

Advances in ion Implant and USJ Metrology

USJ Metrology

West Coast Junction Technology Group

May 11th, 2005



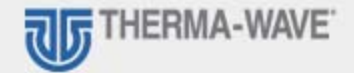
Precision Metrology for Semiconductor Manufacturing

Outline

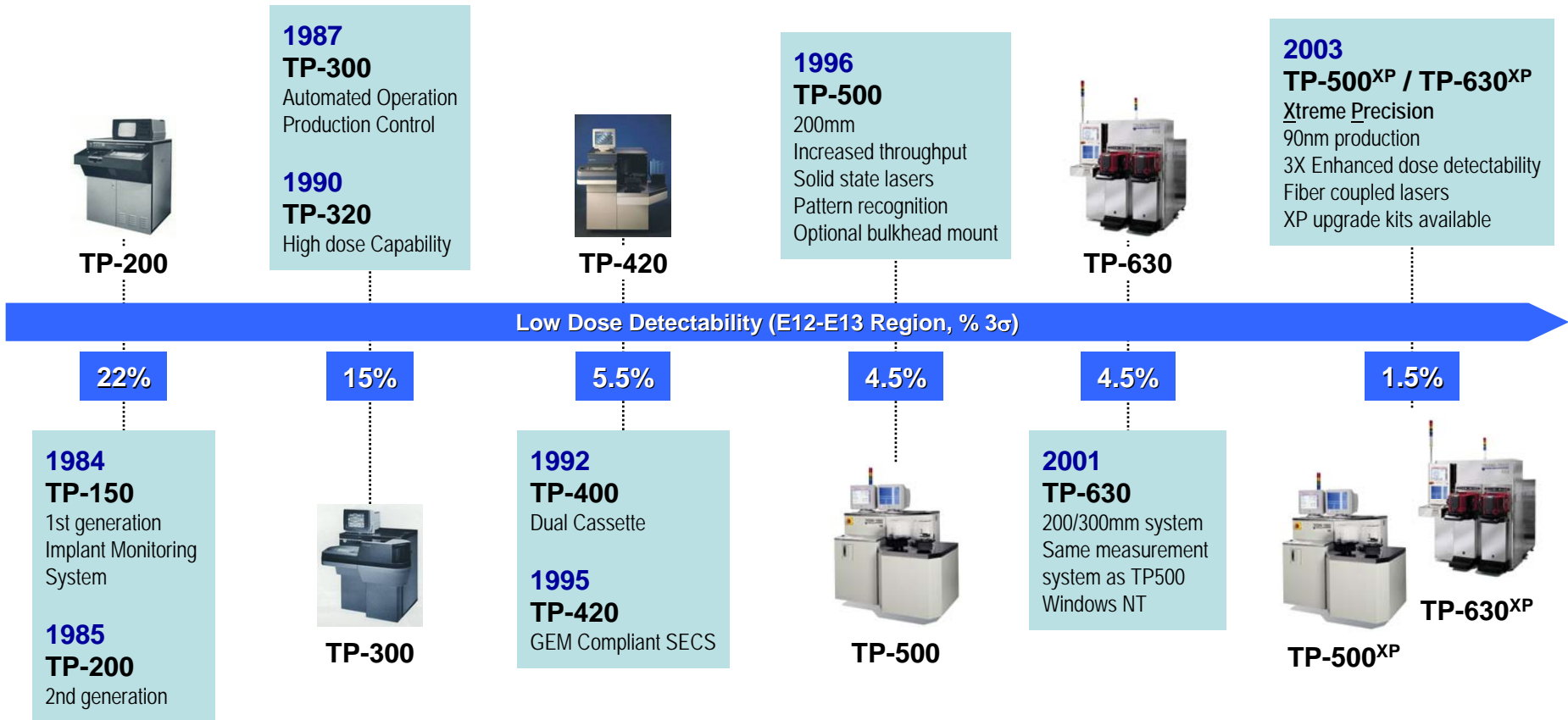


- Introduction
- Enhancements and Applications
 - Ion Implantation
 - USJ capability
- In-line product monitoring
- Conclusions

