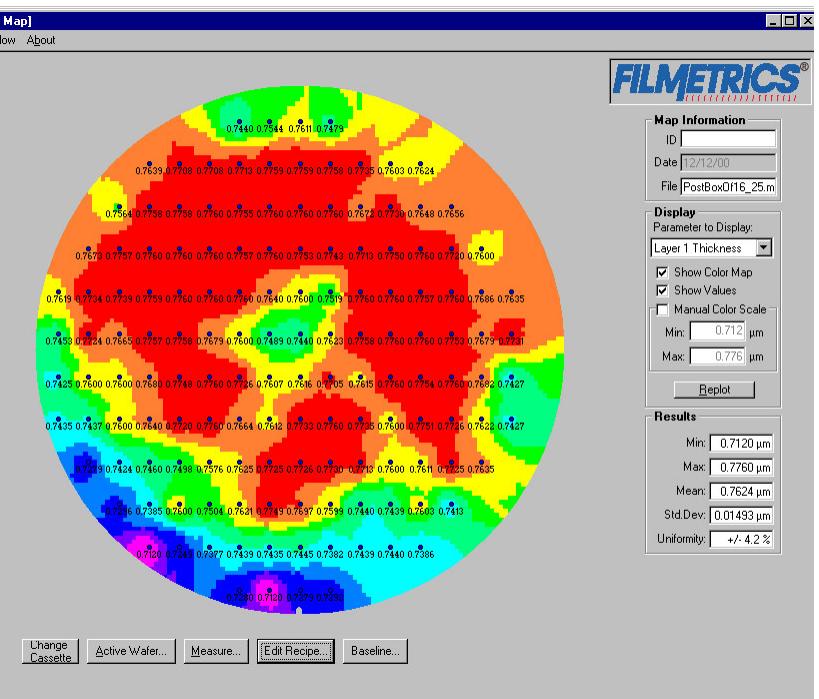
Example of Image after Scan



Examples of Thickness Maps: Pre- & Post-Polish of Oxide in SRAM



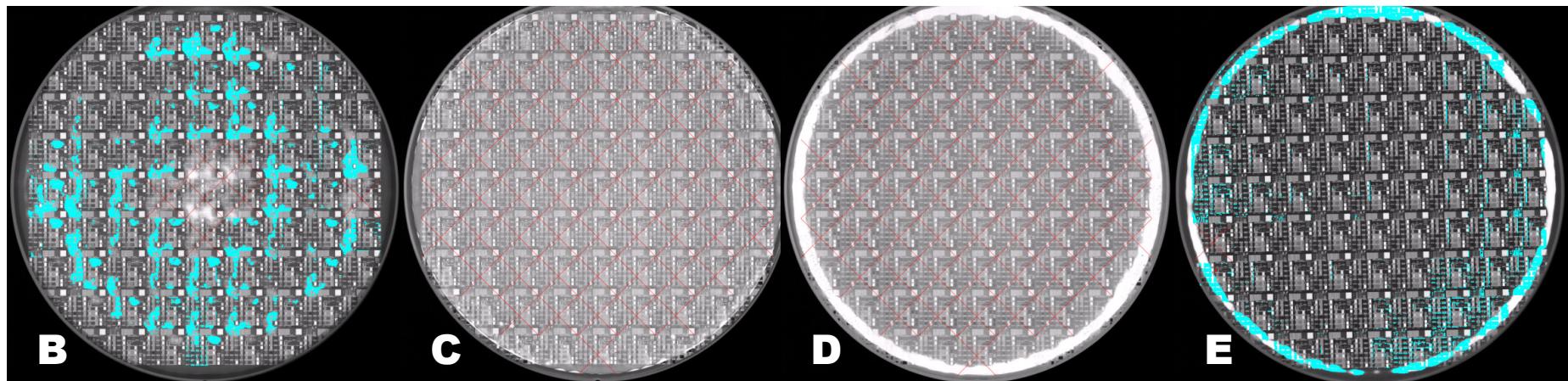
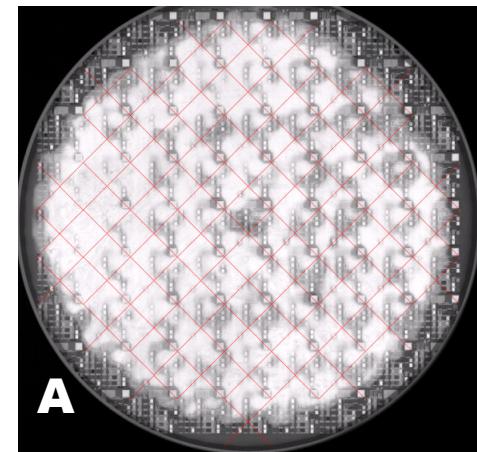
**Min: 7120A
Max: 7760A**



SKW6-3 Wafer Metal Residue

Detection of metal presence after CMP

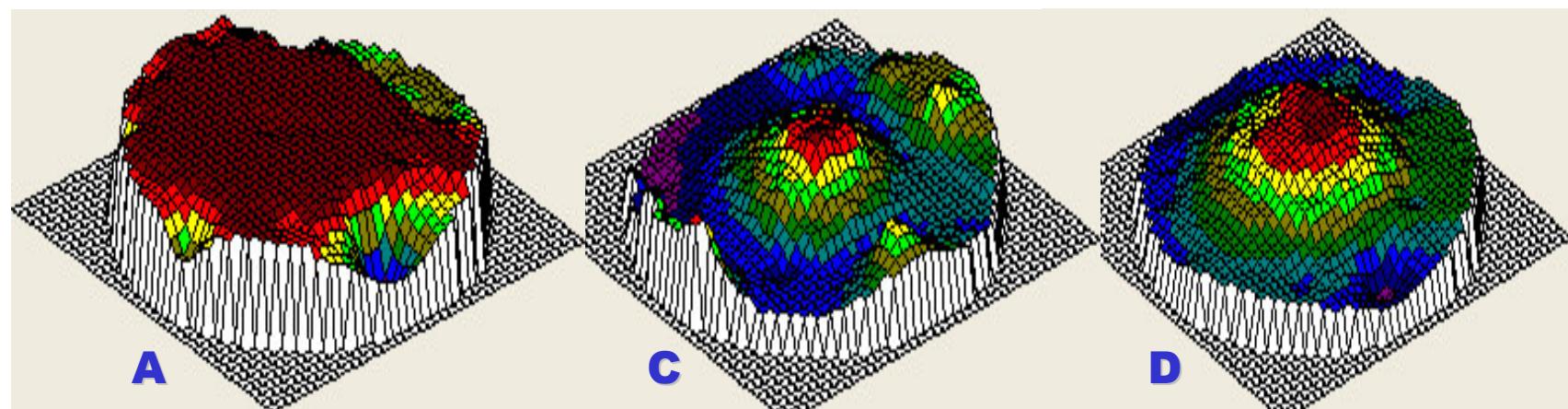
Sample	Wafer ID	Condition	Slurry
A	SKW0140 D09 E7	Cu remain	Non-selective
B	SKW0140 D06 F1	Barrier remain	Non-selective
C	SKW0135 D24 A3	Barrier remain	Selective
D	SKW0135 D19 A5	Cu & Barrier remain	Selective
E	SKW0135 D20 F5	Cu remain	Selective



