Canon's Development Status of EUVL Technologies

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October 16, 2006

Outline

1. Technology Development Update
2. Optics and Infrastructure Development
3. SFET Development and Results
4. Summary and Acknowledgement

Tool and Technology Roadmap

Calendar Year FLASH HP	2005 65nm	2006	2007 45nm	2008	2009 32nm	2010	2011 22nm

EUV platform

- EUV
  - System Design / Unit Development
  - Full-Field EUV Tool
- SFET
  - Unit Development
  - Small Field Exposure Tool
NA0.30 0.6x0.2mm

EUV Technology & Infrastructure

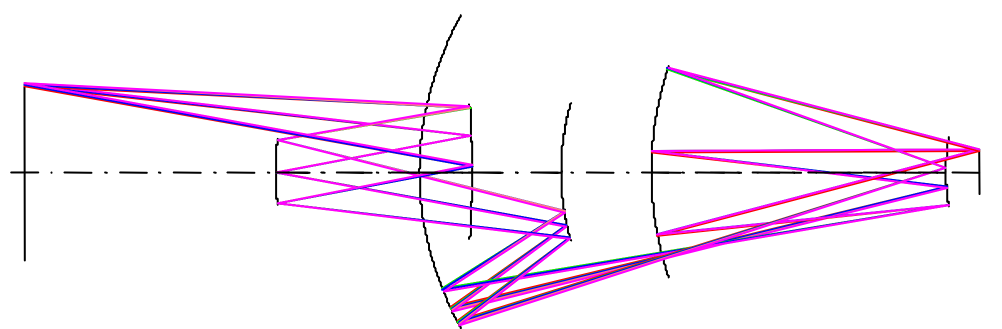
- Optics (Design)
- Production Equipment
- Met r ology development (Element)
- Stage development (1st model, 2nd model)
- Mask handling development

* Collaboration with consortium

Projection Optics Preparation

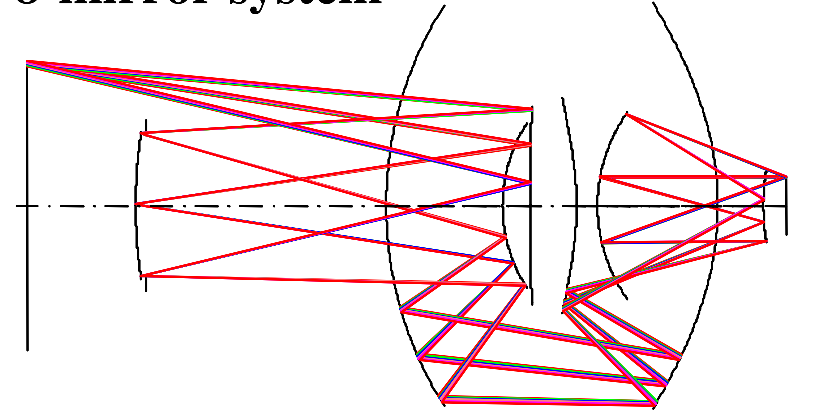
For Full-Field System, PO has been designed .
2 samples in many candidates are indicated here.

NA0.25 6-mirror system



NA = 0.25
Ring field width = 2 [mm]
Etendue (PO) = 10 [mm^2sr]

NA0.4 8-mirror system



NA = 0.4
Ring field width = 2 [mm]
Etendue (PO) = 27 [mm^2sr]

Etendue (PO) = w x h x $2\pi(1-\cos(\mathrm{asin}NA))$
w= 2mm, h= 26mm

Infrastructure Preparation

Mirror polishing tool

Wavefront measurement tool for EUV projection optics

Key technologies are proven through SFET production .

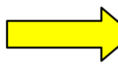
- **Mirror surface Figuring**
  Special tool(IBF) developed for mirror surface creation by EUVA project.
- **Wavefront measurement:**
  Newly developed tool has a measurement accuracy better than 100pm.
- **Multi-layer coating** (Sputtering Tool):
  Exposure test was accomplished in SFET construction.

Ion Beam Figuring Performance

Target and actual removal profiles in IBF operations of the mirror 1 in SFET

Target shape profile for removal
Real shape profile for removal
(nm)
(mm)

Target & actual figure profiles agreed well.
IBF will be highly capable in producing
full field exposure tool.



EUVL symposium2006
01-OP-51
M.Ando et al.

Supported by NEDO

(co-operation with Tokyo Univ. of Science)

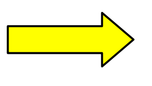
Infrastructure Preparation

Mirror reflection / phase shift Measurement tool

EUV light source evaluation Tool

. Key technologies are proven through SFET production .

- **Multi layer performance evaluation:**
  Mirror reflectivity and phase shift information to be measured simultaneously.



