EUVL Development Status of Canon

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Core Technology Development Headquarters

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Outline

1. Canon’s Roadmap of EUVL tool
2. Exposure results of SFET
3. SFET illuminator enhanced plan
4. Preparation for the Full Field Tool
5. Requested NA and Resolution of EUVL
6. Summary of Canon’s EUVL Development Status

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Canon's Roadmap of EUVL tool

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

EUVL platform

EUV

Tool timing judgment

Full-Field EUV Tool

System Design/ unit production

EUVL system

SFET

Development

Specification Study

Collaboration study with Selete about the tool specification.

EUVL Production Technology

Development

Improvement

EUVL optics requires high precision mirror surface.
→Measurement / machining tool development is almost complete.

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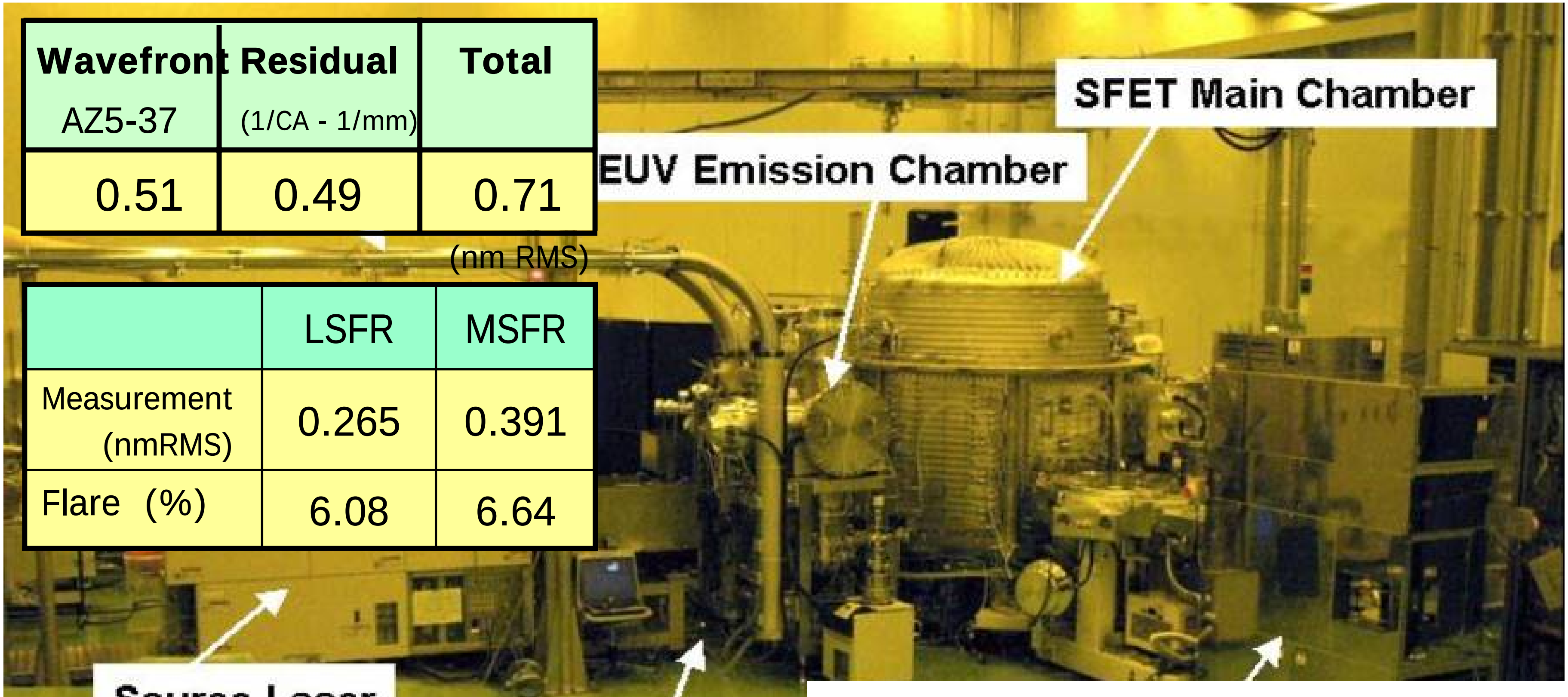
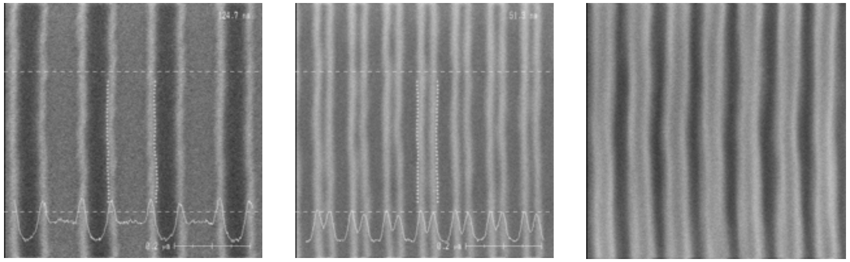
Exposure Results of SFET at Canon



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

(nm RMS)

