Multilayer Deposition for Defect-Free EUVL Mask Blanks

Patrick Kearney[1], C. C. Lin[1], Takashi Sugiyama[2], and Chan-Uk Jeon[1], Rajul Randive[3], Ira Reiss[3], Renga Rajan[3], Paul Mirkarimi[4], and Eberhard Spiller[4]

[1] SEMATECH Mask Blank Development Center; Albany, NY USA
[2] Assignee to SEMATECH Mask Blank Development Center
[3] VEECO Instruments; Plainview, NY USA
[4] Consultants to VEECO Instruments

Solutions for a nanoscale world.™ Accelerating the next technology revolution.

Advanced Materials Research Center, AMRC, International SEMATECH Manufacturing Initiative, and ISMI are servicemarks of SEMATECH, Inc. SEMATECH, the SEMATECH logo, Advanced Technology Development Facility, ATDF, and the ATDF logo are registered servicemarks of SEMATECH, Inc. All other servicemarks and trademarks are the property of their respective owners.

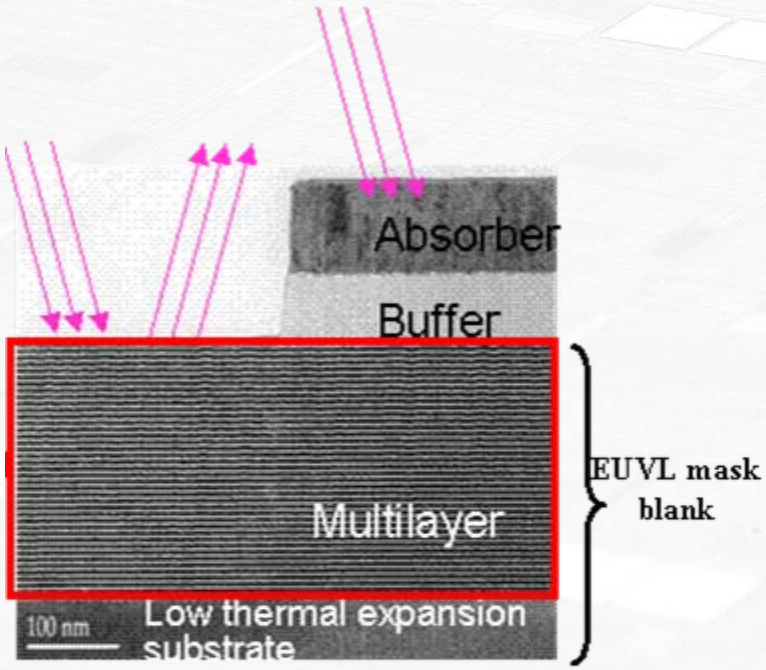
Outline

- Introduction: mask blank defects and the MBDC
  - Defect problem
  - Partners
  - Process
  - M7360
- Current defect results for deposition
  - Tool upgrades
  - M1350 long-term adder trend
  - Champion M7360 total defect results
  - Pareto
- Smoothing process
  - Strategy
  - Requirements
  - Capability
  - Cleanliness
- Conclusion

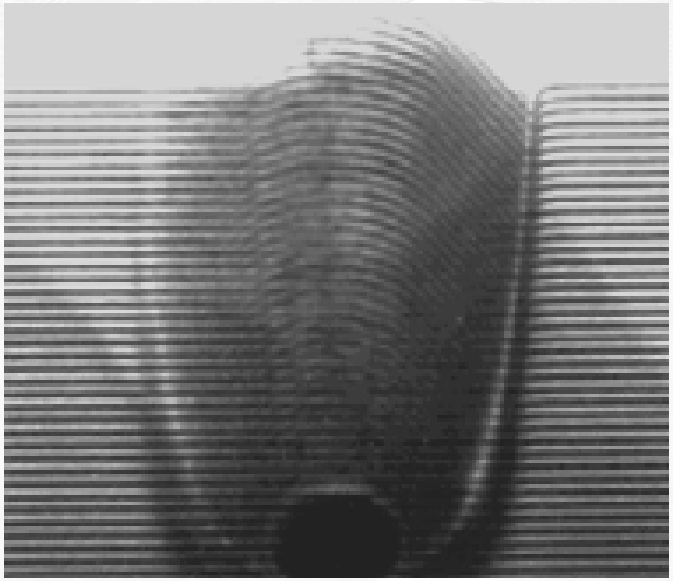
Veeco
Solutions for a nanoscale world.™
SEMATECH
Accelerating the next technology revolution.