THERMA-PROBE Product Evolution

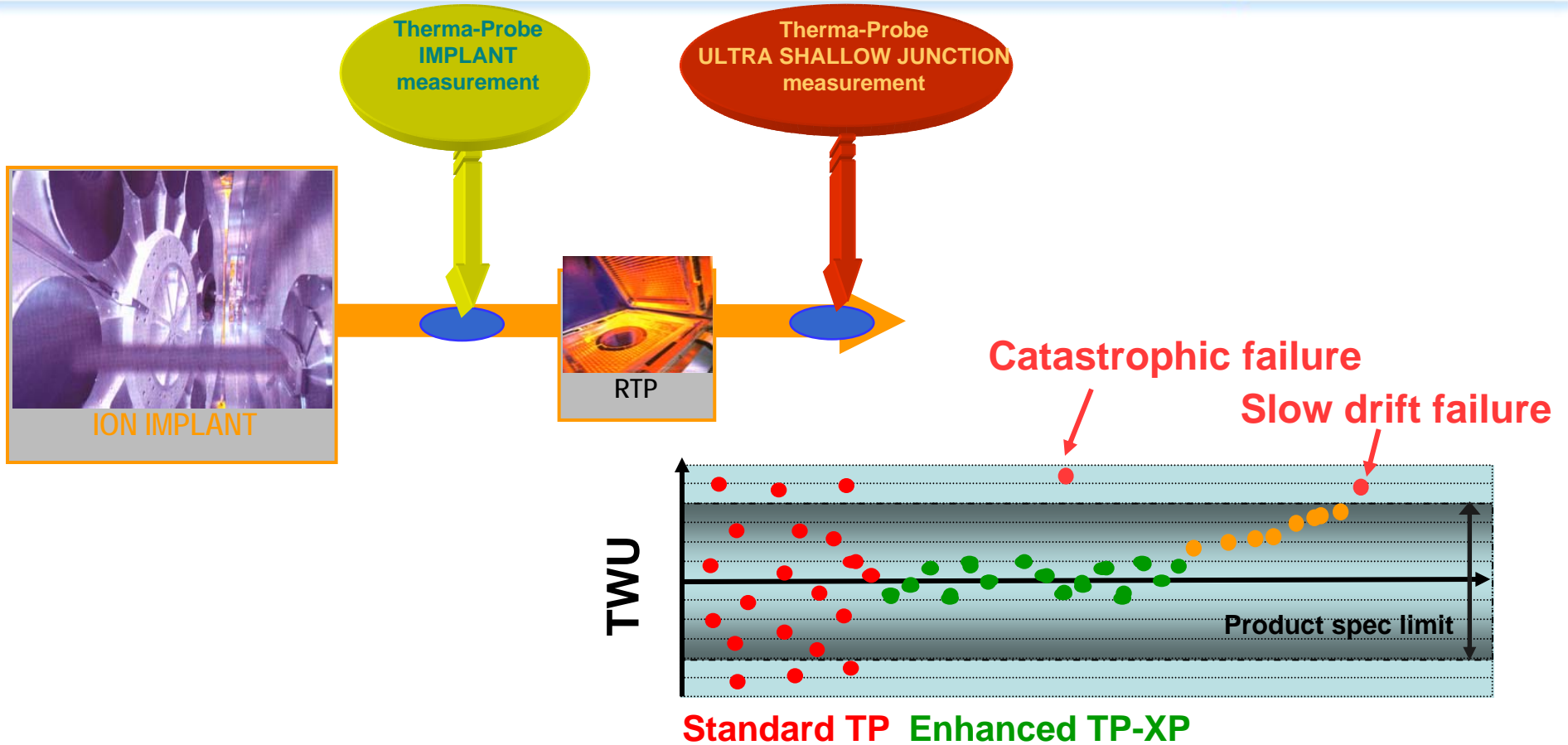


SPC READY



**THERMA-PROBE – New XP Products Enable Lowest Dose Detectability
Eliminate Costly Monitor Wafers – Monitor Drift and Minimize Catastrophic Implant Failure Events**

