2006 International EUVL Symposium

Nikon EUVL development progress update

Nikon Corporation

2nd Development Department

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Presentation Outline

- Roadmap and Tool Specifications
- Development Collaboration and Plan
- Development Strategy
- Development Status
- Projection Optics Development
- Contamination Control and Reticle Protection
- Status of Critical Issues and Challenges
- Future Development Scenario
- Overall Summary

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Nikon Roadmap for Future Lithography

Critical layer exposure method

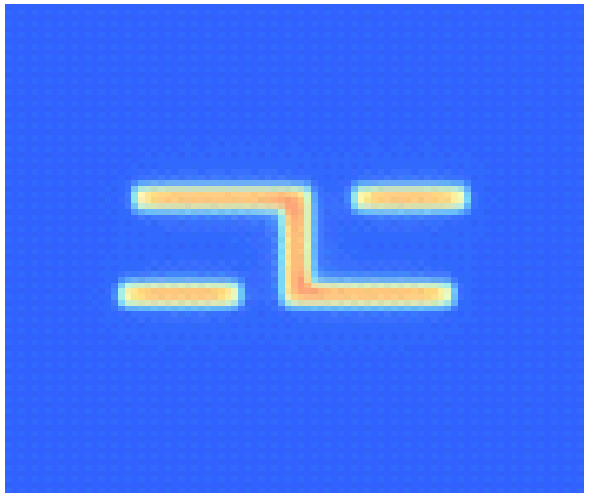
Year(CY)		2006	2007	2010	2013	2016
Technology node(hp nm)		90	65	45	32	22
Lithography	NA	Process Factor (k1)				
ArF	0.85	0.40	0.2[illegible]			
	0.92	0.43	0.31			
ArF Immersion	1.07		0.36	0.25		
	1.30		0.44	0.30		
	1.48			0.35	0.25	
EUVL	0.25			0.83	0.59	0.41

Main Lithography

Normal(K1>0.5) Weak RET(k1>0.4) Strong RET(k1>0.25)

■ EUVL can be the main lithography technology after ArF Immersion technology.

EUVL Advantage
k1 value vs. optical image quality



K1=0.59
32nm hp @EUVL NA0.25

K1=0.25
32nm hp @ArF Immersion

K1=0.41
22nm hp @EUVL NA 0.25

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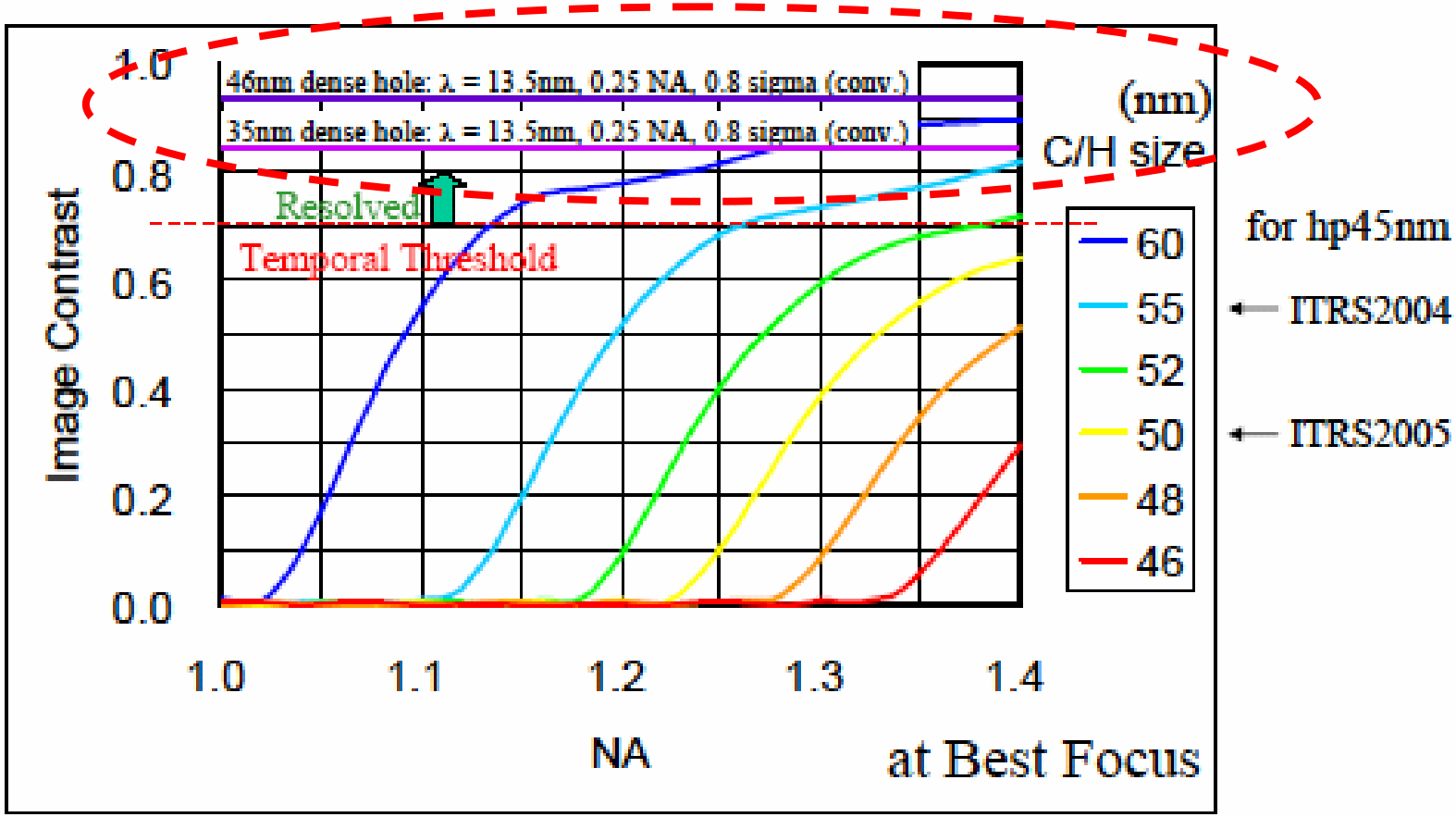
EUVL Advantage
Contact Hole Exposure

λ=193nm; 6% half tone PSM, Quadropole, +20% mask bias

λ=13.5nm; NA=0.25, σ=0.8, flare=2.5%, mask contrast=1%



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EUV1 Tool Specifications

EUV1: For 45nmhp node process development & 32nmhp node R&D

Specification Item	EUV1
Field size	26mm x 33mm
NA and Magnification	0.25, x1/4
Resolution	Dense line: 45nm @hp Isolated line: 25nm (Target 32nm @hp)
Flare	10%
Overlay	15nm
Wafer size (diameter)	300mm
Throughput (10W& 5mJ/cm^2)	5-10WPH