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

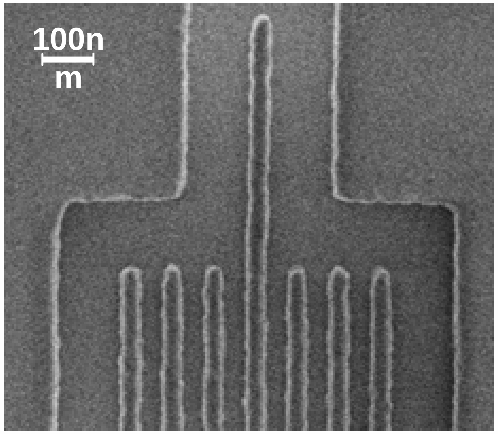


90nm 45nm 32nm

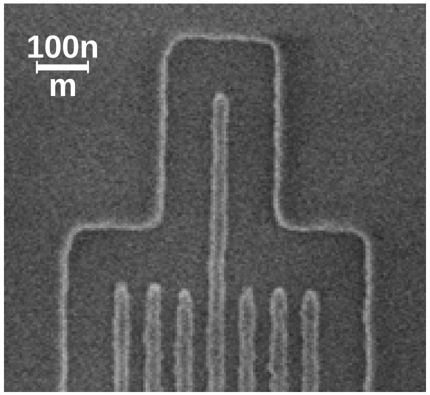
Supported by NEDO

Exposure Results of SFET at Selete

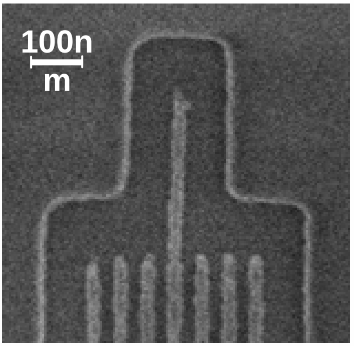
Courtesy of Selete



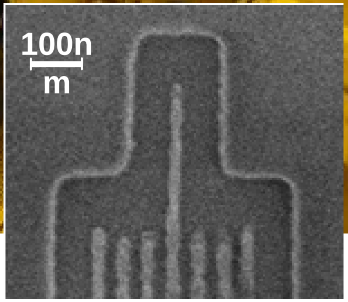
45nm



32nm



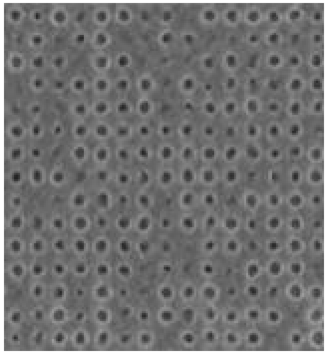
28nm

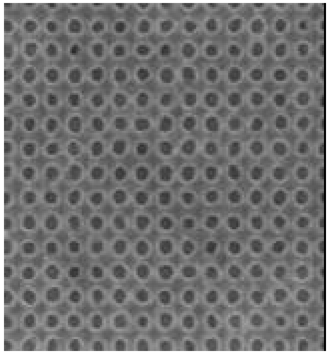


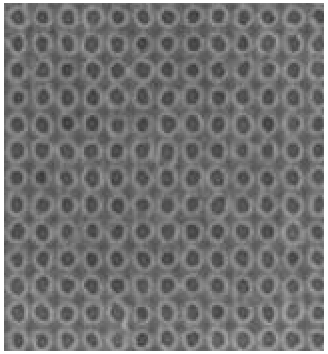
26nm

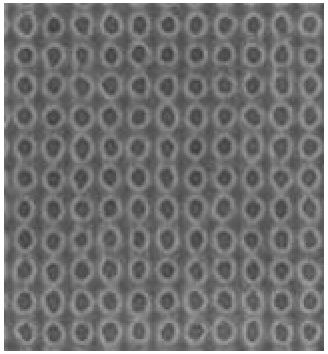
Supported by NEDO

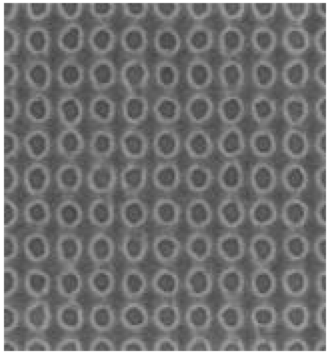
Resolution of Dense C/H Patterns

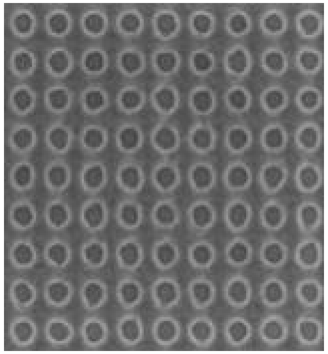

30 nm C/H

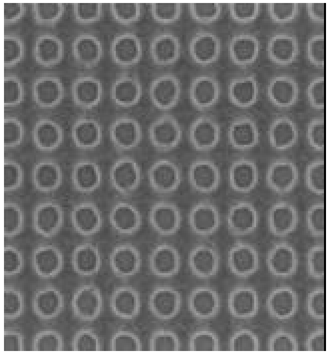

32 nm C/H

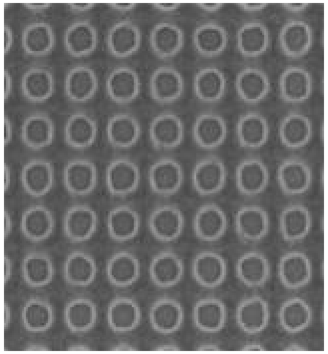

35 nm C/H

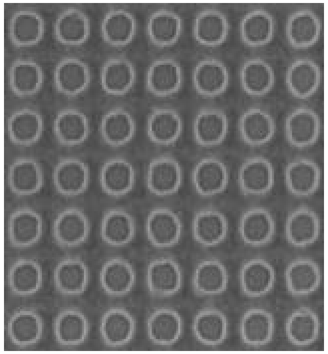

40 nm C/H

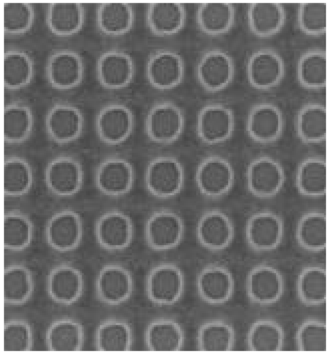

45 nm C/H


50 nm C/H

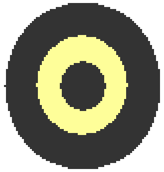

55 nm C/H


60 nm C/H


65 nm C/H


70 nm C/H

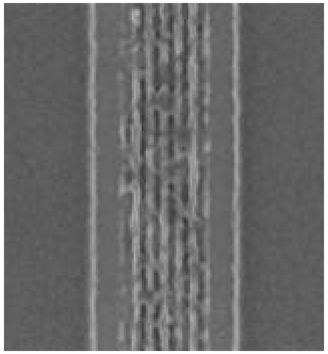
Resist: SSR2 (60 nm^t)

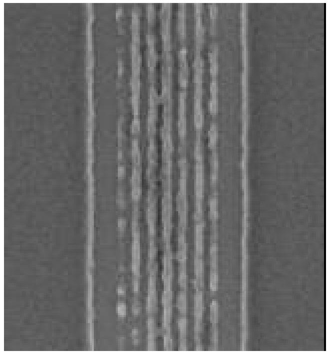

Annular
(s=0.3/0.5)

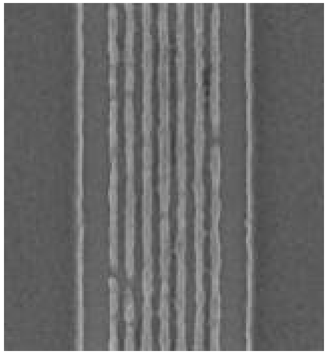
Dense 32 nm C/H patterns were almost resolved.
Resolution might be limited by resist characteristics.

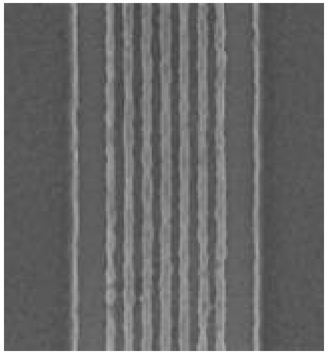
Courtesy of Selete

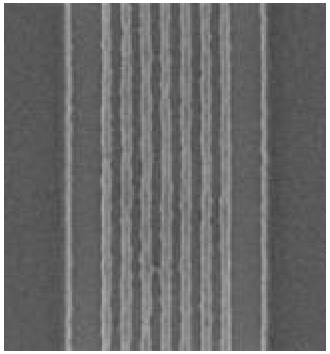
Resolution of L/S patterns (X-slit)

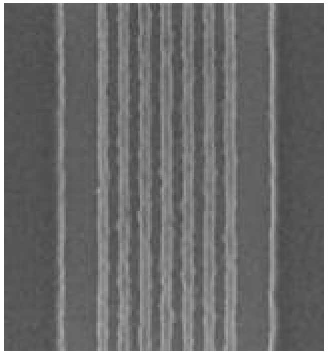

20 nm L/S

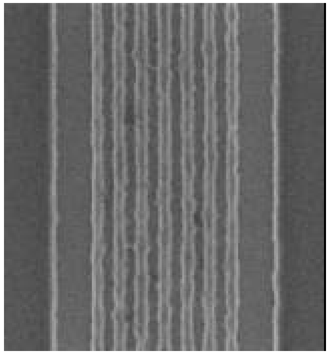

22 nm L/S

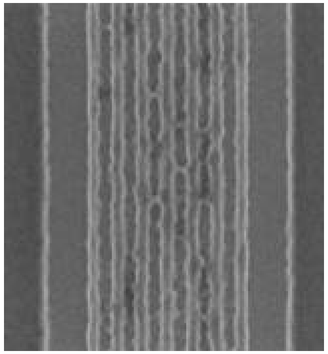

24 nm L/S

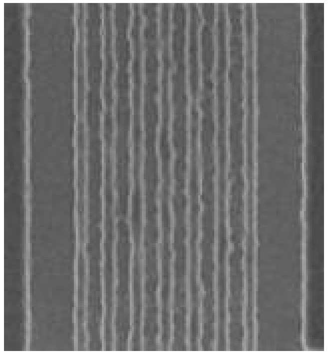

26 nm L/S

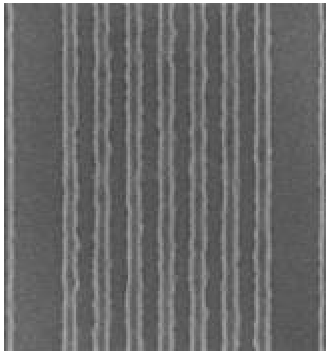

28 nm L/S


30 nm L/S

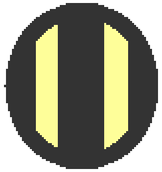

32 nm L/S


35 nm L/S


40 nm L/S


45 nm L/S

Resist: SSR2 (60 nm^t)


X-slit

Pattern shapes of 20-26 nm L/S patterns were improved by using slit Illumination. 24 nm L/S patterns were almost resolved.