TP-XP used for Process Control

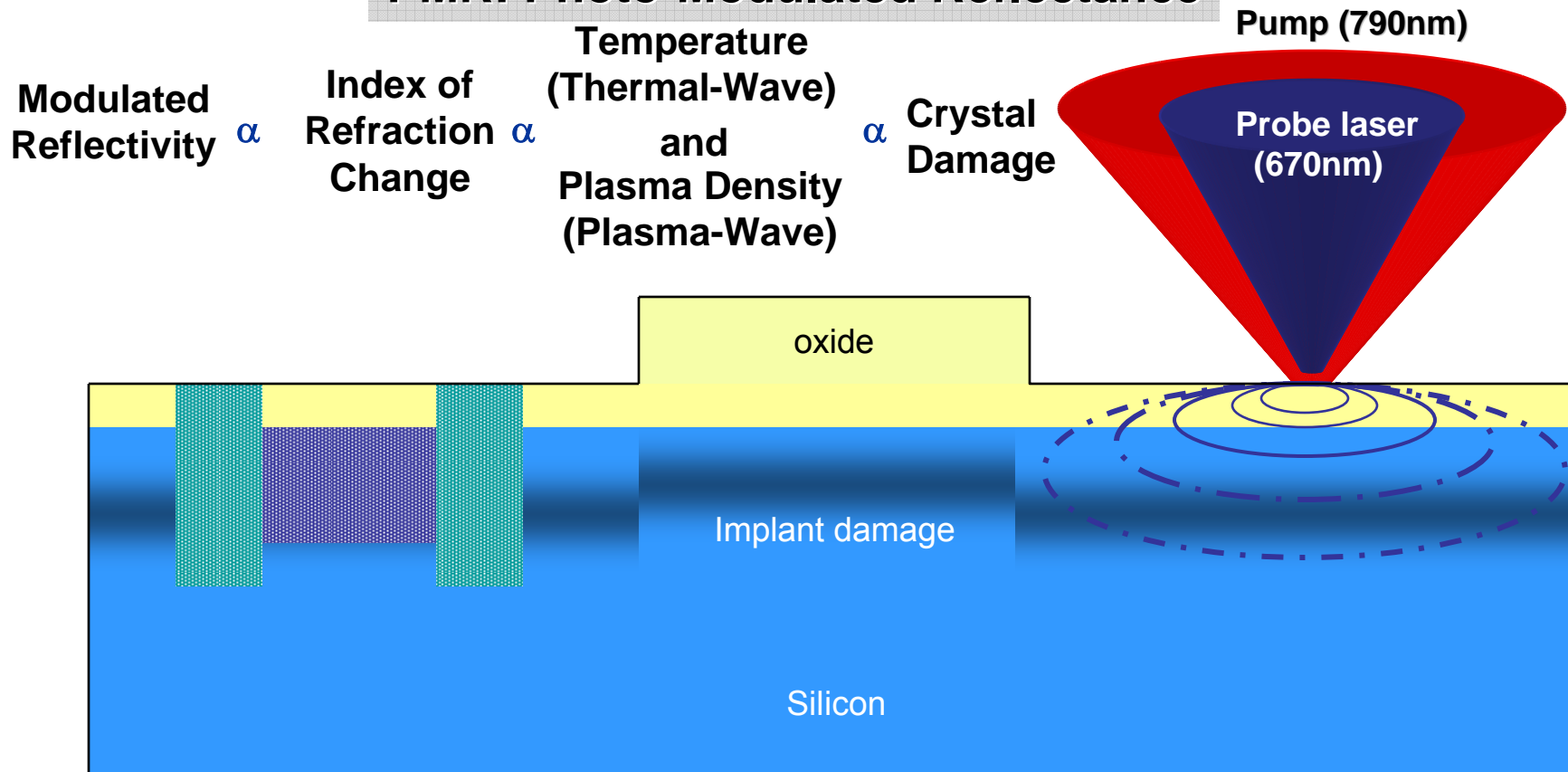


TP-XP minimizes wafer scraps from catastrophic or slow drift failure of process tool

Therma-Probe Signal Response



PMR: Photo-Modulated Reflectance



Modulated Reflectivity \propto Implantation Damage

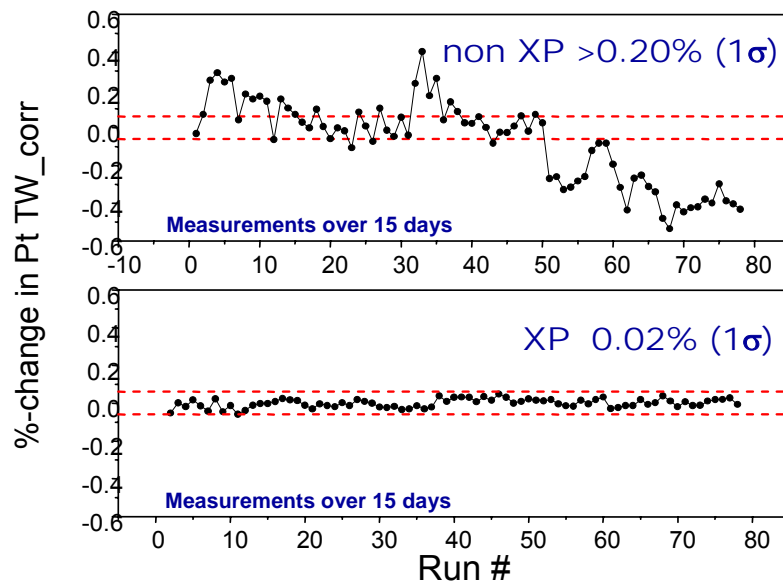
TP-XP Enhancements and Applications



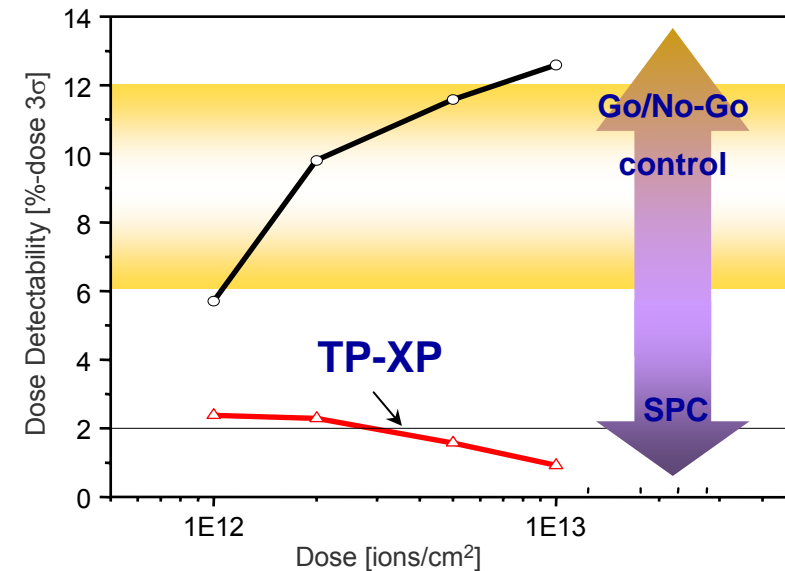
Ion implantation Enhancements



Long-term Stability



Dose Detectability (DD)



- Eliminates drift
- Superior measurement stability
- Improves fab productivity and enables new applications