EUVL mask blank defects are a challenge

Bumps or pits on the substrate or particles added during ML deposition can cause a defect.



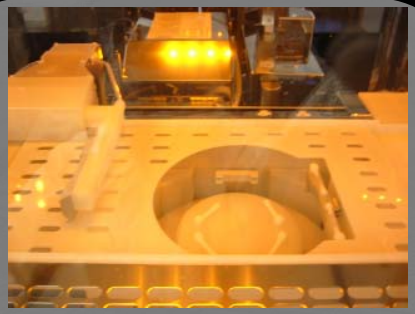
EUV mask construction



Veeco
Solutions for a nanoscale world.™
SEMATECH
Accelerating the next technology revolution.

SEMATECH MBDC brings the experts together

Asahi Glass Mask and substrate supplier

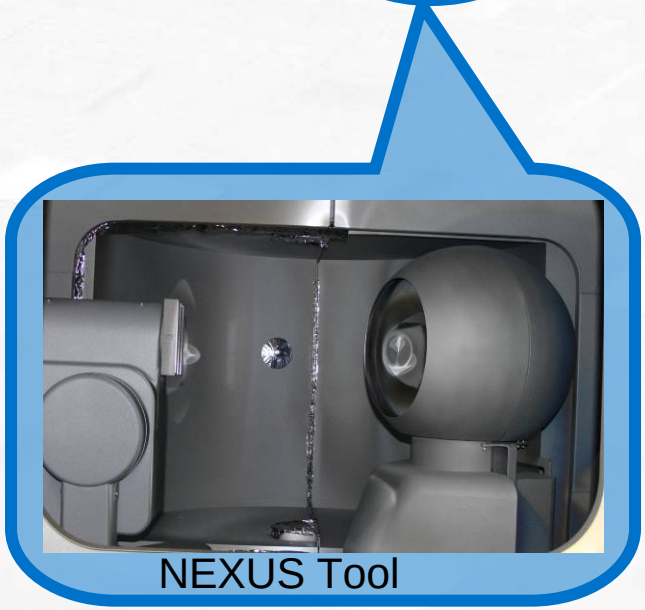


ASC/Masktrack

Veeco Deposition tool supplier

SEMATECH MBDC Collaboration framework

Hamatech Cleaning tool supplier



NEXUS Tool

Lasertec Inspection tool supplier

M1350/M7360

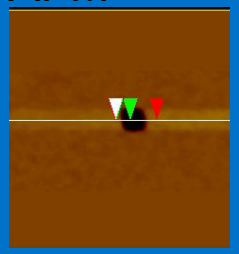
Veeco

SEMATECH

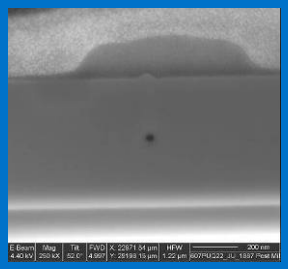
Solutions for a nanoscale world.™ Accelerating the next technology revolution.

Reducing mask blank defects

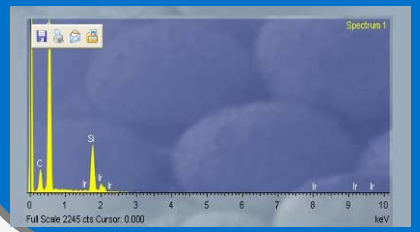
Shape:
AFM



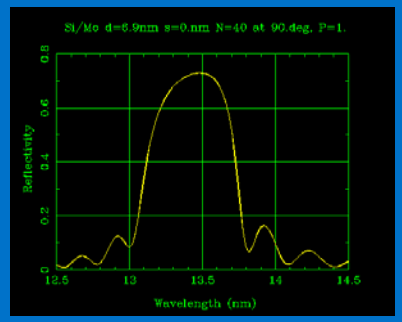
Location:
FIB/SEM



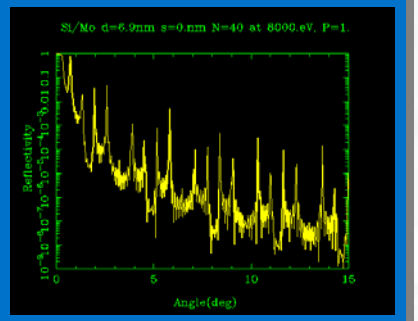
Composition:
EDX



Reflectometer:
EUV technology



Structure:
XRR



Mask substrate

Clean substrate

Deposit ML with Veeco Nexus tool

Inspect for defects with Lasertec tool

Generate Pareto using AFM & FIB/SEM

Veeco

SEMATECH

Solutions for a nanoscale world.™ Accelerating the next technology revolution.

