Status of EUVL Activities at Taiwan

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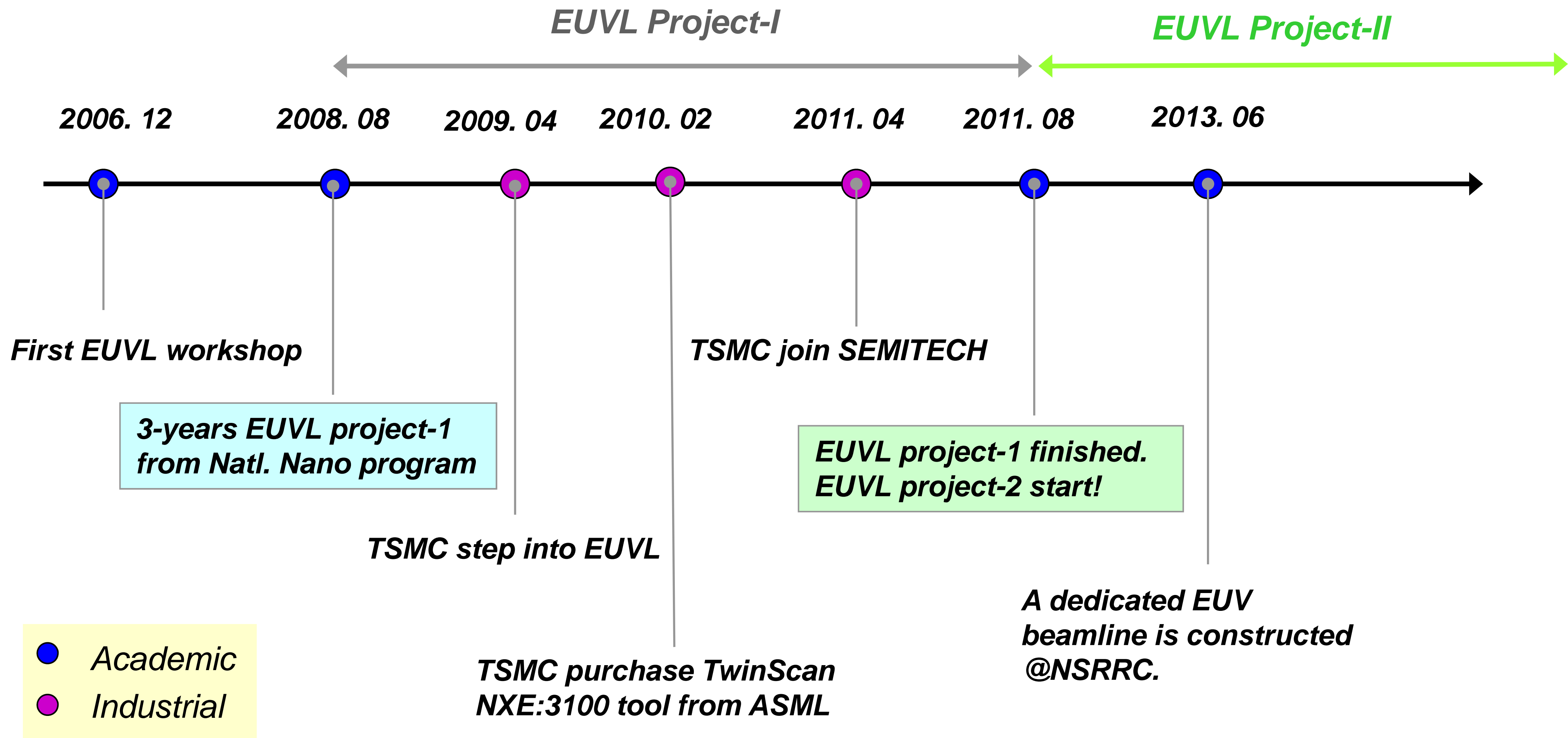
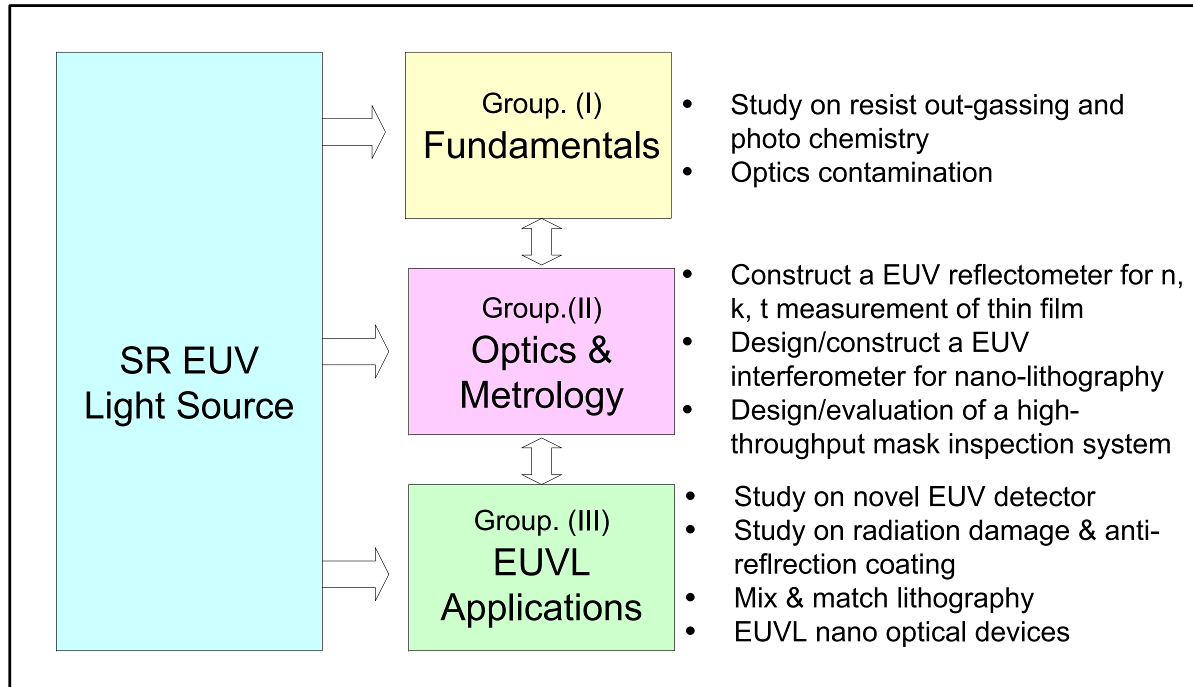
Timeline of EUVL Development @ Taiwan