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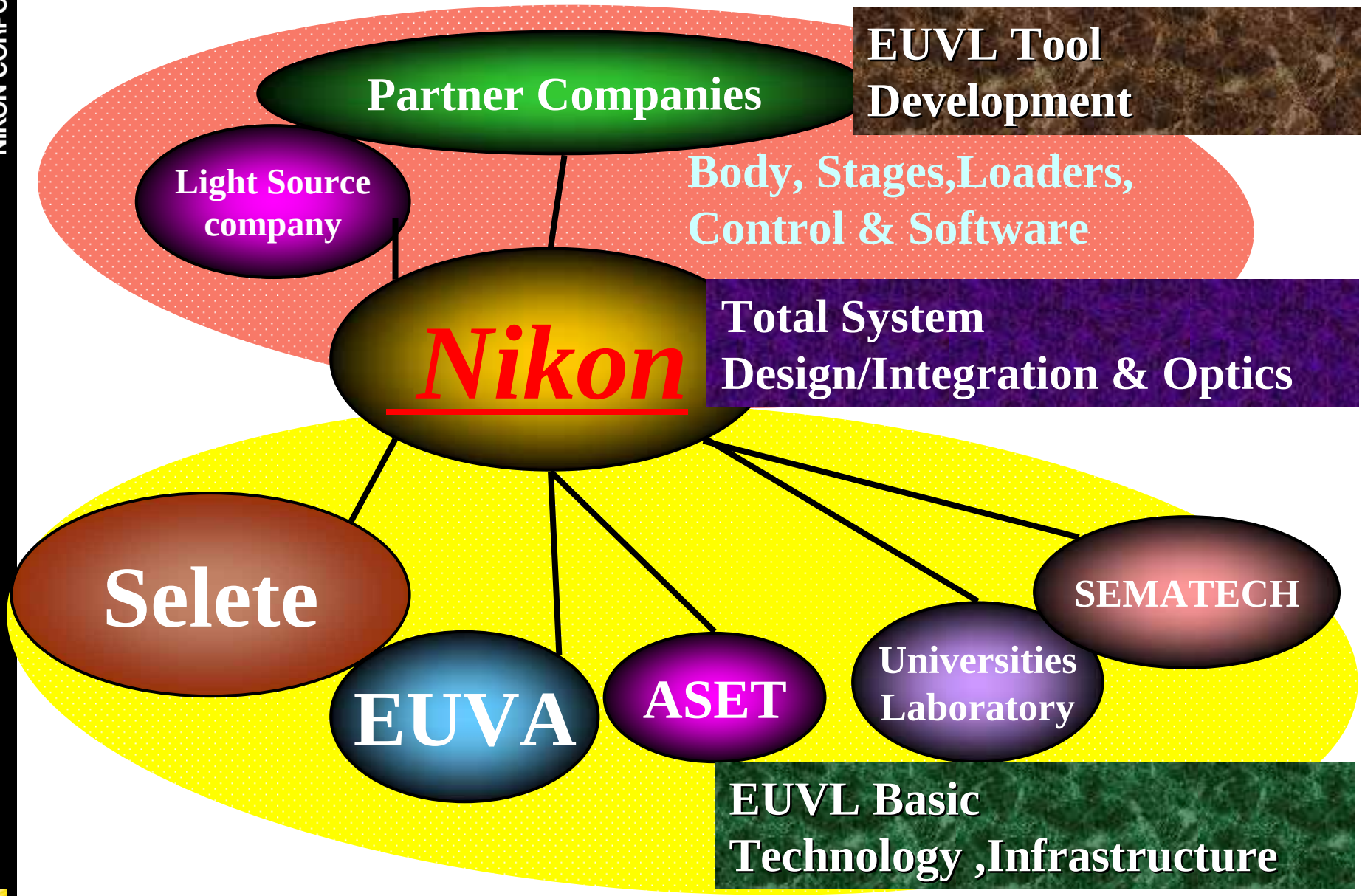
EUVL Tool Development Collaboration



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Current EUVL Tool Development Plan

CY2003				CY2004				CY2005				CY2006				CY2007			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4

EUVA Tool Project

EUVA Metrology Project

Process development at ASET

HiNA-#3 → EUVL Basic Technology

Selete Project

We are here

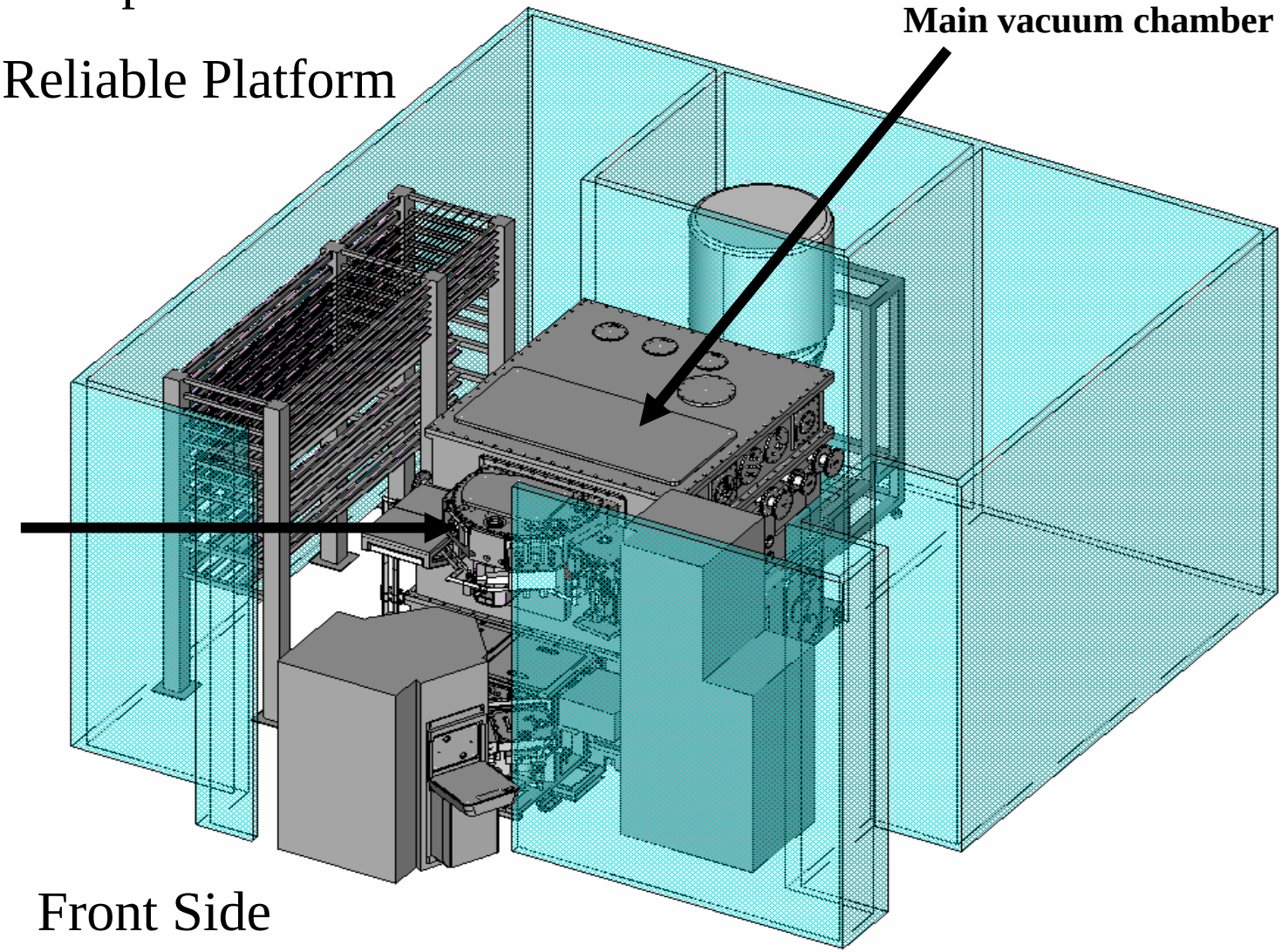
Basic Development

EUV1 tool development

- **EUV1(Process Development Tool)**
  Scheduled Delivery Start 1H/2007
- **EUV2(HVM) Insertion scenario considered**

EUV1 System Configuration

- ◆Module Concept
- ◆Stable & Reliable Platform



Front Side

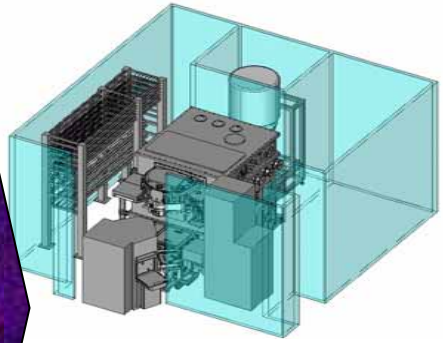
EUV1 Tool Development Status

EUV1 program is underway on schedule.