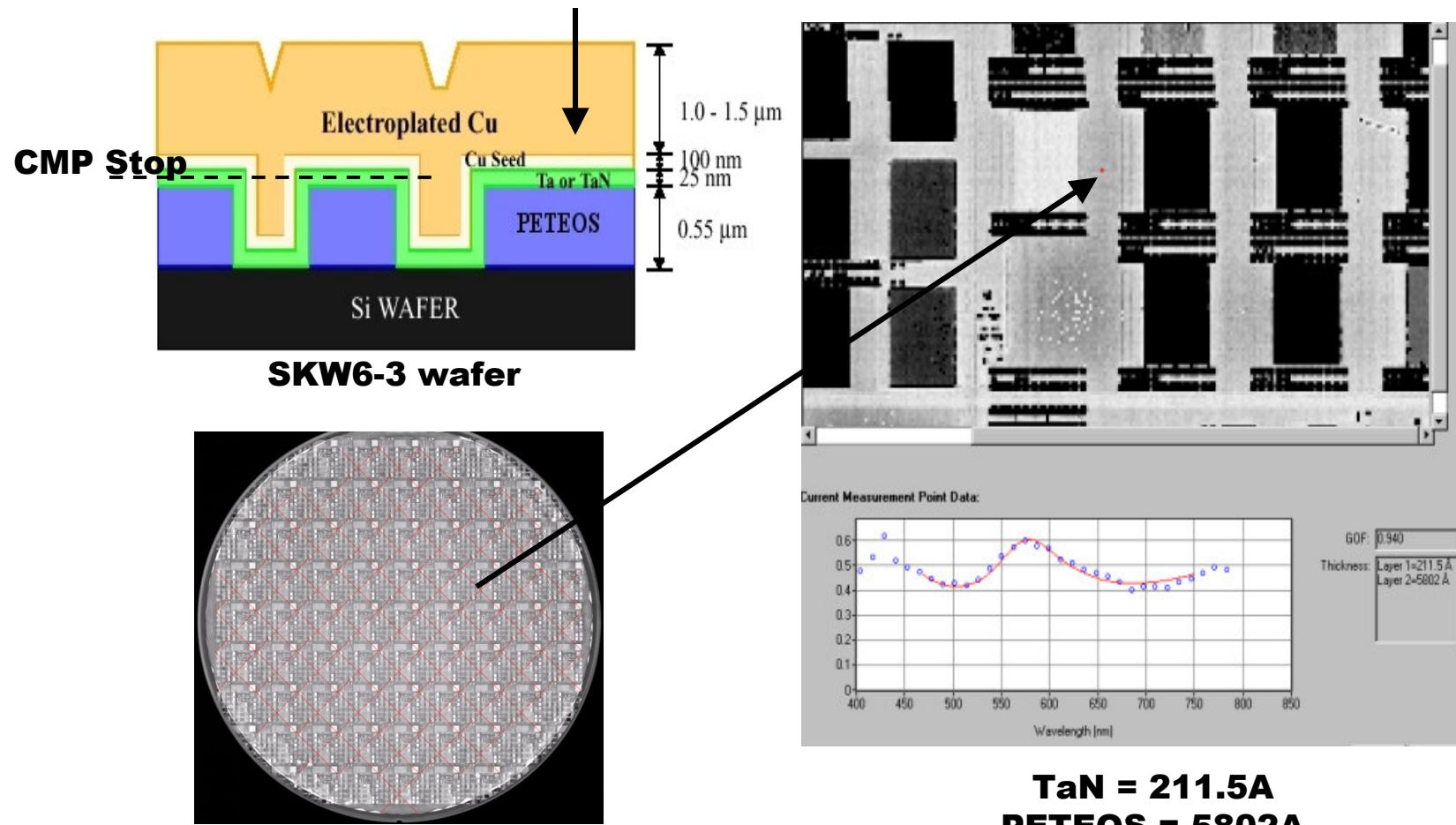
SKW6-3 Metal Residue Results

Sample	Min*	Max*	Mean*	Uniformity
A	59.0%	99.7%	95.6%	21.3%
B	3.6%	85.0%	52.3%	77.7%
C	50.1%	76.9%	63.2%	21.2%
D	47.1%	80.5%	60.3%	27.9%
E	0.0%	46.3%	4.8%	NA

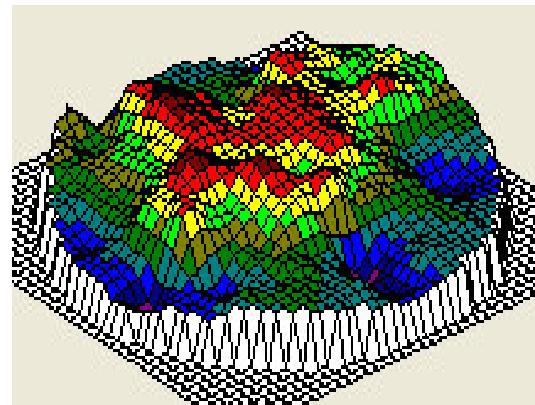
* Number represents that the specific die has residual coverage with the given percentage



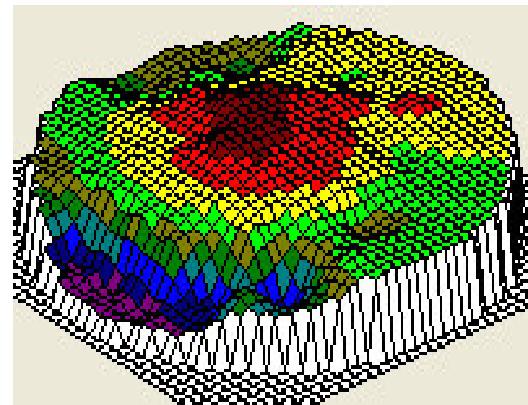
Characterization of TaN by Thickness (SKW6-3 Sample C)