EUVL Project

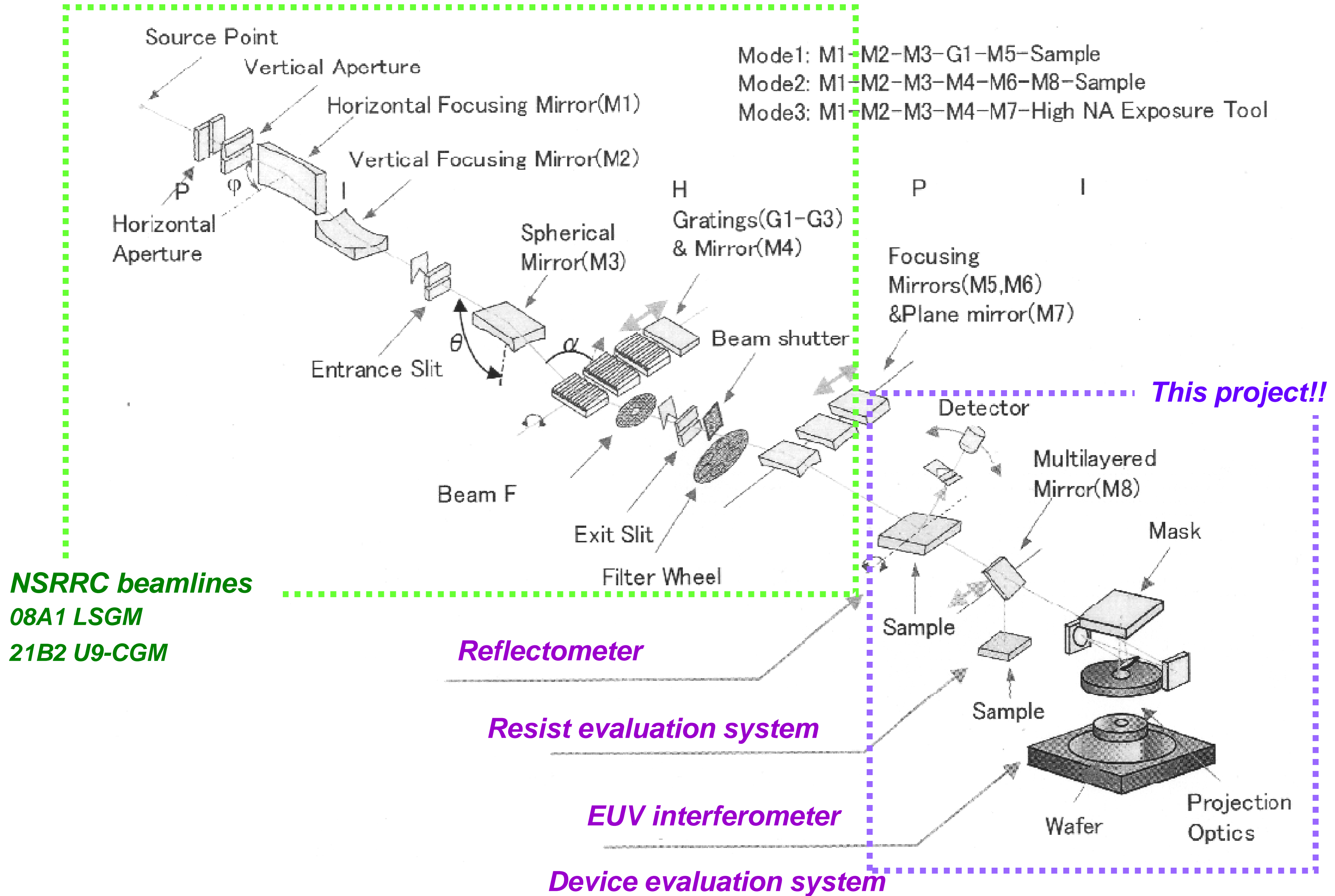


NSRRC Matching **Project Funding**

Major Impacts

- Initiate the EUVL research in Taiwan
- Establish the EUVL core facilities to meet R&D requirements both from academics and industrials.
- Develop novel EUV metrology technologies and instruments
- Integrate and accumulate the talents with various expertise for EUV-related researches

EUVL Project (Phase I)