Courtesy of Selete

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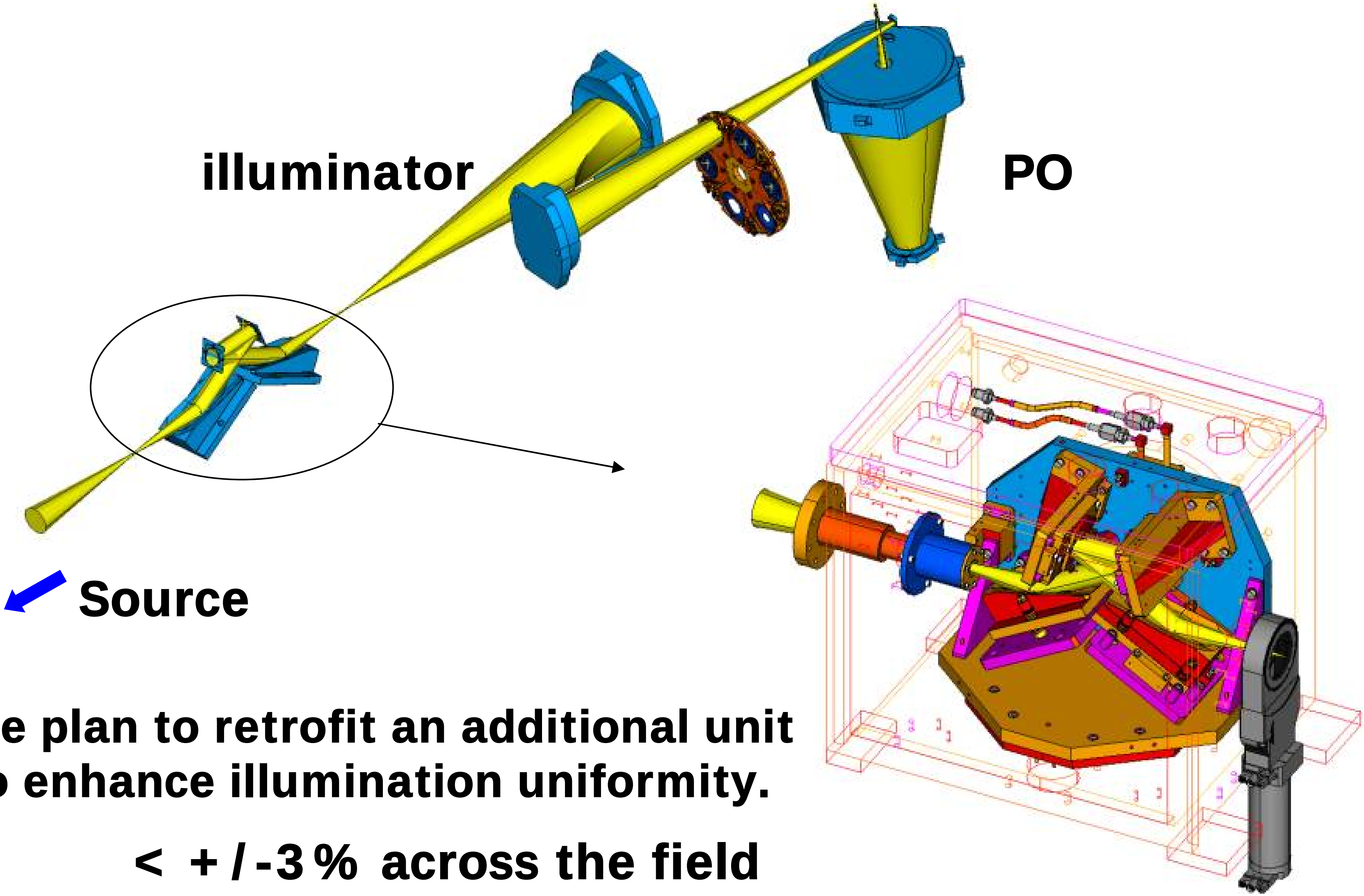
SFET Illuminator Enhancement Plan



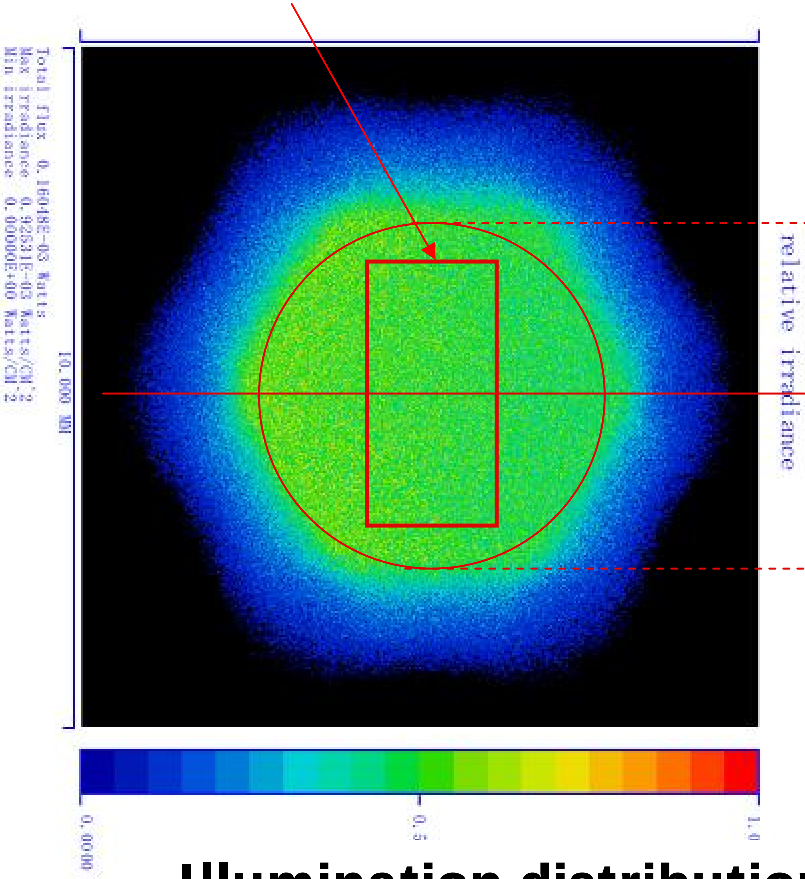
We plan to retrofit an additional unit To enhance illumination uniformity.