We have dramatically improved our inspection capability with the Lasertec M7360

M7360 is a scanning confocal microscope operating at 266nm.

SEMATECH Inspection capability

	M1350	M1350*	M7360	M7360*
Available	2003	2007	2006	12/2007
QZ sens.	60 nm	51 nm	41 nm	~30 nm
ML sens.	80 nm	67 nm	56 nm	~40 nm

* Indicates upgraded tool. M7360* upgrade planned for Q4 07; performance is estimated.

Veeco Solutions for a nanoscale world.™

SEMATECH Accelerating the next technology revolution.

Veeco Nexus upgrades

Target shield

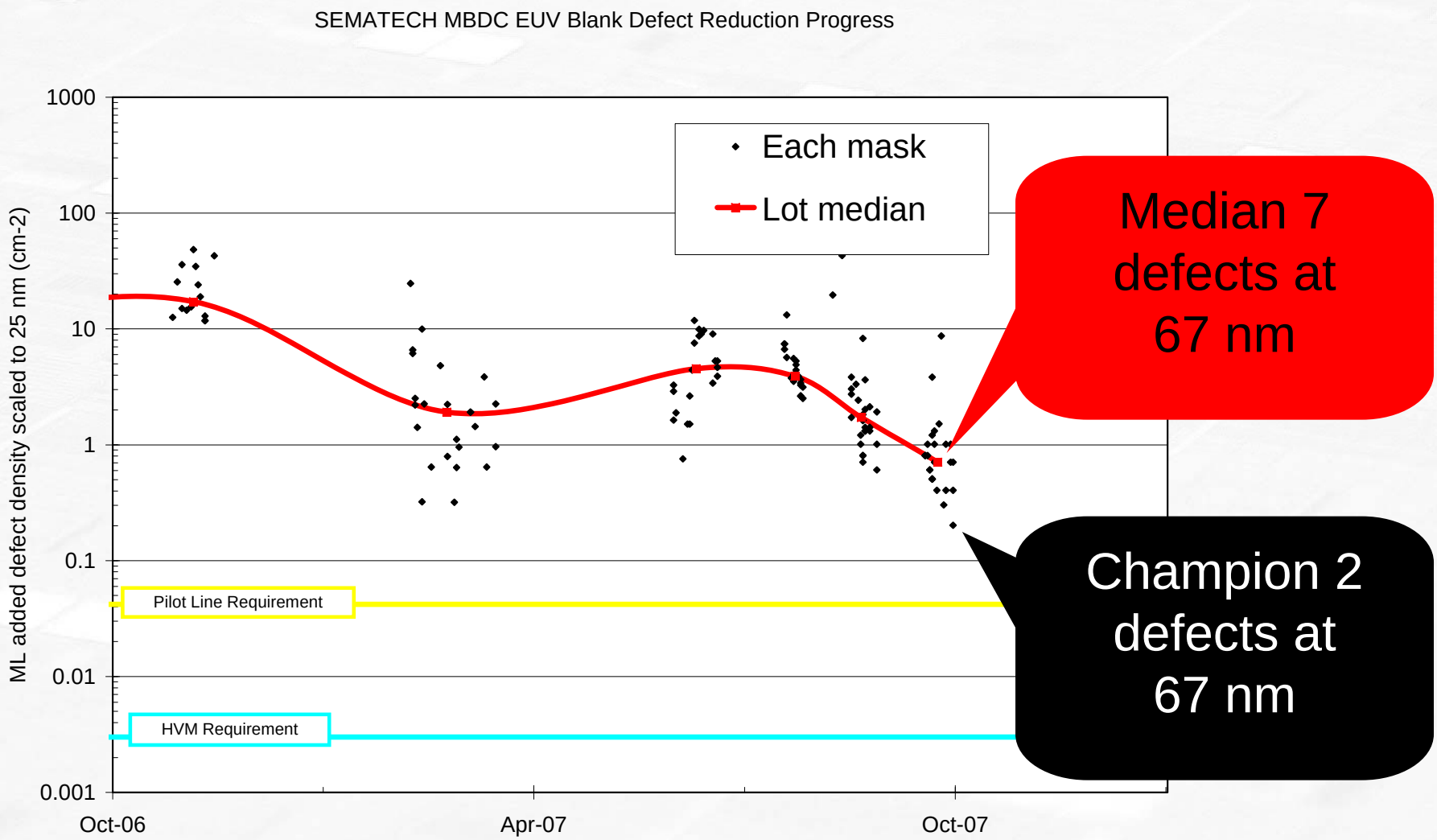
Improved target edge treatment, cleaner installation.