Project Status

(A) Reflectometer

- nkt measurement
- resist evaluation
- mask/optics calibration

(B) Resist evaluation

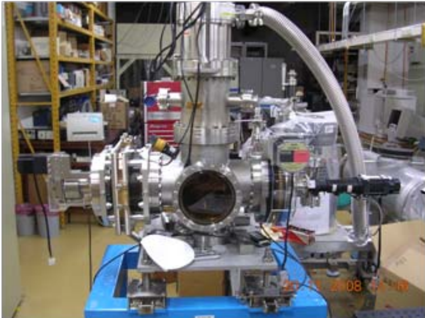
- for outgassing study
- new resist evaluation
- new resist development
- optics contamination study

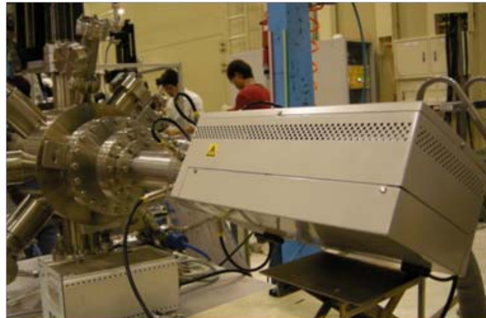
(C) Interference Lithography

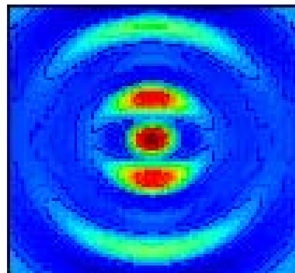
- new resist evaluation
- Nano device fabrication
- Mix/match lithography study

(D) Device evaluation

- radiation damage
- anti-reflection coating
- device evaluation





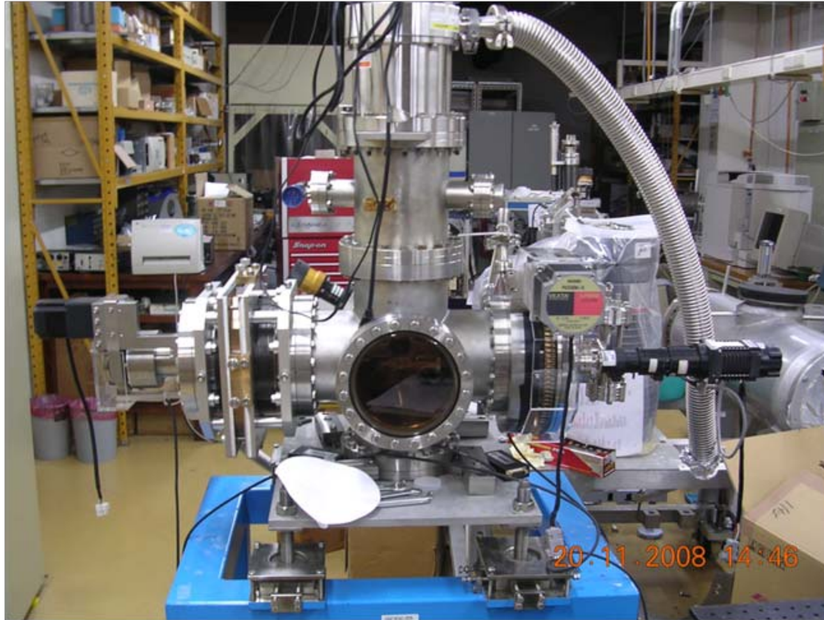


(E) Optical Design/Simulation

- EUV mask OPC
- Zone plate design for EUV mask inspection

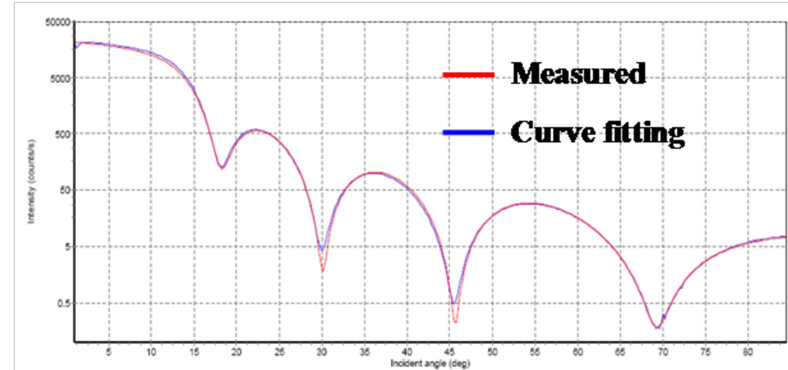
Status Highlight (1)

- Establish a nkt measurement platform @EUV

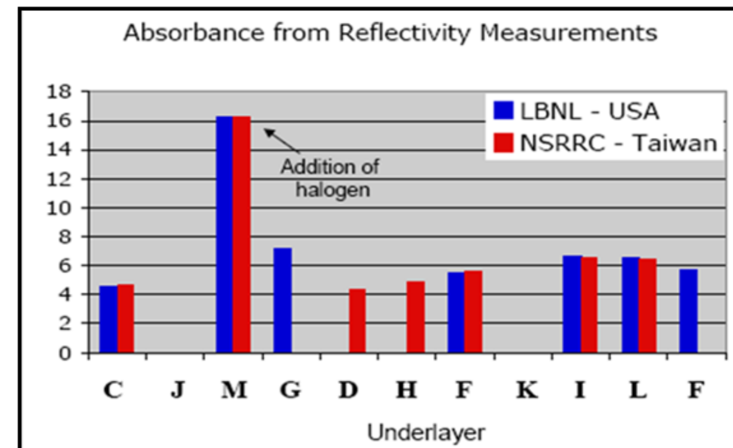


Polarization geometry	S-polarized
Base pressure	1×10^{-7} torr
Angle of incidence	$0^o – 85^o$
Rotation θ (sample stage)	$360^o/0.001^o$
Linear z	50 mm
Rotation 2θ (detector stage)	$360^o/0.0036^o$