< +/-3% across the field

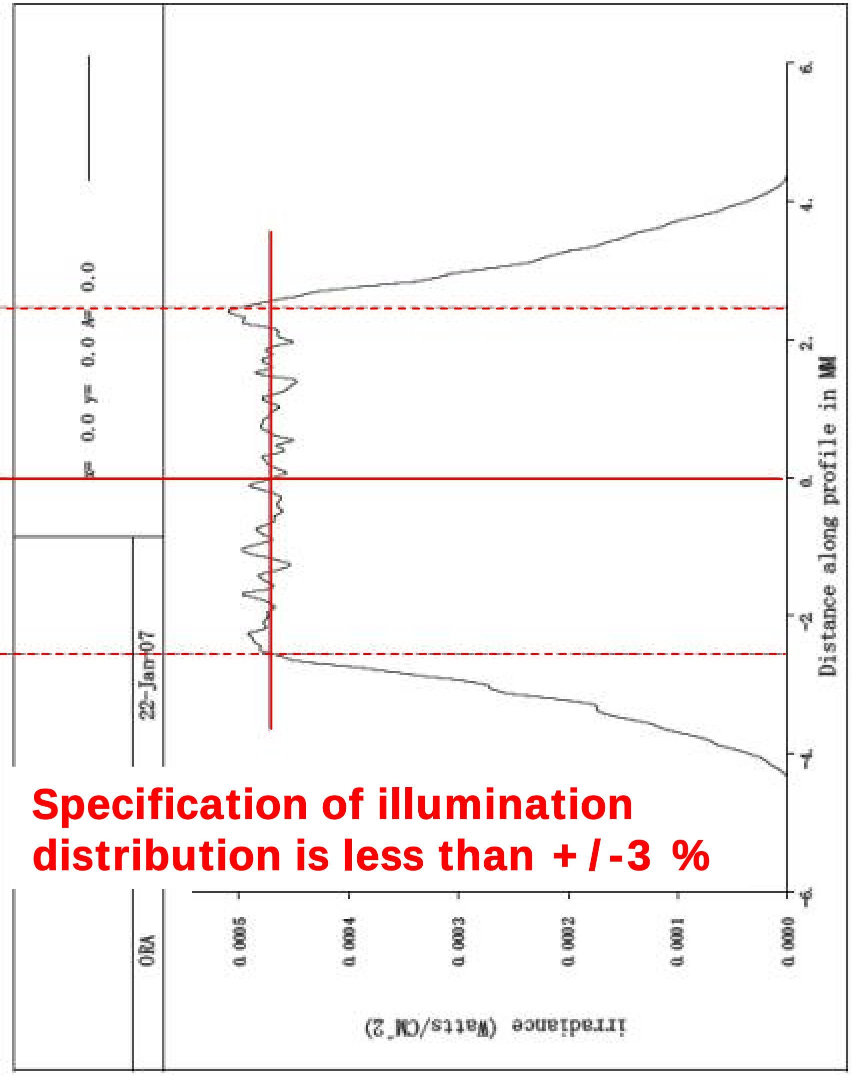
Estimated Illumination Distribution

Canon

Illumination area
2mm×4mm

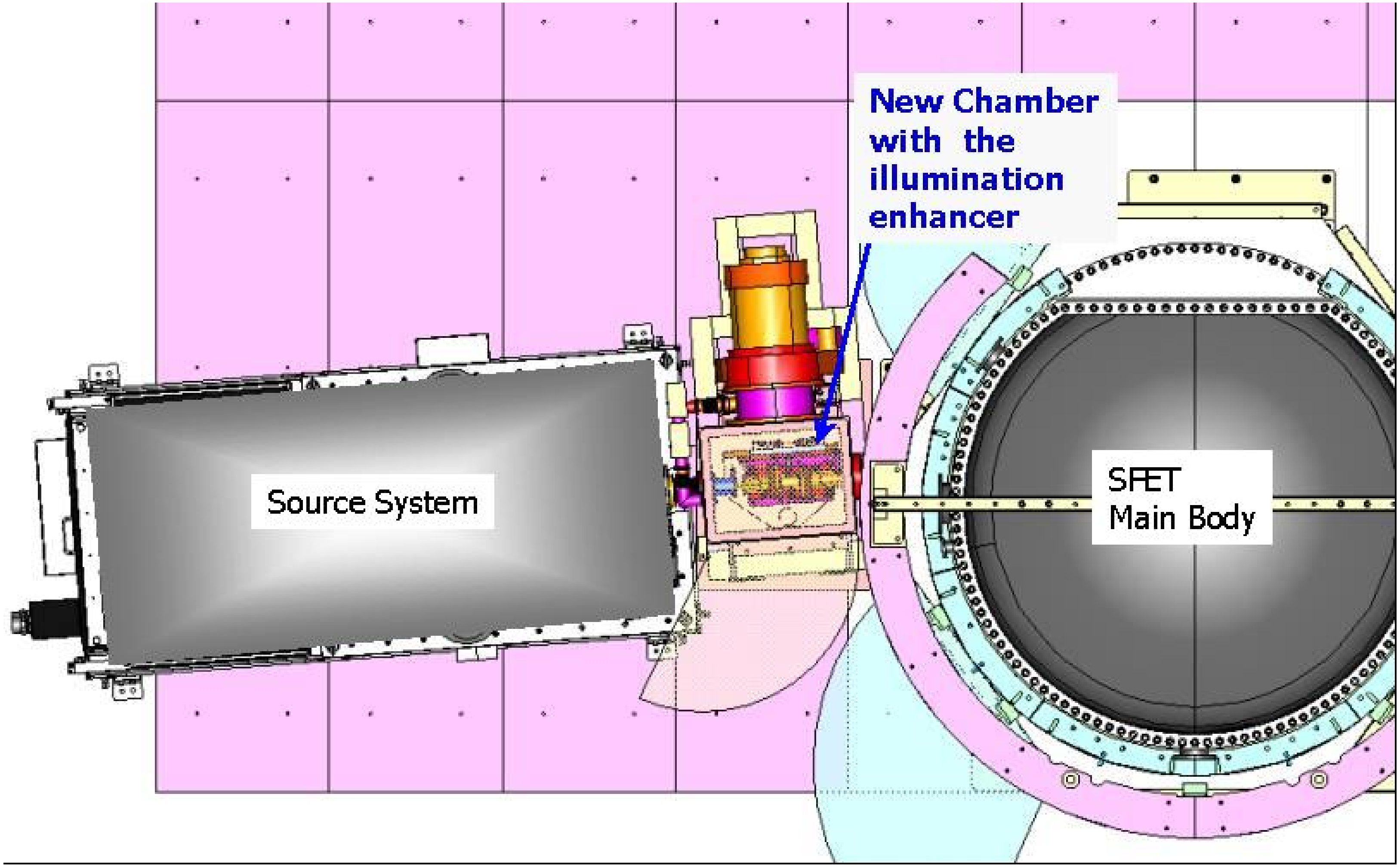


Illumination distribution on mask surface



Specification of illumination distribution is less than +/-3 %

SFET Layout with illumination enhancement



All units were accomplished and the installation is started.

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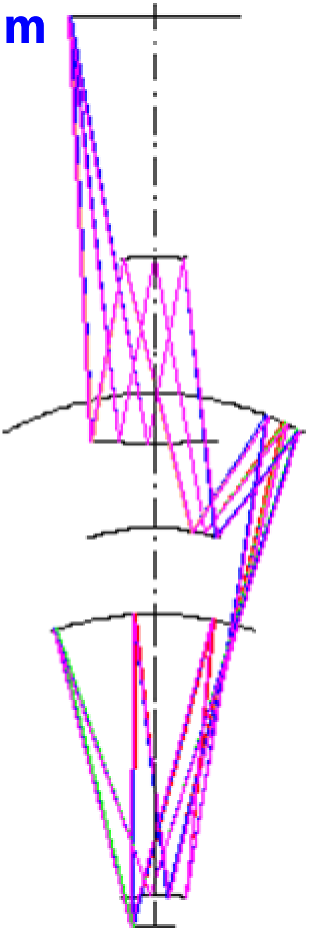
Projection Optics for full field tool

For Full-Field System, PO has been designed .
EUVL is extendable beyond DRAM ½ pitch 32nm generation.

Example of 6-mirror system



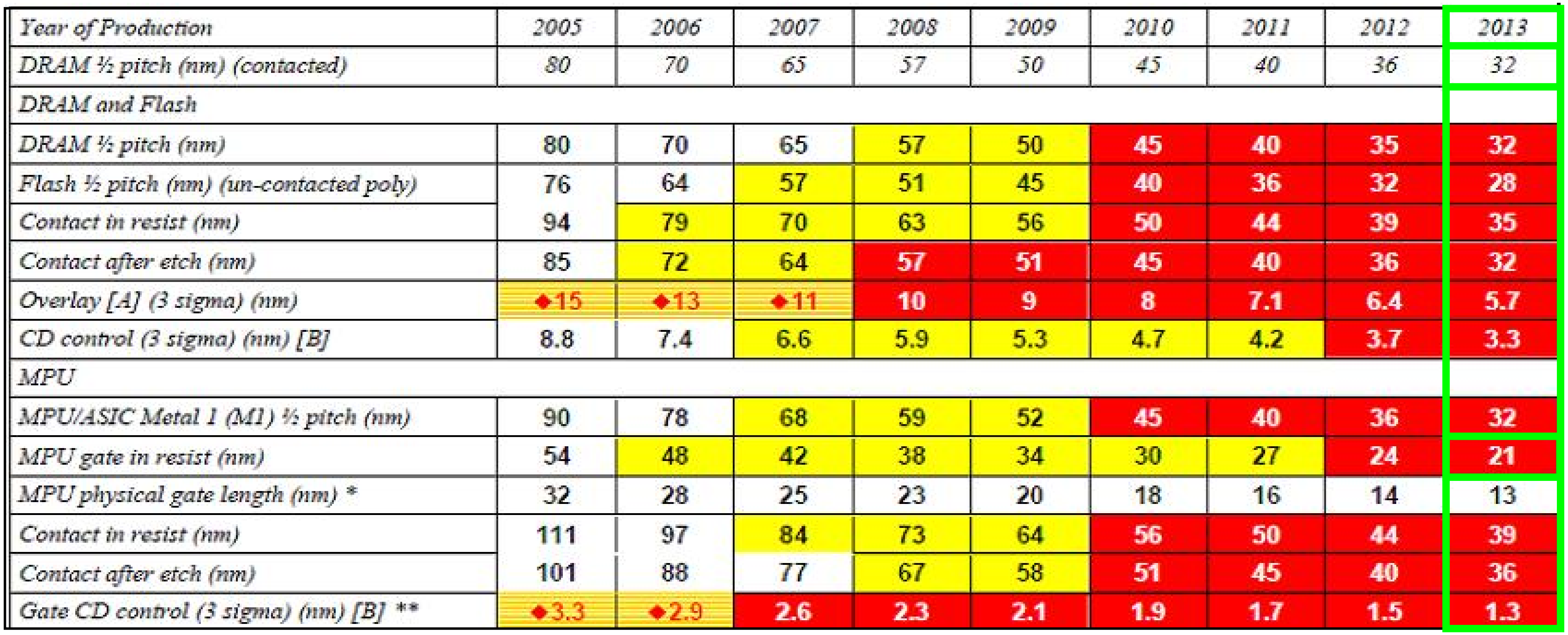
EUVL Optics Specifications

Resolution	**32nm L/S**
NA	**>0. 25**
Magnification	**1/4**
Field size	**26mm x 33mm**
Projection type	**6 Aspheric mirrors**
Wavefront error	**<0.5nm RMS**
Flare	**<11%**
Incident angle	**6 deg**
Illumination mode	**> 5 types**
Though Put	**> 80 wph**
	Source power 115w
	Resist Sensitivity 10mj/cm

