Development of Mask Contamination/Inspection System by coherent EUV light

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Outline

- EUVL Test Bed – Infrastructure for development of EUVL
  - Introduction of EUVL beamline @ Pohang Light Source.
- Mask Contamination/Inspection System
  - What is it's concept?
  - Optical design for mask contamination/inspection system
  - Test results
  : In-situ mask contamination analysis
  : mask inspection - Light source alignment & Noise reduction
- Summary

EUVL R&D program

Development of the Core EUVL technology for 22 nm node

EUVL R&D Program

- **Mask Fabrication**
  - Multilayer
  - Absorber stack
  - Patterning
  - PSM
  - Metrology
  - SAMSUNG ELECTRONICS
  - HANYANG UNIVERSITY
  - SUNG KYUN KWAN UNIVERSITY
  - INHA UNIVERSITY
- **EUV Resist**
  - Resist design
  - Characterization
  - Simulation
  - DONGJIN SEMICHEM CO.,LTD.
  - HANYANG UNIVERSITY
- **Mask Cleaning**
  - UV-LSC Equip.
  - Cleaning process
  - Evaluation
  - iMT /주/아이엠티 Innovative Manufacturing Technology
  - OSTECH
  - HANYANG UNIVERSITY
- **Infrastructure**
  - MET
  - Out-gassing
  - AIMS
  - Reflectometer
  - CSM
  - *National Center For Nanomaterials Technology*
  - HANYANG UNIVERSITY
  - MOCIE / National Center for Nanomaterials Technology
  - PAL 포항가속기연구소 POHANG ACCELERATOR LABORATORY
  - OSTECH

EUVL Test Bed

EUVL Test Bed – development target

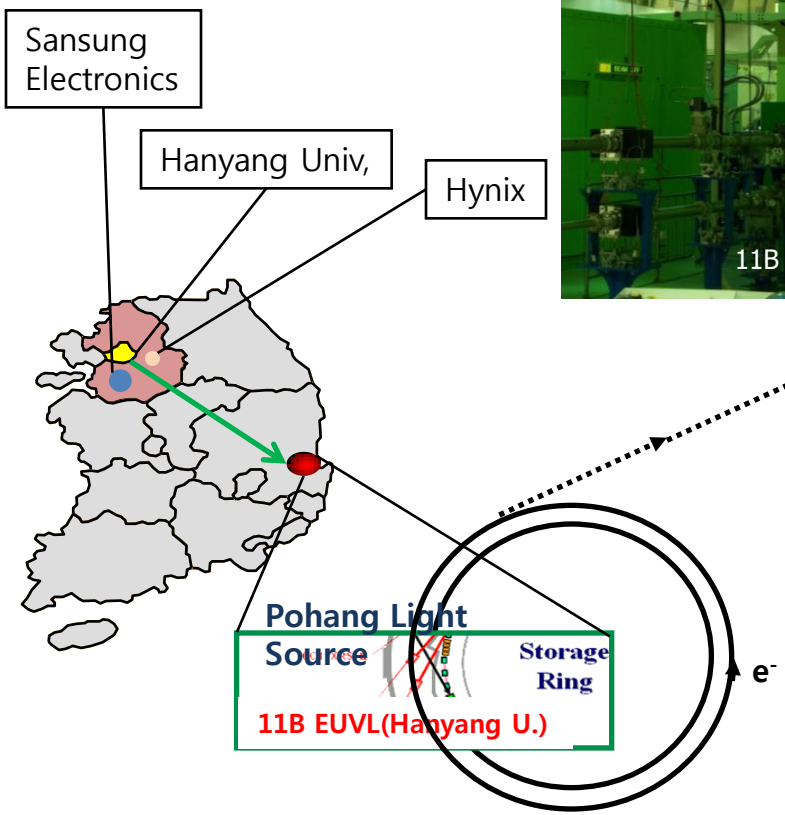
EUV Focus Areas 2003-2008

SEMATECH

2003	2004	2005	2006	2007	2008
1. Source power and lifetime including condenser optics lifetime	1. Availability of defect free mask	1. Resist resolution, sensitivity & LER met simultaneously	1. Reliable high power source & collector module	1. Reliable high power source & collector module	1. Long-term source operation with 100 W at IF and 5MJ/day
2. Availability of defect free mask	2. Lifetime of source components & collector optics	2. Collector lifetime	2. Resist resolution, sensitivity & LER met simultaneously	2. Resist resolution, sensitivity & LER met simultaneously	2. Defect free masks through lifecycle & inspection/review infrastructure
3. Reticle protection during storage, handling and use	3. Resist resolution, sensitivity & LER met simultaneously	3. Availability of defect free mask	3. Availability of defect free mask	3. Availability of defect free mask	3. Resist resolution, sensitivity & LER met simultaneously
4. Projection and illuminator optics lifetime	• Reticle protection during storage, handling and use	4. Source power	4. Reticle protection during storage, handling and use	4. Reticle protection during storage, handling and use	• Reticle protection during storage, handling and use
5. Resist resolution, sensitivity and LER	• Source power	• Reticle protection during storage, handling and use	5. Projection and illuminator optics quality & lifetime	5. Projection and illuminator optics quality & lifetime	• Projection / illuminator optics and mask lifetime
6. Optics quality for 32-nm half-pitch node	• Projection and illuminator optics lifetime	• Projection and illuminator optics quality & lifetime			