Design	Parts	Module	Integration	Installation & Line Operation

WE are here

Proceeding to integration



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Metrology and Production Tool Preparation

EUVA Supported by NEDO

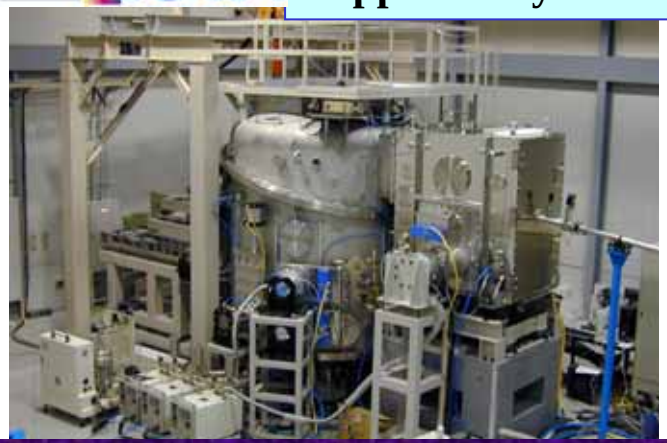
Multi-layer coating system

EUVA Supported by NEDO

High repeatability Interferometer

Visible light wave front sensor

EUVA Supported by NEDO



EUV wave front sensor (EWMS)

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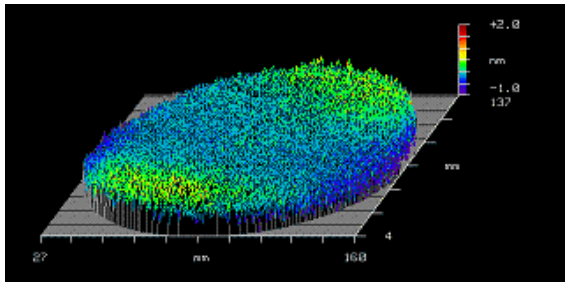
Ion Beam Figuring (IBF)

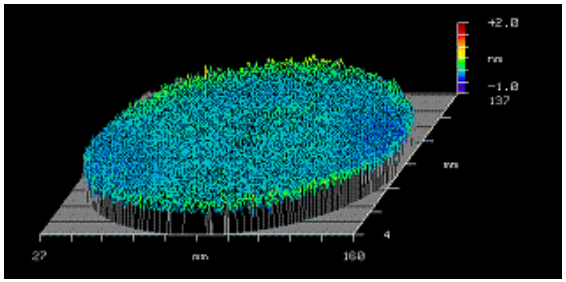
EUVA **Supported by NEDO**

Now in operation

Much improved



0.247 nm rms



0.139 nm rms

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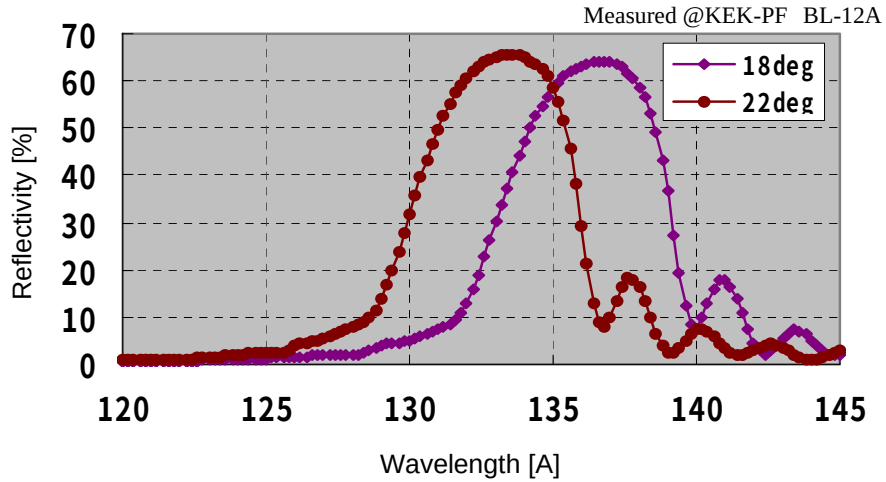
Multilayer coating system

- New low-pressure rotary magnet cathode (RMC) sputtering system installed.
- Max. substrate size: Φ600mm
- 4-target system: capping layer and buffer layer available.

Now in operation

EUV reflectivity first data



EUVA Supported by NEDO

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EUV1 Projection Optics Development

■Proto-type Projection Optics (PO)

- ➢Polishing of 6 mirrors completed.
- ➢PO assembly and adjustment completed.
- ➢Wave front calibration on EWMS is planned.

■EUV1 mirror fabrication

- ➢Polishing of 6 aspherical mirrors completed.

■EUV1 PO assembly

- ➢Assembly and optical adjustment underway.

■Visible light wave front sensor

- ➢System installation completed.

■Actinic wave front sensor (EWMS)

- ➢System adjustment almost completed.

Proto-type Projection Optics barrel

Proto-type mirror(M1)

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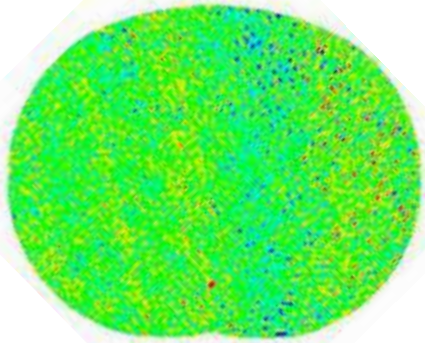
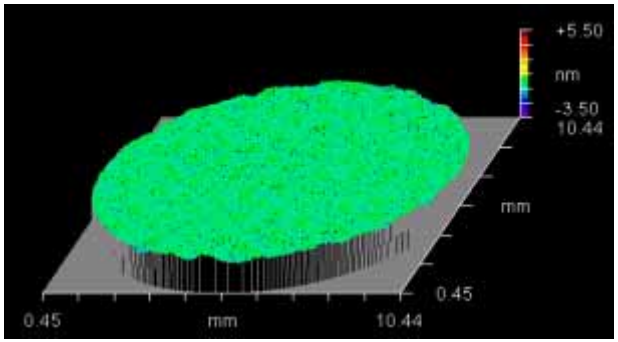
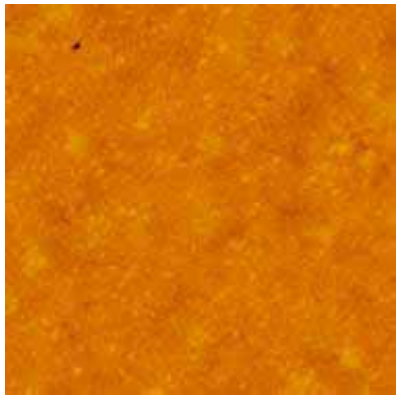
Aspheric Mirror Polishing

Polishing 6 mirrors of proto-type PO completed.

