EUVL Researl Regional Update - Taiwan

Investigations on extreme ultraviolet lithography (EUVL) **II** (3/3)

- from beamline construction, masks, materials, processes, to reliability of nano devices

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總計畫主持人　黃遠東教授/交通大學電子工程系

Light Source

- 許博淵/同步輻射研究中心 副研
- 馮學深/同步輻射研究中心/副研

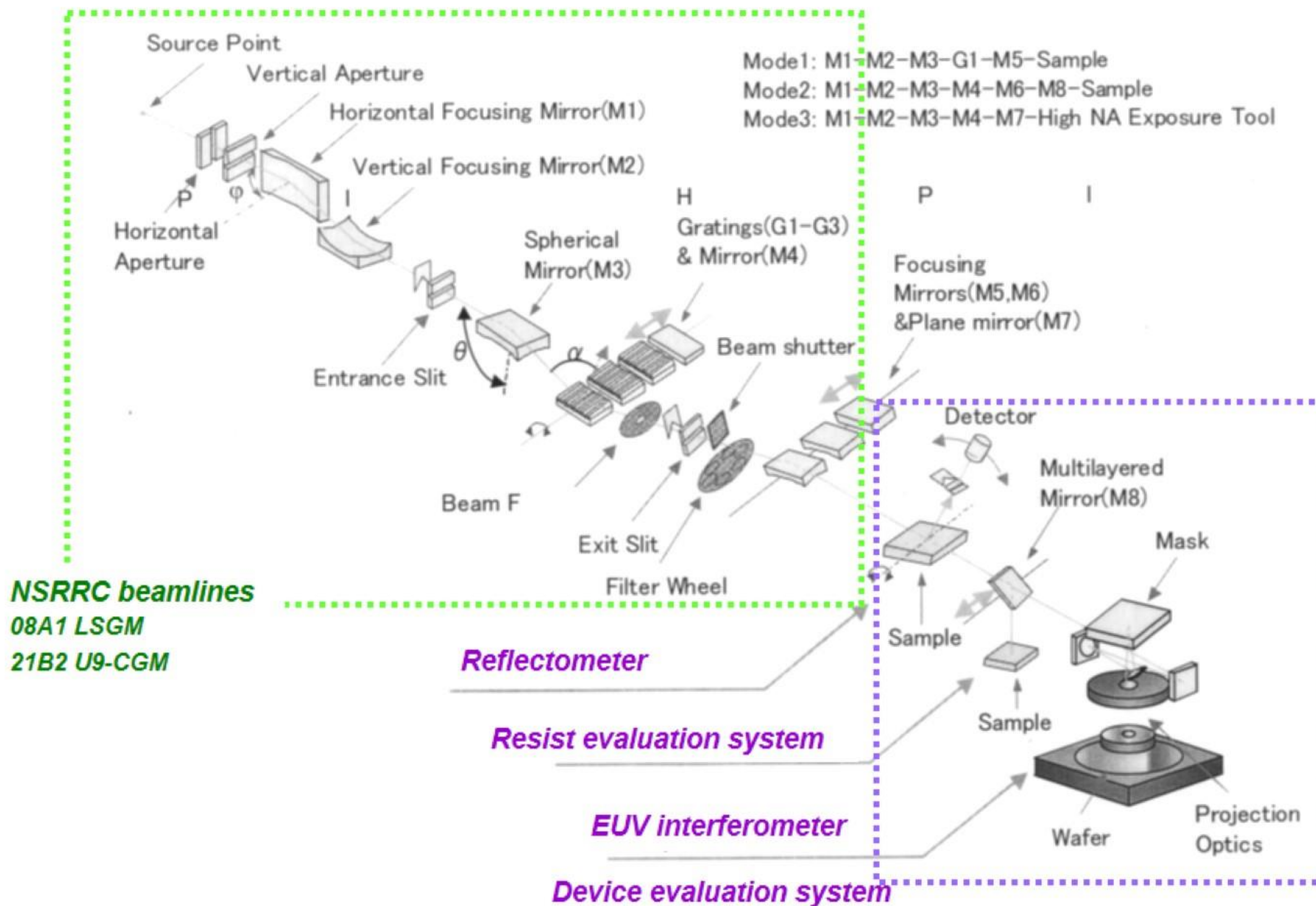
Metrology

- 黃遠東/交大電子系 教授
- 鄭秀英/高大應化系/副教授
- 蔡坤諭/台大電機系副教授
- 李佳翰/台大工科系副教授
- 林俊宏/成大光電所副教授
- 蕭建男/儀科中心/研究員

EUV Applications

- 崔秉鉞/交大電子系 教授
- 劉致為/台大光電所 教授
- 陳仕鴻/奈米元件實驗室 研究員

Phase I Review (2008.08-2011.07)



Phase I Review-2

(A) Reflectometer
- *nkt measurement*
- *resist evaluation*
- *mask/optics calibration*

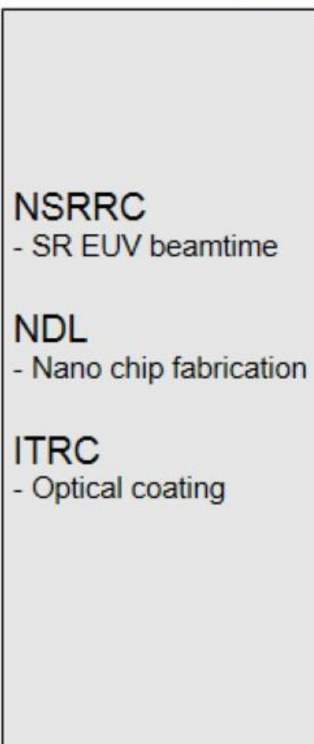
(B) Resist evaluation
- *for outgassing study*
- *new resist evaluation*
- *new resist development*
- *optics contamination study*

