International SEMATECH – North

EUV Mask Blank Development Center

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International SEMATECH / University at Albany - SUNY Initiative

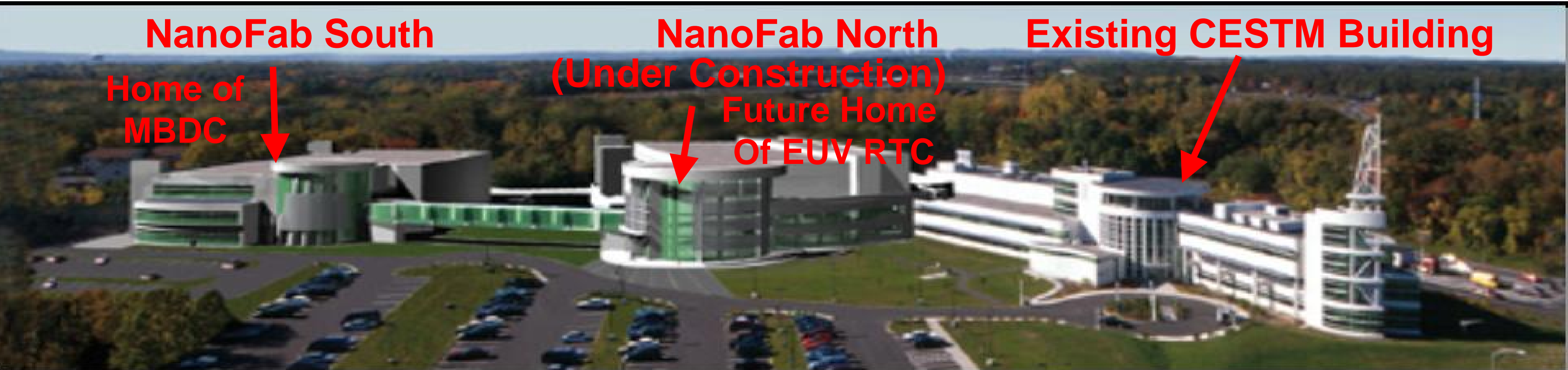
- 5-year, $320M strategic alliance to develop infrastructure for EUV lithography (4:1 funding leverage from New York State)
- EUV Mask Blank Development Center will accelerate the development of commercial EUV mask blanks
- EUV Resist Test Center (RTC) will support the development of commercial EUV photoresists to meet production requirements
- Central location, state-of-the-art equipment and development programs to develop and test tools, materials and processes

ISMT-N at U. Albany - SUNY

NanoFab South Building

3rd floor: ISMT Office area

1st floor: Cleanroom/MBDC



Overview: Mask Blank Development Center (MBDC)

- **Technical Objectives:**
  - Develop infrastructure to work on multilayer defect reduction on EUV blanks.
  - Establish a facility to support metrology and evaluation of EUV blanks
  - Provide facilities for blank suppliers to develop and evaluate new processes for multilayer deposition and metrology
- **Equipment:**
  - Primary equipment set ordered; 4 tools installed and qualified (details follow)
  - Basic infrastructure is in place and we can host users (on limited toolset)
- **Staffing:**
  - 5 ISMT engineers plus program manager
  - 4 process/equipment technicians (7 by December 2003)
  - Administrative and support team in place.
  - Facilities support infrastructure and staffing provided by U. Albany.

Overview: Mask Blank Development Center (MBDC)

- **Status – September 2003:**
  - Mask Blank Development center is "ready for business": all basic infrastructure is in place and we can host users (on limited toolset)
    - IBD Dep tool, Defect inspect tool, AFM and FIB/SEM qual'd
  - Basic metrology toolset on order.

- **Goals for Q4 2003:**
  - Qualify and cross-calibrate first set of metrology, cleans, and support tools
  - Staff and train personnel to support EUV blank development
  - Provide guest access in Albany for metrology and deposition experiments

NanoFab South Cleanroom: Basic Design and Specs

TOP VIEW

SERVICE CHASE | PROCESS BAY | SERVICE CHASE

SIDE VIEW

FAN FILTER UNITS

HEPA FILTERS

SERVICE CHASE (TURBULENT AIRFLOW)

(LAMINAR AIRFLOW)

SERVICE CHASE (TURBULENT AIRFLOW)