EUVA **Supported by NEDO**







LSFR contour map：
0.18 nm RMS

Aberration

MSFR contour map：
0.135 nm RMS

Flare

HSFR contour map:
0.09 nm RMS

Reflectivity

Extremely smooth mirror finish achieved.

LSFR was measured with high-repeatability interferometer developed by EUVA under the support from NEDO.

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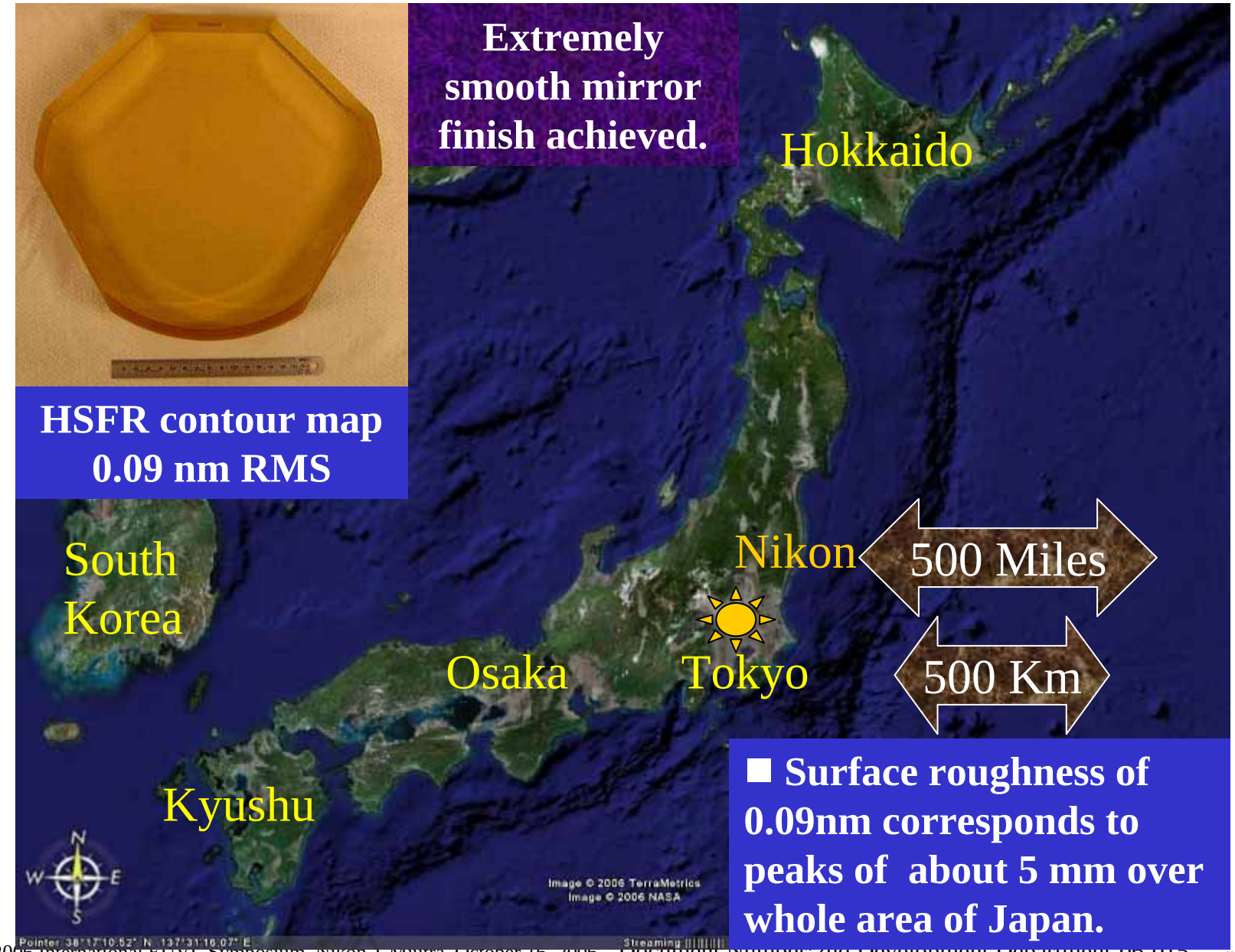
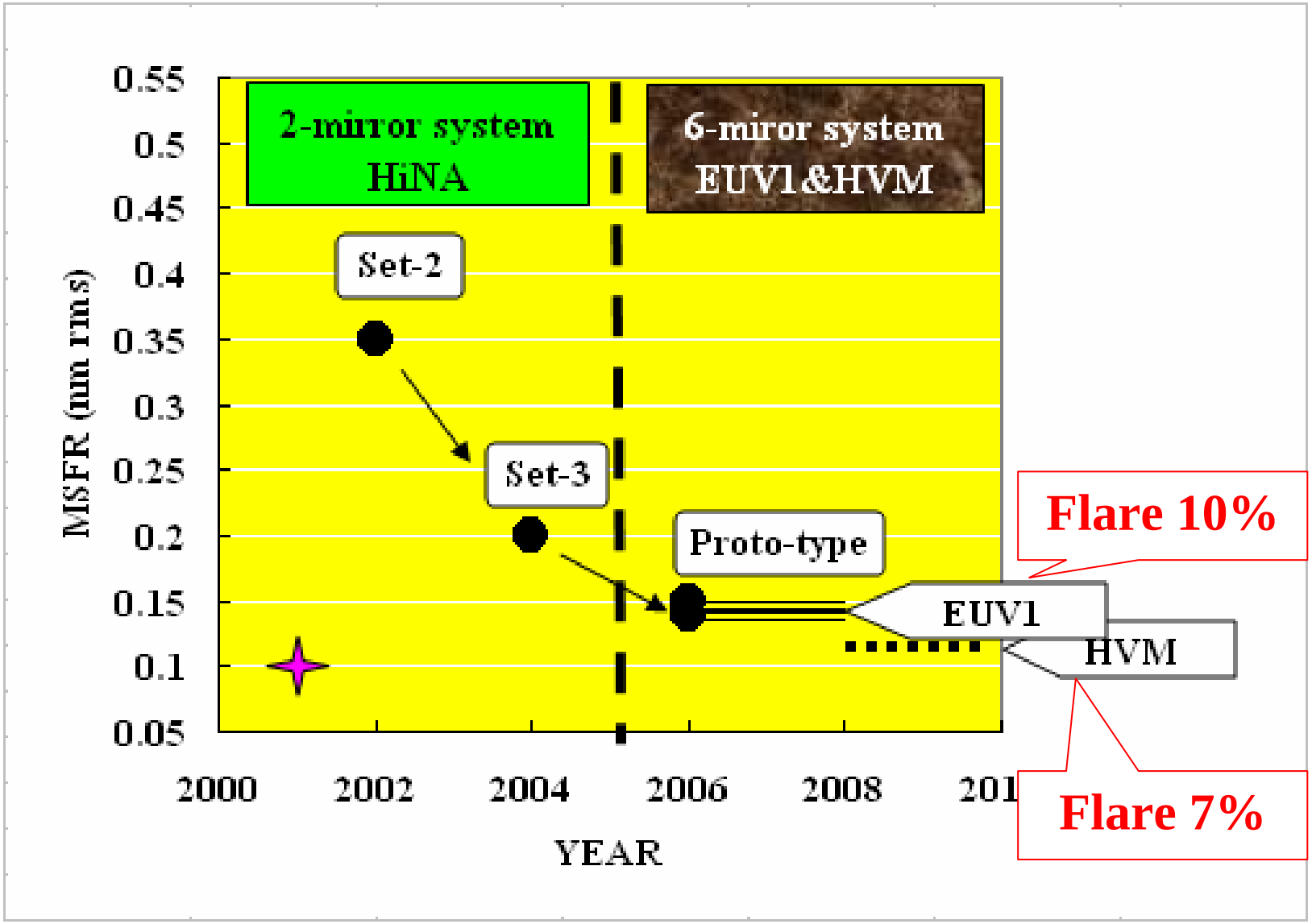
Mirror Figuring Accuracy



■ Surface roughness of 0.09nm corresponds to peaks of about 5 mm over whole area of Japan.