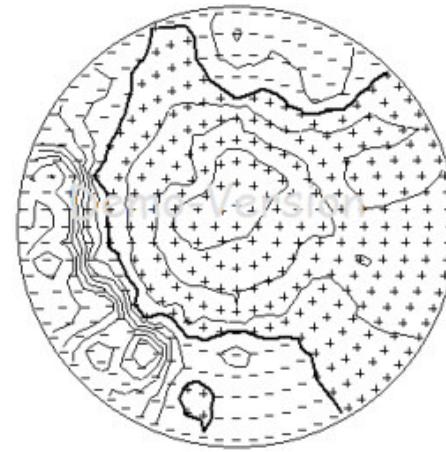
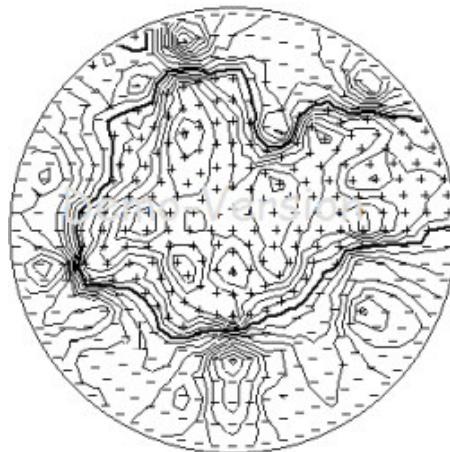
TaN Thickness Maps (SKW6-3 Sample C & D)



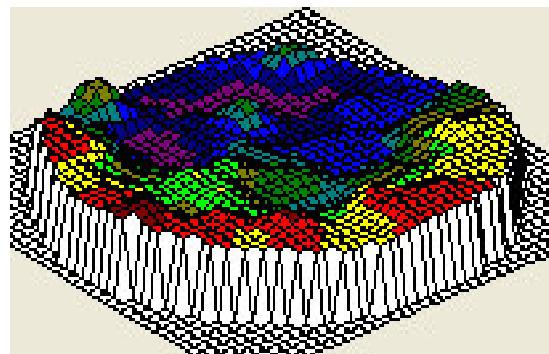
Sample C
Min = 38.5Å
Max = 281.5Å



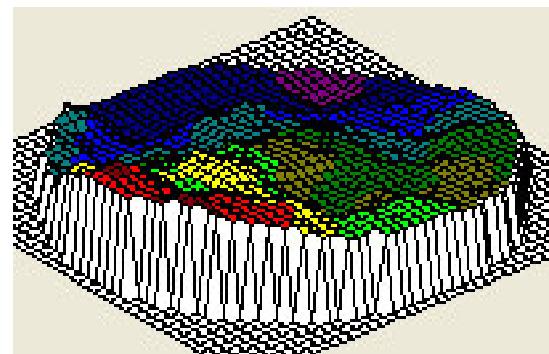
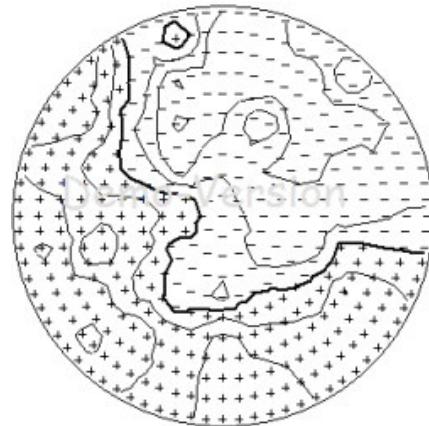
Sample D
Min = 169.4Å
Max = 240.3Å



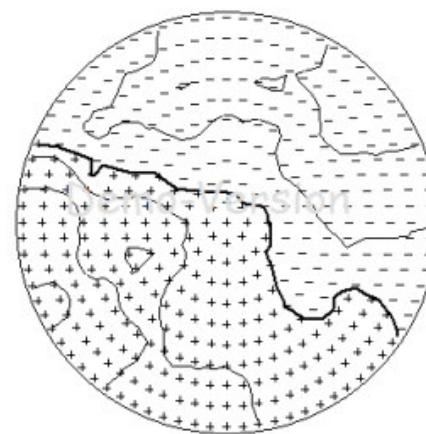
PETEOS Thickness Maps (SKW6-3 Sample C & D)