Lens Aberration Requirement

- **Lens aberration requirements mainly comes from CD variation requirement in the field**
- **The impacts to the CD control at MPU gate 21 nm generations had been calculated**

Lithography Technology Requirements



Year of Production	2005	2006	2007	2008	2009	2010	2011	2012	2013
DRAM ½ pitch (nm) (contacted)	80	70	65	57	50	45	40	36	32
DRAM and Flash									
DRAM ½ pitch (nm)	80	70	65	57	50	45	40	35	32
Flash ½ pitch (nm) (un-contacted poly)	76	64	57	51	45	40	36	32	28
Contact in resist (nm)	94	79	70	63	56	50	44	39	35
Contact after etch (nm)	85	72	64	57	51	45	40	36	32
Overlay [A] (3 sigma) (nm)	◆15	◆13	◆11	10	9	8	7.1	6.4	5.7
CD control (3 sigma) (nm) [B]	8.8	7.4	6.6	5.9	5.3	4.7	4.2	3.7	3.3
MPU									
MPU/ASIC Metal 1 (M1) ½ pitch (nm)	90	78	68	59	52	45	40	36	32
MPU gate in resist (nm)	54	48	42	38	34	30	27	24	21
MPU physical gate length (nm) *	32	28	25	23	20	18	16	14	13
Contact in resist (nm)	111	97	84	73	64	56	50	44	39
Contact after etch (nm)	101	88	77	67	58	51	45	40	36
Gate CD control (3 sigma) (nm) [B] **	◆3.3	◆2.9	2.6	2.3	2.1	1.9	1.7	1.5	1.3

ITRS 2006 Update

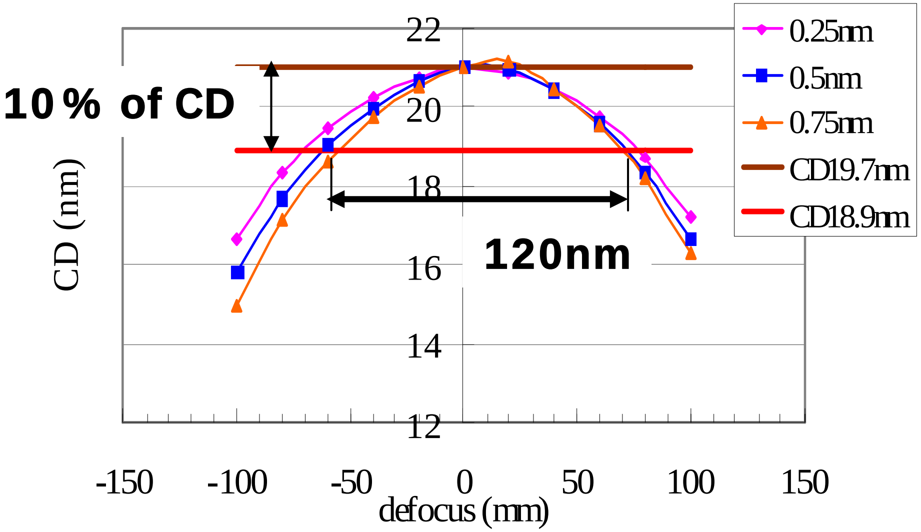
DOF and Lens Aberration

CD variation and NILS at MPU gate 21nm generations

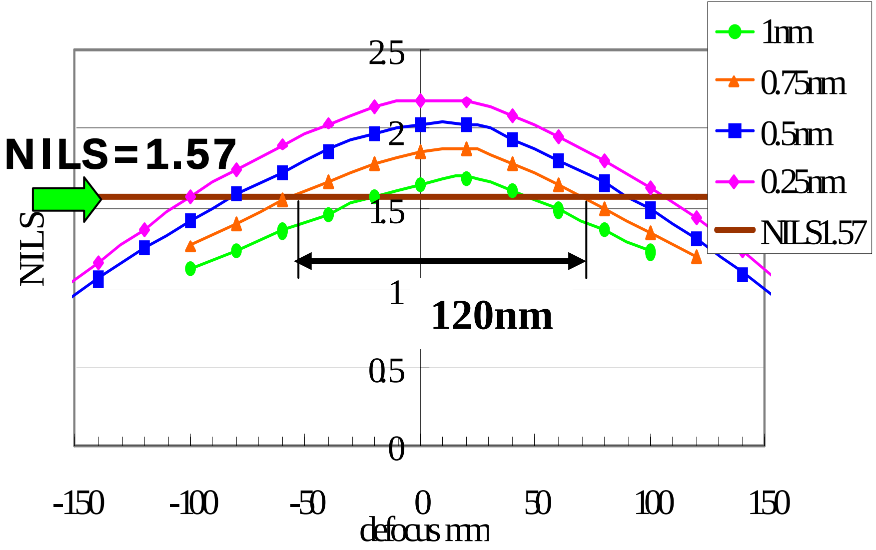
DOF and NILS for MPU gate 21 nm

MPU gate (nm)	DOF(nm)	NILS
21	120	1.57

MPU gate 21 nm CD - Focus



MPU gate 21 nm NILS - Focus



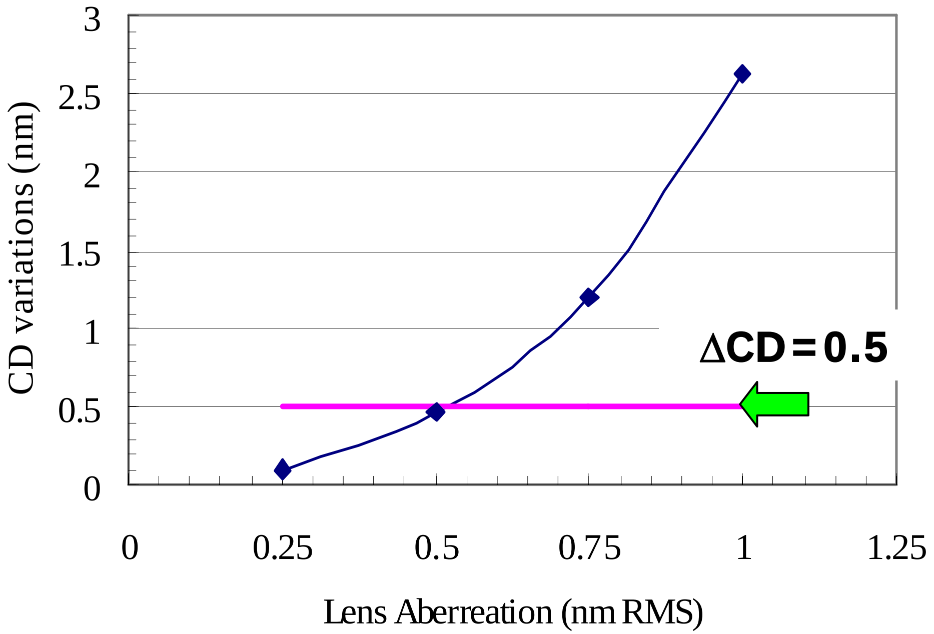
NILS : Normalized Image Log Slope

In the case, when lens aberration less than 0.75nm RMS, both DOF & NILS are within the requirement.