MSFR Improvement Evolution



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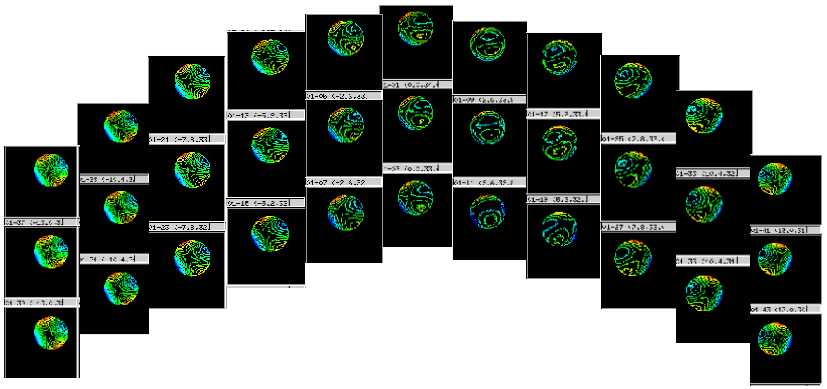
Proto-type projection optics

Proto-type projection optics



Visible wave front sensor measurement

PO manufacturing process established.

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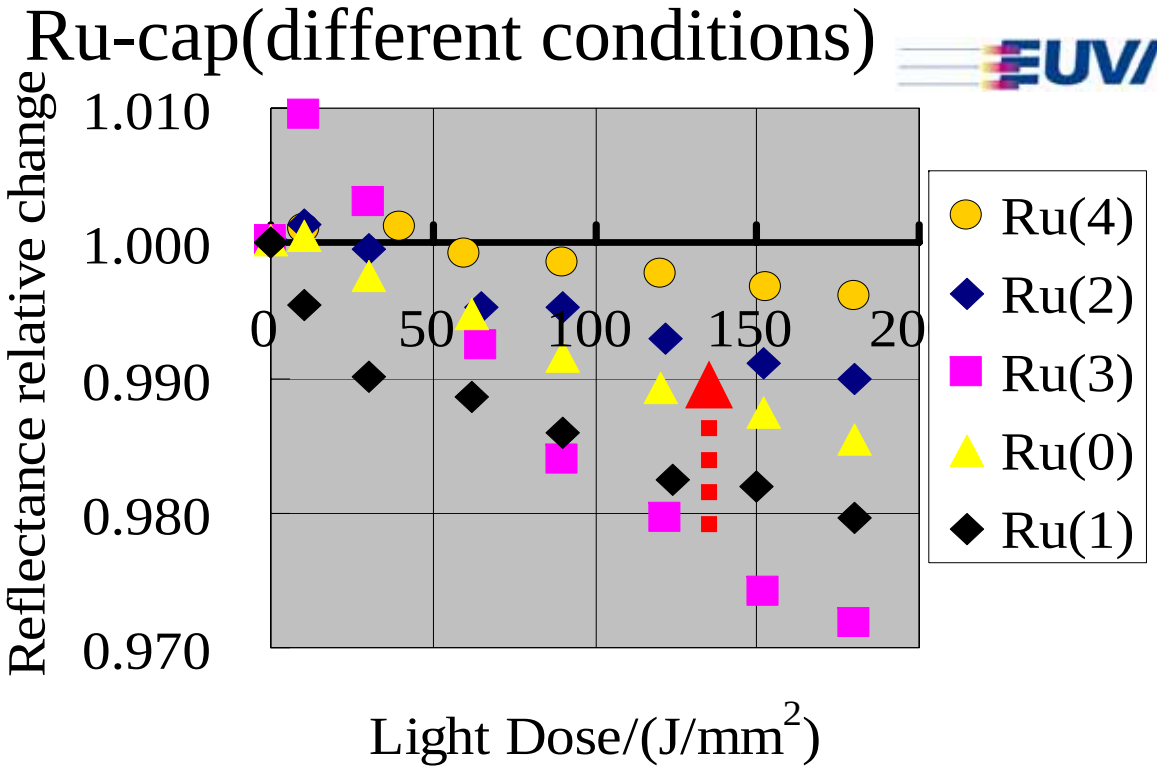
Contamination Control

Durability to oxidation of Ru capping layer



Supported by NEDO

■Ru-cap was improved by the deposition condition optimization.

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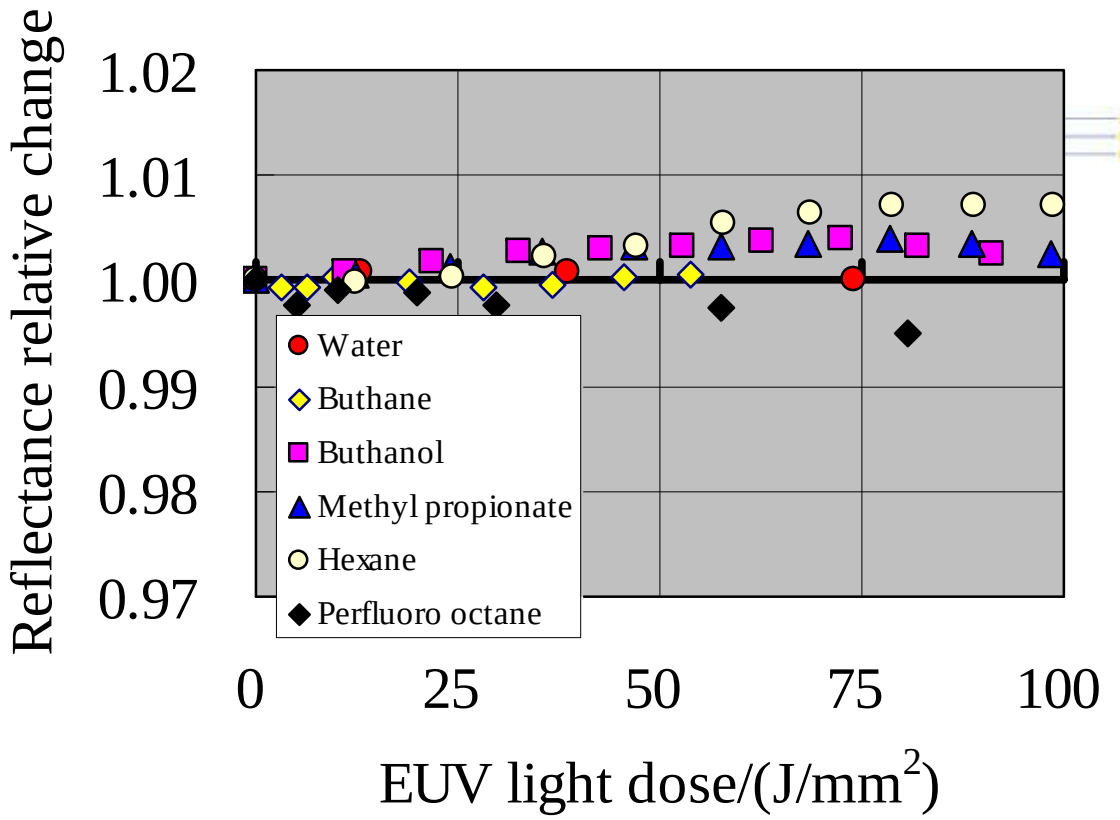
Contamination Control

Experiment of carbon deposition on Si-Capped multi-layer mirrors



EUVA Supported by NEDO

See more details in the presentation titled " Carbon deposition on Si-Capped multi-layer mirrors by extreme ultra violet ray irradiation" on October 18.