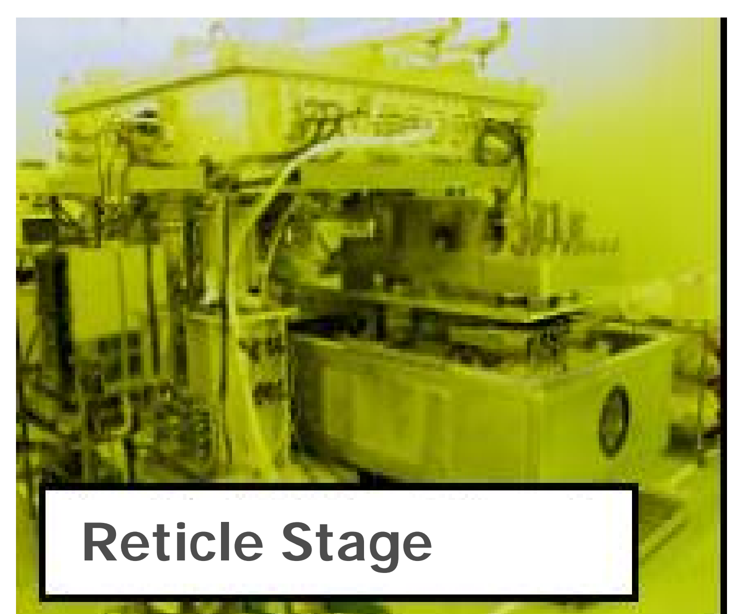
EUVL symposium2006
04-ME-56
F.Masaki et al.

- **Wavefront measurement:**
  Measurement to be done with SOR light by EUVA project (co-operation with University of Hyougo)

EUVL symposium2006
Metrology session
K.Murakami et al.

- **Light source evaluation:**
  Evaluation method for EUV light source performance developed.

Prototype Stages for Full Field Tool

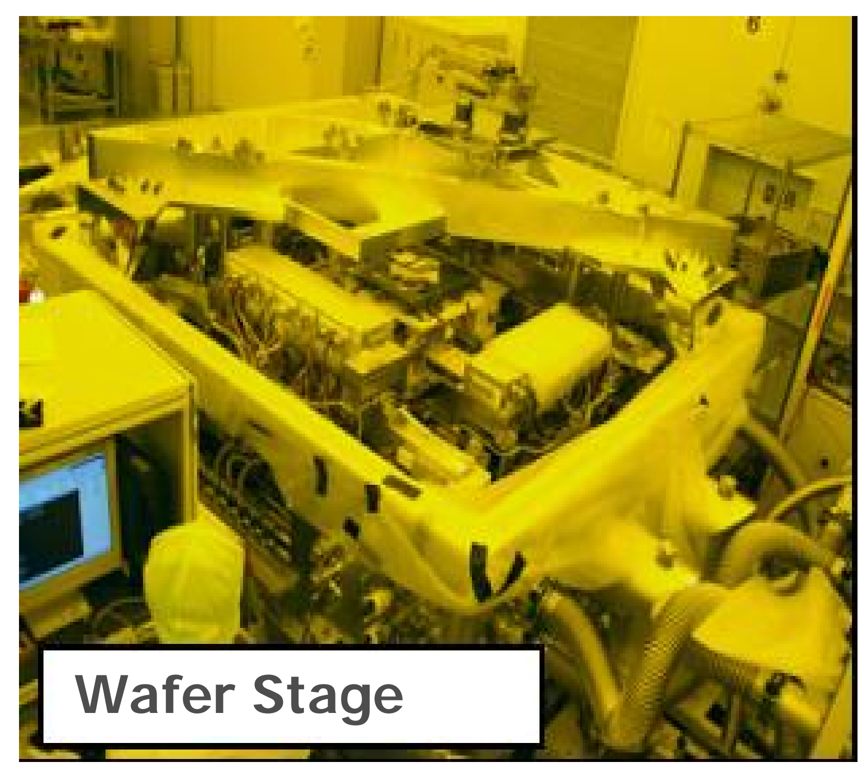


Accomplished all the test items of the wafer and reticle stage in High Vacuum Environment.

2005

Long term stability test is in operation under High Vacuum Environment.

