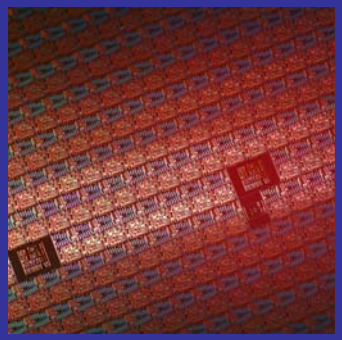
Accelerating the next technology revolution

EUV Mask Readiness Survey

October, 2010



SEMATECH

Scope of Mask Readiness Survey

- Business
- DRAM Pilot line in 2011
- DRAM HVM in 2013
- Logic/MPU in 2013

Participants - Acknowledgement

- Makers (9)
  - AGC
  - Hoya
  - DNP
  - Toppan
  - AMAT
  - KLA
  - Zeiss
  - ASML
  - Nikon
- Users (9)
  - IMEC
  - Selete
  - SEMATECH
  - GlobalFoundries
  - IBM
  - Intel
  - Samsung
  - TSMC
  - UMC

Business Survey Questions

1. Do you believe that commercial blank volume will support demand for DRAM pilot line in 2011, DRAM HVM in 2013, and Logic / MPU Pilot Line in 2013?
2. Do you believe that the rate of learning and capital investments the industry makes support the DRAM pilot line in 2011, DRAM HVM in 2013, and Logic / MPU Pilot Line in 2013?
3. Name the 3 most important issues hindering the industry to meet mask end user demand for DRAM pilot line in 2011, DRAM HVM in 2013, and Logic / MPU Pilot Line in 2013?

Business Survey

1. Do you believe that commercial blank volume will support demand for DRAM pilot line in 2011, DRAM HVM in 2013, and Logic / MPU Pilot Line in 2013?

- Blank suppliers and a few equipment suppliers believe "Yes". Most Consortia, most IDM, and some makers believe volume is OK but not quality within the timeline specified.

Business Survey

2. Do you believe that the rate of learning and capital investments the industry makes support the DRAM pilot line in 2011, DRAM HVM in 2013, and Logic / MPU Pilot Line in 2013?

- Blank makers, some consortia members, and a few makers believe it is sufficient. Majority of IDM and other makers believe the rate is not sufficient.

Business Survey

3. Name the 3 most important issues hindering the industry to meet mask end user demand for DRAM pilot line in 2011, DRAM HVM in 2013, and Logic / MPU Pilot Line in 2013?

- Defect free mask (substrate/blank/pattern mask);
- Mask infrastructure (inspection, AIMS, investment);
- Others:
  - Mask quality (other than defects);
  - Printability;
  - Absorber material uncertainty;
  - Defect free handling (no pellicle);
  - Mask Lifetime (Carbon contamination, backside, radiation induced)

Technical Survey Questions

LTEM SUBSTRATES

Coefficient of Thermal Expansion
Flatness
Defects
Defect Inspection
Defect Analysis
Substrate Cleans

LTEM BLANK

ML Stack Deposition
ML Stack Inspection
Defect Analysis
ML Defect Repair
ML Cleans
Fiducial Mark
Absorber/ARC Cleans
Absorber stack deposition
Film Stress Non-flatness (bow, non-uniform flatness)
Resist

PATTERNING THE MASK

Pattern Write
Image Placement Compensation (3-point mount, non-flatness)
Pattern compensation for off-normal ring-field illumination.
Absorber Etch

MASK PATTERN INSPECTION

Defect Inspection
Image Placement Metrology
CD Metrology
Full-field Actinic Defect Inspection

MASK PATTERN REPAIR

Hard Defect Repair
Phase Defect Repair
Small Field Actinic Inspection

MASK PATTERN CLEAN

Tool/Process
Backside Cleaning
Lifetime, many Cleans cycles

MASK PROTECTION

Substrate / Blank
Handling
Shipping
Storage
Pattern Mask
Handling
Shipping
Storage