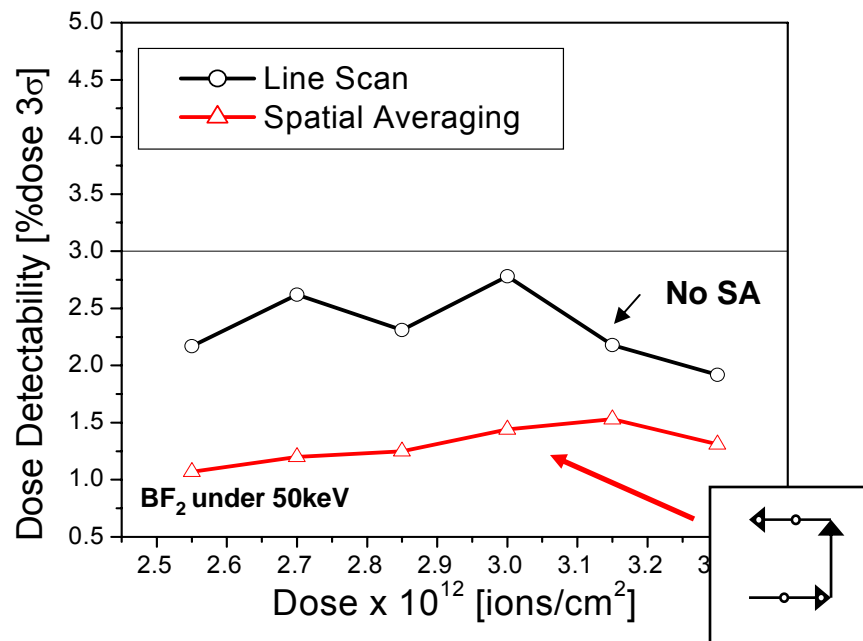
- 3-5x Improvement in DD
- Enables SPC for implant dose monitoring

$$DD: \text{Dose detectability } [\%-\text{dose } 3\sigma] = \frac{3 \times \% 1\sigma}{\text{Sensitivity}}$$

Enabling Technology Transfer

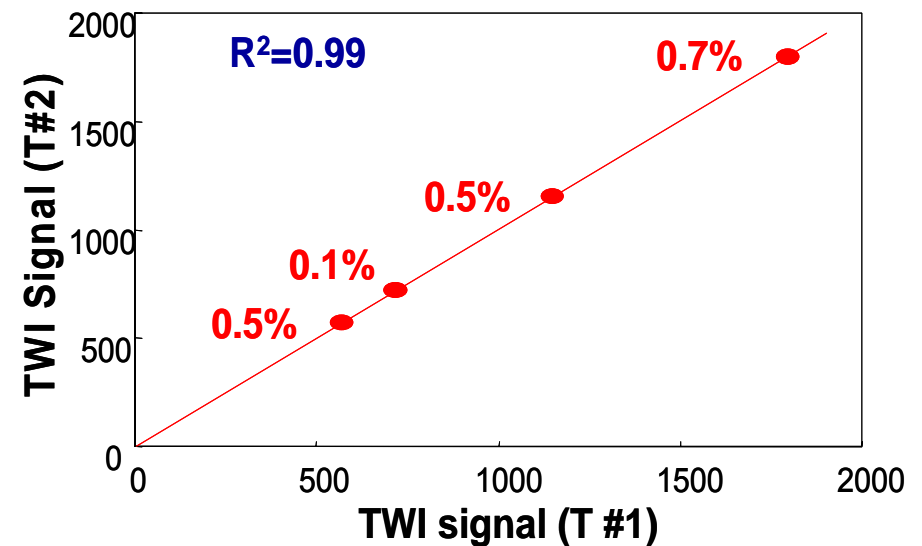


Spatial Averaging (SA)