Source: 2008 EUVL Symposium

EUVL Test Bed – Infrastructure for EUVL



Recent performance.
ICS/CSM to investigate mask life time issue related with C contamination

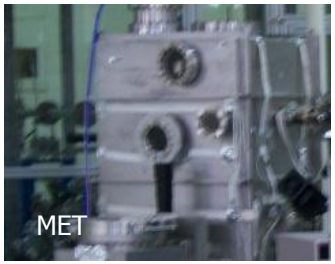
Micro Exposure Tool
: Run / 2007 1st setup

Mask Contamination /Inspection system
: 2009 3th setup

Resist evaluastion system
: Run / 2006 4th setup

Reflectometer / IL
: Run / 2008 1st setup

AIMS
: 2008 2nd setup



EUVL Test Bed – Recent progress

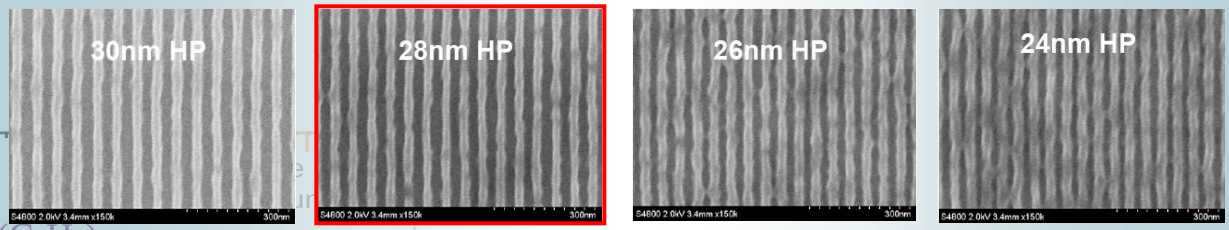
Unit	Resolution	Photo-speed (@50nm, L/S)	LER (@50nm)
07' 4Q	< HP 32 nm	20.0 mJ	5.9 nm
08' 2Q	HP 28 nm	6.2 mJ	5.3 nm

LBNL test results

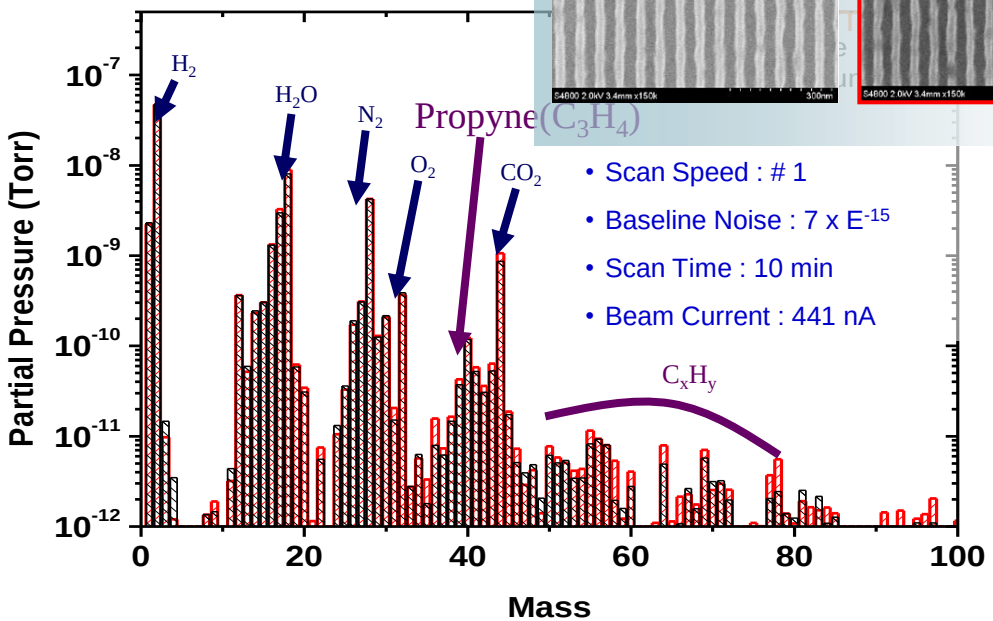
Exposure : LBNL MET
Illumination : Ann (0.3/0.55)
Inspection : L/S 1:1