EUV EXPOSURE

Clean Air/Vacuum Transfers
Clean Scanning (no pellicle, no carrier)
Front side adders by exposure
Backside adders by exposure tool/chucking
Long term irradiation Lifetime

FAB DEFECT ADDERS

In-fab Defect Inspection
In-fab Cleans

Total in 9 different areas and 43 questions

Scoring: 1 = Read now; 2 = will be ready; 3 = will NOT be ready

DRAM Pilot Line 2011

	Makers	Users	Overall
LTEM SUBSTRATES			
Coefficient of Thermal Expansion	1.25	1.00	1.18
Flatness	2.44	2.33	2.42
Defects	2.44	2.33	2.42
Defect Inspection	2.22	2.67	2.33
Defect Analysis	2.11	2.00	2.08
Substrate Cleans	1.88	2.00	1.90
LTEM BLANK			
ML Stack Deposition	2.00	1.25	1.77
ML Stack Inspection	2.22	2.75	2.38
Defect Analysis	2.33	2.25	2.31
ML Defect Repair	2.89	2.75	2.85
ML Cleans	1.89	2.00	1.92
Fiducial Mark	2.44	3.00	2.58
Absorber/ARC Cleans	1.89	1.67	1.83
Absorber stack deposition	1.78	1.75	1.77
Film Stress Non-flatness (bow, non-uniform flatness)	2.22	2.33	2.25
Resist	2.14	1.33	1.90

- Substrate
  - OK
    - CTE,
    - Clean
  - Not OK
    - Flatness
    - Defects
    - Inspection
- LTEM Blank
  - OK
    - ML & Absorber depo, ML & Absorber clean
  - Not OK
    - ML inspection, defect analysis, repair, FM,

DRAM Pilot Line 2011

	Makers	Users	Overall
PATTERNING THE MASK			
Pattern Write	1.44	2.00	1.62
Image Placement Compensation (3-point mount, non-flatness)	2.00	2.00	2.00
Pattern compensation for off-normal ring-field illumination.	2.00	1.33	1.82
Absorber Etch	1.78	1.50	1.69
MASK PATTERN INSPECTION			
Defect Inspection	2.11	1.75	2.00
Image Placement Metrology	1.67	1.50	1.62
CD Metrology	1.56	1.25	1.46
Full-field Actinic Defect Inspection	3.00	3.00	3.00
MASK PATTERN REPAIR			
Hard Defect Repair	1.78	2.00	1.85
Phase Defect Repair	2.89	3.00	2.92
Small Field Actinic Inspection	3.00	3.00	3.00
MASK PATTERN CLEAN			
Tool/Process	1.89	2.00	1.92
Backside Cleaning	2.00	1.67	1.92
Lifetime, many Cleans cycles	2.33	2.33	2.33

- OK
  - Patterning mask
  - Pattern Mask Inspection
  - Placement
  - CD
  - Pattern mask front and back clean
- Not OK
  - Actinic Pattern Mask Inspection
  - Actinic Defect Review
  - Mask Lifetime

DRAM Pilot Line 2011

	Makers	Users	Overall
MASK PROTECTION			
Substrate / Blank			
Handling	1.89	2.00	1.92
Shipping	1.89	1.75	1.85
Storage	2.00	1.75	1.92
Pattern Mask			
Handling	2.00	1.75	1.92
Shipping	2.00	1.50	1.85
Storage	2.11	1.75	2.00
EUV EXPOSURE			
Clean Air/Vacuum Transfers	1.75	2.00	1.82
Clean Scanning (no pellicle, no carrier)	2.14	1.67	2.00
Front side adders by exposure	2.14	2.00	2.09
Backside adders by exposure tool/chucking	2.29	2.25	2.27
Long term irradiation Lifetime	2.43	2.33	2.40
FAB DEFECT ADDERS			
In-fab Defect Inspection	2.43	2.67	2.50
In-fab Cleans	2.57	2.33	2.50