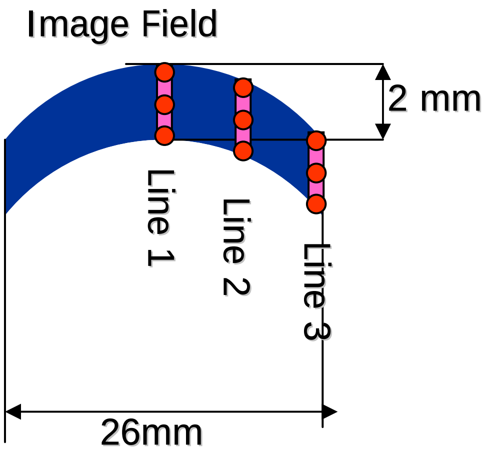
CD Uniformity and Lens Aberration

- CD variations by the lens aberration at MPU gate 21nm generations is less than 0.5nm

Lens Aberration – CD variations in the field

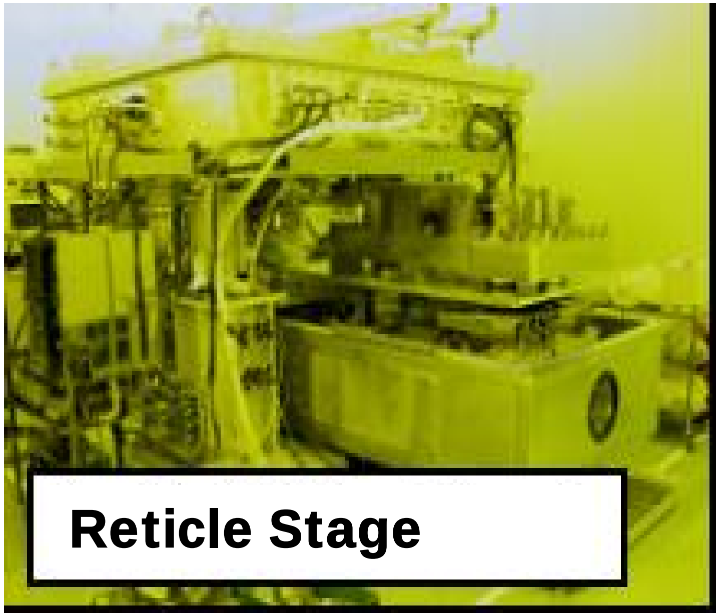


Calculated points in the field



The lens aberration must be less than 0.5nm RMS to satisfy the CD variation at MPU gate 21 nm generations.

Stage units for the HVM are ready

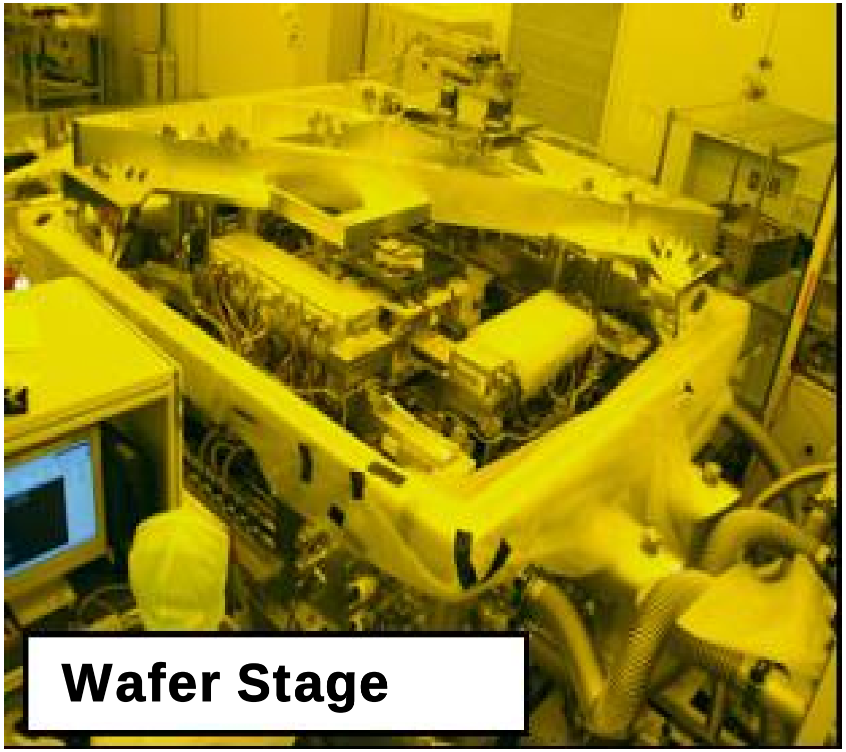


Accomplished all the test items of the wafer and reticle stage in High Vacuum Environment.

2005

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

2006

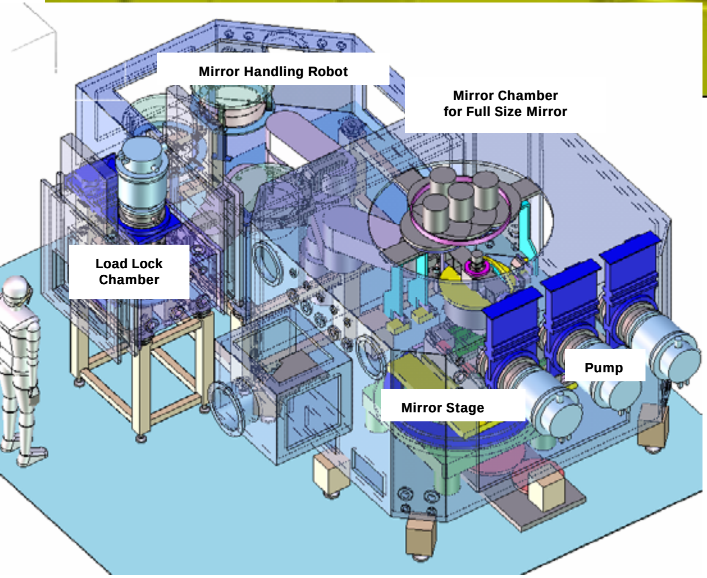


Ion Beam figuring tool is ready for production

The IBF was developed at EUVA supported by NEDO, and was installed at manufacturing site in Canon.

EUV Reflectometer at manufactory site

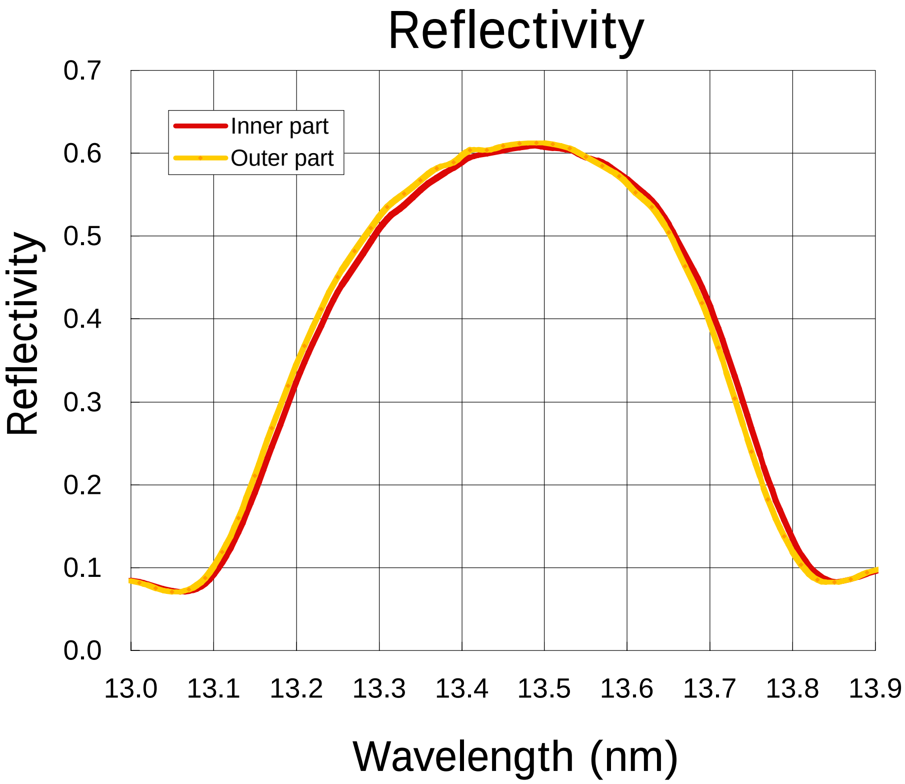
Mirrors of SFET are measured by this reflectometer.