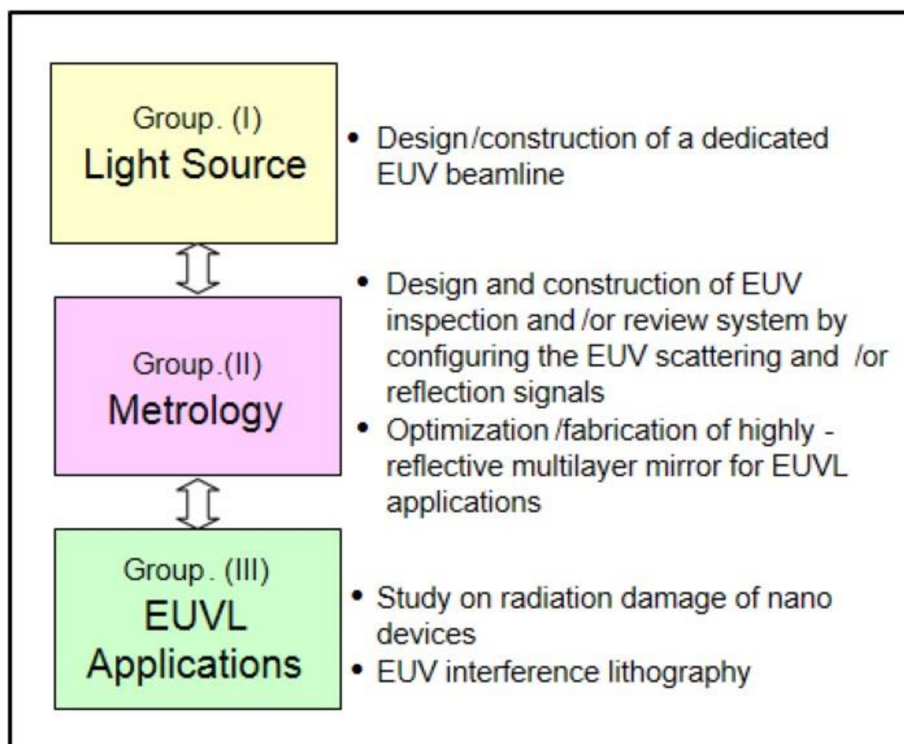
(C) Interference Lithography
- *new resist evaluation*
- *Nano device fabrication*
- *Mix/match lithography study*

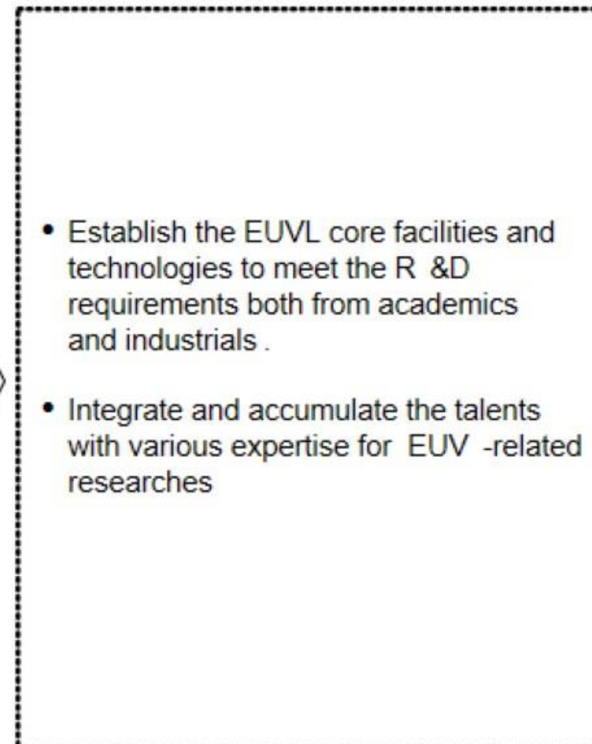
(D) Device evaluation
- *radiation damage*
- *anti-reflection coating*
- *device evaluation*

- ***Initiated the EUVL research at Taiwan***
- ***Several major endstations and technologies established***
- ***More than 20 papers published***
- ***Join-development projects with industries (TSMC, ASML, Nissan Chemical)***