Sample C
Min = 5689A
Max = 5881A

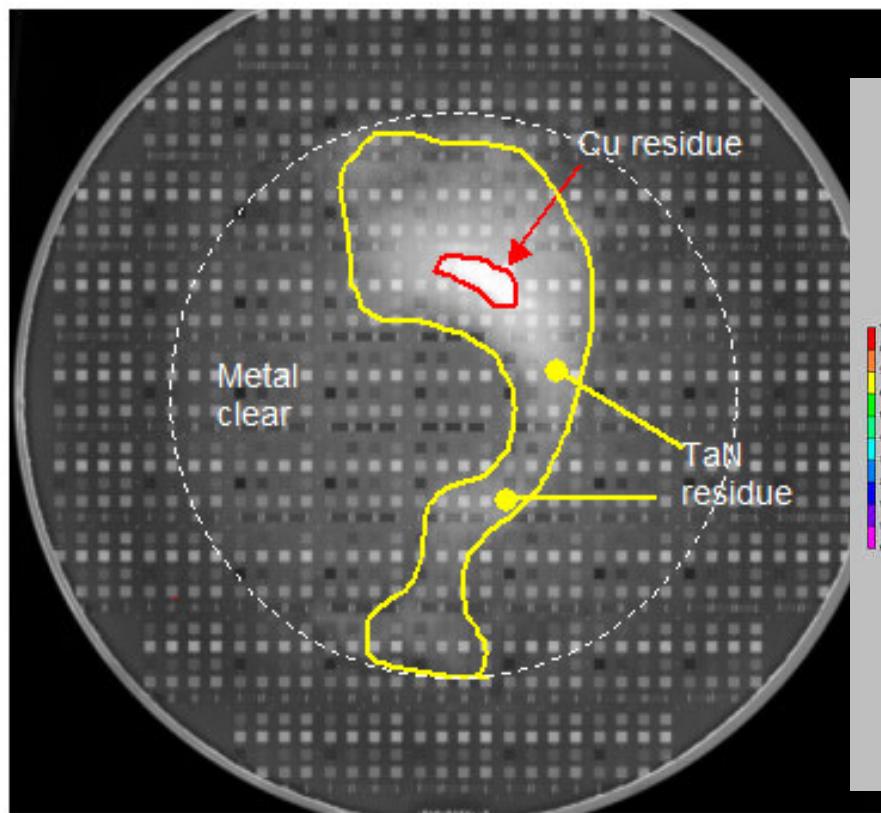


Sample D
Min = 5666A
Max = 5848A

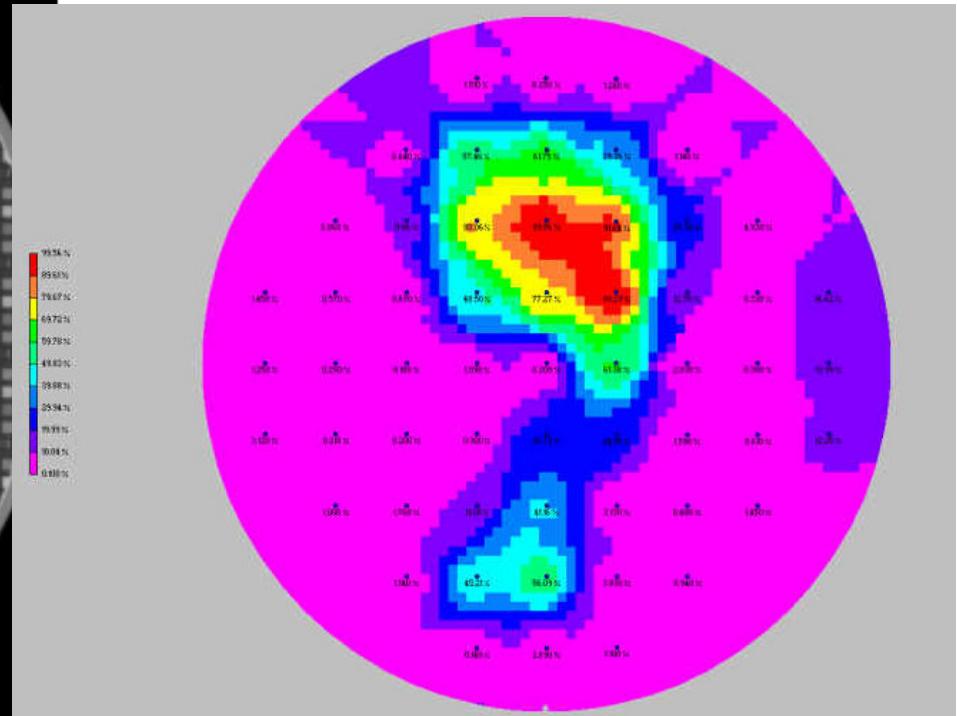


926AZ Wafer Metal Residue (Post-CMP)

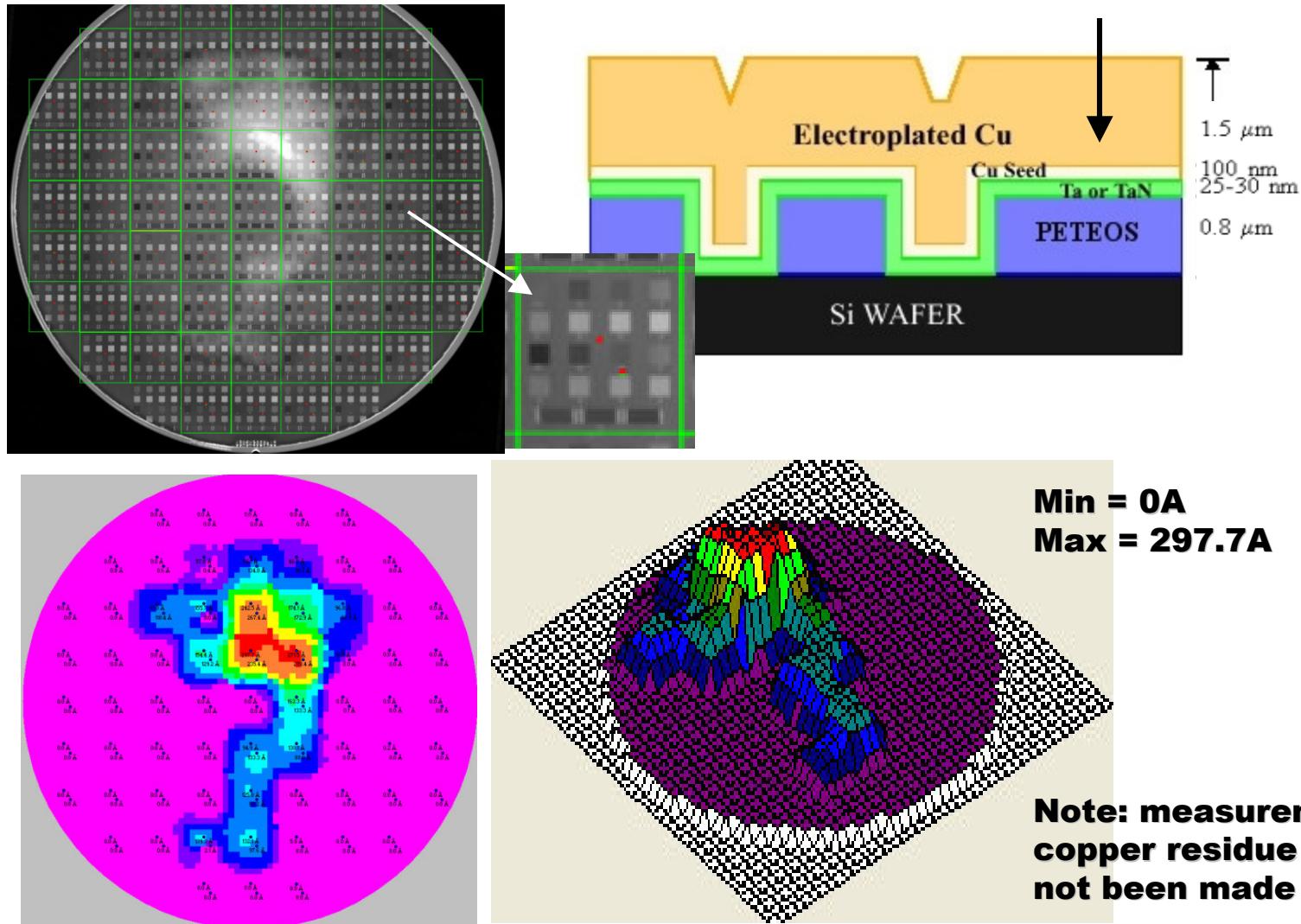
Wafer image after scan



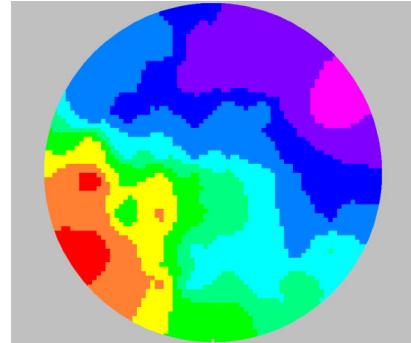
Metal residue map



Characterization of TaN by Thickness (926AZ)