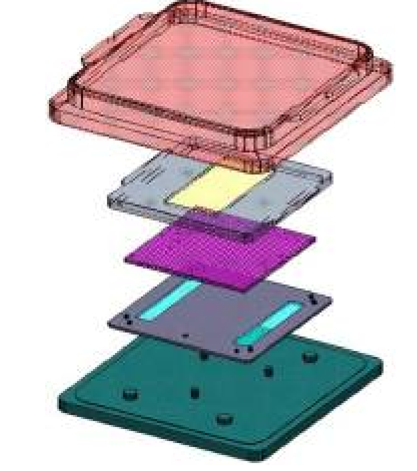
2006



Mask Handling and Contamination Study

Mask Carrier Proposal

- Dual Pod Concept
- Frame transfer
- Clean Filter Pod

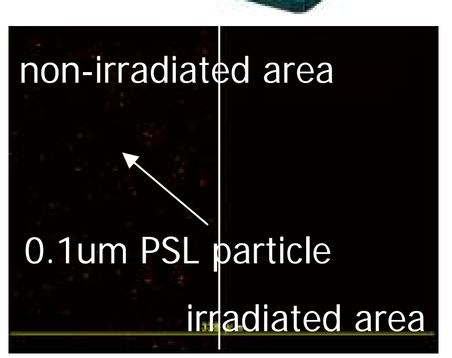


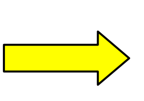
EUVL symposium2006
Reticle handling session
D.Halbmaier et al.

Mask Cleaning Study

Study of a short pulsed
laser cleaning system

Microscope image
on Ru capped ML/mirror



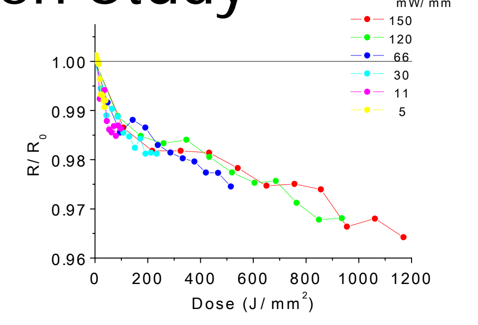


EUVL symposium2006
04-ME-56
M.Yonekawa et al.

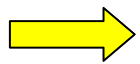
Chemical Contamination Study

High acceleration test for
mirror contamination, and

In situ XANES Analysis for
projection optics.



EUVL symposium2006
01-CC-11
Y.Kakutani et al.



EUVL symposium2006
02-CC-13
M.Niibe et al.

SFET Abstract Model

Picture of 1/10 model

Coater/Developer

Wafer Transport Mechanism

LPP source (EUVA)