- *Measurement and curve fitting*



- *bench marking with international facilities.*



Status Highlight (2)
- construct a resist outgassing evaluation system with QMS

Achievements in 2008 – 2010:

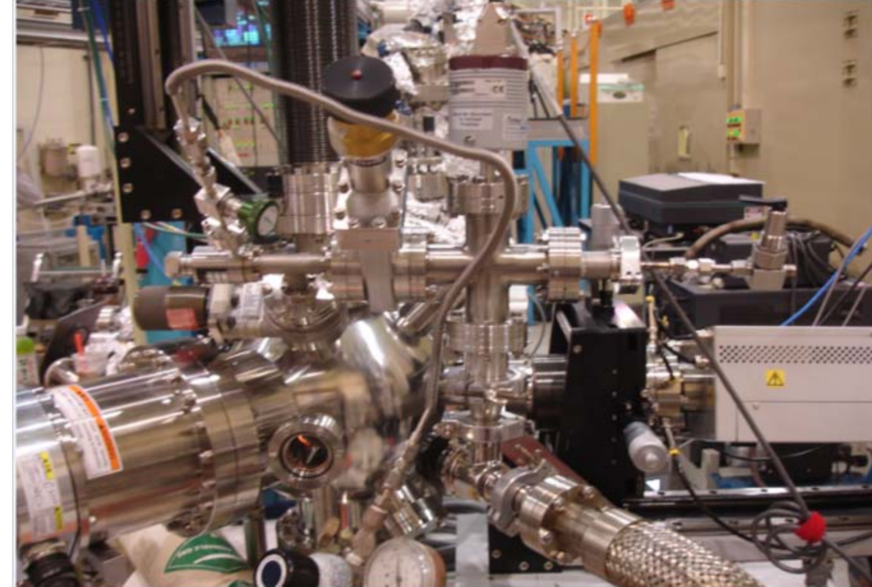
(1) Construction of an outgassing evaluation system

(2) SOP for absolute measurements

(3) Join development projects with TSMC, Nissan Chemical Industries, Ltd., Japan

(4) EUV photochemistry

- *G. H. Ho* et al., (2010) "Photochemistry of photoresists and underlayer materials upon irradiation at 13.5 nm", J. Photochem. Photobiol.: Chemistry, 211, P. 78-87.*
- *G. H. Ho* et al., (2010), "Absorption and outgassing of photoresists and underlayer materials upon irradiation at 13.5 nm", Proc. SPIE on Advanced Lithography, 7637, P. 76362U, P. 1-12.*



- The chamber is equipped with:

(1) QMS (quadruple mass spectrometer) for the resist outgassing study.

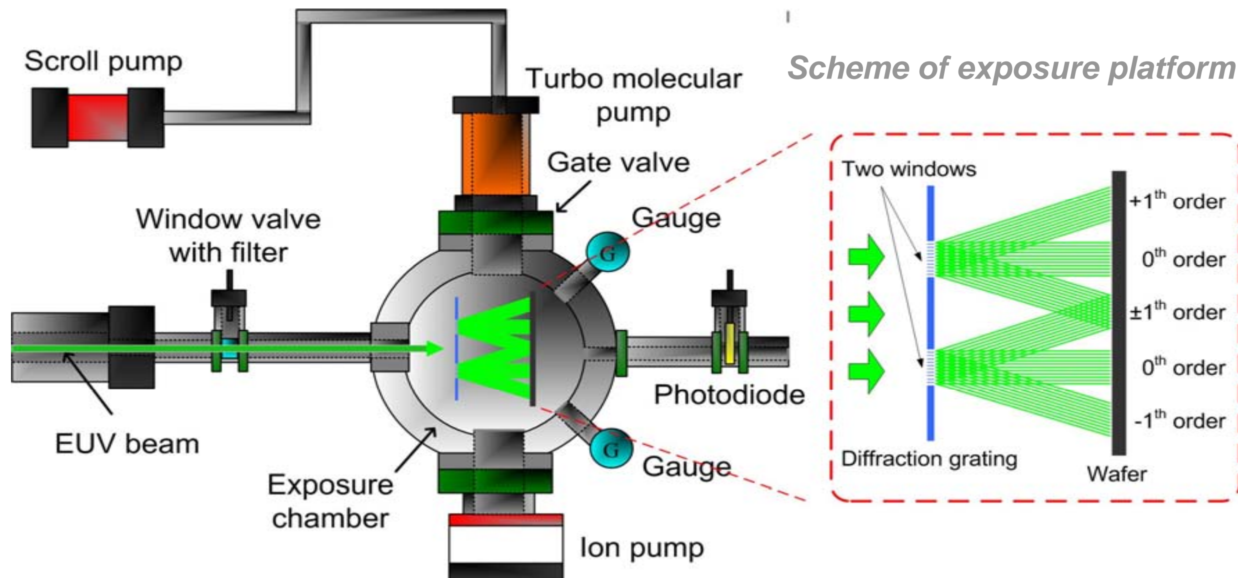
(2) Double-ion chamber for precise photon-flux measurement