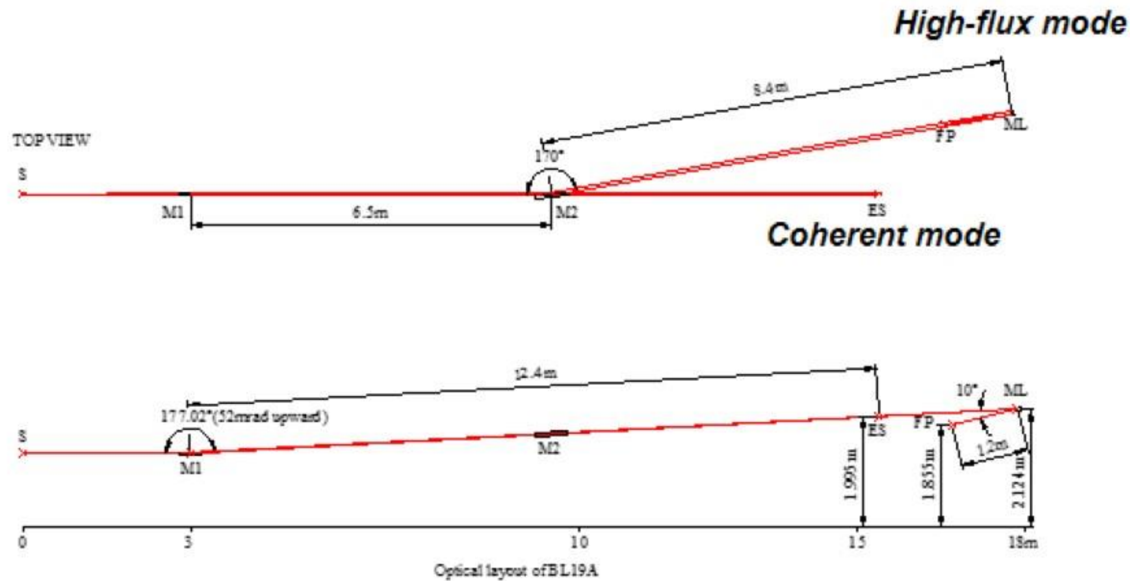
EUVL Phase II Project Outlook







Key Results (1. Light source)
- Construction of the EUV Beamline



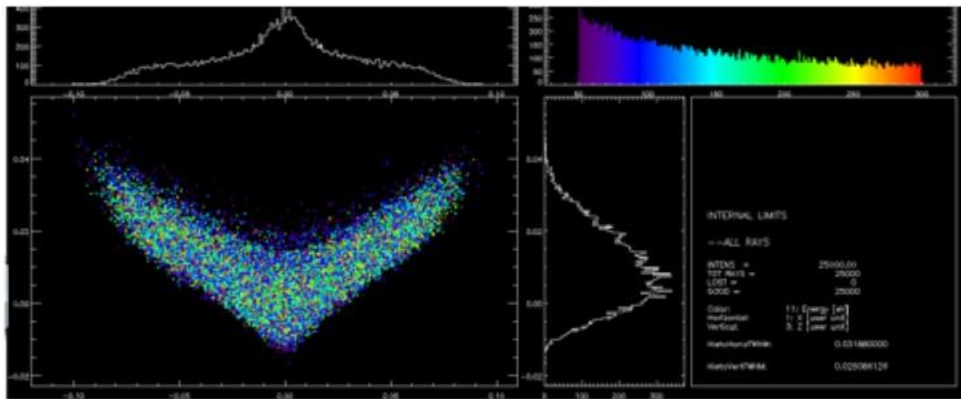
Optical layout of BL19A

- *The beamline can be switched and operated in two modes:*

  ***Coherent mode** for inspection study*

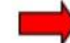
  ***High-flux mode** for outgassing and radiation damage study.*

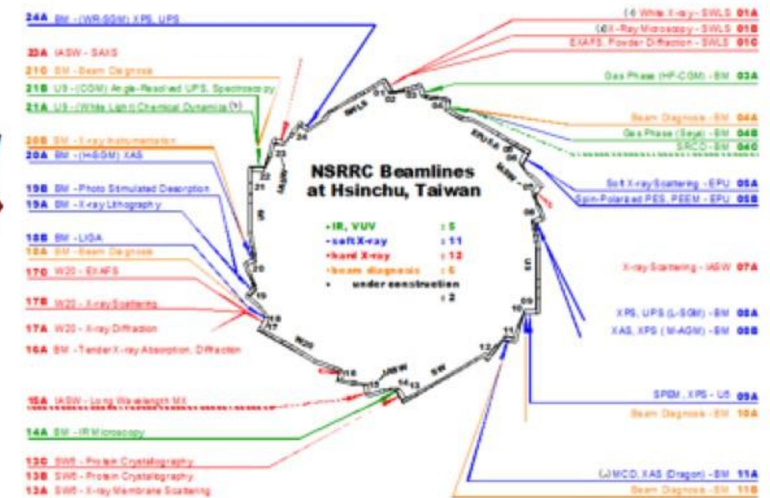
- *the beamline has been constructed.*
  - *Benchmarking with LBNL*