Main Body / Vacuum Chamber

Mask Transport Mechanism

EUVA Selete

Supported by NEDO

Overview of SFET

Exhaust Ventilation

EUV Emission Chamber

SFET Main Chamber

Source Laser

Beam Delivery

Wafer Handling

Supported by NEDO

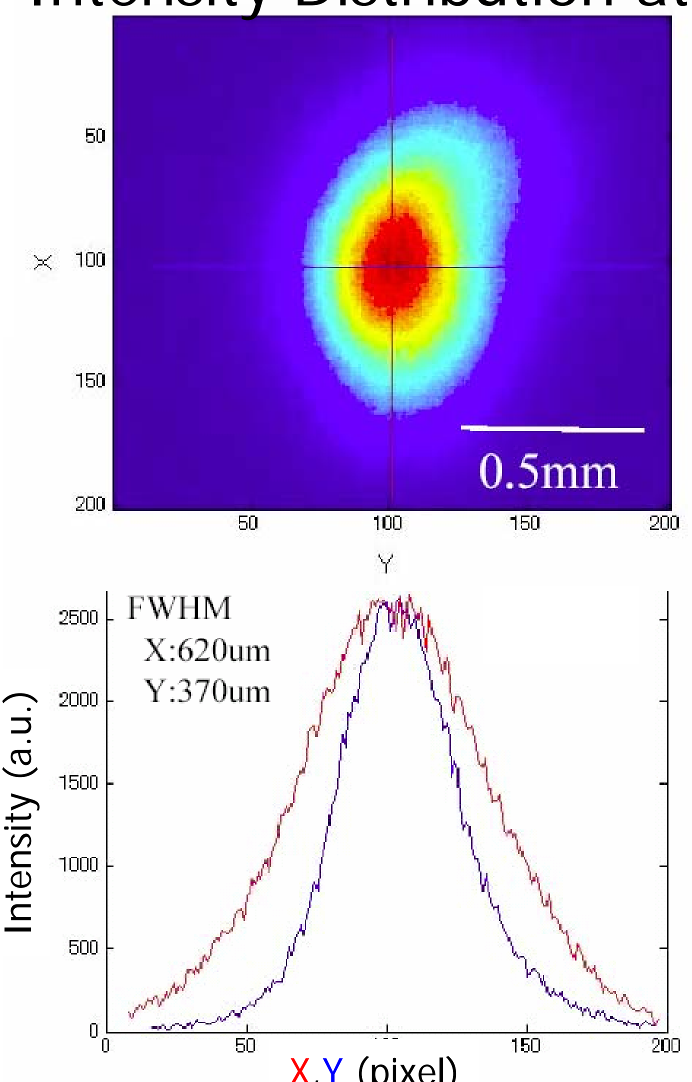
Optics Specifications

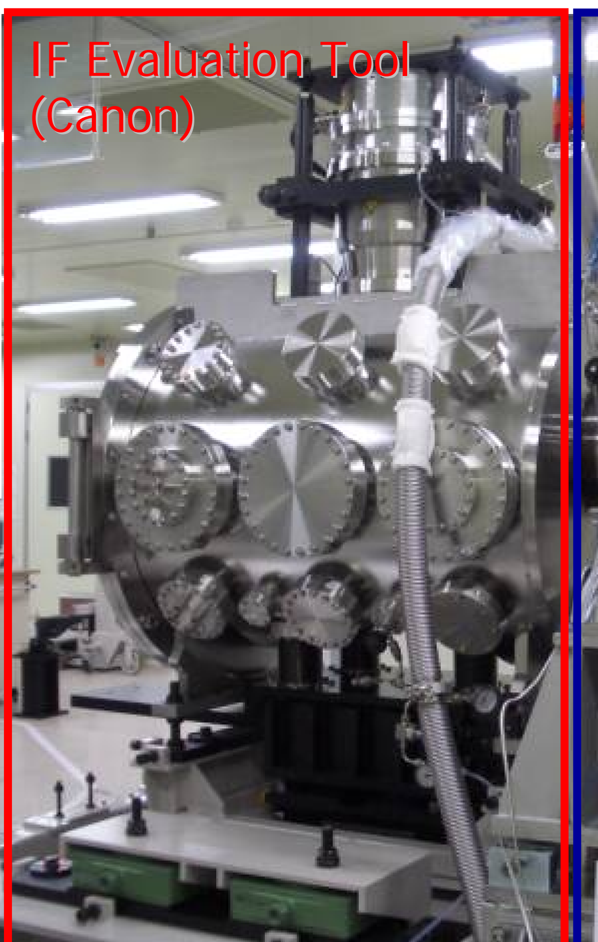
Resolution	32nm L/S
NA	0.3
Magnification	1/5
Field size	0.2mm X 0.6mm
Projection type	Aspheric two mirror system
Wavefront error	<0.9nm rms
Flare	<7%
Illumination type	Koehler type
Reticle incident angle	6 deg
Illumination mode	maxσ 0.7

Supported by NEDO

LPP EUV Source

Intensity Distribution at IF

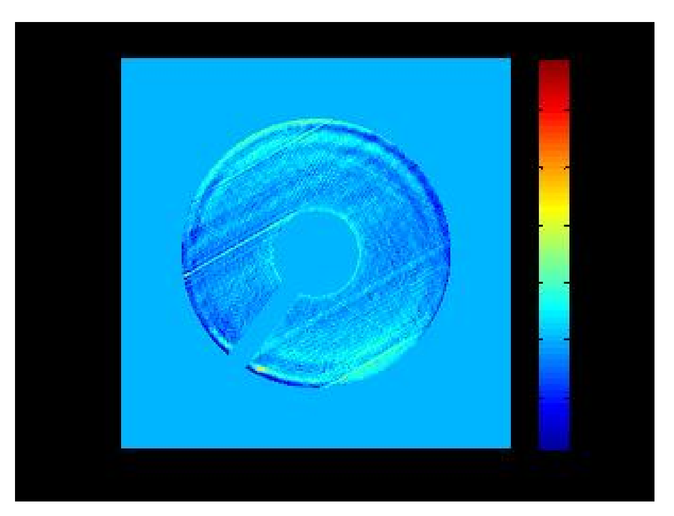




LPP: Laser-Produced Plasma
IF: Intermediate Focus

Supported by NEDO

Wavefront aberration and Flare



Wavefront AZ5-37	Residual (1/CA - 1/mm)	Total
0.51	0.49	0.71

(nm RMS)

PSD (nm^2 *mm)

1.0E+00
1.0E-01
1.0E-02
1.0E-03
1.0E-04
1.0E-05
1.0E-06
1.0E-07

0.001 0.01 0.1 1 10 100 1000

Frequency (1/mm)