➤ 2x Improvement in DD for SPC

T2T Matching < 1%



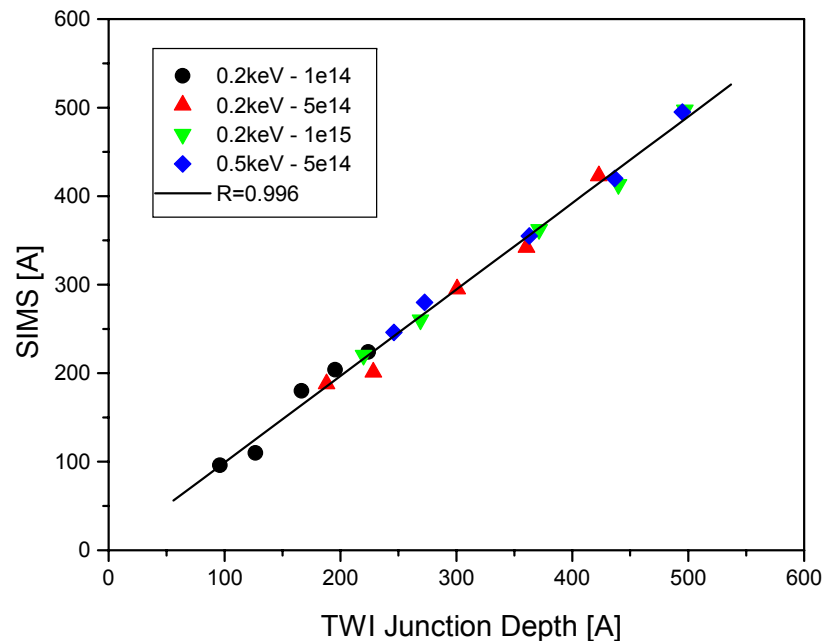
➤ Enables technology transfer

Ultra Shallow Junction Capability

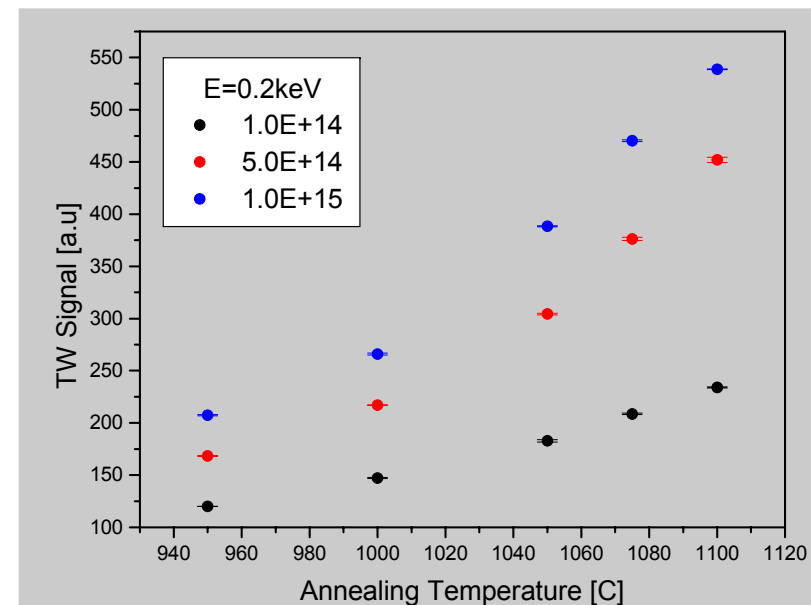
x_j and anneal temperature



Junction Depth



Anneal temperature monitoring



- Measured after implant and anneal
- Application specific correlation
- <math><1.5\%</math>

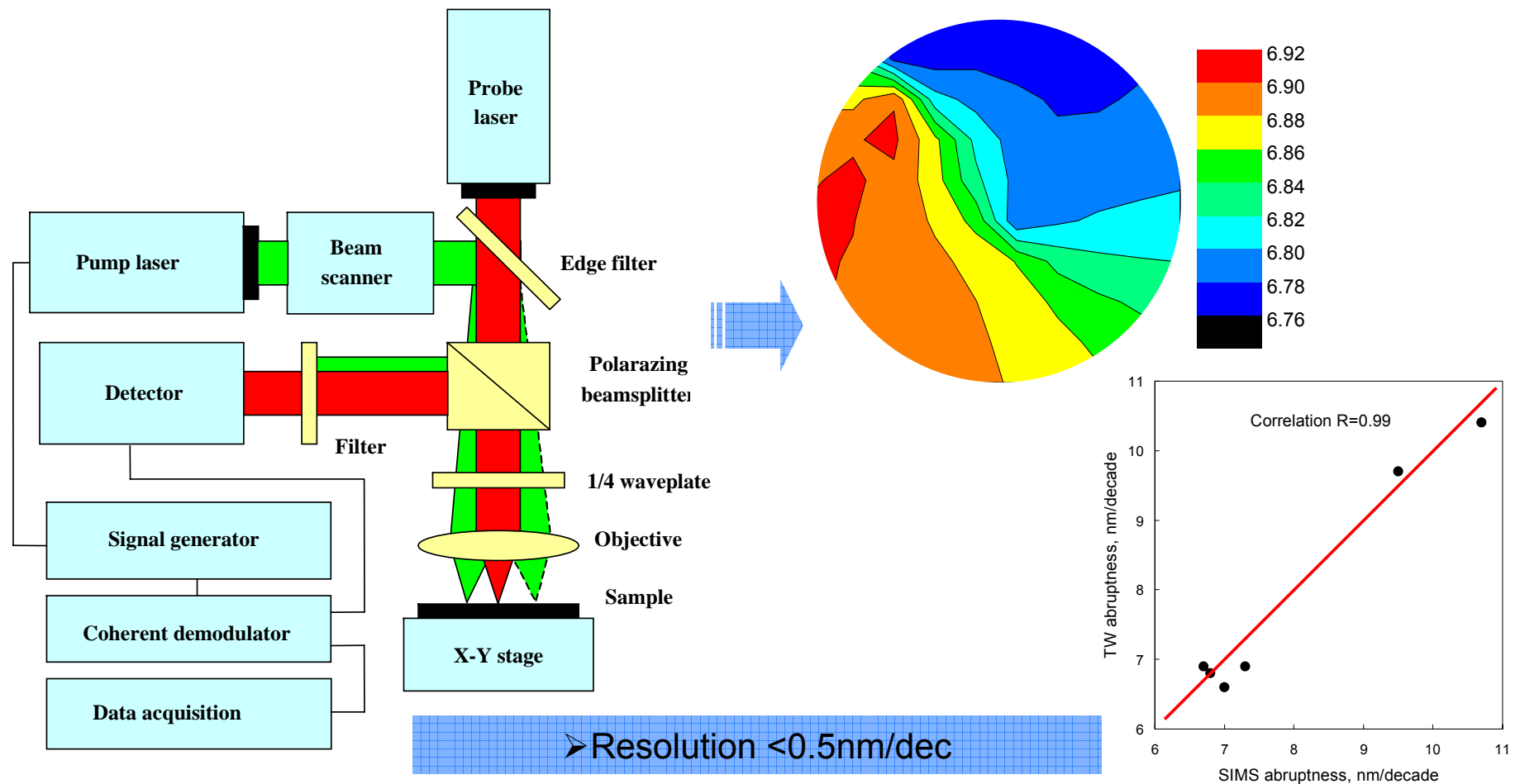
- Anneal temperature resolution <math><2</math> deg
- Enables RTP and spike anneal process monitoring