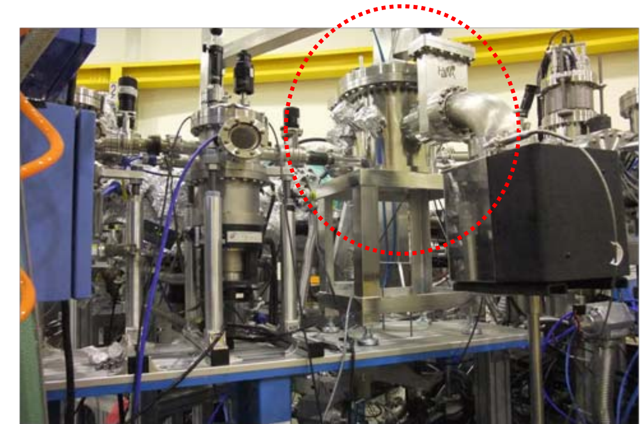
- The system can Identify outgassed ion species directly and quantitatively.

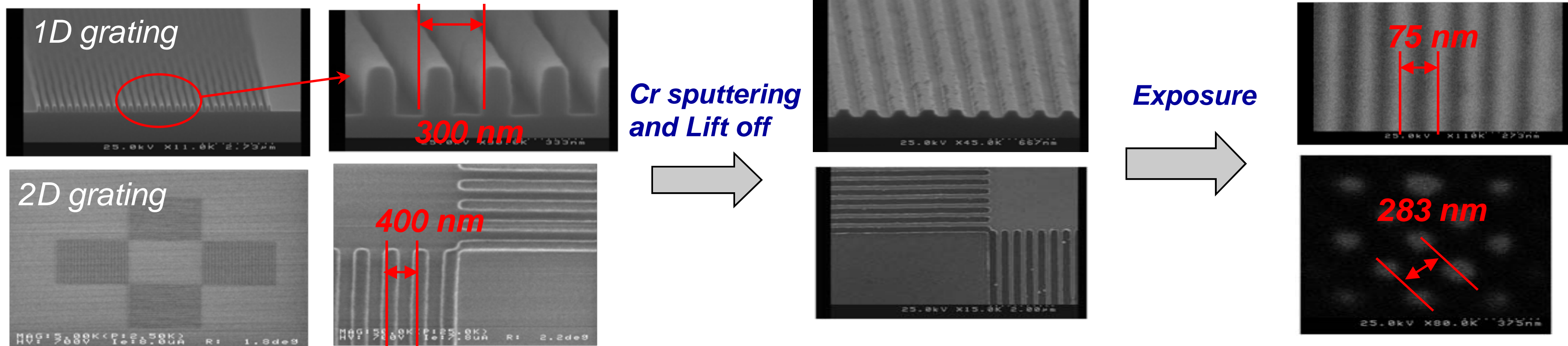
Status Highlight (3) :

- Exposure platform with EUV interferometric lithography

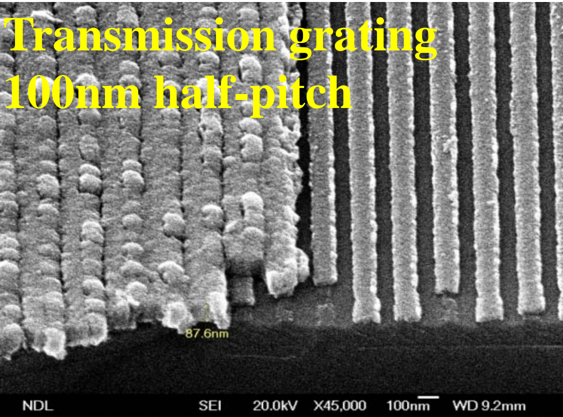
Scheme of exposure platform







•C.H. Lin* et al, "EUV interferometric lithography and structural characterization of an EUV diffraction grating with nondestructive spectroscopic ellipsometry," Microelectron. Eng. (2011)