Film Thickness : 50nm

Dongjin DHE-1158



2008.05. LBNL test result

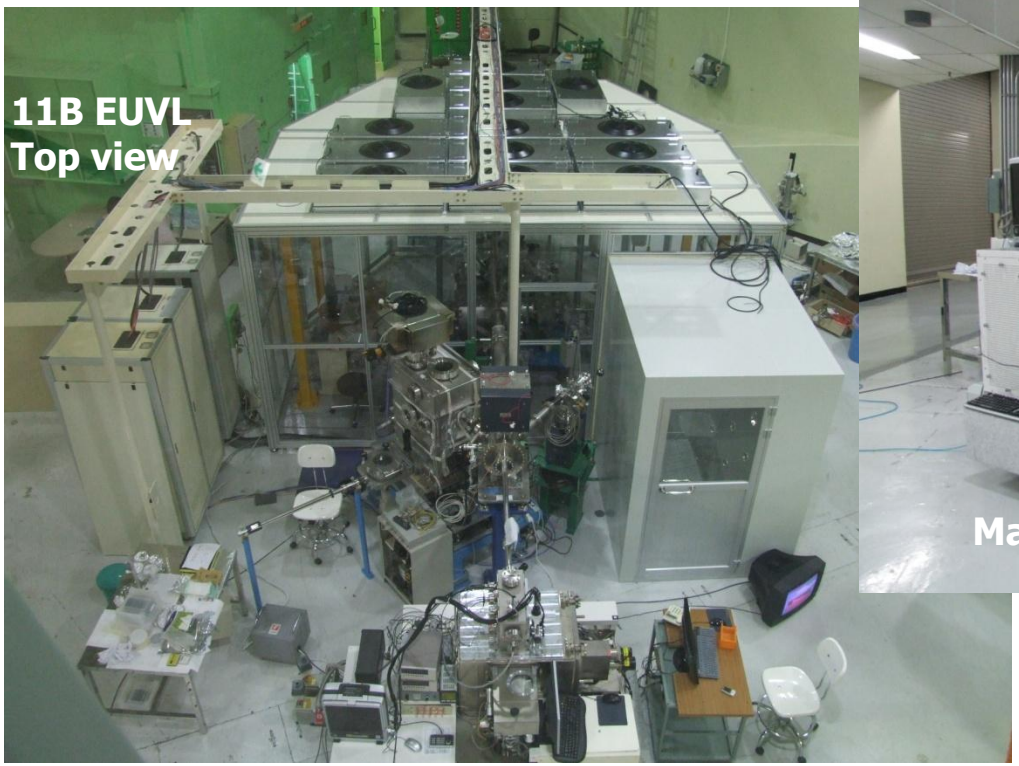


Resist outgassing test result
-> Dongjin EUV resist evaluation

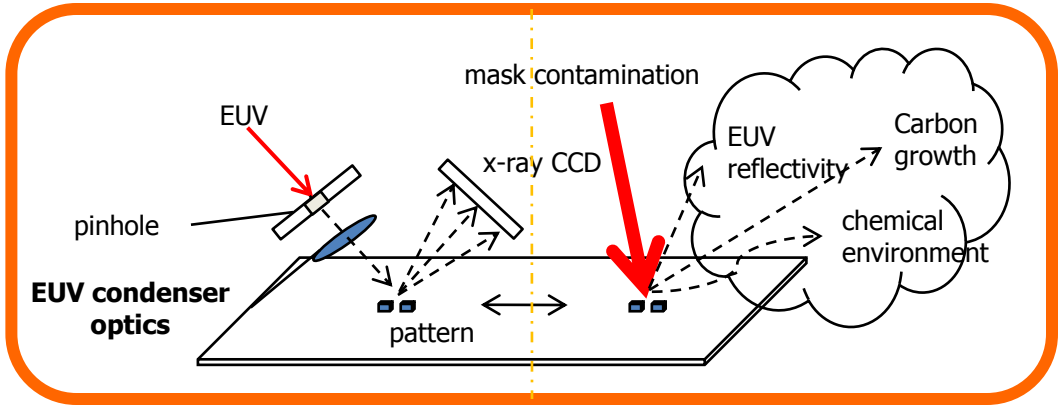
EUVL Test Bed – new challenge (mask inspection)

1. EUV mask analysis (CD, H-V bias)
2. In-situ mask contamination & analysis (reflectance, carbon thickness)

In-situ measurement of mask contamination effect on the imaging performance



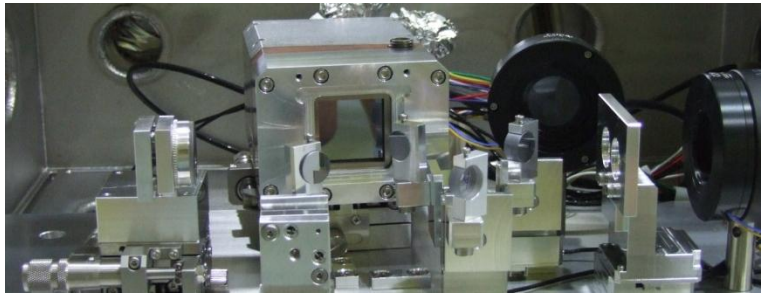
Mask Contamination/Inspection System



EUV CSM
-EUV coherent scattering microscopy
-Mask image reconstruction using EUV diffraction beam
-Critical dimension (CD) measurement