Ultra Shallow Junction Capability

Abruptness



TWI proprietary Abruptness method



In-Line Product Monitoring Using TP-XP System



In-line Metrology for Ion Implant and USJ



→ Drivers for In-line Metrology

- Tighter control needs of evolving ITRS requirements
- Cost of advanced technology & 300 mm scraps
 - Cost of re-work labor and materials
 - CoO decline for process tools
 - Production flow interruption
- In-line metrology enables advanced equipment and process control
 - Identified by International SEMATECH as a key technology challenge for 2006

→ In-line Ion Implant and USJ Metrology

- Non-destructive, fast, and reliable
- Optical methods like PMR
- Thermo-Probe^{XP} offers field-proven solutions

Necessary components for Product Monitoring



TP-XP

Measurement Performance

- Repeatability
- Stability
- Tool Matching

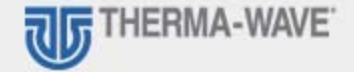


System Performance

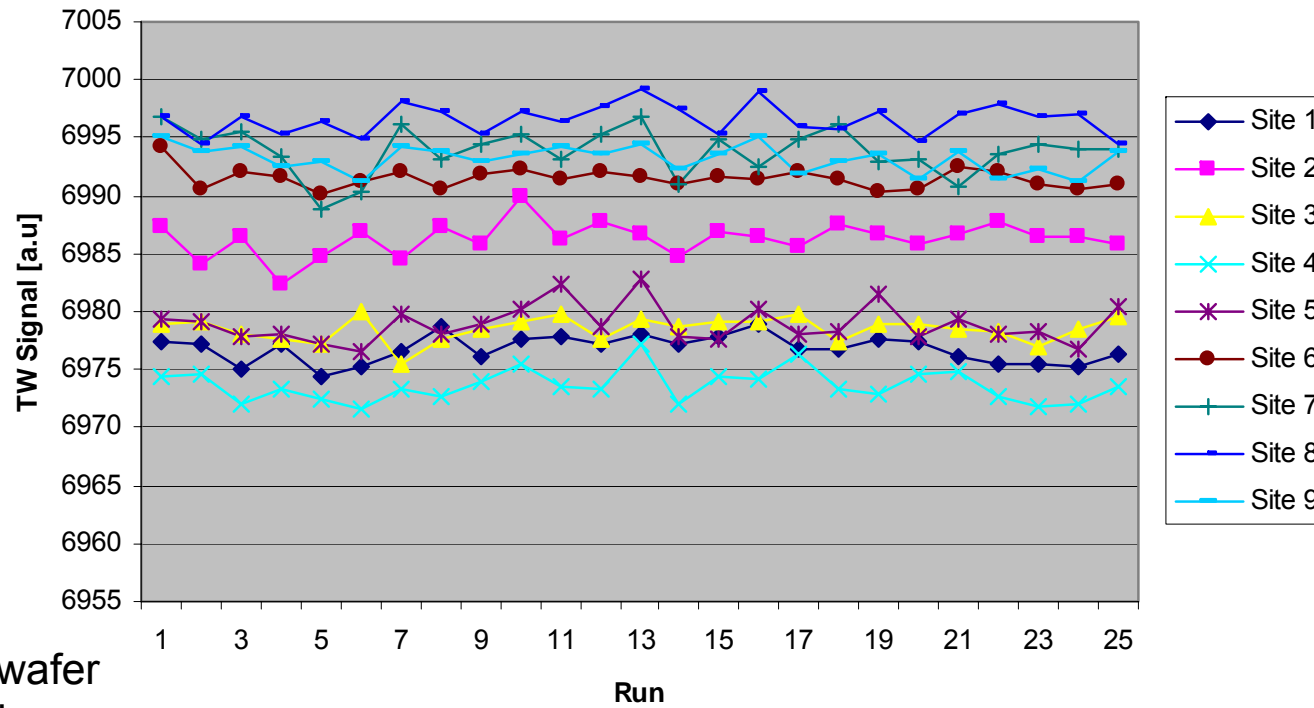
- Pattern Recognition
- Throughput
- Automation
- Reliability