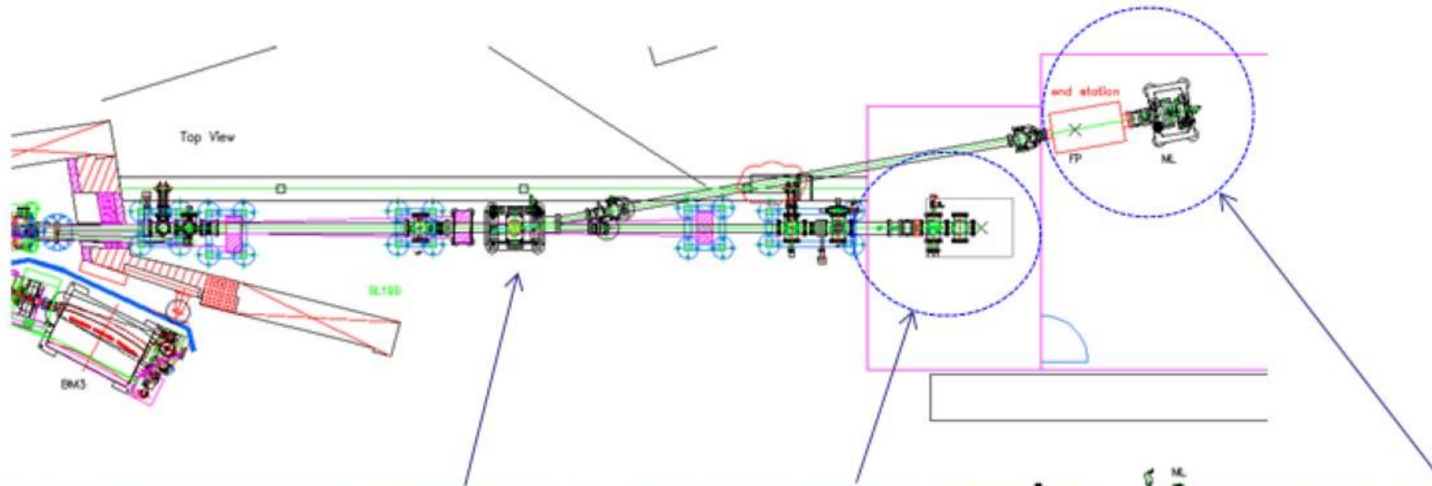
- *ray tracing*

19A1



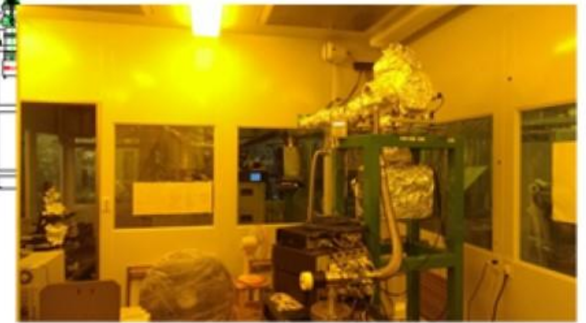


Key Results (1. Light source)
- Construction of the EUV Beamline



• beamline

• inspection endstation



• Outgassing/radiation damage endstation

Commission results:

- Focused beam size: 0.4 mm x 0.3 mm
- Photon flux: 3×10^{13} photons/sec (@1.5GeV/360mA)

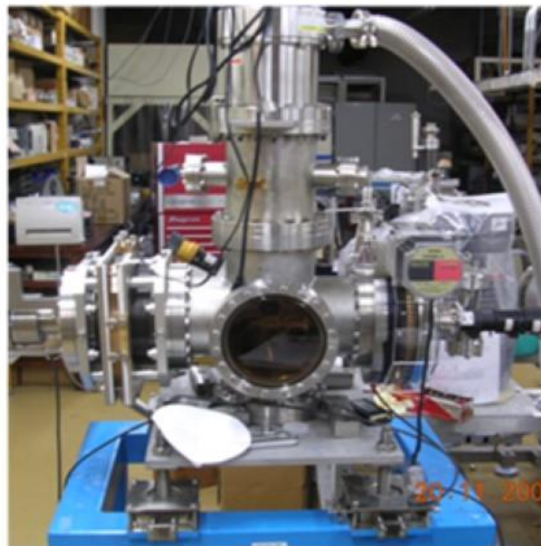
Key Results (1. Light source)
- Construction of the EUV Beamline

Beamline #	Beamline name	characteristics	Suitable research
19A1	EUV Lithography	• High flux	• Outgassing • EUV inspection • Radiation damage
04B1	Seya	• Lower energy	• Out-of-band measurement
08A1	Photoelectron spectroscopy	• High resolution	• Reflectometry for optical measurement
21B2	Gas Phase	• High flux/coherence	• Interference lithography

Key Results (2. Metrology)

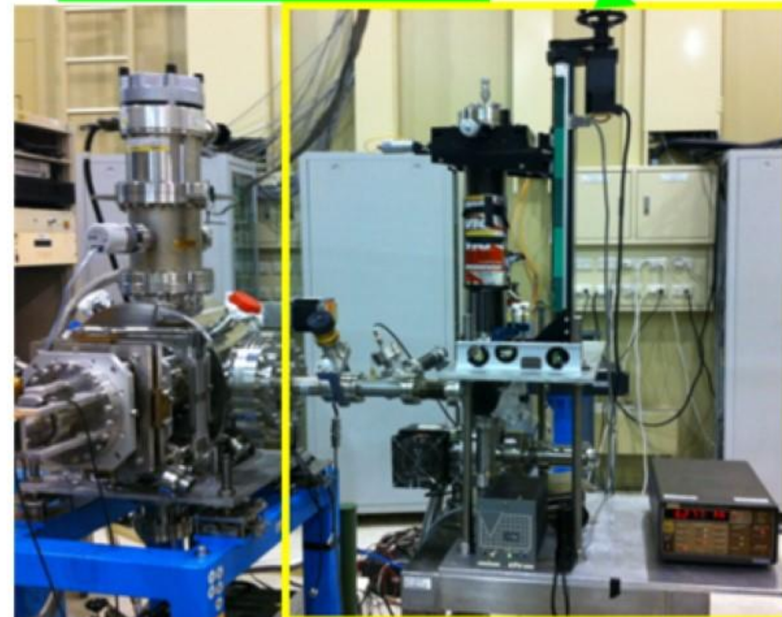
- Construction of an EUV reflectometer for in situ and actinic investigation of thin-film materials on their resistance against EUV irradiation