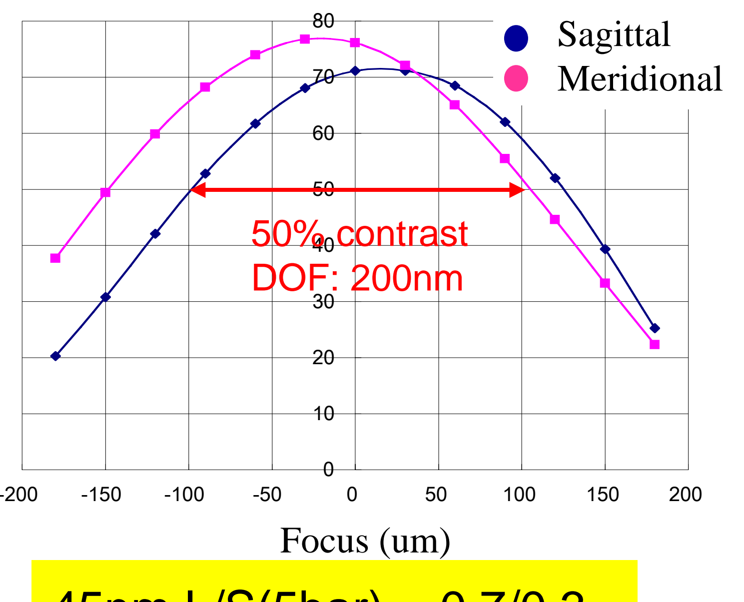
M2_LSFR
M1_MSFR
M2_MSFR

LSFR | MSFR

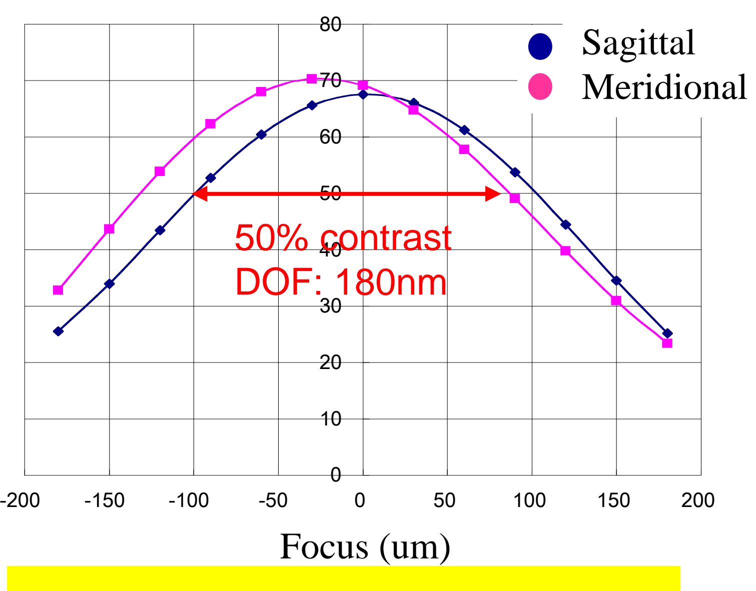
	LSFR	MSFR
Measurement (nmRMS)	0.265	0.391
Flare (%)	6.08	6.64

Supported by NEDO

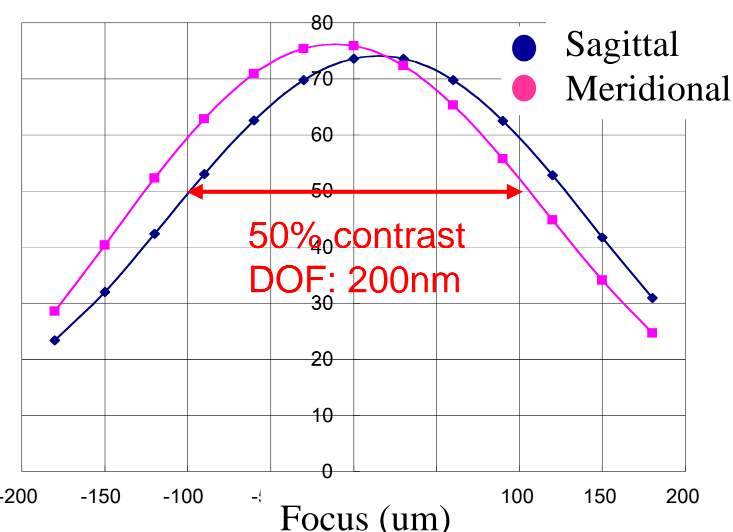
Contrast Simulations Based on Wavefront



45nm L/S(5bar), σ0.7/0.3



32nm L/S(5bar), σ0.7/0.3

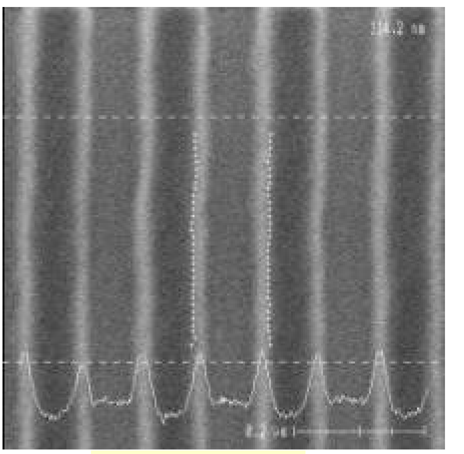


32nm L/S(5bar),σ0.55/0.36

Exposure Result

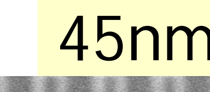
Exposure test has been started at the end of September 2006, Initiated by SELETE, on Canon site.