EUV-IL – 50 & 25nm half-pitch

L L L

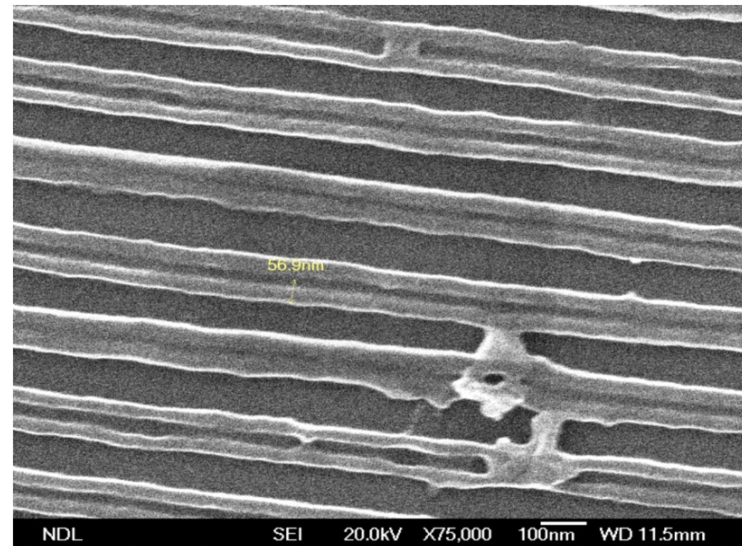
Exposure pattern
25nm half-pitch

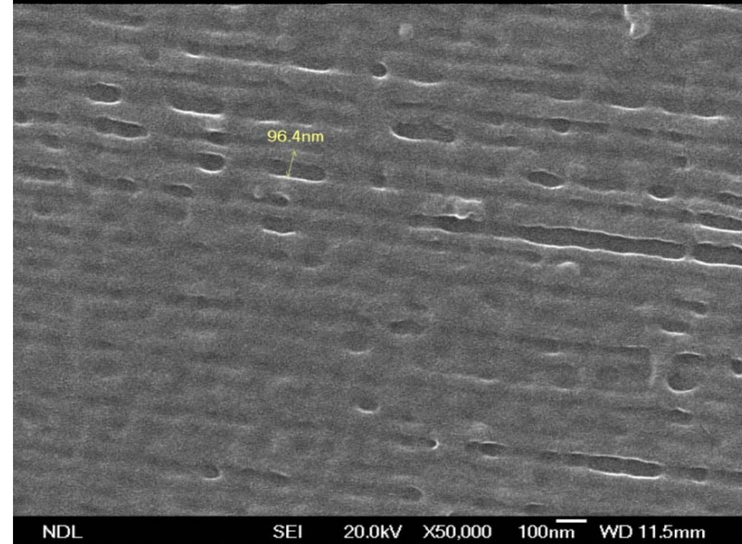
1st working distance

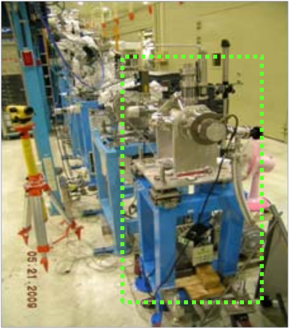
2nd working distance

Exposure pattern
50nm half-pitch

-2nd -1st +1st +2nd



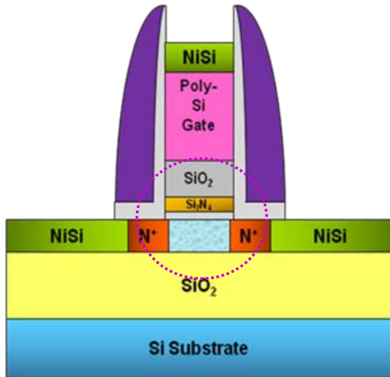


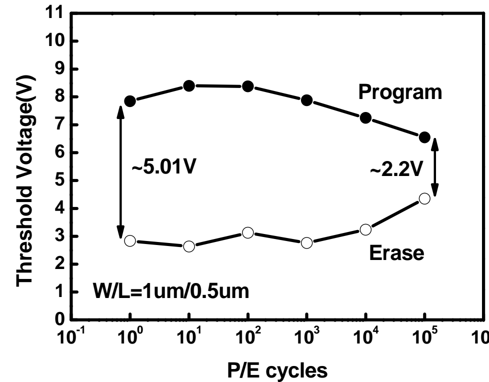


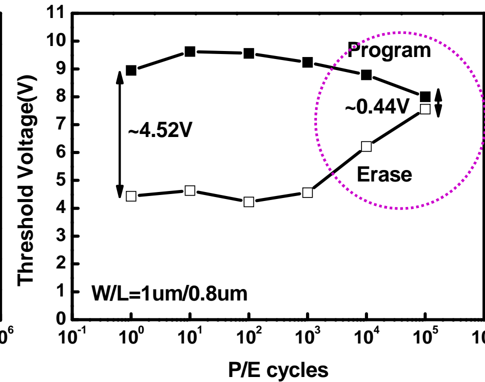
Status Highlight (4)
- EUV Irradiation Damages of Nano Devices: Memory Device

Before EUV Irradiation　　After EUV Irradiation

- SONOS memory

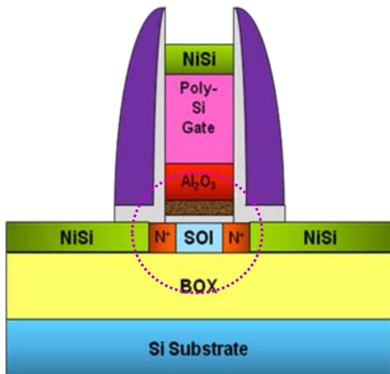


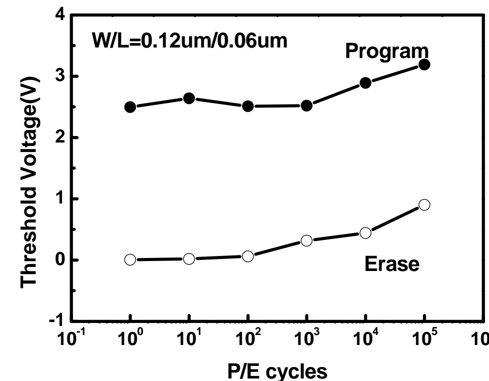


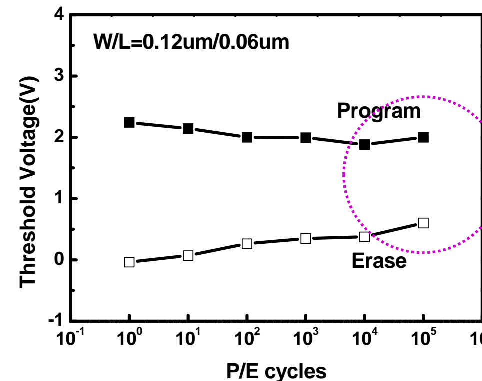


- EUV irradiation generates net positive charges. New traps are generated in Si3N4.
- Endurance performance degrades, especially in the erase state due to blocking layer damage.
- Endurance performance can not be recovered by 600°C annealing.