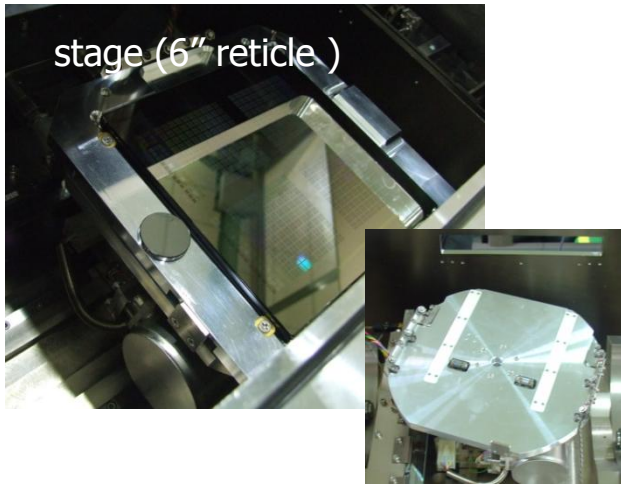
In-situ contamination system
- Exposure acceleration system
- ML reflectance & carbon thin film thickness measurement(In-situ spectroscopic ellipsometer)
- Exposure environment optimization for lower contamination

Mask Contamination/Inspection System

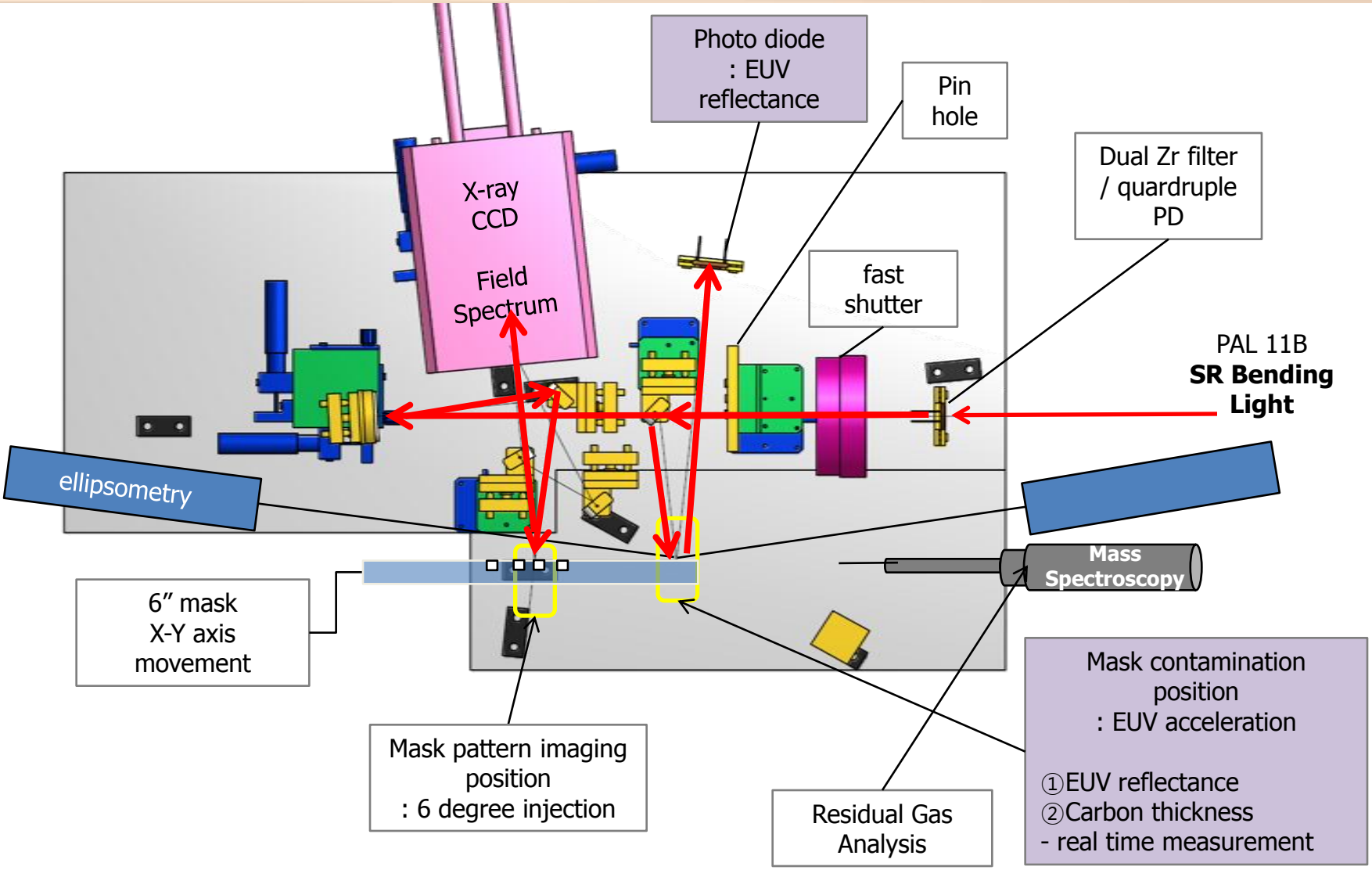


X-ray CCD camera
: Pixel - 2048 X 2048 imaging array
Pixel size – 13.5 X 13.5 um^2
Imaging area – 27.6 X 27.6 mm^2
Vacuum compatible