MET-2D resist Rohm-Haas



Exposure conditions
illumination σ0.7/0.3

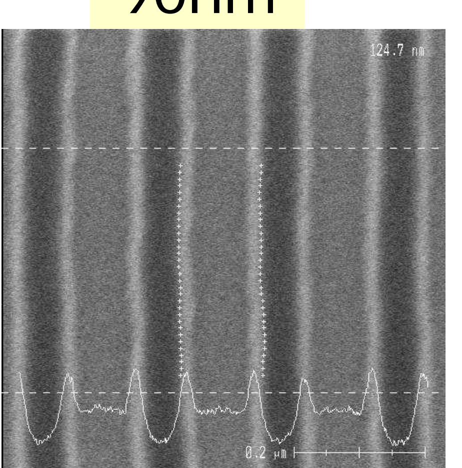
90nm

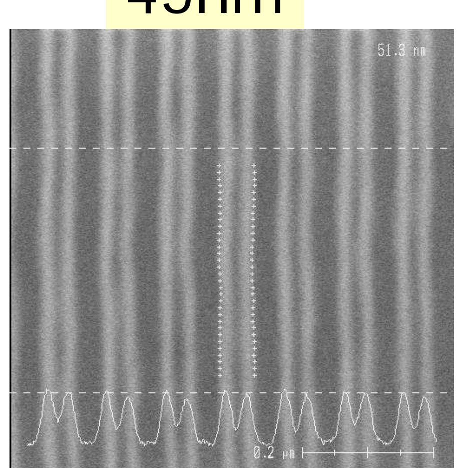


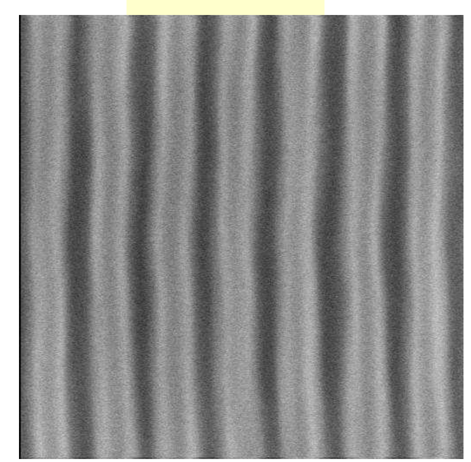
45nm

32nm

TOK resist

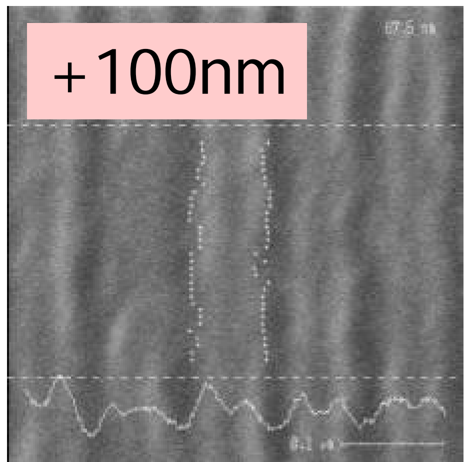


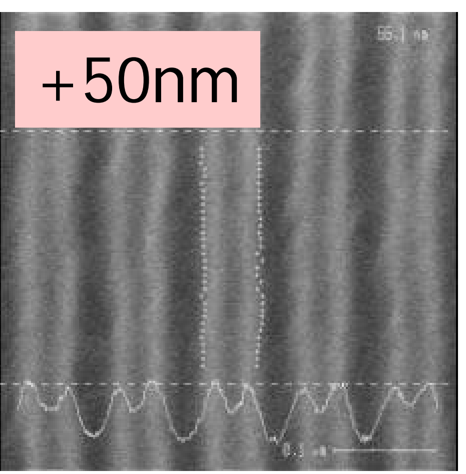


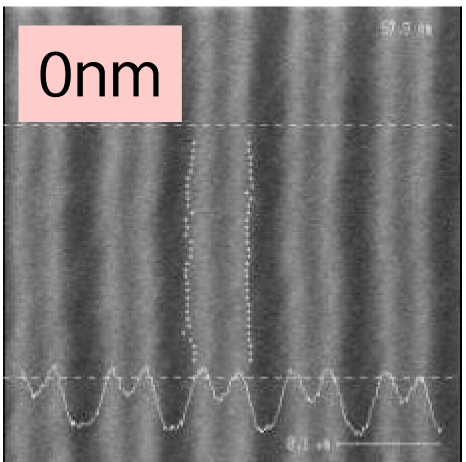


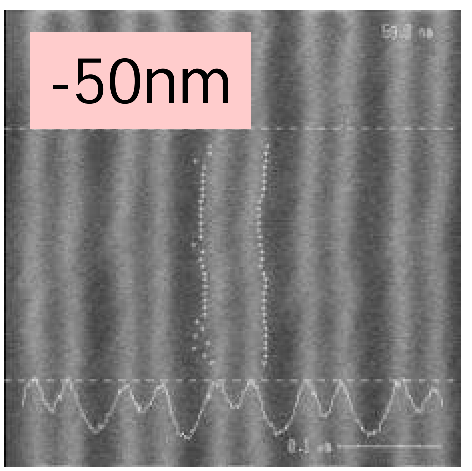
Supported by NEDO

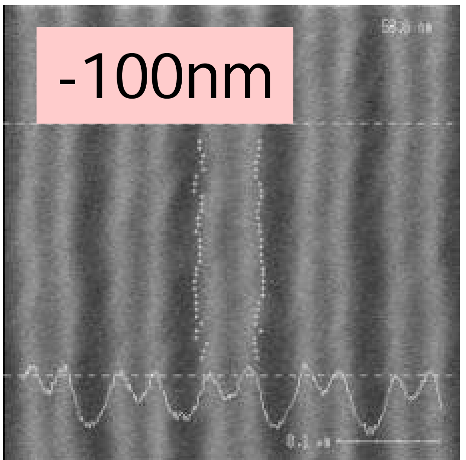