Reflectance changes didin't show a big difference among residual organic gas species.

Reticle Protection

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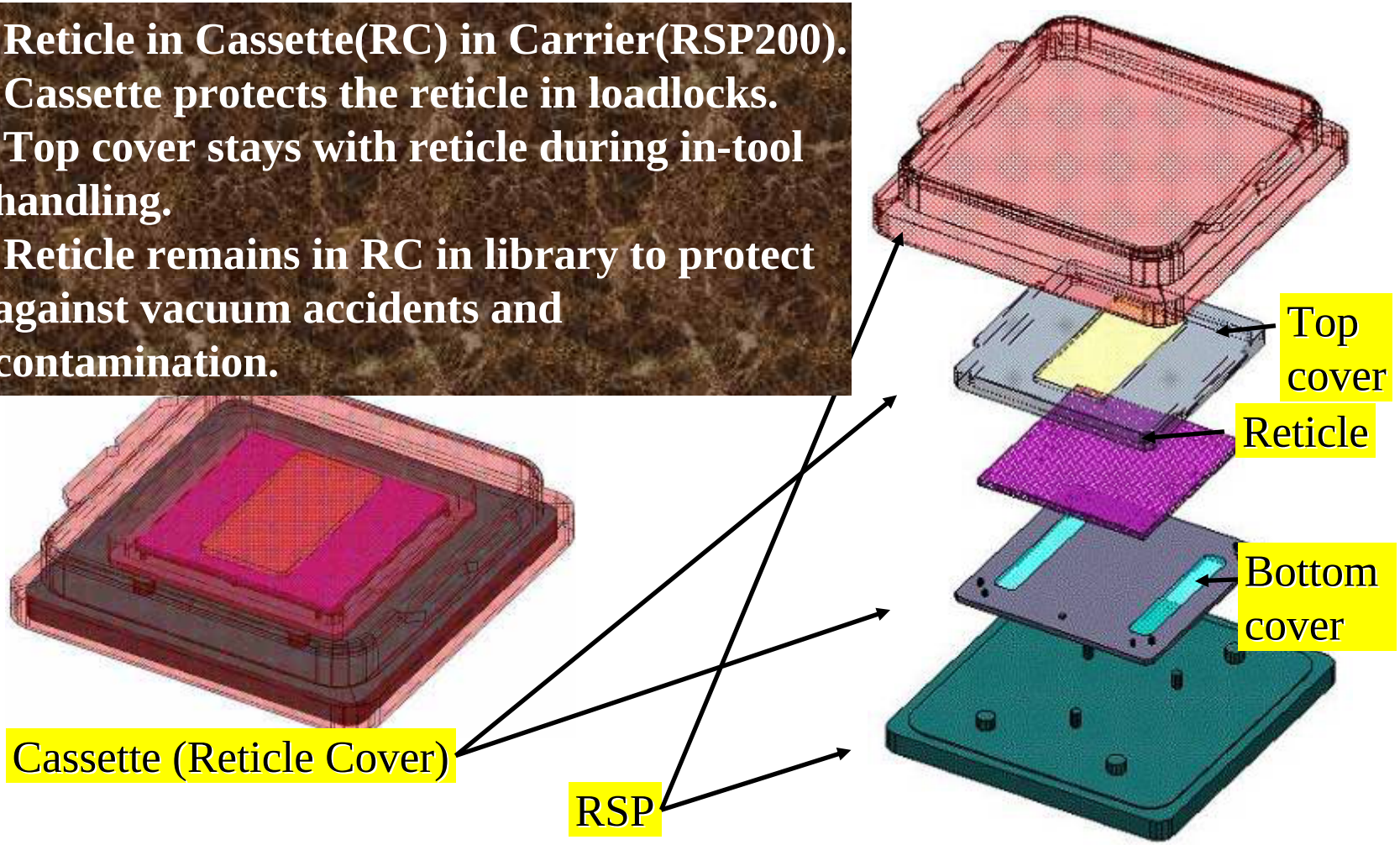
✧ *Dual Pod Concept by Canon and Nikon*

1. Reticle in Cassette(RC) in Carrier(RSP200).
2. Cassette protects the reticle in loadlocks.
3. Top cover stays with reticle during in-tool handling.
4. Reticle remains in RC in library to protect against vacuum accidents and contamination.



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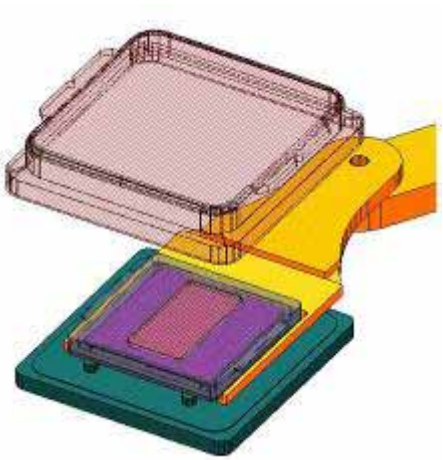
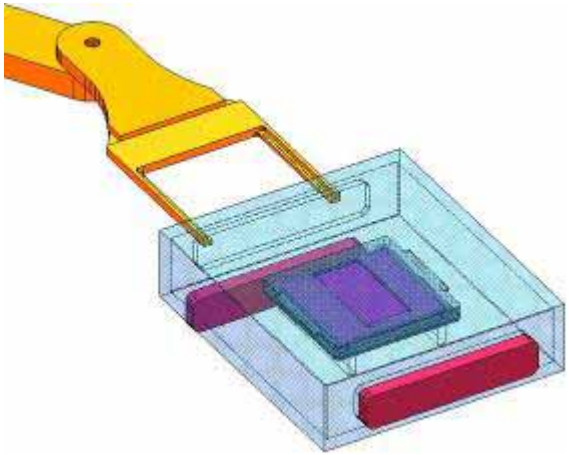
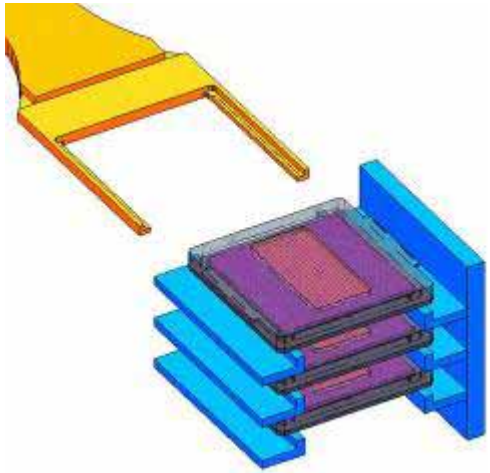
Handling sequence of Dual Pod Concept