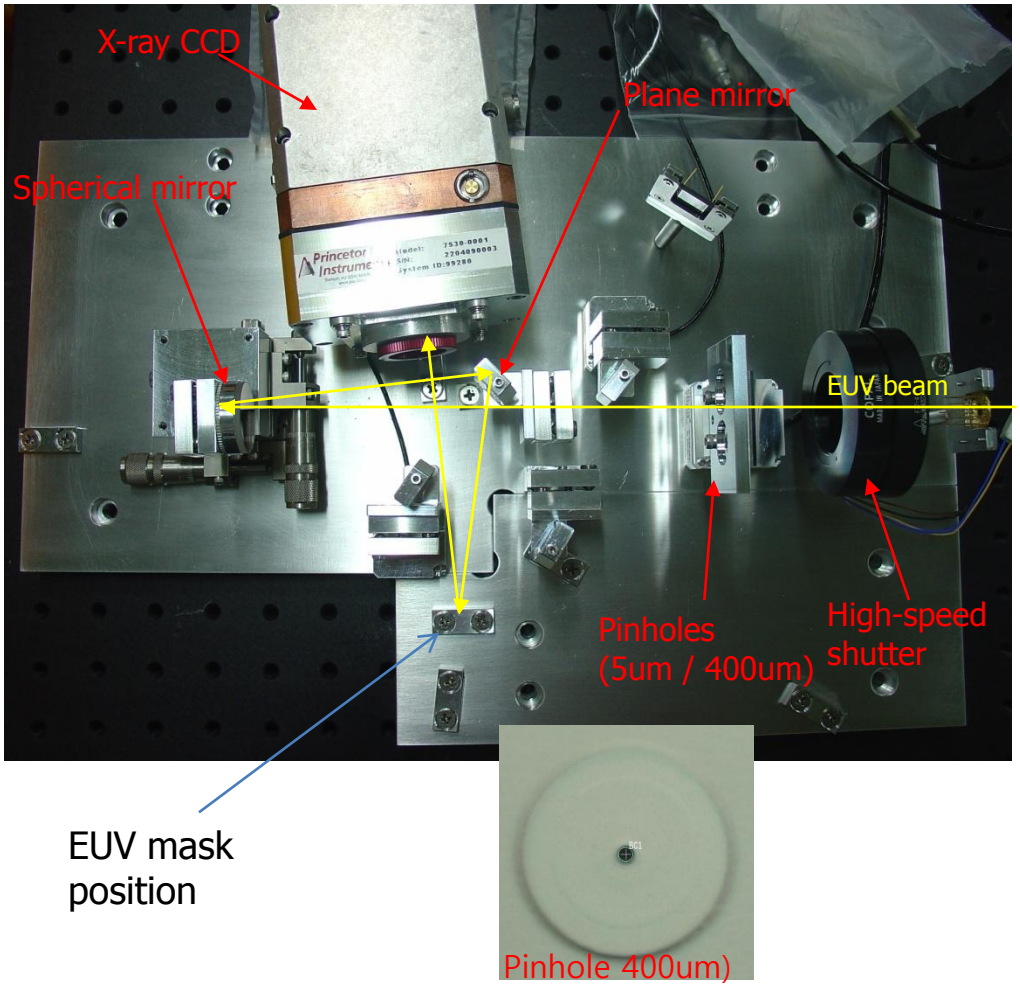
microscope
: 85mm beam distance
X 5000 zoom