OK

- Mask Protection in general

Not OK

- Long term irradiation lifetime
- In-Fab adders

DRAM HVM 2013

	Makers	Users	Overall
LTEM SUBSTRATES			
Coefficient of Thermal Expansion	1.44	1.00	1.33
Flatness	2.38	2.00	2.27
Defects	2.50	2.33	2.45
Defect Inspection	2.33	2.67	2.42
Defect Analysis	2.13	2.00	2.09
Substrate Cleans	1.86	2.00	1.89
LTEM BLANK			
ML Stack Deposition	1.78	2.00	1.85
ML Stack Inspection	2.33	2.50	2.38
Defect Analysis	2.25	2.00	2.17
ML Defect Repair	2.67	2.50	2.62
ML Cleans	1.89	2.00	1.92
Fiducial Mark	2.44	2.00	2.33
Absorber/ARC Cleans	1.89	2.00	1.92
Absorber stack deposition	1.78	2.00	1.85
Film Stress Non-flatness (bow, non-uniform flatness)	2.25	2.00	2.18
Resist	2.13	1.67	2.00

- Substrate
  - OK
    - CTE, Clean
  - Not OK
    - Defects
    - Inspection
- LTEM Blank
  - OK
    - ML & Absorber depo
    - ML & Absorber clean
  - Not OK
    - ML inspection, repair, FM,

DRAM HVM 2013

	Makers	Users	Overall
PATTERNING THE MASK			
Pattern Write	1.50	2.00	1.67
Image Placement Compensation (3-point mount, non-flatness)	1.67	2.00	1.77
Pattern compensation for off-normal ring-field illumination.	1.88	1.67	1.82
Absorber Etch	1.67	2.00	1.77
MASK PATTERN INSPECTION			
Defect Inspection	2.00	2.00	2.00
Image Placement Metrology	1.67	1.75	1.69
CD Metrology	1.44	1.50	1.46
Full-field Actinic Defect Inspection	3.00	3.00	3.00
MASK PATTERN REPAIR			
Hard Defect Repair	1.56	1.75	1.62
Phase Defect Repair	2.56	2.75	2.62
Small Field Actinic Inspection	2.78	2.50	2.69
MASK PATTERN CLEAN			
Tool/Process	1.67	2.00	1.75
Backside Cleaning	1.78	2.00	1.83
Lifetime, many Cleans cycles	2.13	2.00	2.09

- Everything seems to be OK except
  - Actinic Pattern Mask Inspection
  - Actinic Defect Review
  - Phase Repair

DRAM HVM 2013

	Makers	Users	Overall
MASK PROTECTION			
Substrate / Blank			
Handling	1.89	2.00	1.92
Shipping	1.89	1.75	1.85
Storage	1.89	1.75	1.85
Pattern Mask			
Handling	1.89	1.75	1.85
Shipping	1.89	1.50	1.77
Storage	1.89	1.50	1.77
EUV EXPOSURE			
Clean Air/Vacuum Transfers	1.75	2.00	1.82
Clean Scanning (no pellicle, no carrier)	1.86	2.00	1.90
Front side adders by exposure	1.86	2.00	1.91
Backside adders by exposure tool/chucking	2.00	2.00	2.00
Long term irradiation Lifetime	2.29	2.33	2.30
FAB DEFECT ADDERS			
In-fab Defect Inspection	2.43	2.33	2.40
In-fab Cleans	2.43	2.00	2.30

- Everything is OK except
  - Long term irradiation lifetime
  - In Fab defect inspection
  - In Fab Clean?

Logic / MPU Pilot Line 2013

	Makers	Users	Overall
LTEM SUBSTRATES			
Coefficient of Thermal Expansion	1.44	1.50	1.47
Flatness	2.38	2.13	2.25
Defects	2.50	2.38	2.44
Defect Inspection	2.33	2.38	2.35
Defect Analysis	2.13	2.00	2.07
Substrate Cleans	1.86	2.14	2.00
LTEM BLANK			
ML Stack Deposition	1.78	2.00	1.89
ML Stack Inspection	2.33	2.67	2.50
Defect Analysis	2.25	2.14	2.20
ML Defect Repair	2.67	2.78	2.72
ML Cleans	1.89	2.00	1.94
Fiducial Mark	2.44	2.00	2.24
Absorber/ARC Cleans	1.89	1.63	1.76
Absorber stack deposition	1.78	1.44	1.61
Film Stress Non-flatness (bow, non-uniform flatness)	2.25	2.00	2.13
Resist	2.13	1.50	1.81