Reflectometer 2011/07



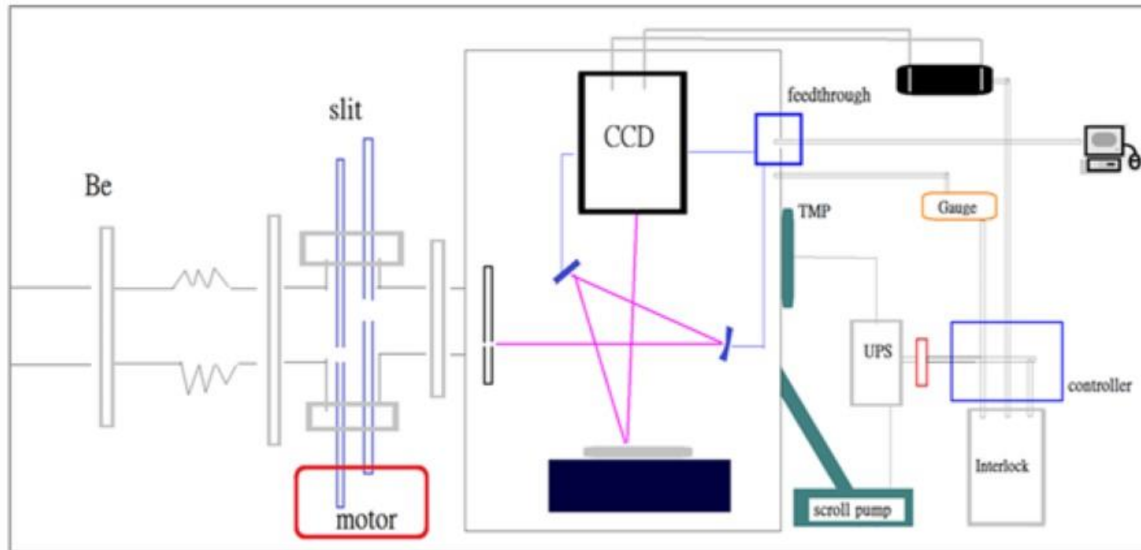
2012/06

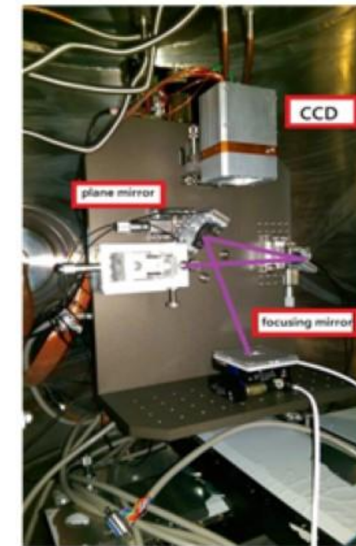
precise stepping motor

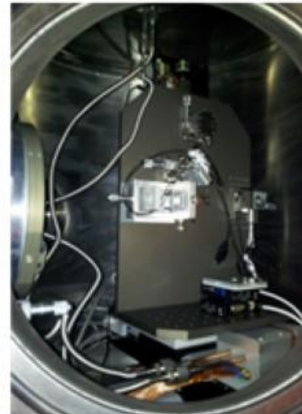


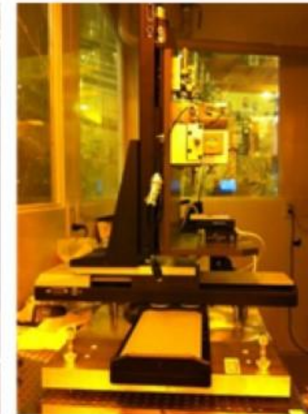
- The reflectometer was upgraded with an automatic exposure dose control system at the actinic wavelength.
- In-situ nkt measurement can be done after EUV exposure

Key Results (2. Metrology)
- Design/Construction of a EUV inspection system









Key Results (2. Metrology)
- New Inspection Method for EUV Mask Defect Inspection System

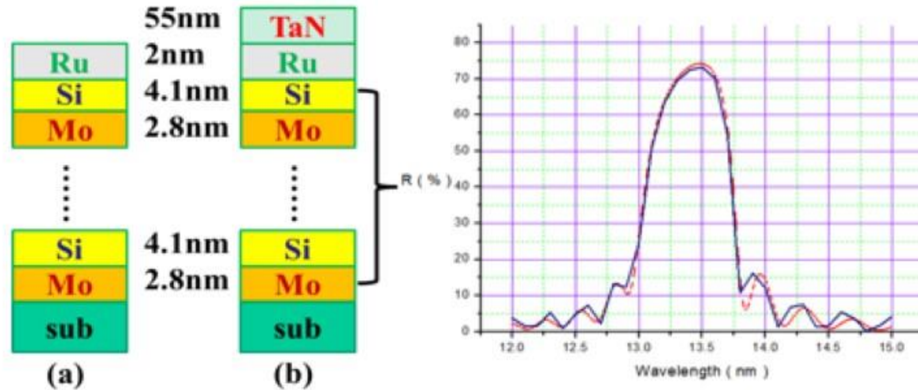
To be presented in Session 6: EUV Masks on Thursday

"A New Inspection Method for a EUV Mask Defect Inspection System" (P63)

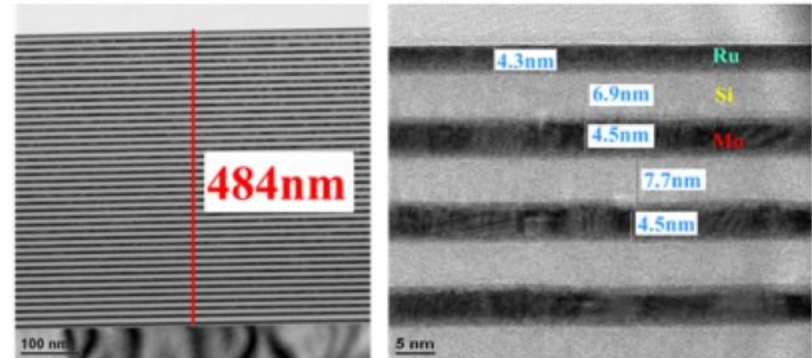
Key Results (2. Metrology)