Chamber door

Move chamber wall away from target to reduce flaking.

Solutions for a nanoscale world.™ Accelerating the next technology revolution.

This years progress in ML deposition adders



Countable defects at 67 nm.
Need more sensitivity to make progress.

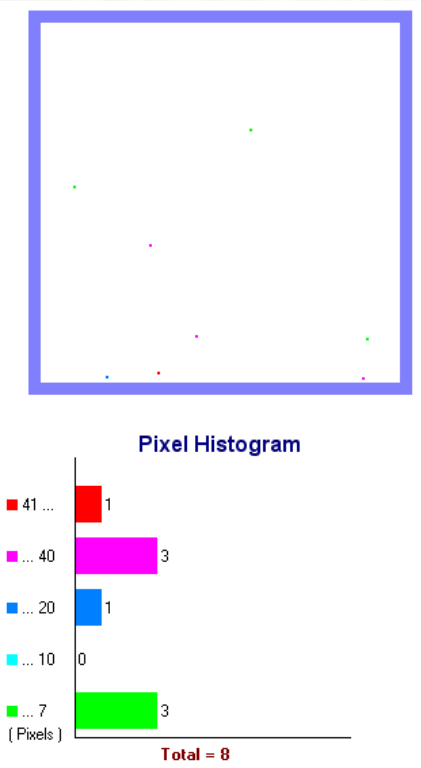
Veeco
Solutions for a nanoscale world.™

SEMATECH
Accelerating the next technology revolution.

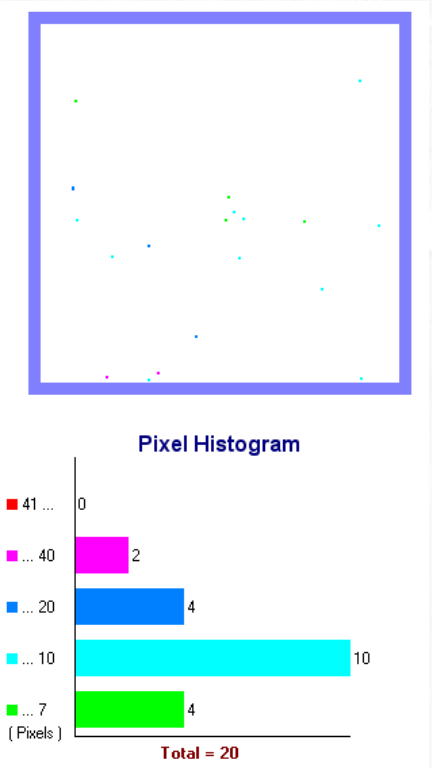
Champion data measured on new inspection tool: the Lasertec M7360

- 8 total defects at 67 nm (M1350)
- 20 total defects at 56 nm (M7360)