Dynamic Repeatability on product



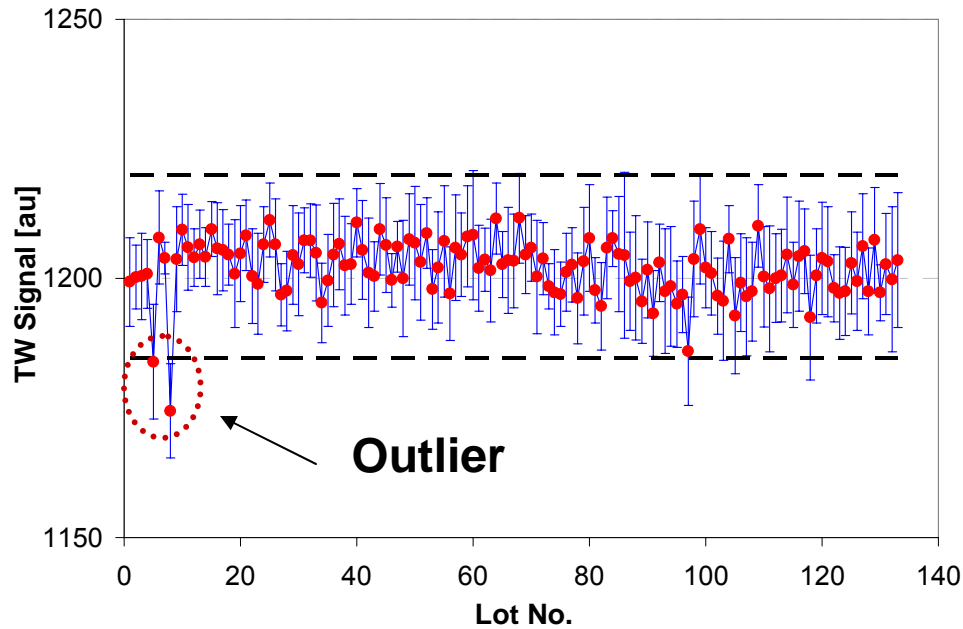
Repeatability Dynamic on Pattern wafer



Same pattern wafer
25 load/unload

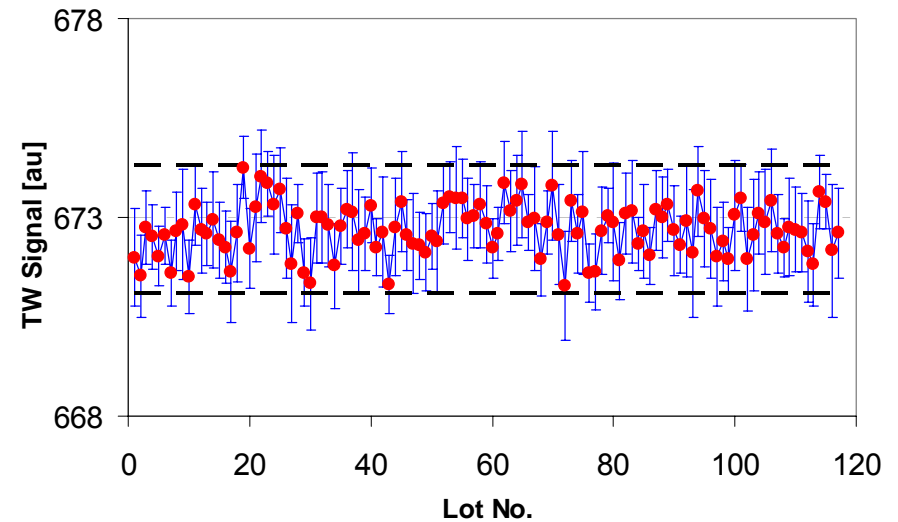
Site by site (9 sites) dynamic repeatability <0.02% 1σ

Production Lot stability on Double Implant (one month)



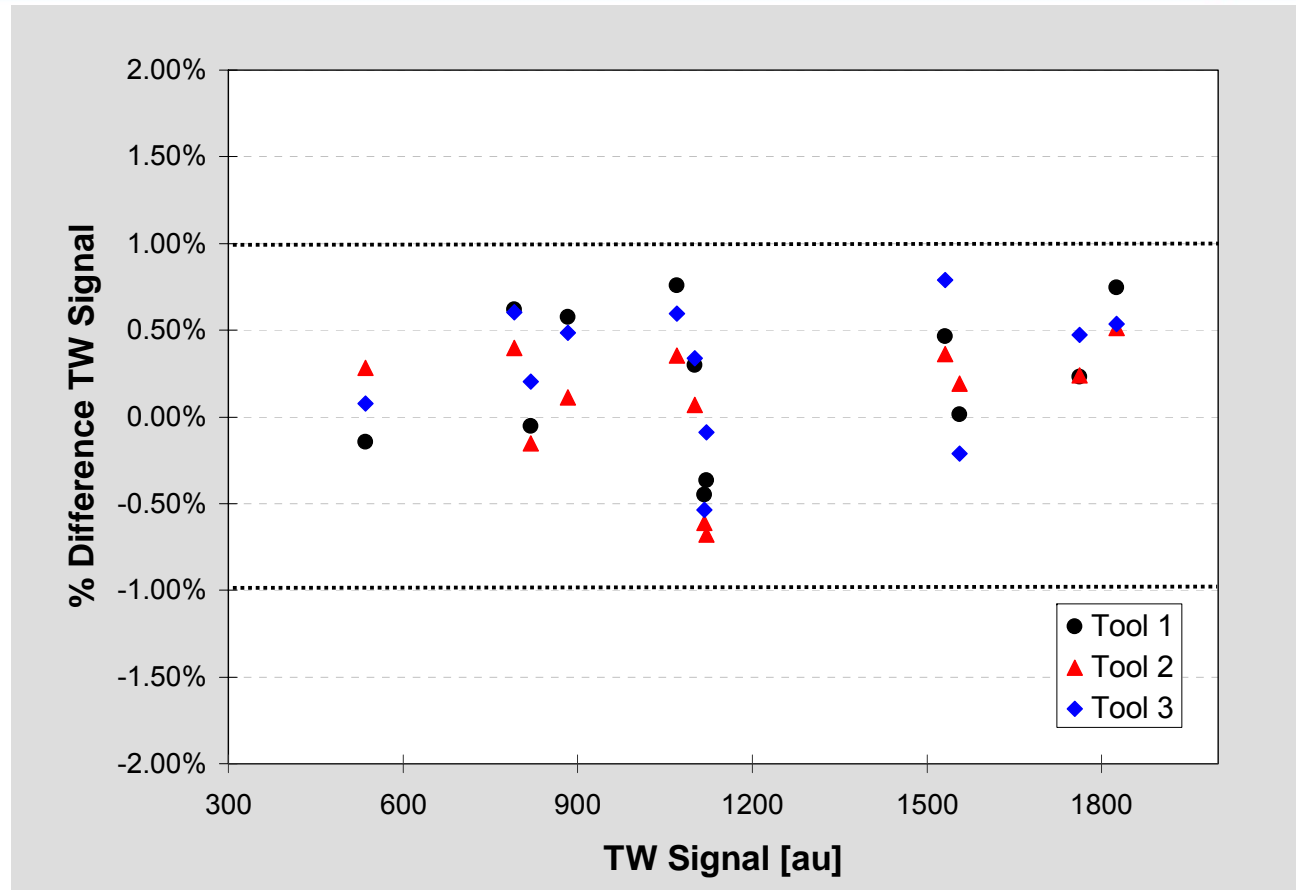
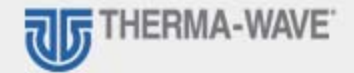
Process variation $\pm 2\%$ dose