- Not OK
  - Substrate Inspection
  - Defect level
  - Defect analysis
  - Substrate Inspection
  - ML defect repair

Logic / MPU Pilot Line 2013

	Makers	Users	Overall
PATTERNING THE MASK			
Pattern Write	1.50	1.67	1.59
Image Placement Compensation (3-point mount, non-flatness)	1.67	1.78	1.72
Pattern compensation for off-normal ring-field illumination.	1.88	1.86	1.87
Absorber Etch	1.67	1.56	1.61
MASK PATTERN INSPECTION			
Defect Inspection	2.11	1.78	1.94
Image Placement Metrology	1.67	1.44	1.56
CD Metrology	1.44	1.33	1.39
Full-field Actinic Defect Inspection	3.00	3.00	3.00
MASK PATTERN REPAIR			
Hard Defect Repair	1.56	1.67	1.61
Phase Defect Repair	2.56	2.78	2.67
Small Field Actinic Inspection	2.78	2.44	2.61
MASK PATTERN CLEAN			
Tool/Process	1.78	2.00	1.88
Backside Cleaning	1.78	1.75	1.76
Lifetime, many Cleans cycles	2.13	2.00	2.06

- Everything seems to be OK except
  - Actinic Pattern Mask Inspection
  - Actinic Defect Review
  - Phase Repair

Logic / MPU Pilot Line 2013

	Makers	Users	Overall
MASK PROTECTION			
Substrate / Blank			
Handling	1.89	1.89	1.89
Shipping	1.89	1.56	1.72
Storage	1.89	1.67	1.78
Pattern Mask			
Handling	1.89	1.89	1.89
Shipping	1.89	1.56	1.72
Storage	1.89	1.67	1.78
EUV EXPOSURE			
Clean Air/Vacuum Transfers	1.63	2.00	1.81
Clean Scanning (no pellicle, no carrier)	1.86	2.00	1.93
Front side adders by exposure	1.86	2.11	2.00
Backside adders by exposure tool/chucking	2.00	2.22	2.13
Long term irradiation Lifetime	2.29	2.00	2.13
FAB DEFECT ADDERS			
In-fab Defect Inspection	2.43	2.00	2.20
In-fab Cleans	2.43	2.00	2.20

- Everything looks OK

Top issues (Score > 2.3) Mitigation

From Highest to Lowest

DRAM Pilot Line in 2011	DRAM HVM in 2013	Logic/MPU in 2013
Full-field Actinic Defect Inspection	Full-field Actinic Defect Inspection	Full-field Actinic Defect Inspection
Small Field Actinic Inspection	Small Field Actinic Inspection	ML Defect Repair
Phase Defect Repair	ML Defect Repair	Phase Defect Repair
ML Defect Repair	Phase Defect Repair	Small Field Actinic Inspection
Fiducial Mark	Defects - Sub	ML Stack Inspection
In-fab Defect Inspection	Defect Inspection - Sub	Defects - Sub
In-fab Cleans	In-fab Defect Inspection	Defect Inspection - Sub
Flatness - Sub	ML Stack Inspection	
Defects - Sub	Fiducial Mark	
Long term irradiation Lifetime		
ML Stack Inspection		
Defect Inspection - Sub		
Lifetime, many Cleans cycles		
Defect Analysis - BL		

- Top 4 issues remain unchanged for the next 3 years. EMI is addressing small field actinic inspection, ML stack inspection, and PMI.
- DRAM Pilot line relies on existing infrastructure and tolerate some defects. Mitigation strategy such as FM needed. In fab inspection and clean are important. Mask lifetime is of concern.
- Substrate defect and inspection will remain as issue and become more important during DRAM HVM and Logic pilot line production in 2013.