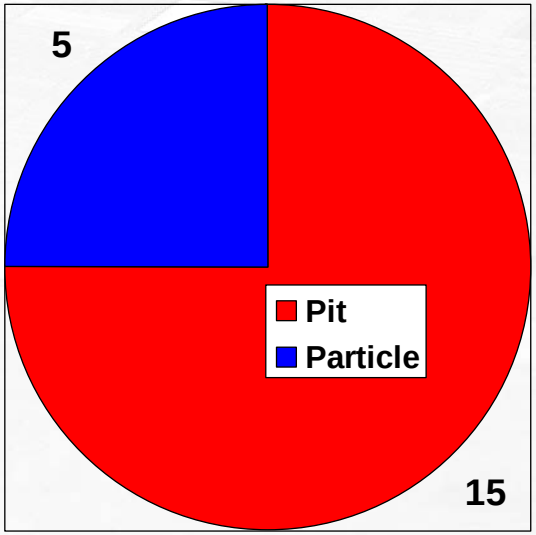
M1350
8 @ 67 nm+



M7360
20@ 56 nm+



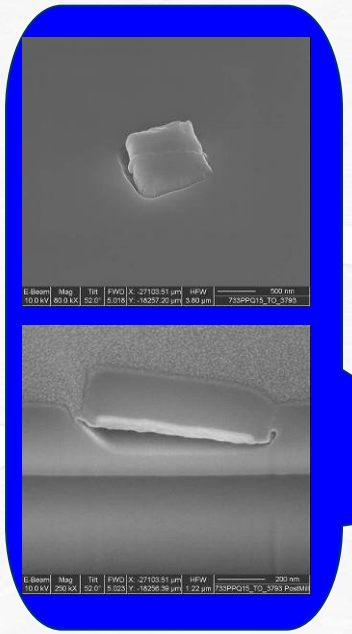
M7360 Classification

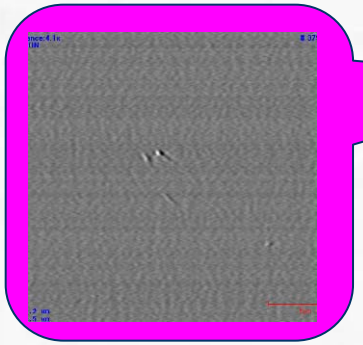


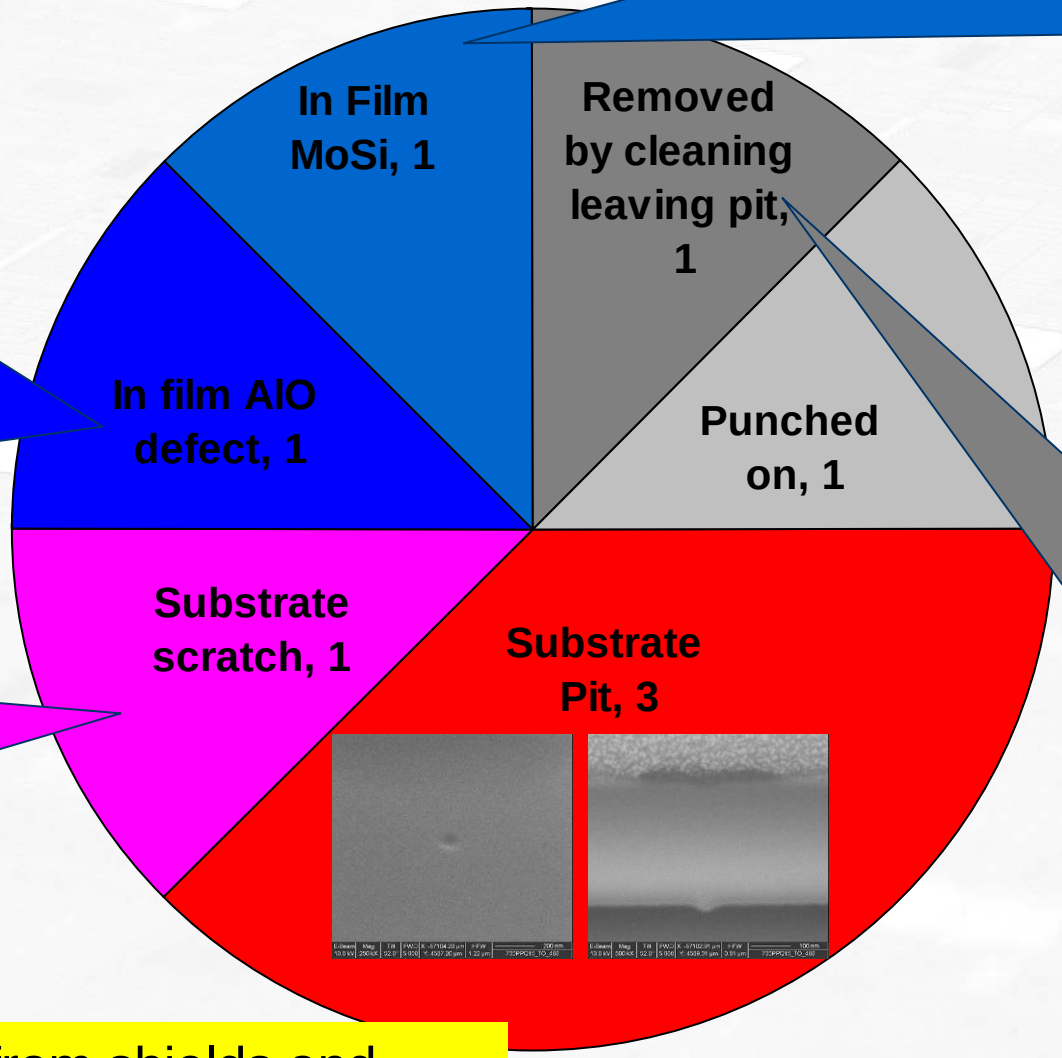
75% of defects at 56 nm are pits.