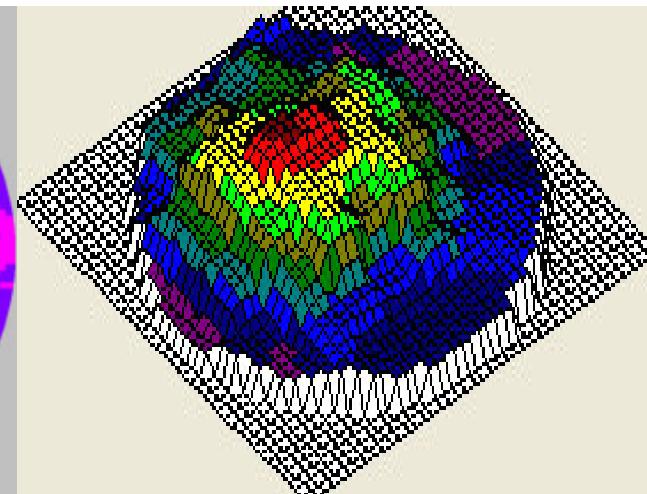
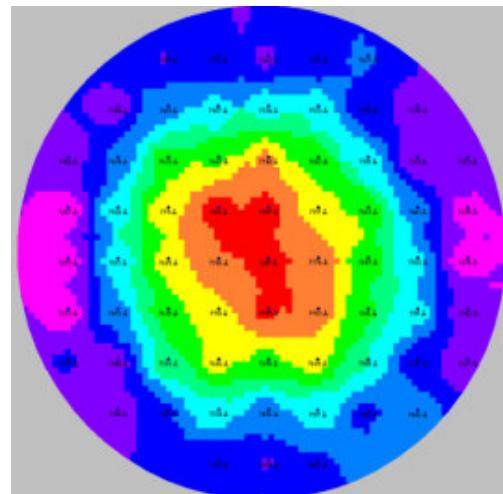


PETEOS Thickness (926AZ)



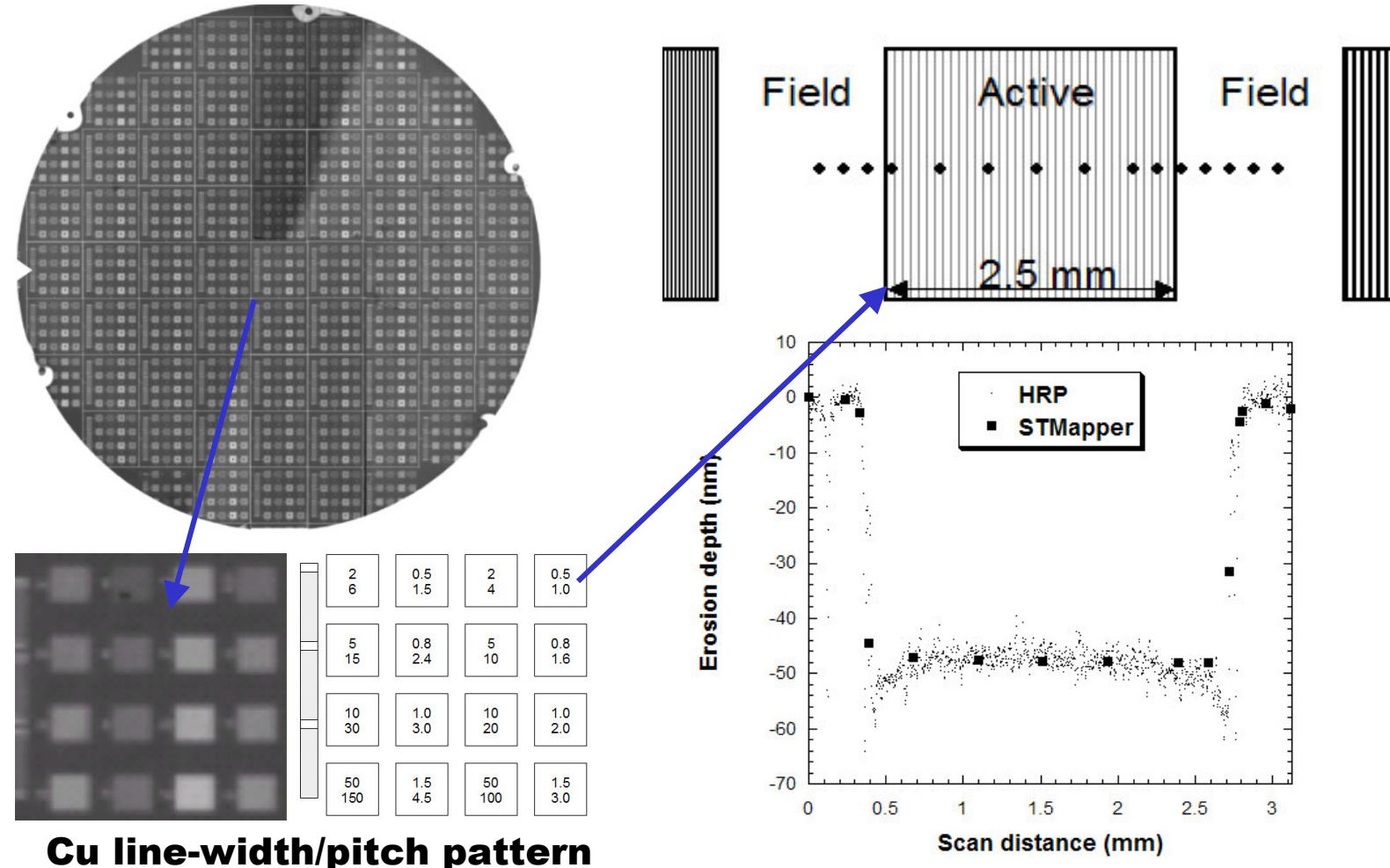
Before CMP
Min = 7615A
Max = 7958A

(Results not from the
same sample, but from the
similar sample)