Optical design for Mask Contamination/Inspection System

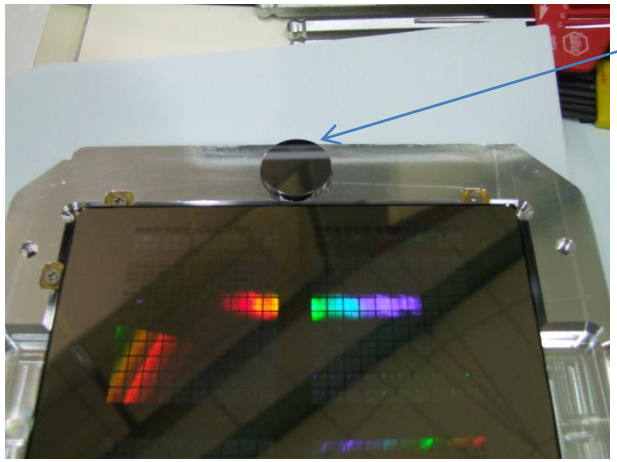


Optical design for Mask Contamination/Inspection System



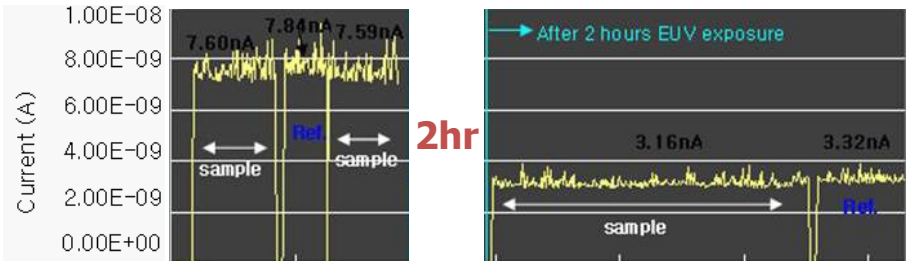
	Optics Name	Size	Radius of Curvature(mm)	Beam incidence angle to optics (deg.)
1	Pinhole	5 (um)	inf.	0
2	Spherical mirror	1''	165	3
3	Plane mirror	1/2''	inf.	39
4	Mask	6''	inf.	6
5	CCD center	1''	inf.	0
6	Plane mirror for imaging	1/2''	inf.	26
7	Spherical mirror for imaging	1/2''	88	16
8	Mirror for acceration	1/2''	inf.	42
9	Mask	6''	inf.	6
10	Reference mirror	1''	inf.	6
11	Photodiode-2nd(sqar)	10 mm	inf.	0
12	Photodiode-1st(quad)	10 mm	inf.	0