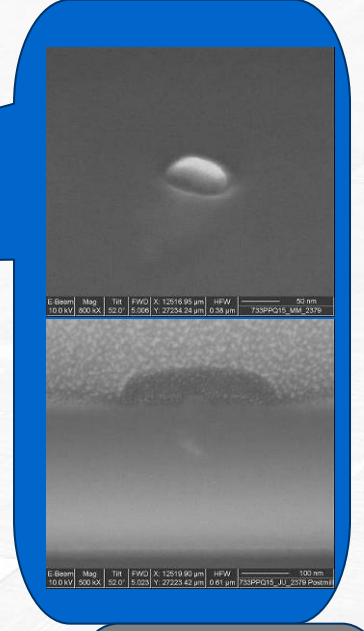
Veeco
Solutions for a nanoscale world.™
SEMATECH
Accelerating the next technology revolution.

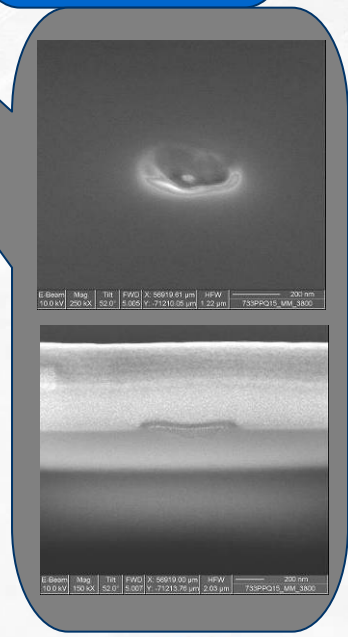
Champion Pareto











In film defects are from shields and flaking. Substrate defects dominant.

Veeco

SEMATECH

Solutions for a nanoscale world.™ Accelerating the next technology revolution.

SEMATECH strategy for substrate defects

1. Work with suppliers to eliminate defects.
   - Provide access to SEMATECH's world class inspection capability (Lasertec M7360).
2. Develop substrate defect smoothing process:
   - Use a combination of ion beam deposition and etch to smooth substrate defects.
3. Targeted substrate defect mitigation to remove particles and fill pits.
   - FIB and e-beam deposition and etch to repair.
   - Cost-effective for small numbers of defects.

Goal is a cost effective manufacturable solution to the problem.

- Smoothing process time can drive cost of ownership.

Measure incoming number of defects vs. size → Find quickest smoothing process that leaves <~100 defects (possibly none) → Use targeted technique to mitigate remaining defects

Veeco Solutions for a nanoscale world.™

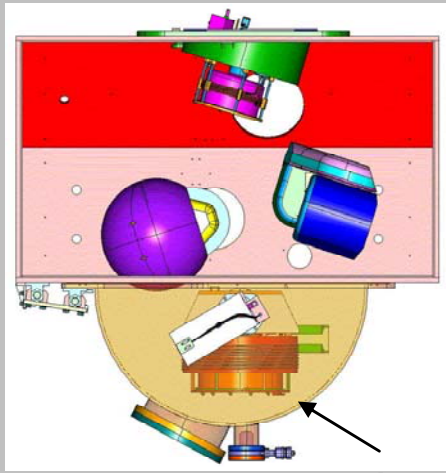
SEMATECH Accelerating the next technology revolution.

Smoothing requirements

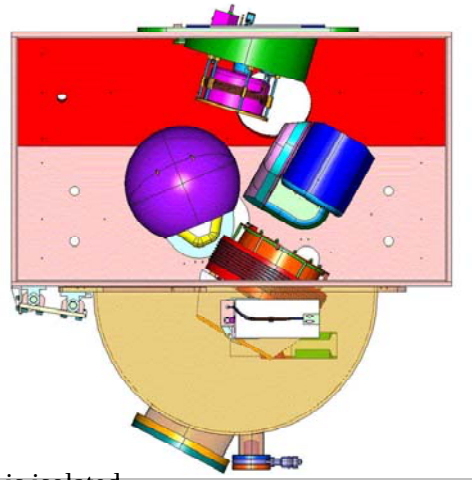
- Must be able to smooth the majority of substrate defects.
- Must keep substrate smooth enough for EUV.
- Must be cost-effective.
- Must be clean.