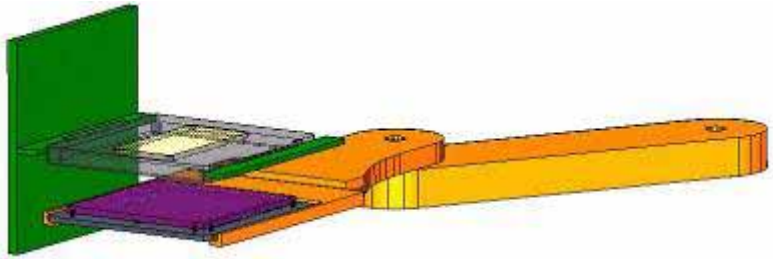
(1) Open the Carrier and take out the Cassette



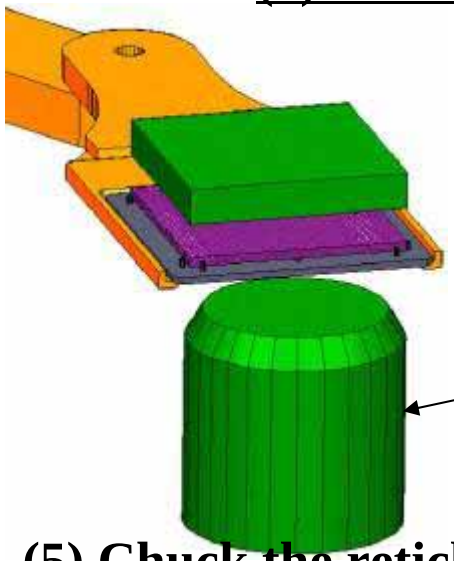
(2) In a loadlock



(3) Library in vacuum



(4) Prior to loading, remove the top cover



(5) Chuck the reticle

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Reticle Protection Development

- **Nikon takes dual approach for reticle protection development considering the earliest tool application.**

1. **Nikon Reticle Case development based on Dual Pod concept for EUV1 tool.**

➢ **Proto-type Reticle Case fabrication and evaluation experiment have been completed.**

2. **Nikon/Canon/Entegris joint development of Dual Pod concept**

➢ **1st phase of proto-typing has been completed.**

- **Nikon will work with Selete and SEMATECH for further evaluation.**

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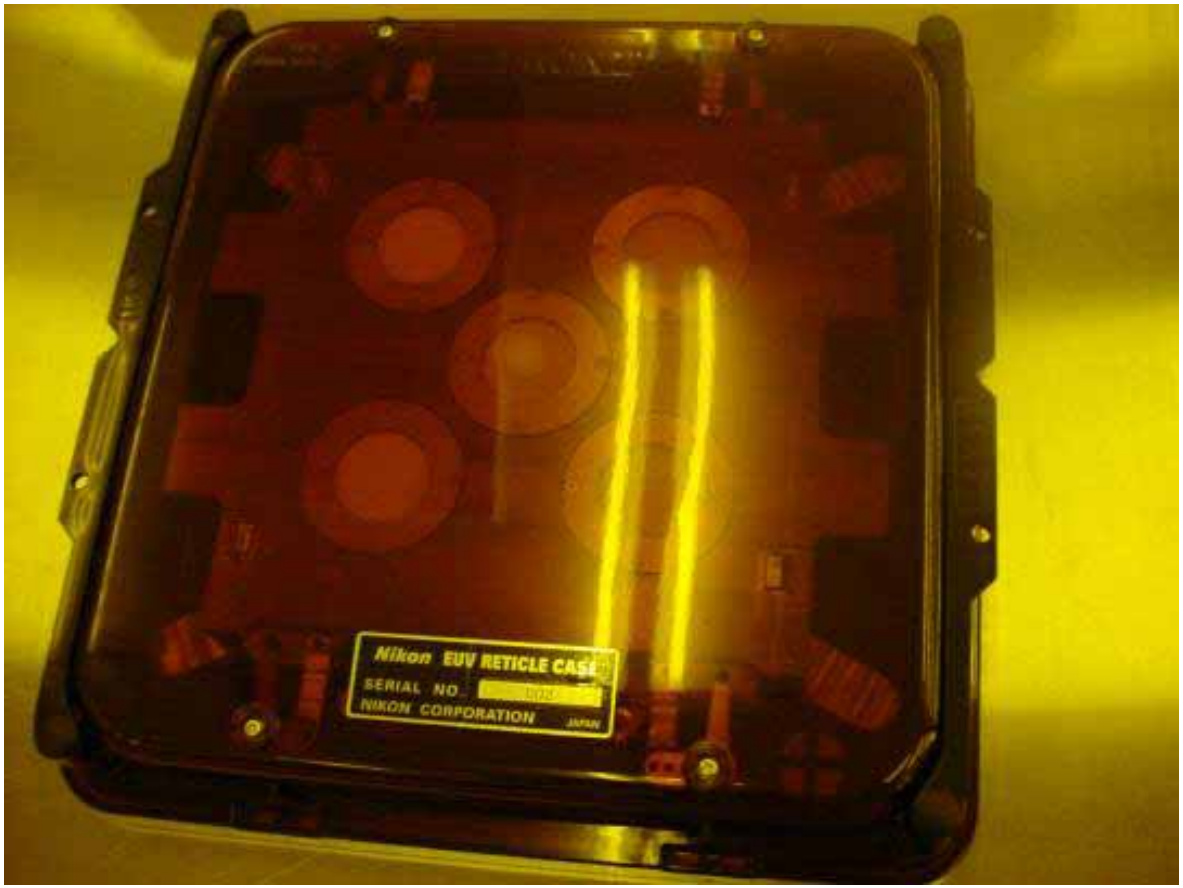
Nikon Reticle Case for EUV1



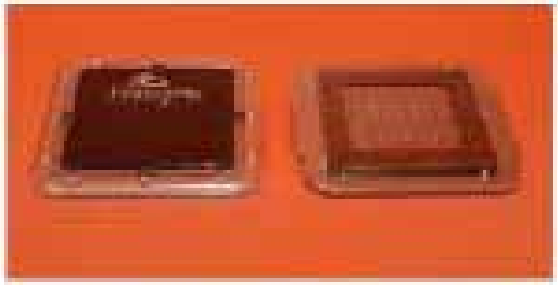
Reticle Carrier for HVM (Dual Pod)

Prototypes

Entegris

- Two types of carrier prototypes were manufactured.
  - 2 alpha and 2 beta.
  - Beta is more handling friendly.

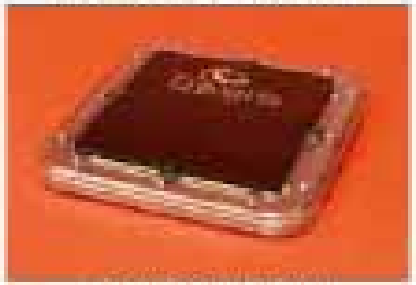
Illustration of EUV pod w/Mod. RSP



Reticle mounted EUV pod

EUV pod installed RSP

Reticle dismounted EUV pod



Closed EUV pod

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EUV Mask Carrier Standards Workshop, 2/19/2006 6

Canon

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Status of Critical Issues and Challenges

■ EUVL tool development is ahead of infrastructure development.