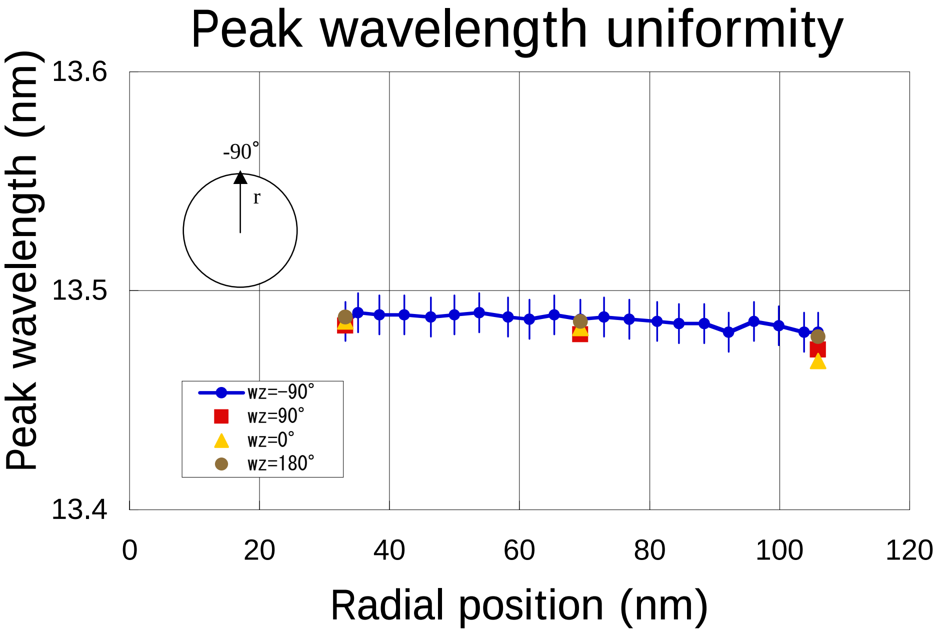


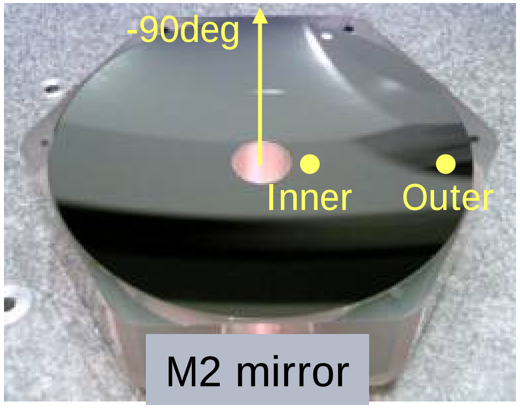
Wavelength range	12.5 - 15 nm
Monochromaticity (FWHM)	0.06 nm
Angular distribution	5 mrad
Polarizer extinction factor	< 1E-3
Measurement Repeatability	0.2%
Maximum sample diameter	0.5 m

Multilayer Coating performance is proved by SFET.