45nm L&S Exposure Result

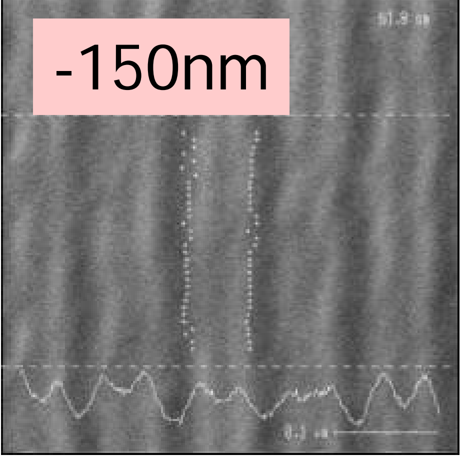












Exposure conditions;
MET-2D, Rohm&Haas
illumination σ0.7/0.3

Supported by NEDO

45nm L&S Exposure Result

+120nm

+80nm

+40nm

0nm

-40nm

-80nm

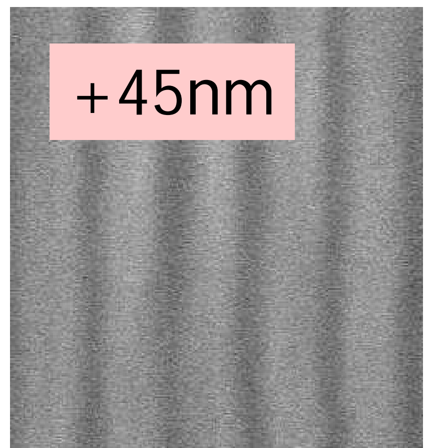
-120nm

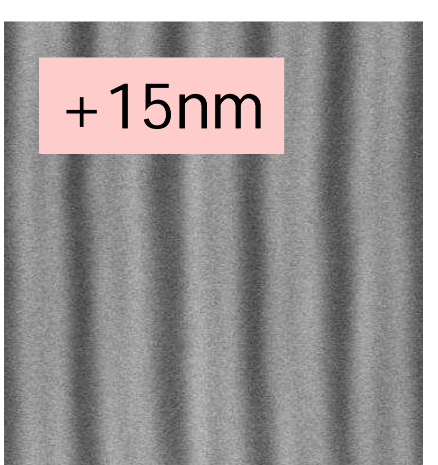
-160nm

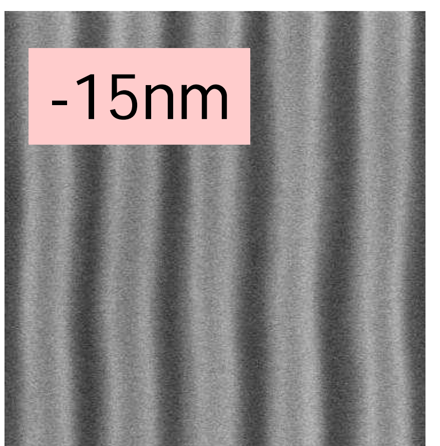
Exposure conditions;
TOK resist
illumination σ0.7/0.3