EUVL Tool

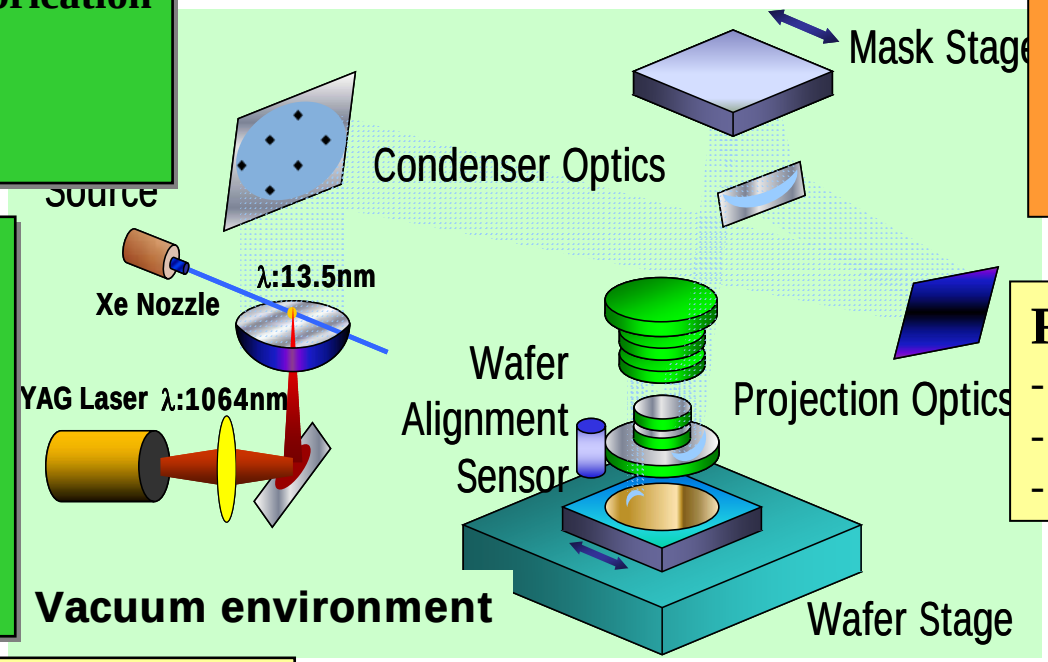
Reflective Optics
- Aspherical mirror fabrication
- Reflectivity
- Wavefront error
- Flare

Vacuum Compatible Body/Stages
- Synchronization accuracy
- Electrostatic Chuck
- Vacuum

Contamination Control
- Vacuum Quality
- Optics Lifetime
- Reticle particle protection

Progress Made

High — Low



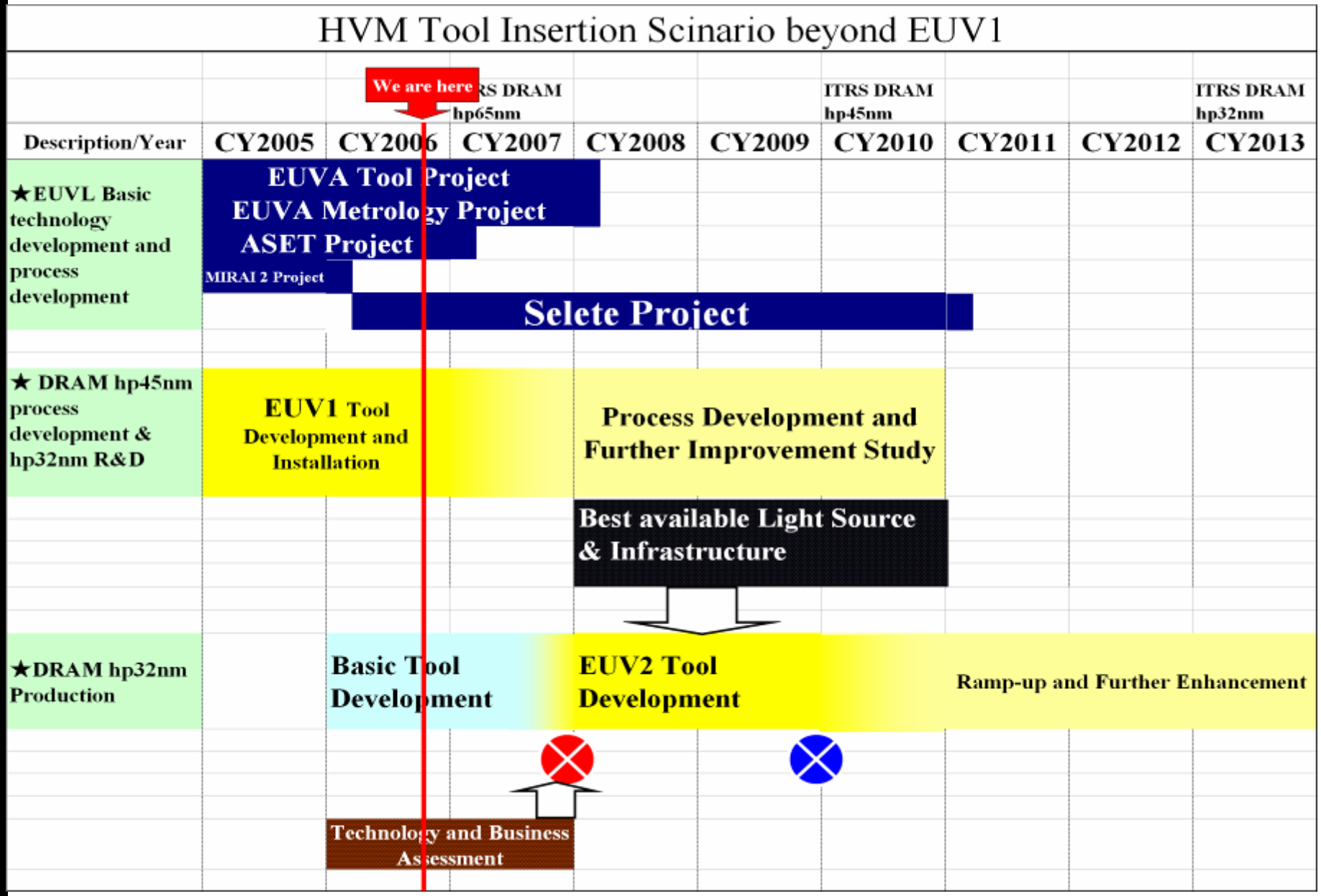
Infrastructure

EUV Source
- Power
- Debris
- Lifetime

Reflective Mask
- Reflectivity
- Defect
- Flatness

EUV resist
- Sensitivity
- LER/LWR

Future EUVL Tool Development Scenario



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Overall Development Status Summary

- EUV1 tool module fabrication underway on schedule.
- Polishing of 6 mirrors of proto-type PO successfully completed.
- Polishing of 6 mirrors of EUV1 PO underway on schedule.
- All Metrology tools for EUV1 PO production in operation.
- Xe DPP light source manufacturing underway.

- EUV1 tool development underway on schedule along with mask, resist and other infrastructure developments.
- EUV1 will be delivered in 1H/2007 for process development.
- EUV2(HVM) development scenario considered.

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Acknowledgements

■A part of this work was conducted under EUVA project. EUVA project has been supported by NEDO.

-*Nikon gratefully acknowledges METI and NEDO for their support.*

✧The authors would like to extend our sincere thanks to partner companies and many engineers working for Nikon EUVL development program.