Error bars represent wafer uniformity $\pm 1\sigma$ over 9 sites



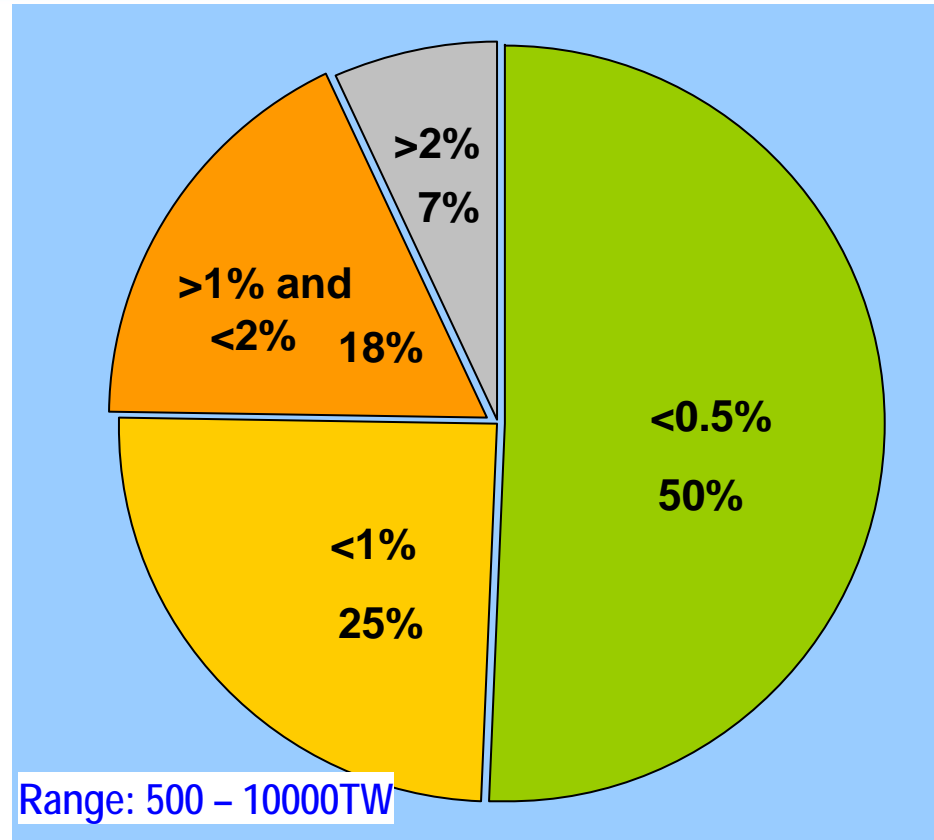
Mean TW Signal deviation suggests likely process variation

Three tools Matched to the Fab Customer Golden Tool – Different Lines



Currently more than eight tools are matched to the golden tool

Matching results over a broad range of production wafers



**>90% match
at <2%**

Matching could be optimized in the more critical signal range without seriously impacting the rest of the signal ranges.

Conclusions



- Dose and energy detectability
 - Wide range of implant and dopant type
 - SPC ready (DD < 2.0 % 3σ with spatial averaging)
 - Tool-to-tool matching is better than 1% in a specific range
- USJ monitoring
 - Better than 1.5 % (3σ) precision
 - Simultaneous monitoring of USJ depth and abruptness
- Productivity
 - Pattern recognition with ability of 30x30micron box size
 - Excellent dynamic repeatability and stability on product
 - Unparallel matching performance in the industry
 - Fully automated, high throughput and reliability
 - TP-XP minimizes wafer scraps from catastrophic or slow drift failure of process tool