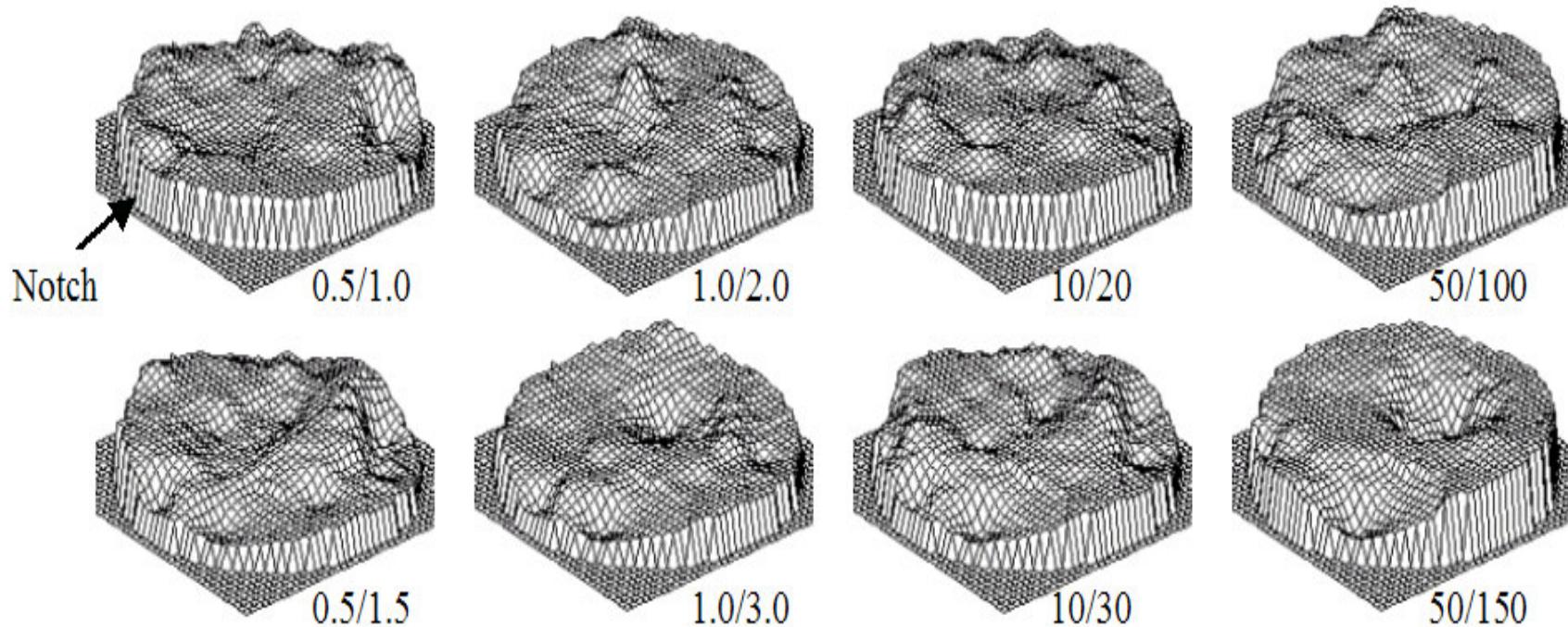
After CMP
Min = 7269A
Max = 7822A

Characterization of Copper Erosion (926AZ)



Cu line-width/pitch pattern

Cu Erosion Wafer-Scale Profiles

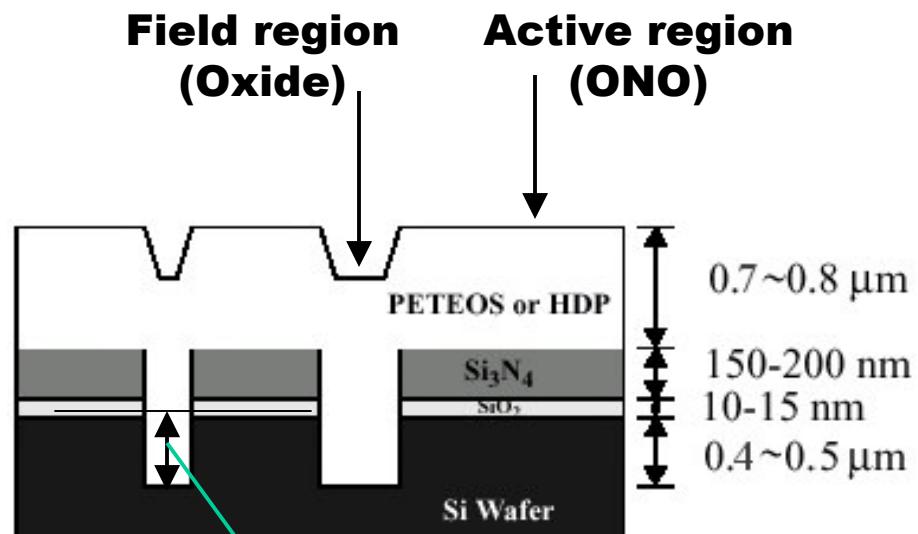
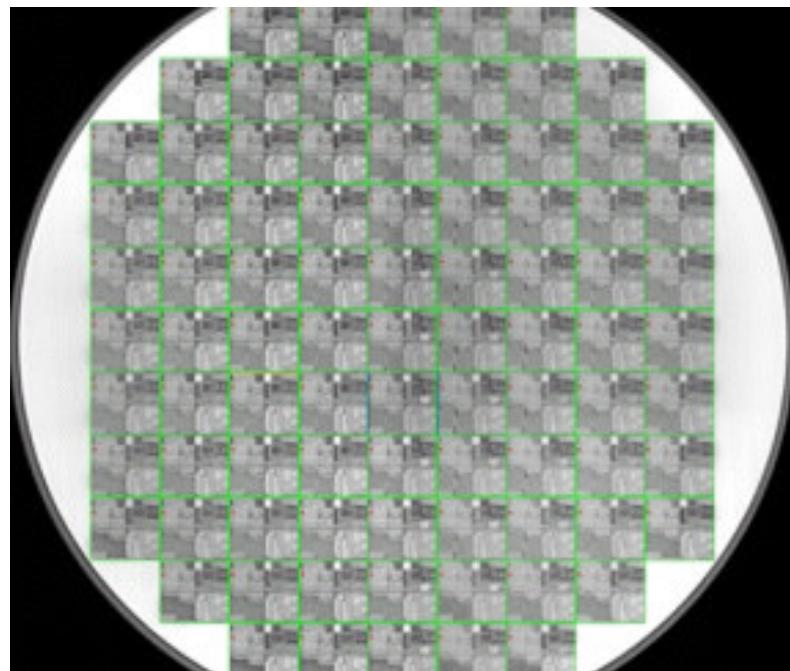


Erosion results

Block	Minimum	Maximum	Average	Uniformity
0.5/1.0	36.2	55.6	44.0	± 21%
1.0/2.0	33.7	58.8	43.4	± 27%
10/20	17.1	48.8	32.5	± 48%
50/100	17.2	39.1	27.4	± 39%
0.5/1.5	28.7	52.0	37.3	± 29%
1.0/3.0	34.2	58.3	42.5	± 26%
10/30	20.0	45.9	30.0	± 39%
50/150	16.0	37.0	21.7	± 40%