- Optical design/deposition of EUV multilayer mirror

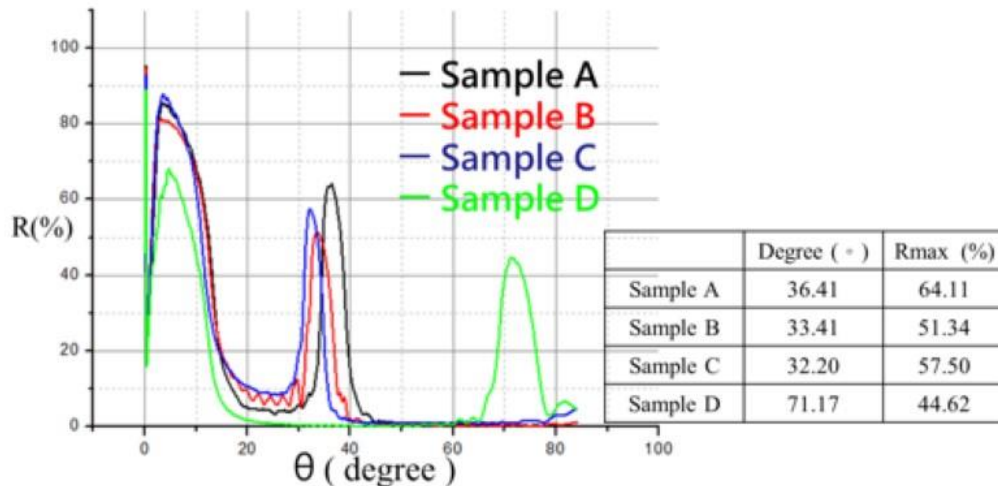
- *Design/simulation*



- *TEM photos*

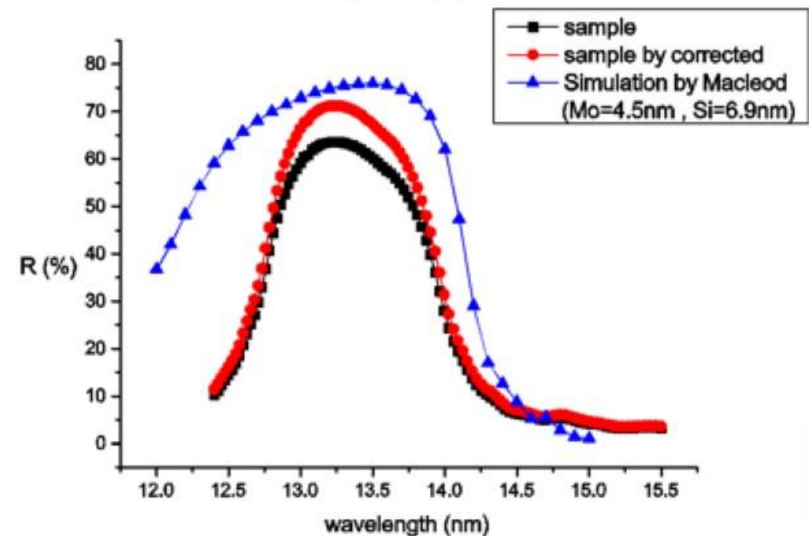


- *Reflection measurement*



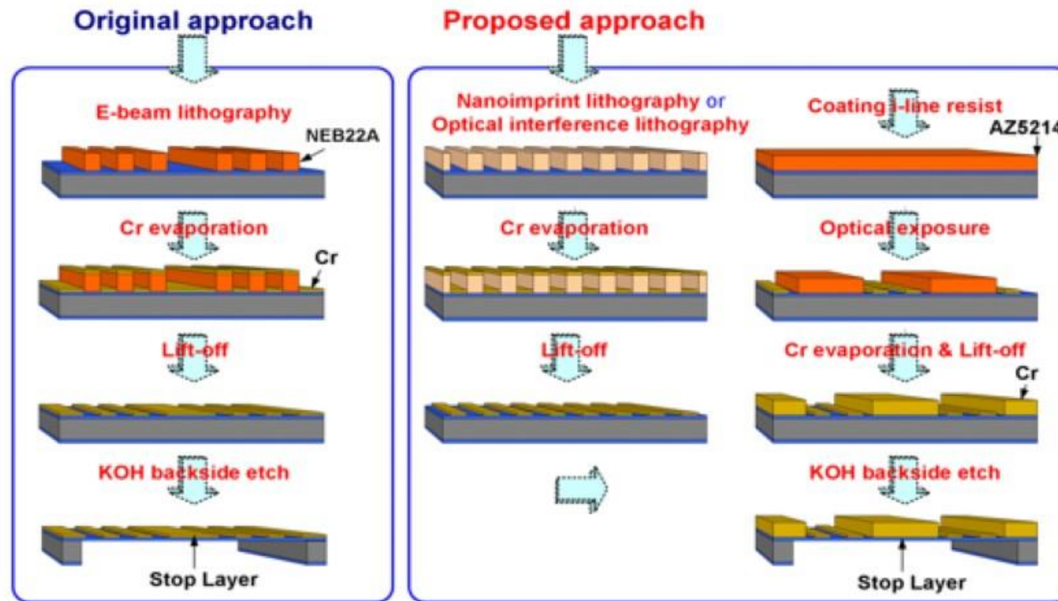
	Degree (∘)	Rmax (%)
Sample A	36.41	64.11
Sample B	33.41	51.34
Sample C	32.20	57.50
Sample D	71.17	44.62