PROCESS TOOL

PROCESS BAY

METRO TOOL

SOLID WALL

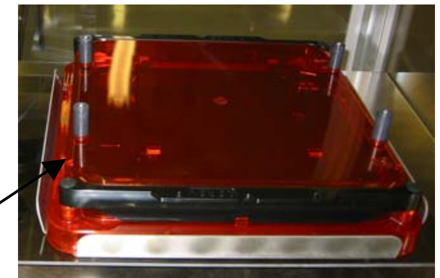
LOUVERS

RSP Load/ unload ports

(Enlarged View)

Cleanroom Statistics

- ~10,000sf (950sm) cleanroom
- slab on grade construction (good for vibration)
- Bay/chase design (no sub-fab)
- Class 100 bays, ~Class 1000 chases
- 100% SMIF (RSP) capability for in-line tools



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MBDC Layout

Advanced cleans (2005)

EUV Reflectometer (1Q04)

Ion Beam Deposition

Pod Washer (10/03)

Defect Inspection

Next Generation Defect Inspection (2005)

Mask Cleans (10/03)

FIB/SEM

Interferometer/ Phase Contrast microscope (10/03)

Atomic Force Microscope

Optical microscope

EUV AIMS (2005)

X-ray Reflectivity (12/03)

ISMTN AREA

(ISMTN: 7052 sf)

SPACE RESERVED FOR FUTURE CLEAN TOOL

Total area = 655 m^2

Installed

Ordered

Future

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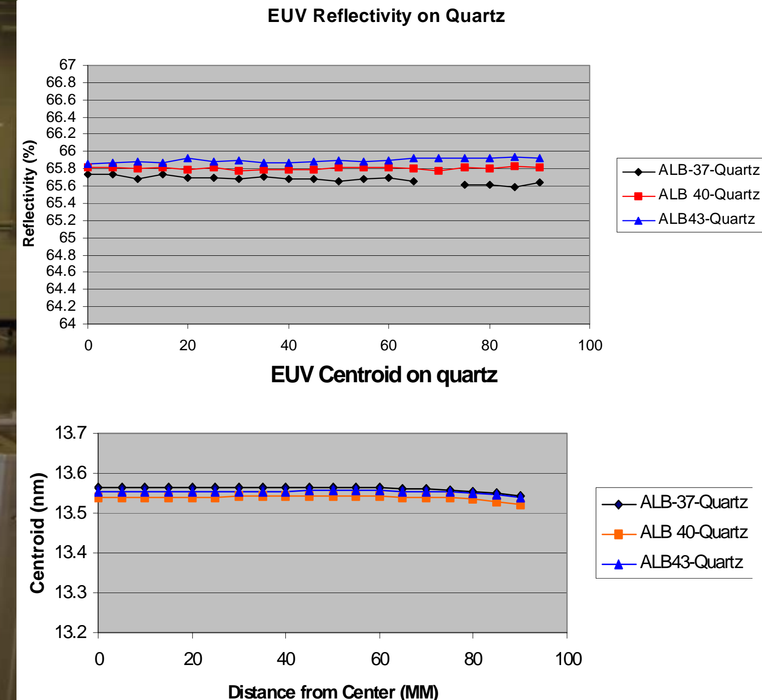
Veeco Nexus Ion Beam Deposition

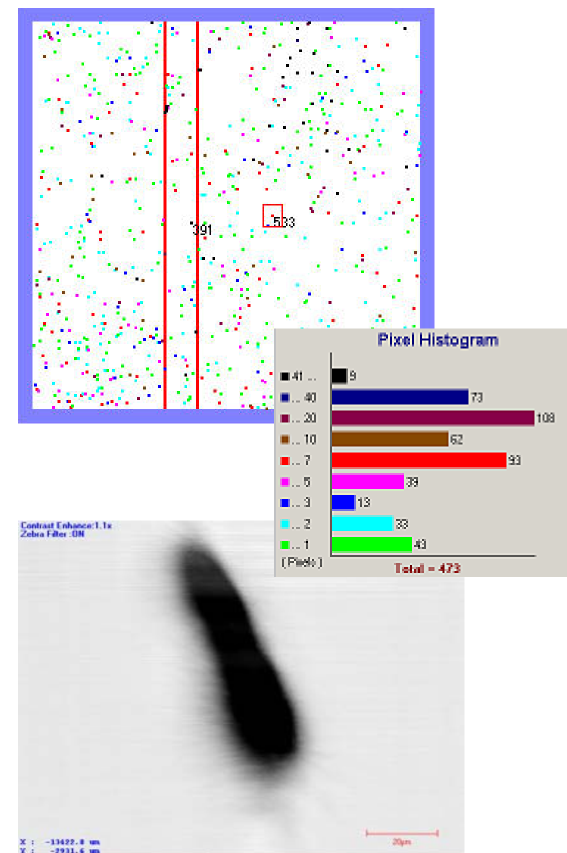
Purpose	Deposit reflective coatings on EUV mask blank substrates (40 pairs of alternating Si/Mo films)
Capability	Reflectance (%) 65.8 +/- **0.075** (3 δ) — Centroid (nm) 13.55 +/- **0.012** (3 δ) — FWHM 0.53 +/- **0.0021** (3 δ)
Usage	Processing
Status	Qualified, in use