- NC memory







- EUV irradiation generates net positive charges. In contrast, the charges are trapped in **metallic NCs** but not in traps in dielectric.
- NC memory exhibits better EUV irradiation damage immunity than the SONOS memory.

•B.Y. Tsui et al., "Effects of Extreme Ultra-Violet Irradiation on Poly-Si SONOS Non-Volatile Memory", IEEE Electron Device Lett., vol.32, No.5, pp.614-616, 2011

Industrial Application/Cooperation

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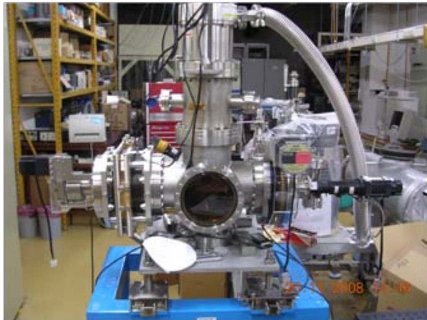
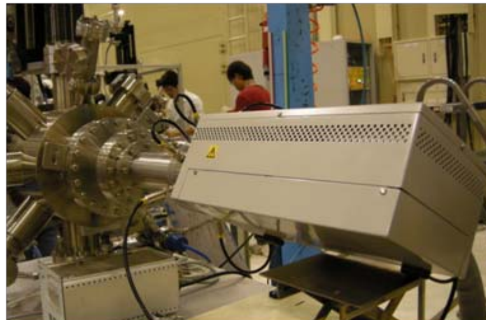


• TSMC, NCI



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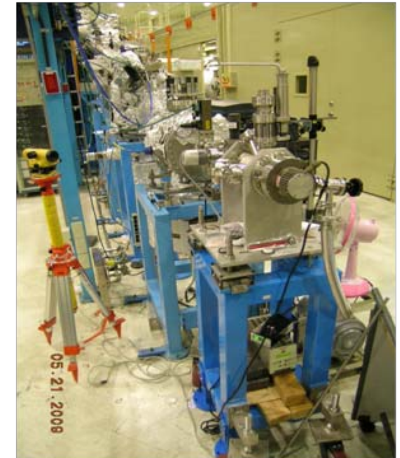
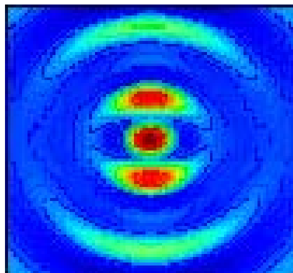


• TSMC



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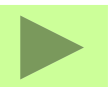
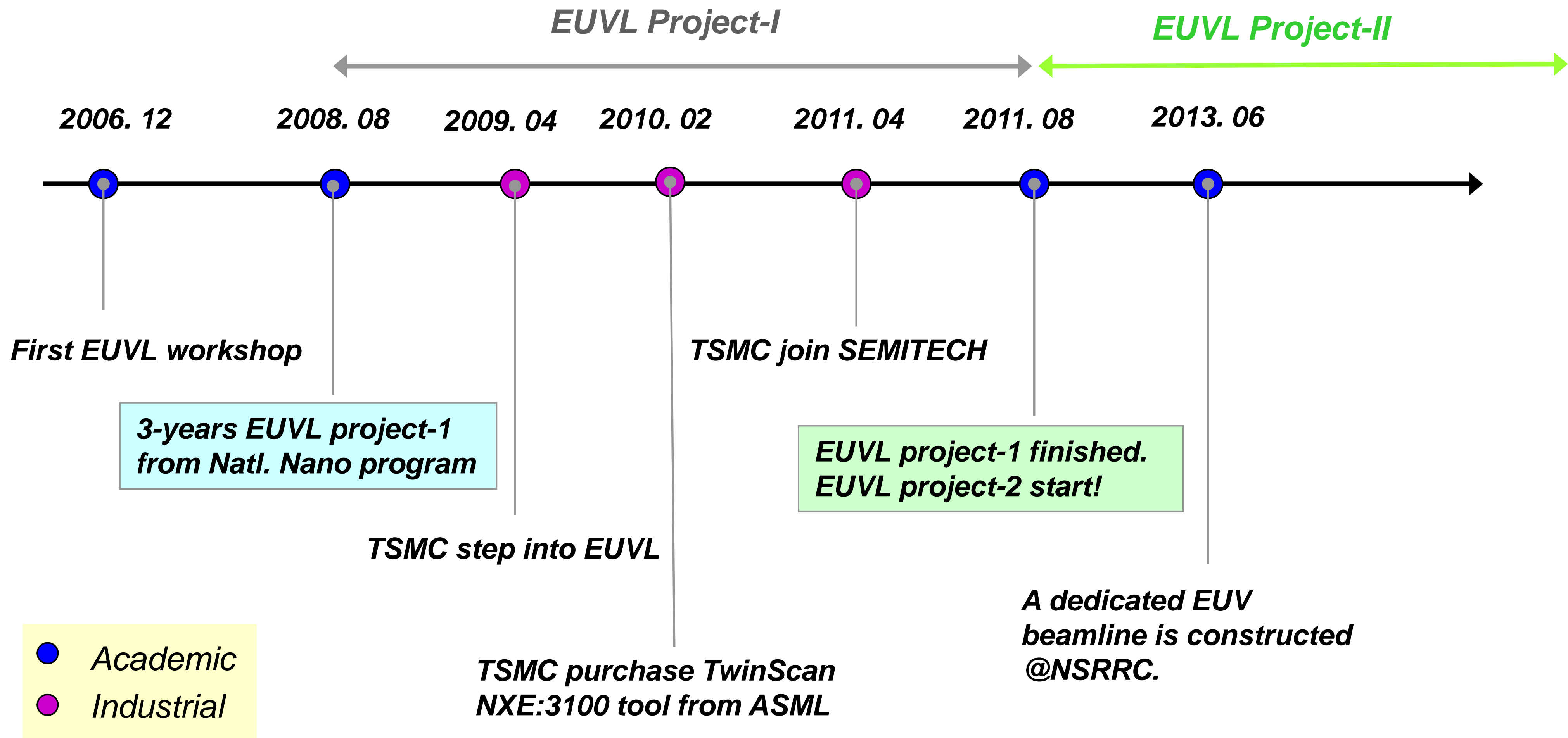
• ASML