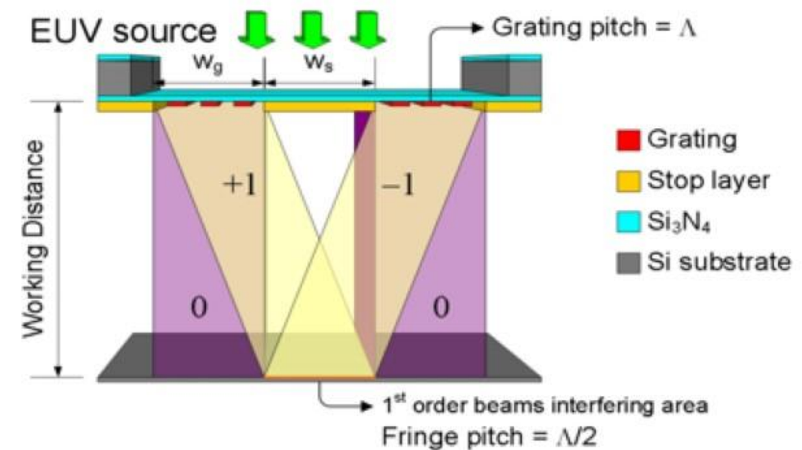
- *Reverse simulation*

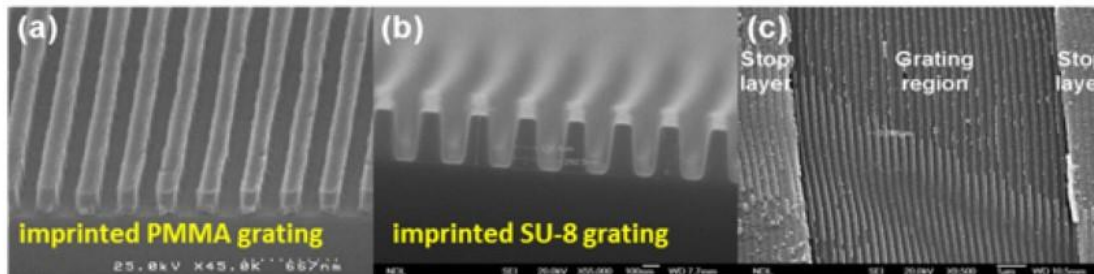


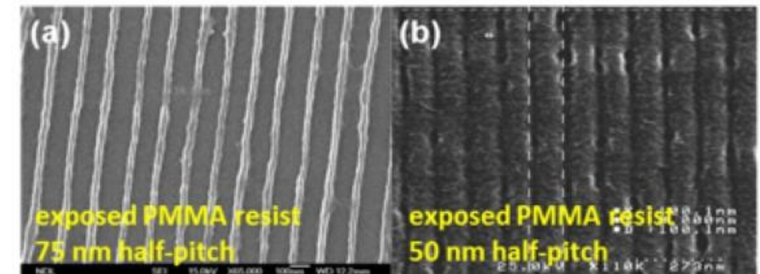
Key Results (3. EUV Application)

-EUV diffraction grating fabricated by nanoimprint lithography







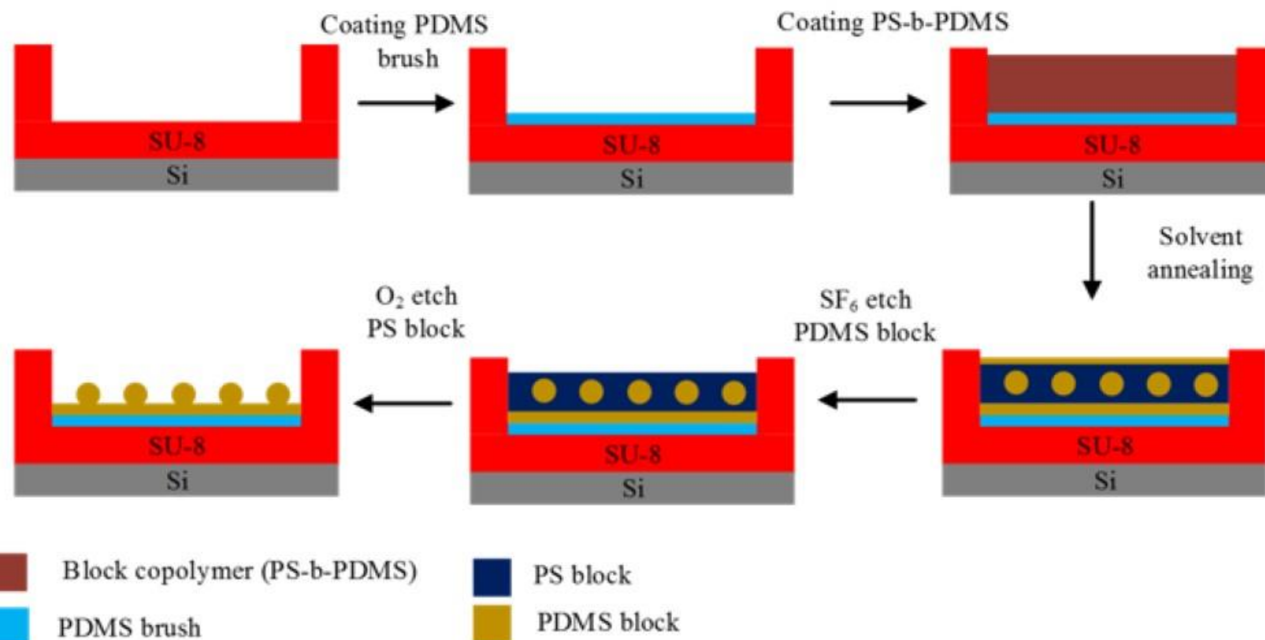


- *The grating patterning can be more efficient by using nanoimprint lithography owing to its advantages of being low cost and high throughput.*
- *The imprinted SU-8 grating can function as the EUV diffraction grating directly without the need of the additional lift-off process.*