INTERNATIONAL SEMATECH — Veeco — INTERNATIONAL SEMATECH

Lasertec M1350 Defect Inspection

Purpose	Measure defect density on mask blanks or substrates
Capability	~75nm (PSL equivalent)
Usage	In-line and end-of-line metrology
Status	Qualified, in use



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Veeco Dimension 9000PM Atomic Force Microscope

Purpose	High spatial frequency surface roughness + defect characterization
Capability	~1 Angstrom (+ defect navigation)
Usage	In-line and end-of-line metrology
Status	Qualified, in use

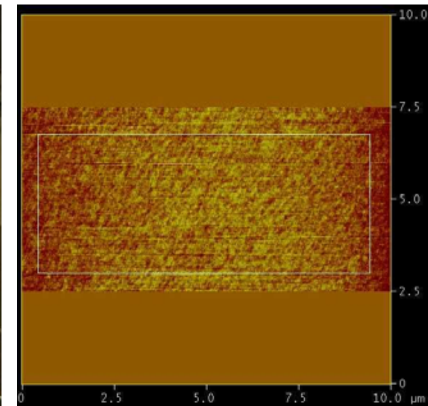


Image Statistics

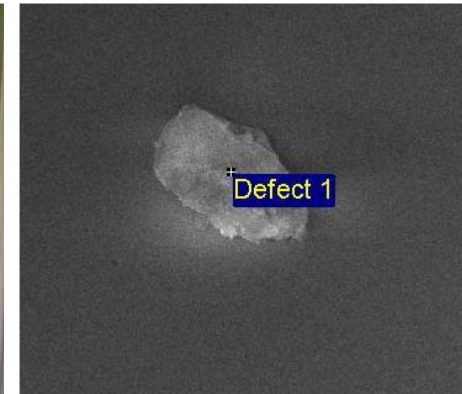
Img. Z range	2.122 nm
Img. Mean	0.000000 nm
Img. Raw mean	563.02 nm
Img. Rms (Rq)	0.139 nm
Img. Ra	0.077 nm

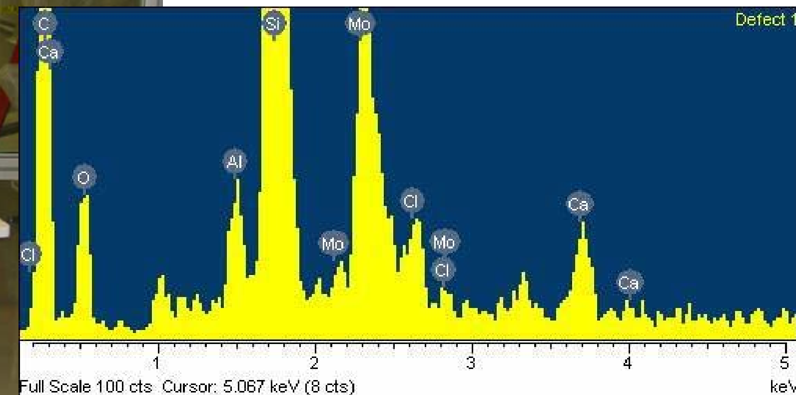
Box Statistics

Z range	1.986 nm
Mean	0.024 nm
Raw mean	565.21 nm
Rms (Rq)	0.179 nm
Mean roughness (Ra)	0.142 nm
Max height (Rmax)	1.970 nm

FEI Altura 835 FIB/SEM/EDX

Purpose	Characterize defects to assist in root-cause analysis: morphology, composition, etc…
Capability	~5-6nm resolution
Usage	End-of-line metrology, FA + TEM sample prep
Status	Qualification expected September 2003





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Future Tools

TOOL	SUPPLIER - MODEL	APPLICATION	DELIVERY
Mask Blank Clean	Contrade Verticlean	Wet chemical cleaning of mask substrates	Oct 2003
Mask Flatness Interferometer	Zygo VeriFire MST1550	Mask/substrate flatness	Oct 2003
Phase Microscope/ Interferometer	Zygo NewView 5000	Mid spatial frequency roughness/local slope	Oct 2003
Reticle Sorter	Fala Technologies	Clean transfer between SMIF pods	Nov 2003
X Ray reflectivity	Rigaku GXR300	Characterize multilayer structure, thickness, interfaces	Dec 2003
EUV Reflectometer	EUV Technologies LPR1016-FS1515	Multilayer reflectivity, FWHM, centroid wavelength	Mar 2004