Veeco Nexus tool

Deposition Position



Etch Position



Etch source is isolated

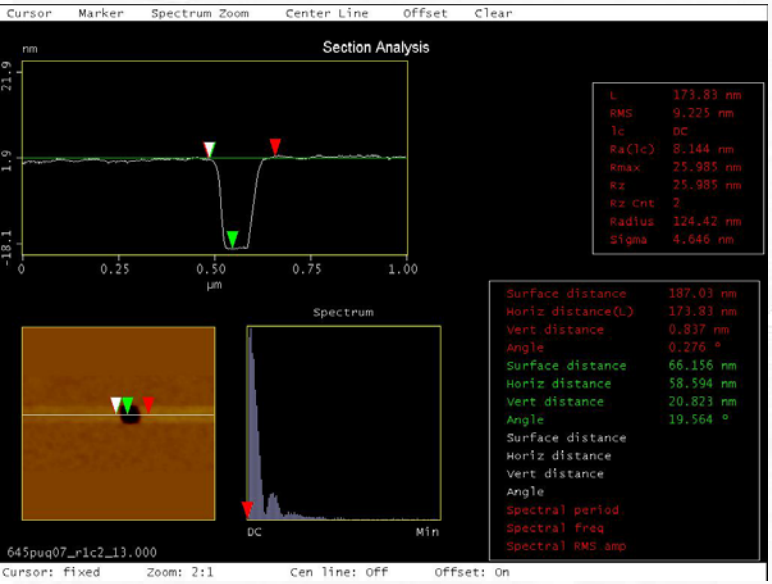
Veeco

Solutions for a nanoscale world.™

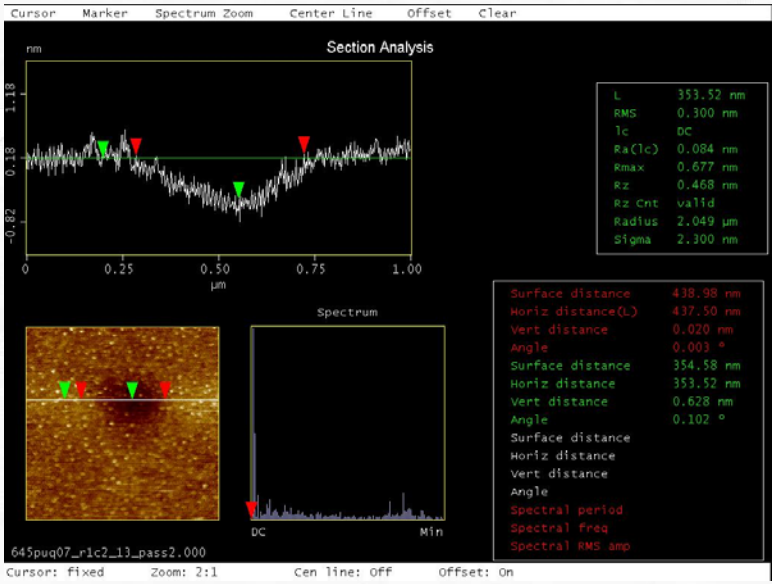
SEMATECH

Accelerating the next technology revolution.