Mask Contamination Analysis

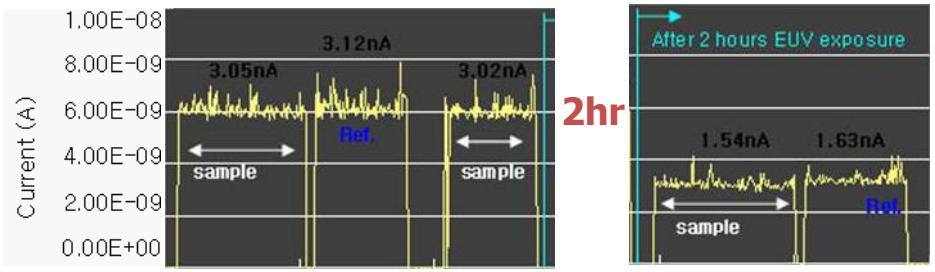


1. Reference ML mirror
2. EUV mask acceleration test
(XX hours) : Change of EUV reflectance
Carbon thin film thickness

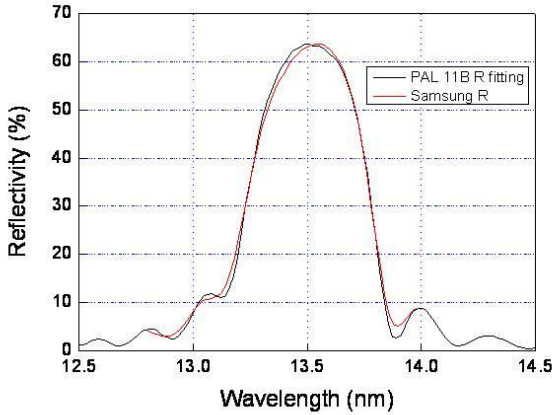
*** EUV acceleration, 2hr**



Blank mask (A) : 1.85% Reflectivity Drop

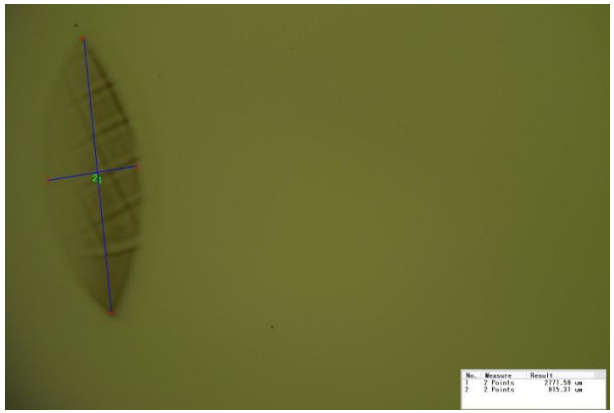


Blank mask (B): 2.92% Reflectivity Drop



EUV reflectometer

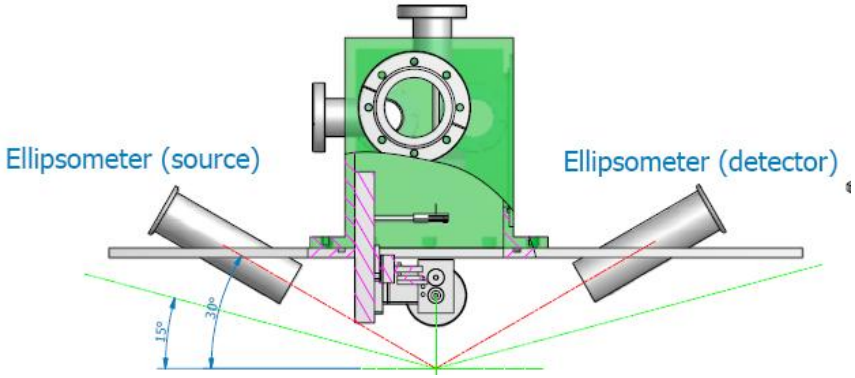
Mask Contamination Analysis - ellipsometry

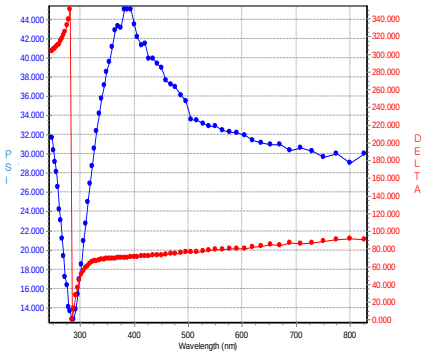


Carbon contamination image
(Measurement of In-situ microscope)