MBDC "Ready For Development" Milestone

- **Purpose of "Ready for Development":**
  - Accelerate transition from startup to development
  - Develop operational policies and procedures
  - Generate clear roles and responsibilities for each team member
- **"Ready for Development" milestone:**
  - We reached "Ready for Development" milestone on 8/4/2003
  - Specifications developed for cleanroom protocol, tool operation
  - Tool product logs implemented.
  - Cleanroom badging, access procedures and training implemented
  - Tool calendars and scheduling implemented
  - Visitor hosting procedures established
  - Experiment template and prioritization/review process implemented
- **We are open for business (albeit with a limited toolset and capability)**

Process cards, logs, numbering (example)

Reticle # 327PHQ10

	Process	Recipe/ Specification	DESCRIPTION
1	Blank Record	Write in the Full title	Quartz test . .. ______-________-_________-
2	Hoya Box 143RD slot 2	Write in all the information	
3	Trans	Place in RSP200	Manual Fala tool
4	Clean	Contrade	
5	Measure	Zygo-Flatness	
6	Inspect	lasertech	
7	Deposit	Veeco	
8	Trans	Fala Auto transfer	
9	Measure	lasertech	
10	Clean	Contrade	
11	Inspect	lasertech	
12	Measure	XRR	

Reticle lot tracking convention

Year	Week	Prime/Test	Supplier	material	plate number
3	27	T	U	Q	10

Year	
2003	3
2004	4
2005	5
2006	6
2007	7

Supplier key		Material Key	
Schott	S		
Hoya	H	ULE	L
Asahi	A	Zerodur	Z
Corning	C	Quartz	Q
Shin-Etsu	E	Unknown	U
Other	O		
Unknown	U		

Number order
10, 11, 12..

Lot number
328TSQ10

Lasertec tool								
Blank lot number	Product/Test	Owner	LOG IN	OPERATOR	LOG OUT	OPERATOR	Purpose	Notes
327PHQ10	Product	John Maltabes	700	JGM	1130	AM	First plate on tracking system	images captured

Technical Progress to Date: EUV Multilayer Deposition Process

- Baseline process has been established
- Tool currently being upgraded with electrostatic substrate holder
- Defect partitioning and analysis has begun

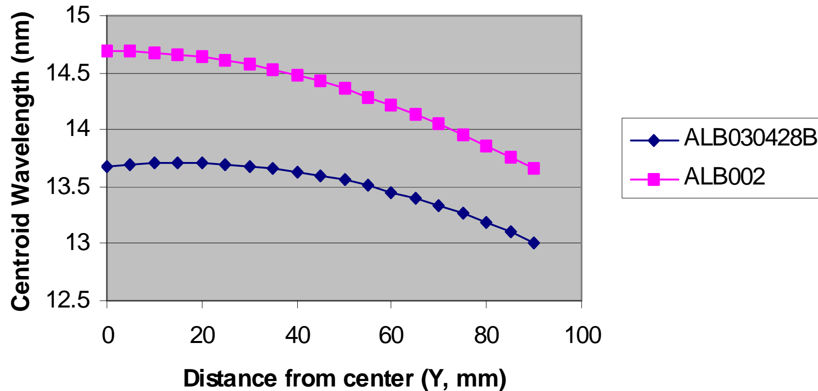
	Reflectance (%)	Centroid (nm)	FWHM
	65.8 +/- **0.075%** 3σ	13.55 +/- **0.012** 3σ	0.53 +/- **0.0021** 3σ
P38-1102 SEMI Standard- class A	0.50%	0.05	0.006

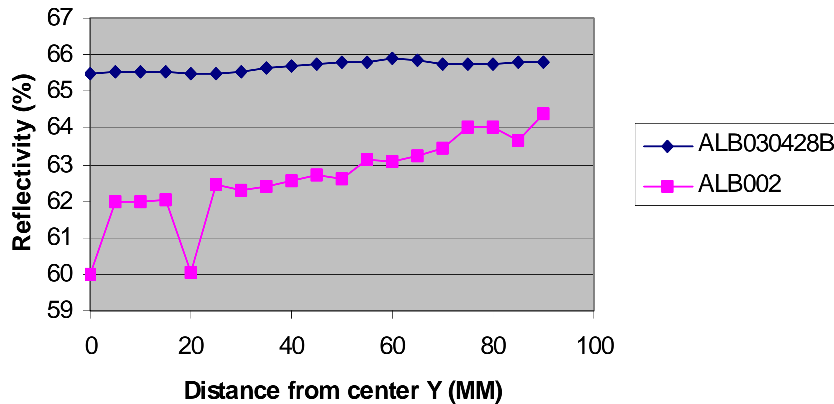
- **We have exceeded P38 SEMI production specifications for reflectance and centroid wavelength uniformity**