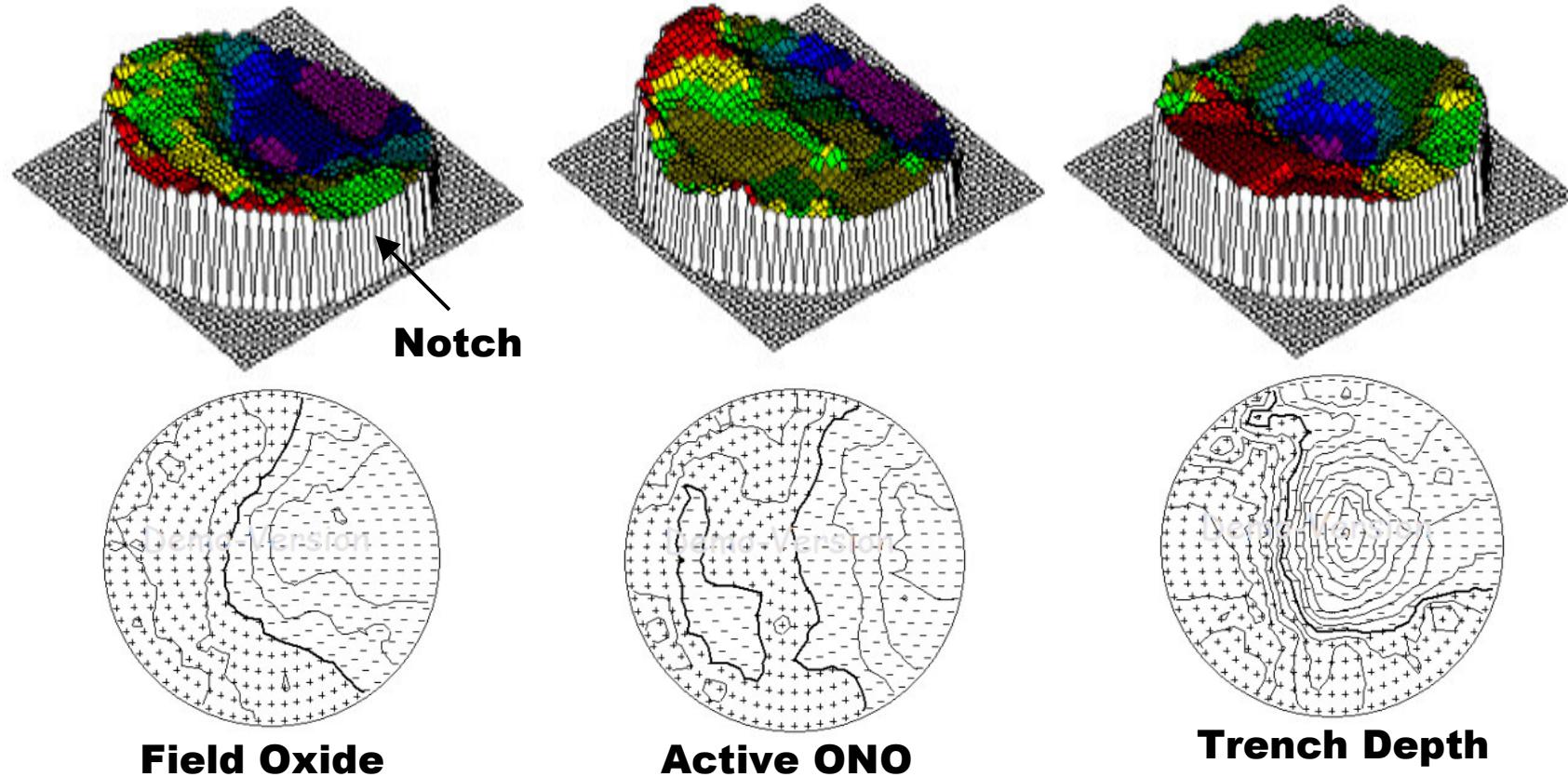
Nanometers

Characterization of STI CMP (SKW3 Wafer)



Trench Depth =
Field Oxide - Active Layer Thickness
After CMP

STI Depth and Field Oxide

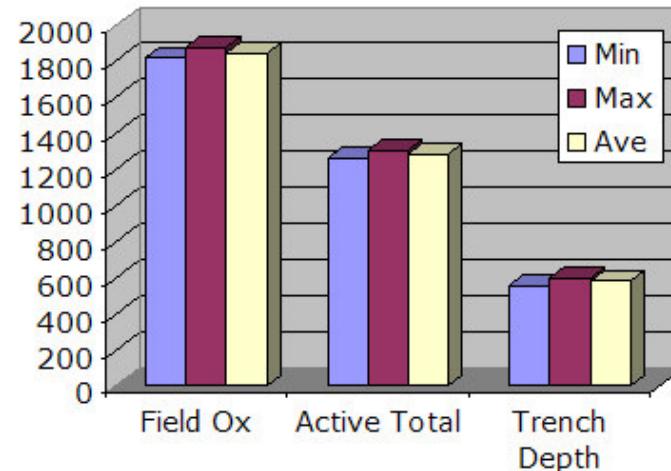


**Maintain trench depth profile before/during/after CMP by monitoring
Field oxide and Active layer stack**

CMP STI Results

Layer	Wafer Minimum	Wafer Maximum	Wafer Average	Wafer Uniformity
Field Ox	1819.1	1878.1	1847.9	± 1.6%
Active Ox	1075.1	1123.4	1100.6	± 2.2%
Active Nit	158.56	179.10	167.12	± 6.1%
Active Total	1265.0	1307.0	1287.7	± 1.6%
Trench Depth*	554.88	598.42	580.27	± 3.8%

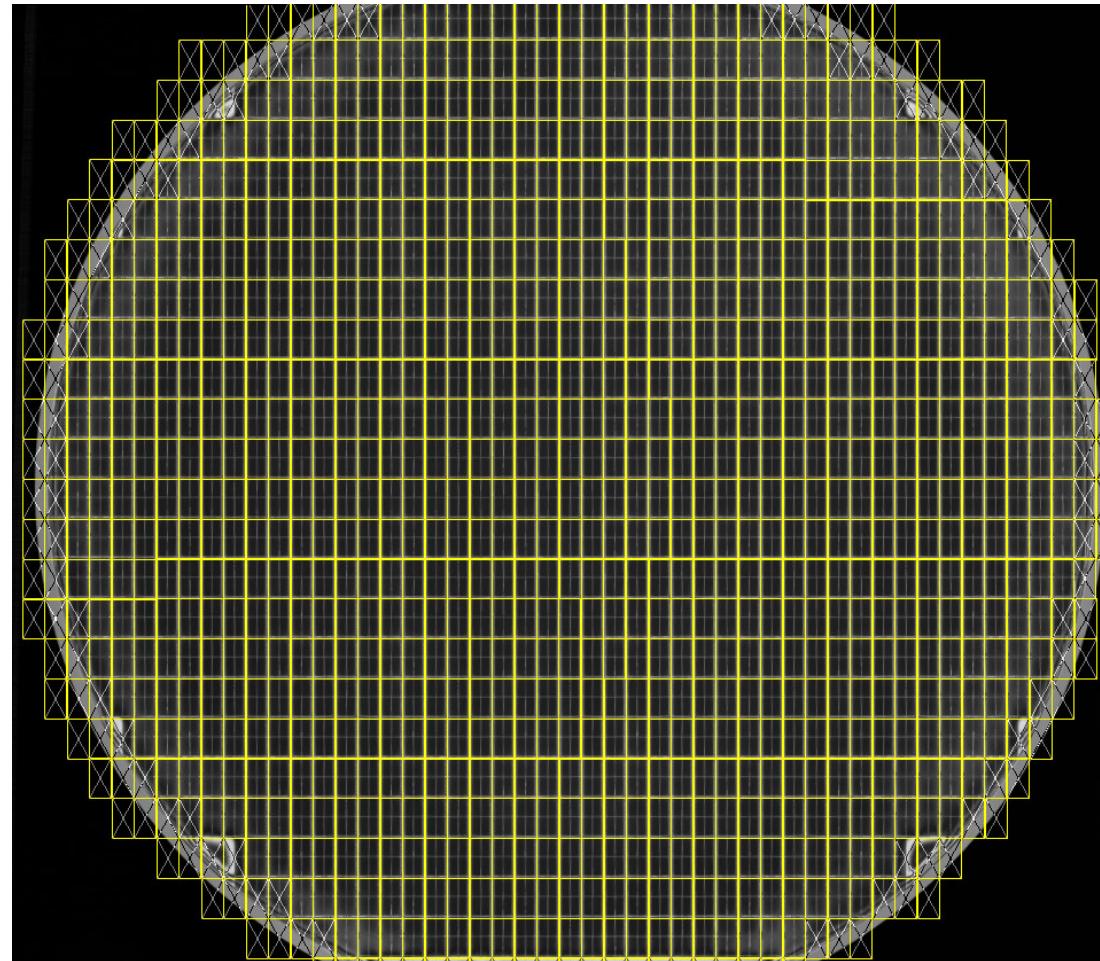
Wafer min & max values from Field region do not necessarily coincide with those of Active region at the same measurement locations. All units in Nanometers.