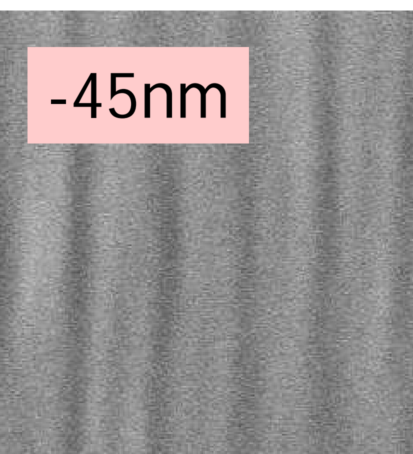
Supported by NEDO

32nm L&S Exposure Result









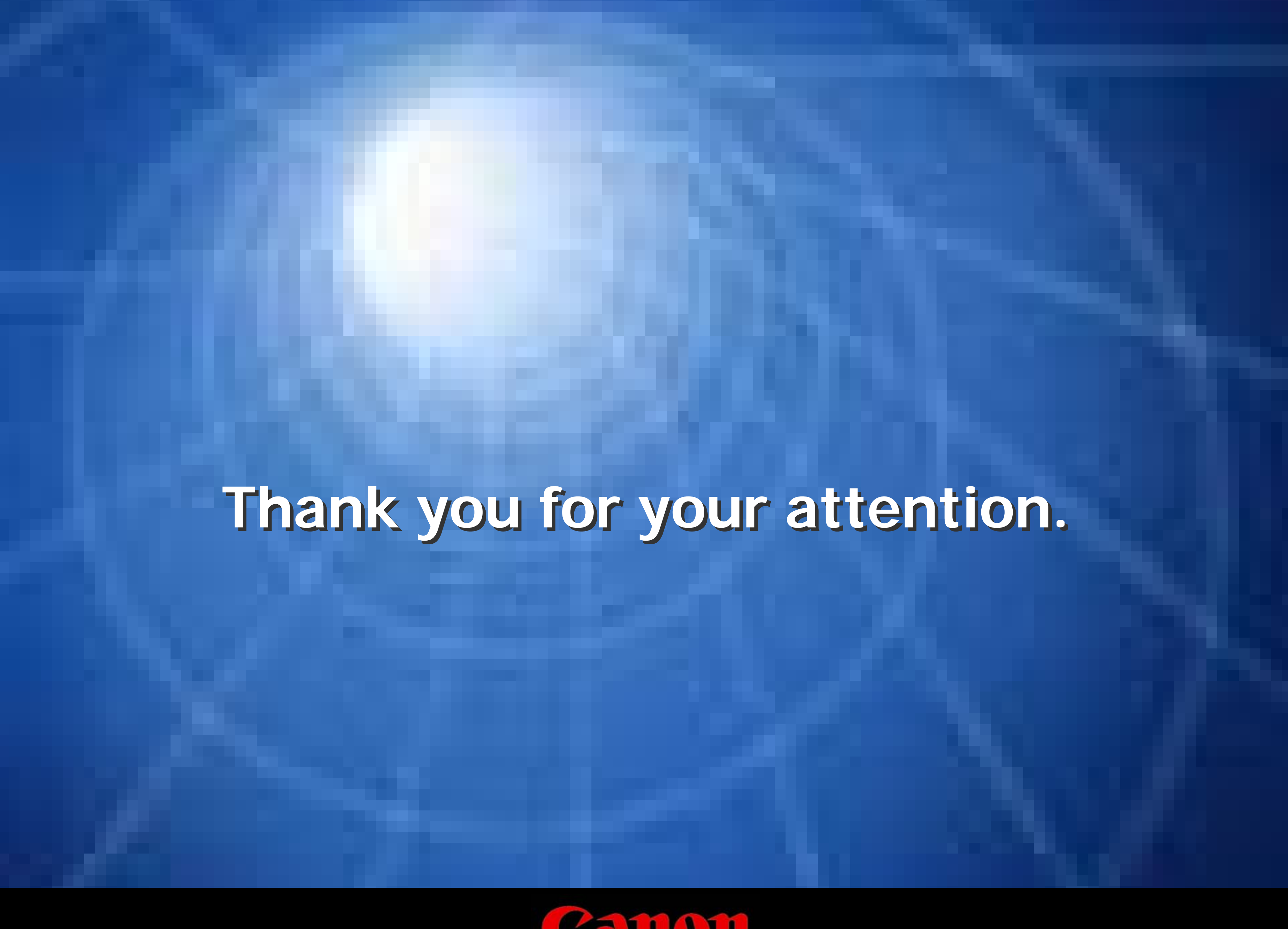
Exposure conditions;
TOK resist
illumination σ0.7/0.3

Supported by NEDO

Summary & Acknowledge

1. Canon will develop the Full Field Tool. The schedule will be fixed in middle of 2007.
2. Some of key technologies in infrastructures were proven through SFET production .
3. For full field Tool, key units will be ready before 2009.
4. SFET will be applied for EUV resist evaluation and development in Selete.

Thanks for support and co-operation to ;
EUVA, Selete, Aset, NEDO, NTT atsugi Lab.
Univ.of Hyogo, Tokyo Univ.of Science and
Lawrence Livermore National Laboratory


Thank you for your attention.
Canon