EUV Deposition Process Improvement

May 2003

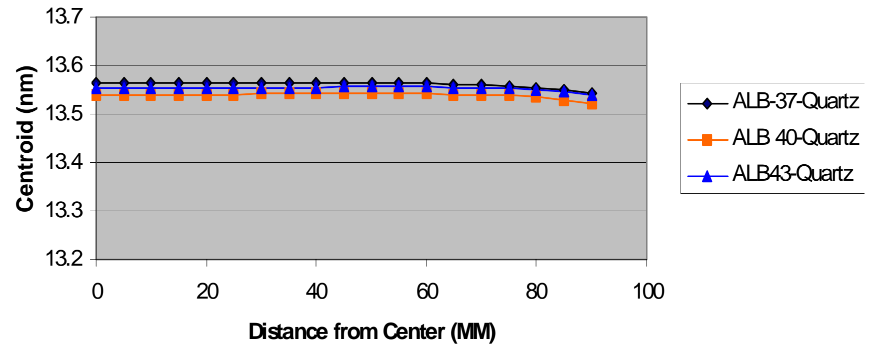
Centroid uniformity = 0.7nm 3sigma

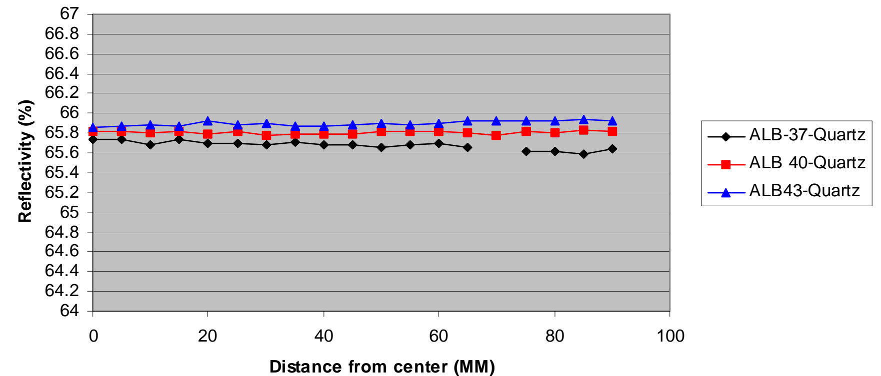




July 2003

Centroid uniformity = 0.01nm 3sigma (Goal < 0.07nm)





INTERNATIONAL SEMATECH Veeco

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Process Repeatability

Silicon Coupons

	Reflectivity	3 Sigma	Centroid	3 Sigma
ALB035	65.23	1.23	13.58	0.0114
ALB036	65.17	1.41	13.57	0.0099
ALB038	65.15	1.59	13.54	0.0129
ALB039	64.64	1.92	13.56	0.0108
ALB041	64.73	1.86	13.56	0.0111
Average	64.984		13.562	
3 sigma	0.83		0.04	

Quartz Substrates

	Reflectivity	3 Sigma	Centroid	3 Sigma
ALB037	65.6	0.123	13.56	0.0168
ALB040	65.8	0.048	13.54	0.015
ALB043	65.89	0.075	13.55	0.0132
Average	65.76333		13.55	
3 sigma	0.45		0.03	

Summary

ISMT's Mask Blank Development Center is open and ready for EUV mask blank development!

Solid results already demonstrated:

- Veeco Nexus Mo/Si multilayer deposition tool has been installed and accepted
  - Repeatable EUV reflectance > 65%
  - Wavelength uniformity 0.012 nm (3σ)
  - Reflectance uniformity 0.075 % (3σ)
- Defect inspection & atomic force microscope qualified.
- Remaining basic metrology toolset to be qualified by EOY2003
- Wet bench to be delivered and qualified for EOY2003
- Staffing and logistics plans on schedule.
- Facility and metrology tool characterizations have begun
- **For more information, or to inquire about access to the facility: Kevin.Kemp@SEMATECH.org or Dave.Krick@SEMATECH.org**