Typical All-Die Setup in Production

Undisclosed Customer Sample (~900 Dice)

450 Dice w/2site per die optional



Performance and Throughput

- **Typical Measurement Performance:**

- Repeatability: 15 Load/Unload repeatedly.
- Accuracy - Result against NIST-traceable non-patterned oxide wafer.

1-sigma Repeatability: 0.25%

1-sigma Accuracy: 0.5%

- **Throughput*:**

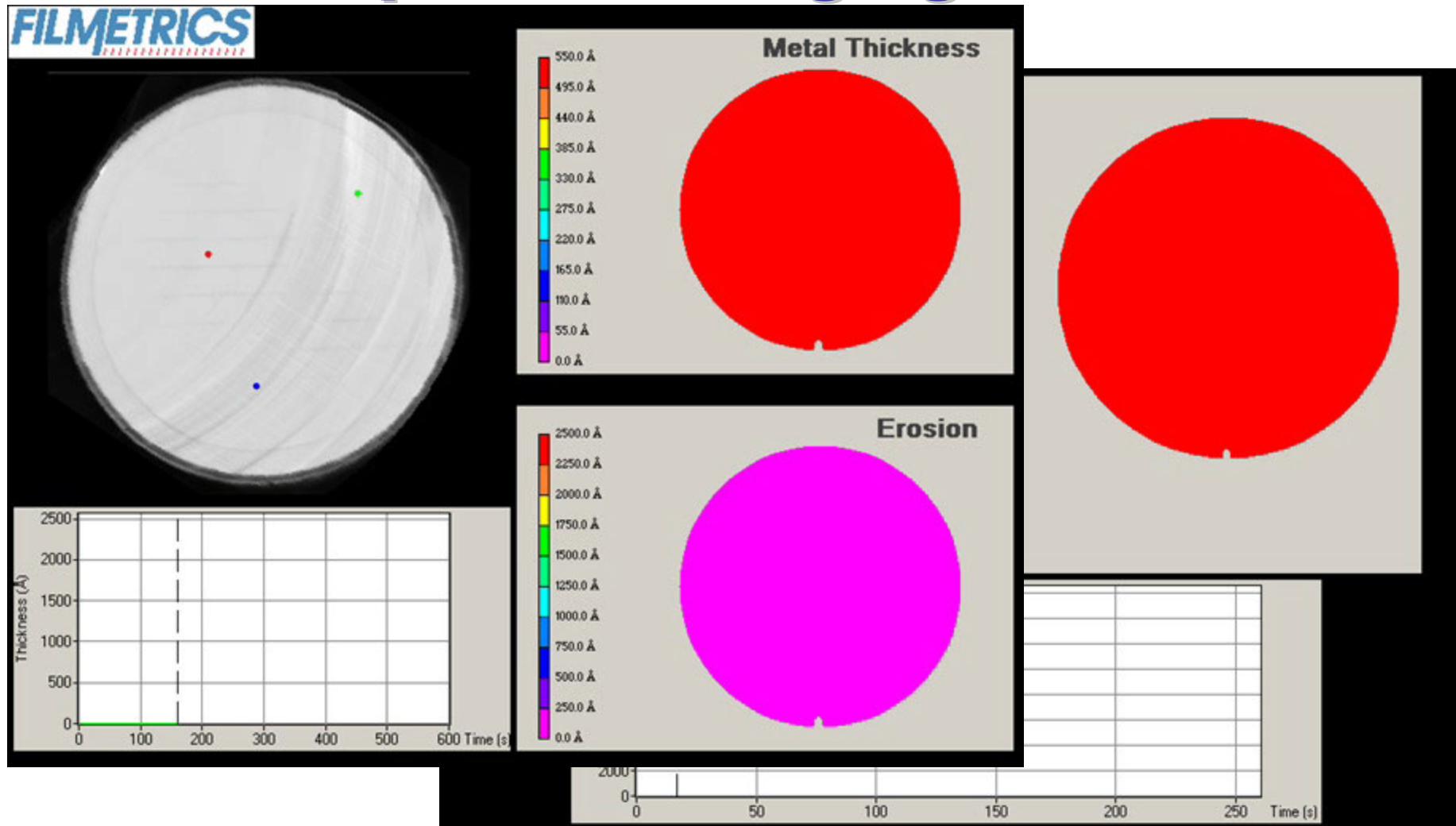
- 240 WPH for standard 70 points or less / wafer measurements on both patterned and non-patterned oxide wafers.
- 180 WPH for 200 points / wafer on patterned wafers.
- 95 WPH for 900 points / wafer on patterned wafers.

* Based on 1.7GHz Pentium III Processor including contour display of the measurement result - typical production run does not need the result display from each measurement.

STMapper Capability in CMP

- Cu Damascene, TaN barrier, STI & ILD/IMD
- CMP Thickness; Metal Erosion; Residue; Macro Defects (e.g. CMP scratches)
- Any number of dice in a wafer; Any number of sites in a die - no impact to scan-throughput
- Multiple recipes with one scan
- Rapid 'Go/No-Go' metrology option
- Typical test box (pad) measurement or customized within-die measurement
- Stand-Alone, In-Line or In-Situ CMP Module for full production environment

In-Situ Extension (Cu & Oxide) Spectral Imaging EPD



STMapper Summary for CMP

Measurement Environment Stand-alone (UFE Integrated tool optional), In-Line, or In-Situ

Wafer 150, 200 or 300 mm patterned or non-patterned, notch or flat

Measurement Technique Scanning Spectral Reflectance - STMapper

Measurement Speed 15 Sec/wafer for 70 point wafer map
(wafer scanning time is less than 5 sec) including robot and wafer handling overhead and calculation;
Faster speed with 'Go/No-Go' option

Pattern Recognition Filmetrics proprietary imaging analysis
> 99.9% wafer success rate on typical CMP wafers

Effective Spot Size 100µm x 100µm; resolution 50µm x 50µm (Stand-alone)

Communication GEM/SECS, Ethernet compatible, or other serial

User Interface

- Integrated/In-Situ configuration available
- STMapper parallel processing on CMP tool
- Clean room facade (optional)