Timeline of EUVL Development @ Taiwan



Proposal of the EUVL Project II

Light Source
Co-construct a dedicated EUV Beamline @NSRRC

- *from Bending magnet*
- *high-flux design*
- *tunable wavelength (6~13.5 nm)*

Metrology

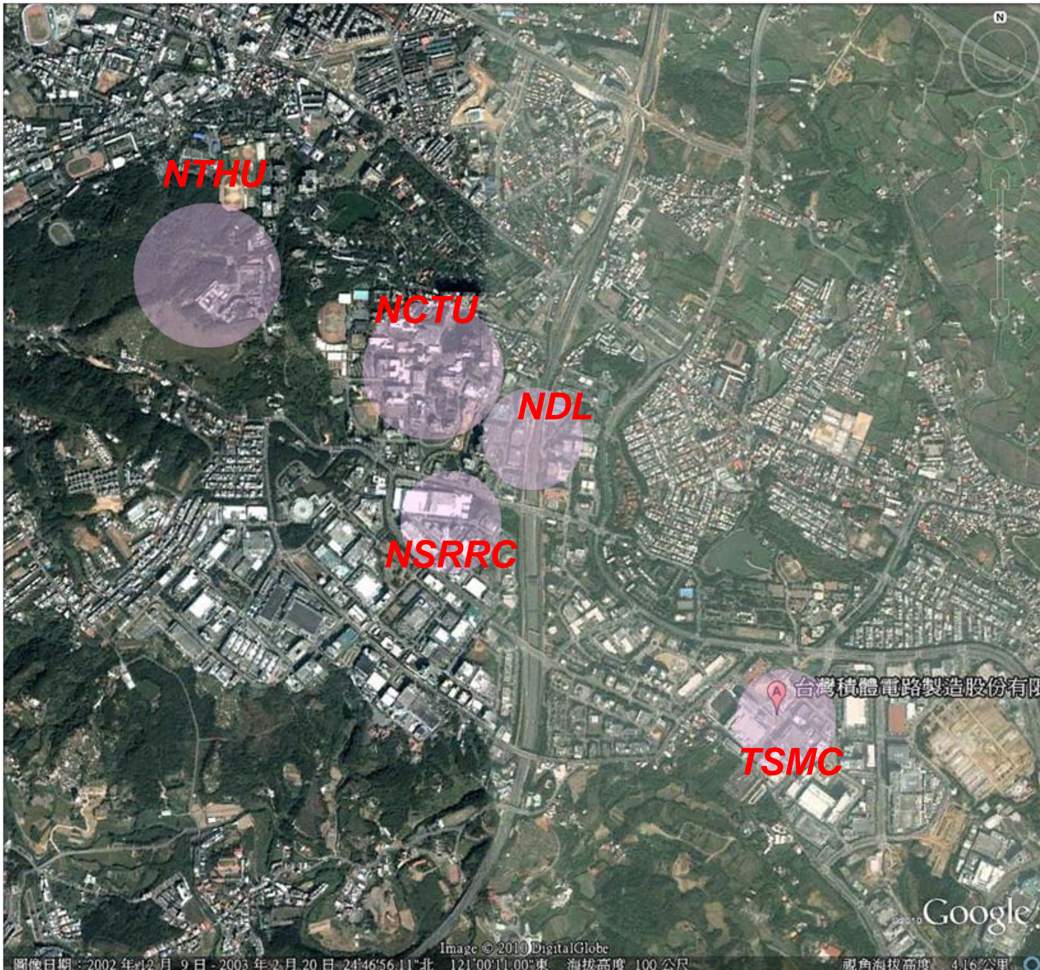
- *Design/Construct of a high-throughput EUV mask inspection system*
- *Develop a spectroscopic ellipsometry and EUV actinic scatterometry*

Photochemistry
Design/ Construct a resist evaluation system on 300mm wafers.

EUV Applications

Summaries

EUVL Campus@ Taiwan



3x3 km²

- *The EUVL research @Taiwan start late, but is going well!*
- *TSMC has put more efforts on developing EUVL tech.!*
- *An integrated "EUVL campus" is formed at Hsinchu science park.*
- *Just like immersion litho., we believe Taiwan will play an important role on EUVL mass production in the near future.*

Thanks for your Attention!