: Si capping mirror

EUV expose : 2hr
Thickness : ~420 A
n : 1.6 k : 0.0 @ λ = 633nm

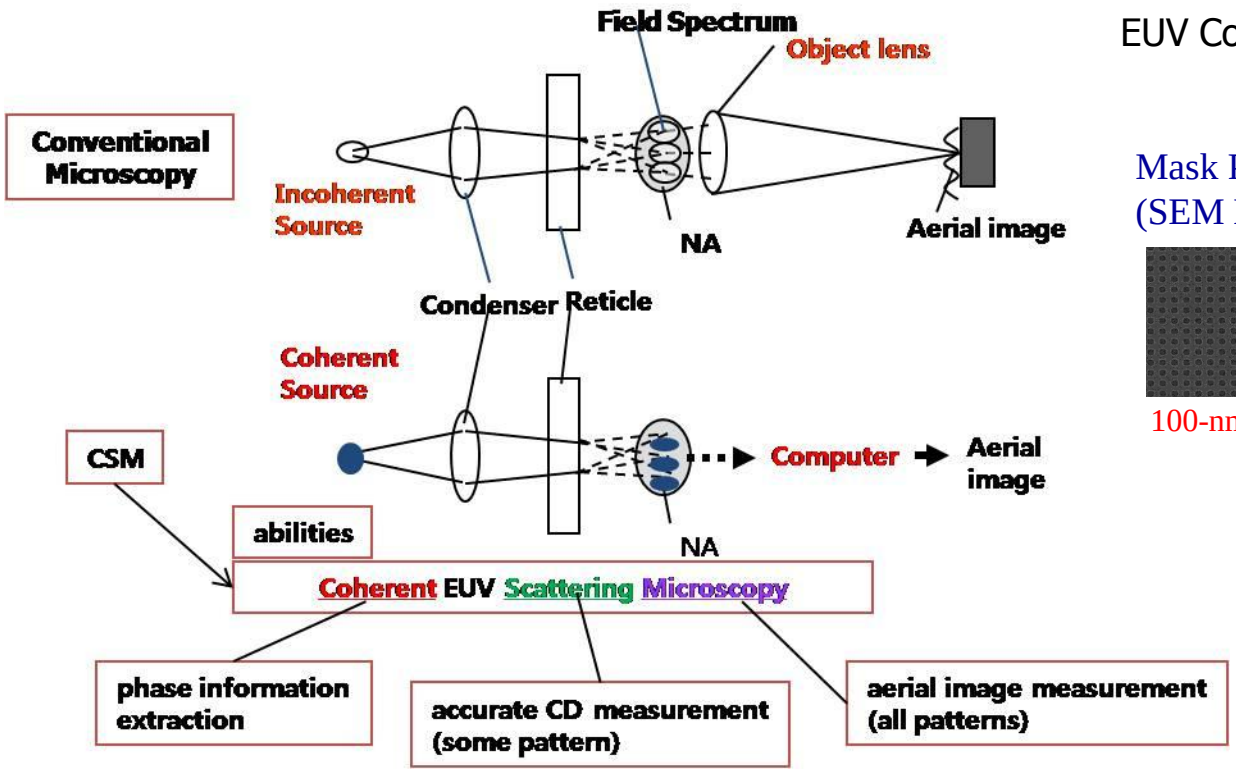




50μm ~ 1 mm beam diameter
In-situ measurement
: carbon thickness

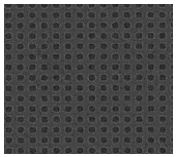
65º incident angle

Development of Coherent Scattering Microscopy

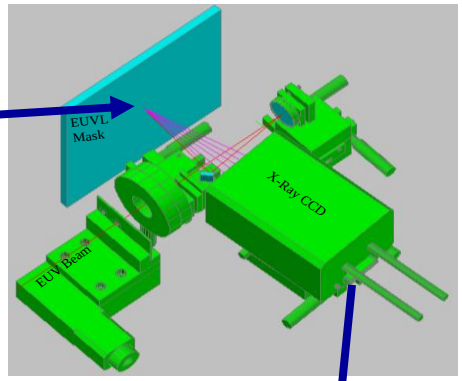


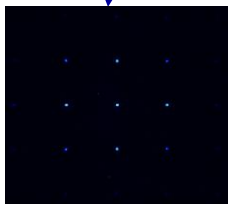
EUV Coherent Scattering Microscopy

Mask Pattern (SEM Image)



100-nm (4X)

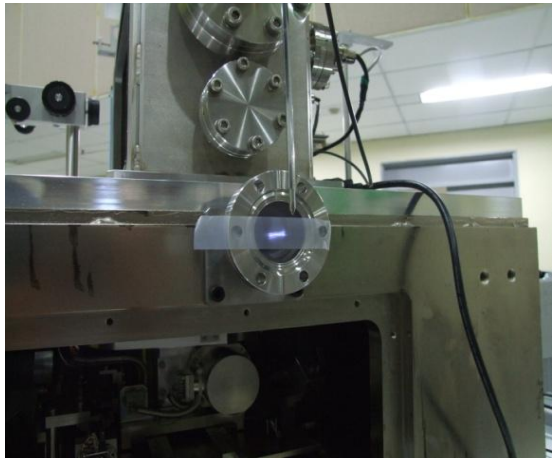


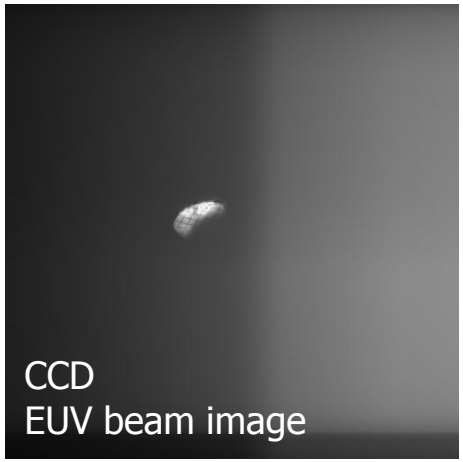


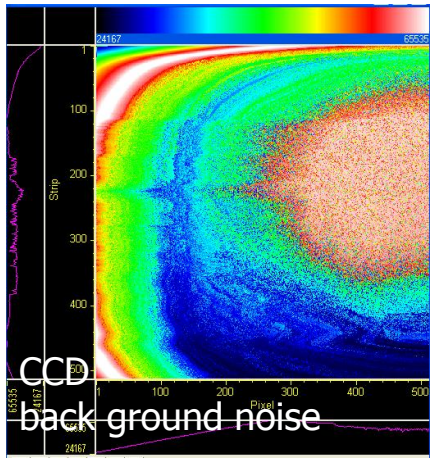
Field Spectrum Measurements

Source : EUV symposium 2008
Donggun Lee., et al

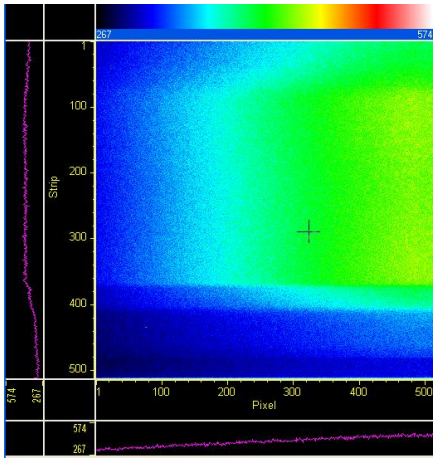
Beam alignment & noise reduction



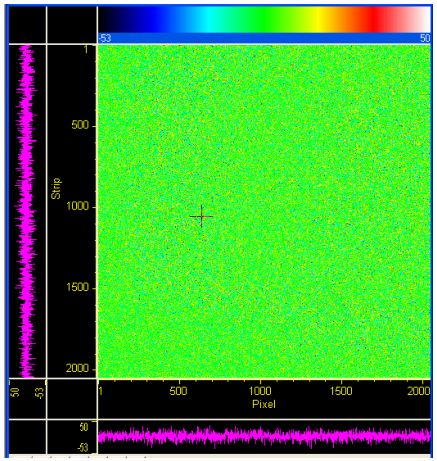




remove noise source



back ground subtraction



Summary

We set up Mask Contamination/Inspection system at PAL.

Our system will help to quantize and correlate the degree of contamination and the degradation of mask performance.

Acknowledgements

The authors would like to thanks the team of Korean EUVL society.

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