Smoothing capability/smoothness

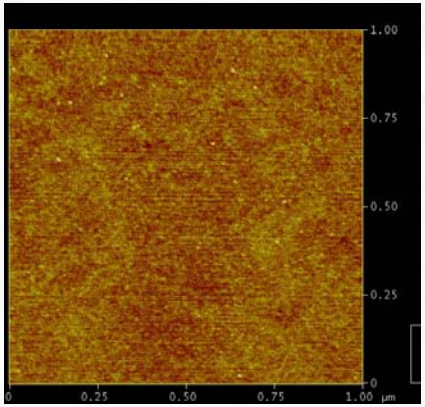


Smoothing



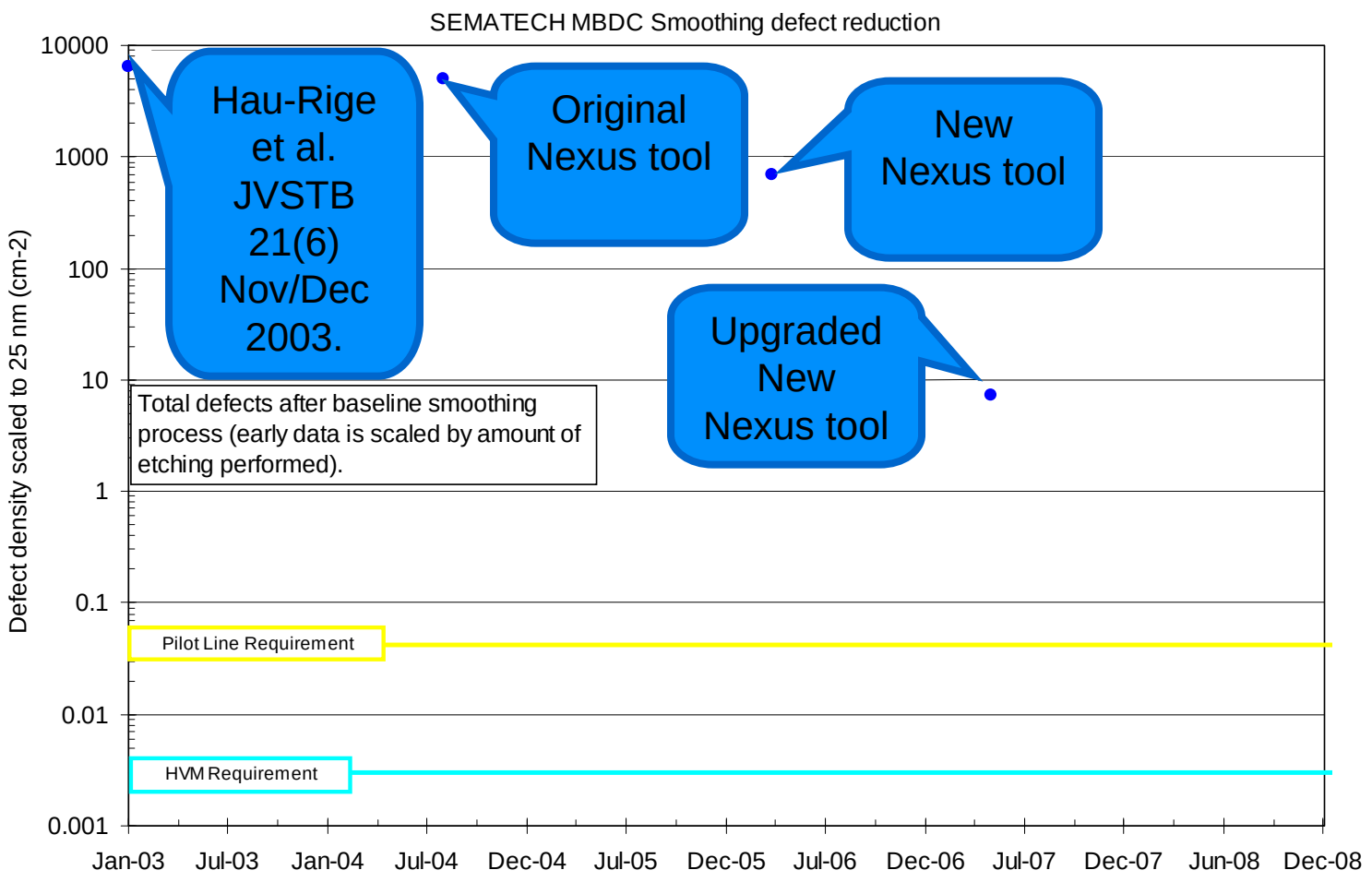
20 nm deep, 150 nm wide pit smoothed to 0.6 nm deep, 300 nm wide pit (unprintable) using combined particle and pit smoothing process. Surface remained smooth enough for ML deposition (<0.15 nm).

Surface after smoothing



Veeco
Solutions for a nanoscale world.™
SEMATECH
Accelerating the next technology revolution.

Smoothing cleanliness



Much progress, a long way to go.

Veeco
Solutions for a nanoscale world.™
SEMATECH
Accelerating the next technology revolution.

Conclusion

- SEMATECH's MBDC is driving towards a solution to the mask blank defect problem.
- Our new inspection tool, the Lasertec M7360, is providing 56 nm sensitivity and we anticipate upgrades to achieve 40 nm sensitivity in the near future.
- We have produced a mask blank with 20 total defects at 56 nm. Most of the defects are substrate-related; the remaining 5 defects are ML deposition adders.
- We have also demonstrated median ML adder levels of 7 at 67nm.
- SEMATECH has a blended strategy to reduce substrate defects, working with substrate suppliers, developing the smoothing process, and developing targeted pit fill.
- We have successfully demonstrated particle and pit smoothing and have dramatically improved the defect density of smoothed plates.

Acknowledgements

This work could not have been performed without the support of the MBDC team. Particularly Wonil Cho on inspection and Abbas Rastegar, Sean Eichenlaub, Vivek Kapila and John Arun on cleans, Richard Clark on handling, Robert Sherman on facilities, and Anne Rudack on operations.

The technicians who performed this work were James Kuss, Nelson Lethbridge, Lenny Gwenden, Butch Halliday, and Jake Whitbeck. Without them none of this would have happened.

Thanks

Veeco Solutions for a nanoscale world.™

SEMATECH Accelerating the next technology revolution.