Key Results (3. EUV Application)

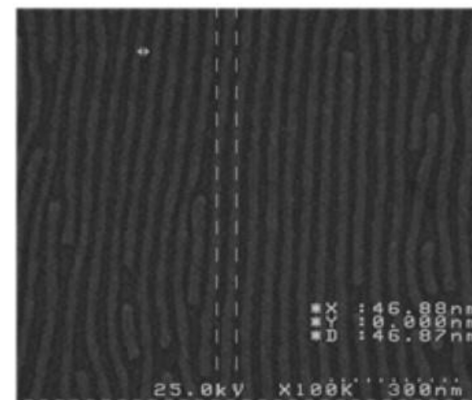
-EUV diffraction grating fabricated based on DSA (directed self-assembly)

- ***PS-b-PDMS (cylinder-forming) DSA***

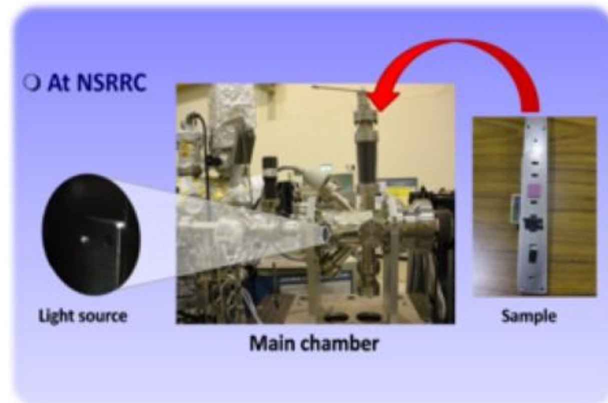


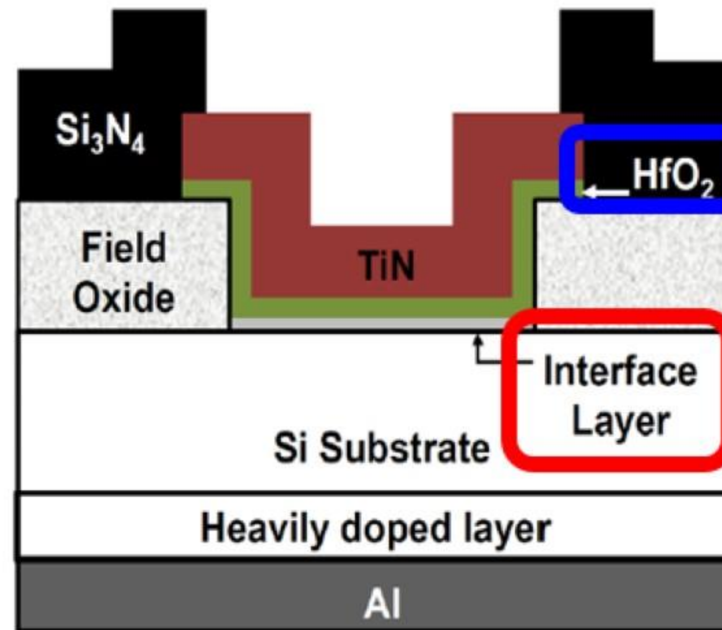
- *PS-b-PDMS has larger Flory-Huggins interaction parameter, so it can direct self-assembly on long-range area.*

- ***SEM photos***



Key Results (3. EUV Application)
- Interface Engineering to improve EUV radiation damage hardness





Different oxide thickness
- *15 nm*
- *5 nm*

Different plasma treatment
- *w/o plasma*
- *N_2 plasma*
- *NH_3 plasma*

➤ ***Sample ID and process conditions:***

Sample ID	R15	N15	NH15	R05	N05	NH05
HfO_2 thickness	15 nm	15 nm	15 nm	5 nm	5 nm	5 nm
Plasma	X	N_2	NH_3	X	N_2	NH_3

Completed Tasks & Some 2014 Research Efforts

First year

- ✓ Design/optimization of a dedicated, high-flux EUV beamline.
- ✓ Design/simulation of a novel EUV mask inspection and/or review system by configuring the EUV scattering and/or reflection signals.
- ✓ Design/optimization of a system for in situ and actinic investigation of thin-film materials on their resistance against EUV irradiation
- ✓ Design/simulation of a nondestructive EUV actinic characterization platform for nanostructure and linewidth roughness measurement
- ✓ Optimum/fabrication/evaluation of Mo/Si multilayer mirror for high reflectivity
- ✓ Investigation on EUV radiation damage of advanced logic devices.

Second year

- ✓ Construction of a dedicated, high-flux EUV beamline.
- ⊙ Development of a novel EUV mask inspection system by configuring the EUV scattering and/or reflection signals.
- ✓ Construction of a system for in situ and actinic investigation of thin-film materials on their resistance against EUV irradiation
- ✓ Development of a nondestructive EUV actinic characterization platform for nanostructure and linewidth roughness measurement
- ⊙ Optimization/fabrication/evaluation of Mo/Si multilayer mirror for high reflectivity
- ✓ Investigation on EUV radiation damage of advanced memory devices.

Third year

- Fabrication and metrology of EUV mask with programmed defects
- (Best effort) Build up the EUV mask review system
- ✓ In-situ and actinic investigation of thin-film materials under EUV irradiation