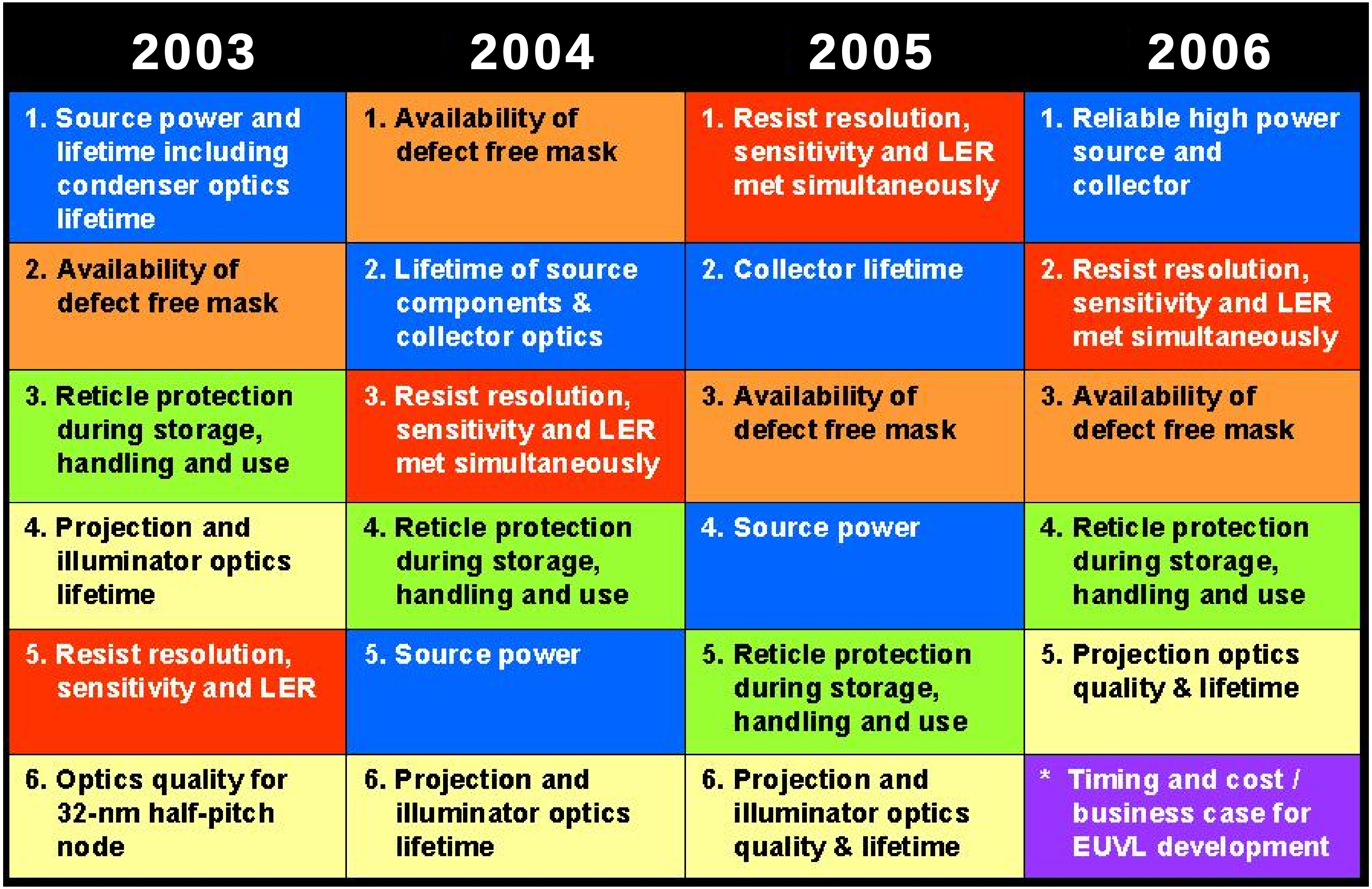
EUV reflectivity of M2







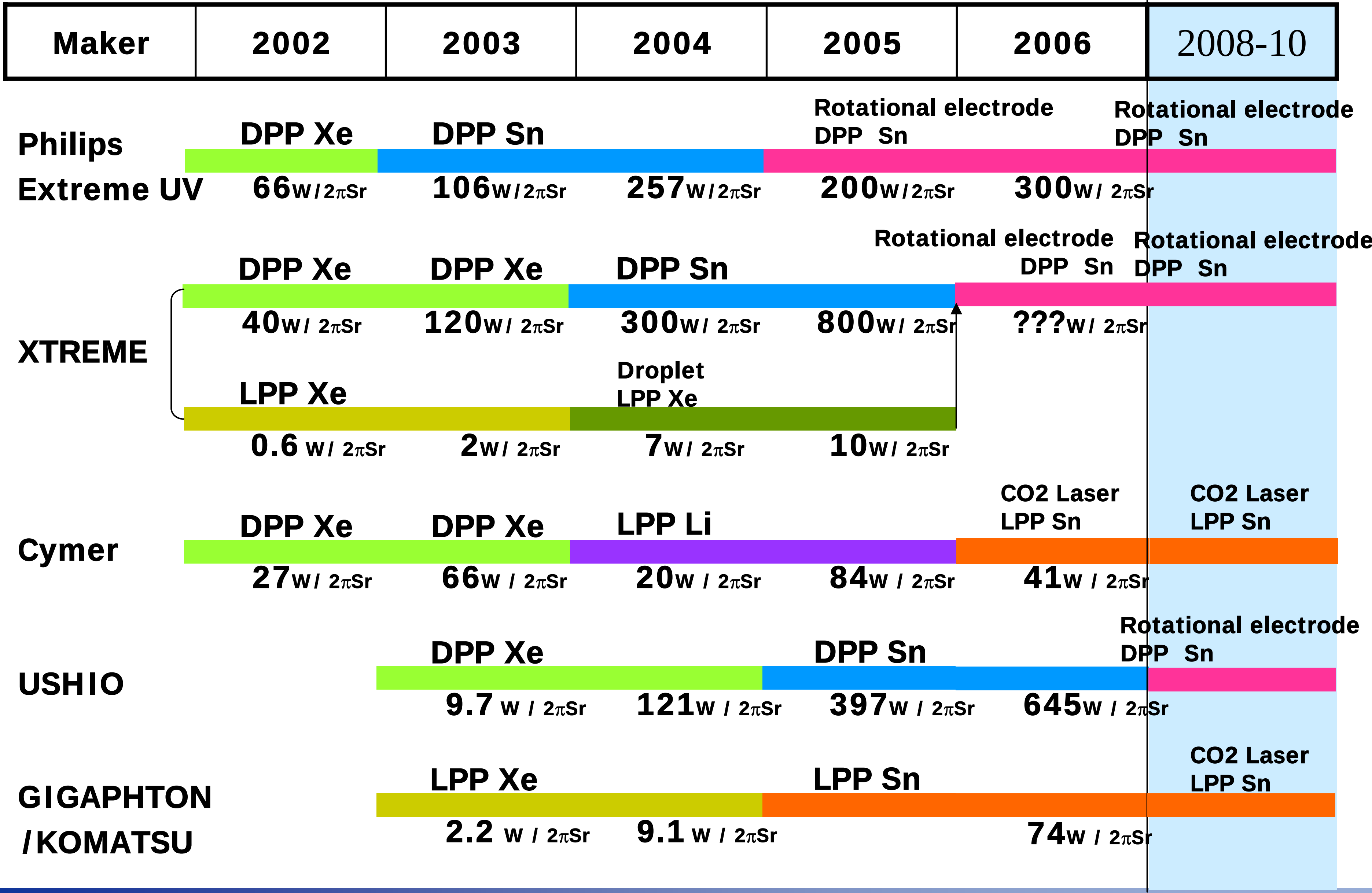
Top Critical Issues in EUVL



2003	2004	2005	2006
1. Source power and lifetime including condenser optics lifetime	1. Availability of defect free mask	1. Resist resolution, sensitivity and LER met simultaneously	1. Reliable high power source and collector
2. Availability of defect free mask	2. Lifetime of source components & collector optics	2. Collector lifetime	2. Resist resolution, sensitivity and LER met simultaneously
3. Reticle protection during storage, handling and use	3. Resist resolution, sensitivity and LER met simultaneously	3. Availability of defect free mask	3. Availability of defect free mask
4. Projection and illuminator optics lifetime	4. Reticle protection during storage, handling and use	4. Source power	4. Reticle protection during storage, handling and use
5. Resist resolution, sensitivity and LER	5. Source power	5. Reticle protection during storage, handling and use	5. Projection optics quality & lifetime
6. Optics quality for 32-nm half-pitch node	6. Projection and illuminator optics lifetime	6. Projection and illuminator optics quality & lifetime	* Timing and cost / business case for EUVL development

Ref: Steering Committees – 2nd, 3rd, 4th, and 5th International EUVL Symposia

HVM EUVL Source is narrowed down to 2-type



Maker	2002	2003	2004	2005	2006	2008-10
Philips Extreme UV	DPP Xe 66w/2πSr	DPP Sn 106w/2πSr	257w/2πSr	Rotational electrode DPP Sn 200w/2πSr	300w/ 2πSr	Rotational electrode DPP Sn
XTREME	DPP Xe 40w/ 2πSr	DPP Xe 120w/ 2πSr	DPP Sn 300w/ 2πSr	800w/ 2πSr	Rotational electrode DPP Sn ???w/ 2πSr	Rotational electrode DPP Sn
	LPP Xe 0.6 w/ 2πSr	2w/ 2πSr	Droplet LPP Xe 7w/ 2πSr	10w/ 2πSr		
Cymer	DPP Xe 27w/ 2πSr	DPP Xe 66w / 2πSr	LPP Li 20w / 2πSr	84w / 2πSr	CO2 Laser LPP Sn 41w / 2πSr	CO2 Laser LPP Sn
USHIO		DPP Xe 9.7 w / 2πSr	121w / 2πSr	DPP Sn 397w / 2πSr	645w / 2πSr	Rotational electrode DPP Sn
GIGAPHTON /KOMATSU		LPP Xe 2.2 w / 2πSr	9.1 w / 2πSr	LPP Sn	74w / 2πSr	CO2 Laser LPP Sn

Resist & Source Development Status

1. Rapid progress in the last 2 years.
2. There are still issues to be conquered.
3. All specification will be clear within next 2 years (rosy prospect).

From 2007 SPIE

	Target	A	B	C	D
Resolution nm HP	32	29	28	45	25
Sensitivity mJ/cm2	10	27	12	6	49
LER nm	1.6	4.8	6.5	>10	2.3

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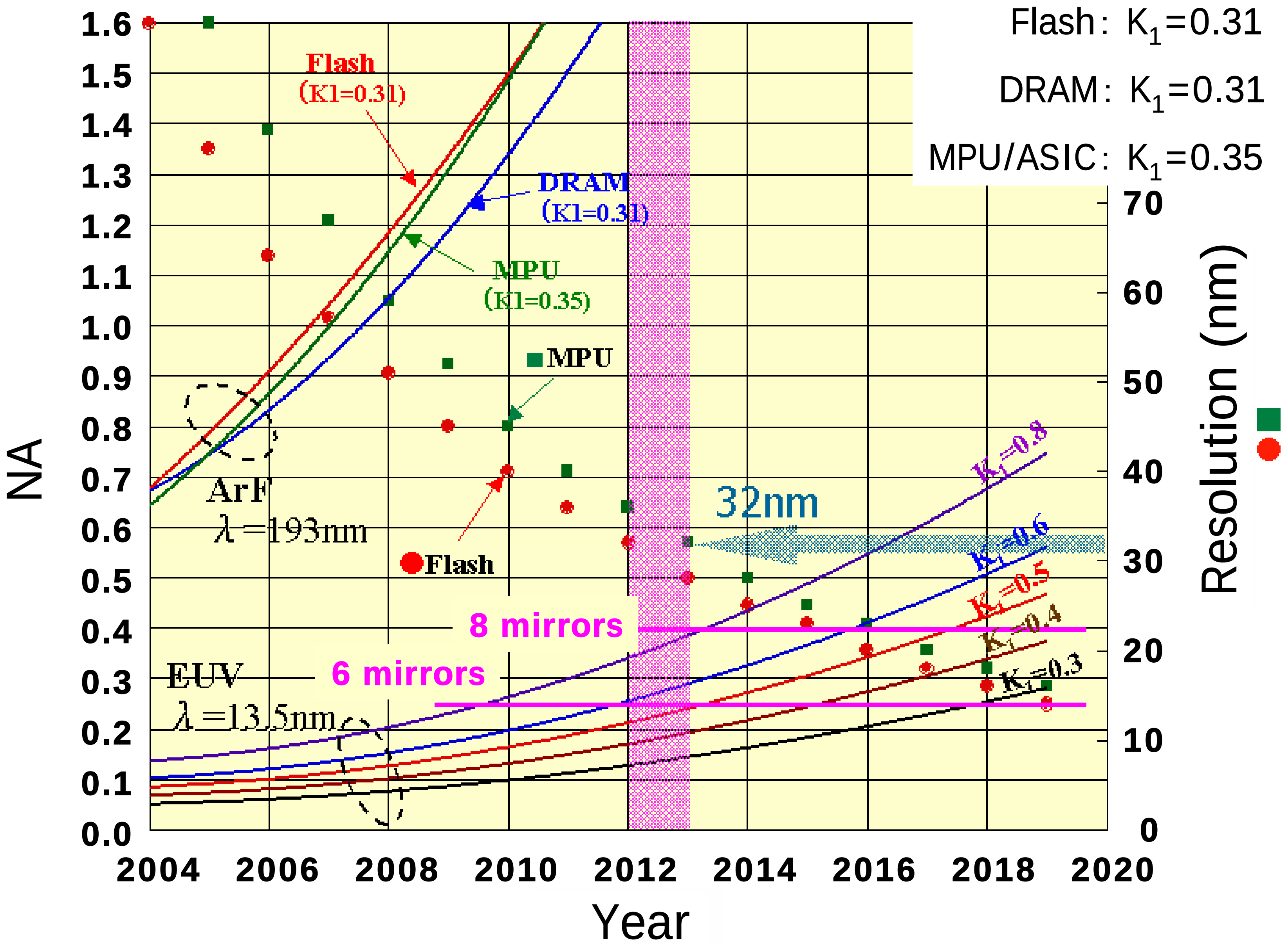
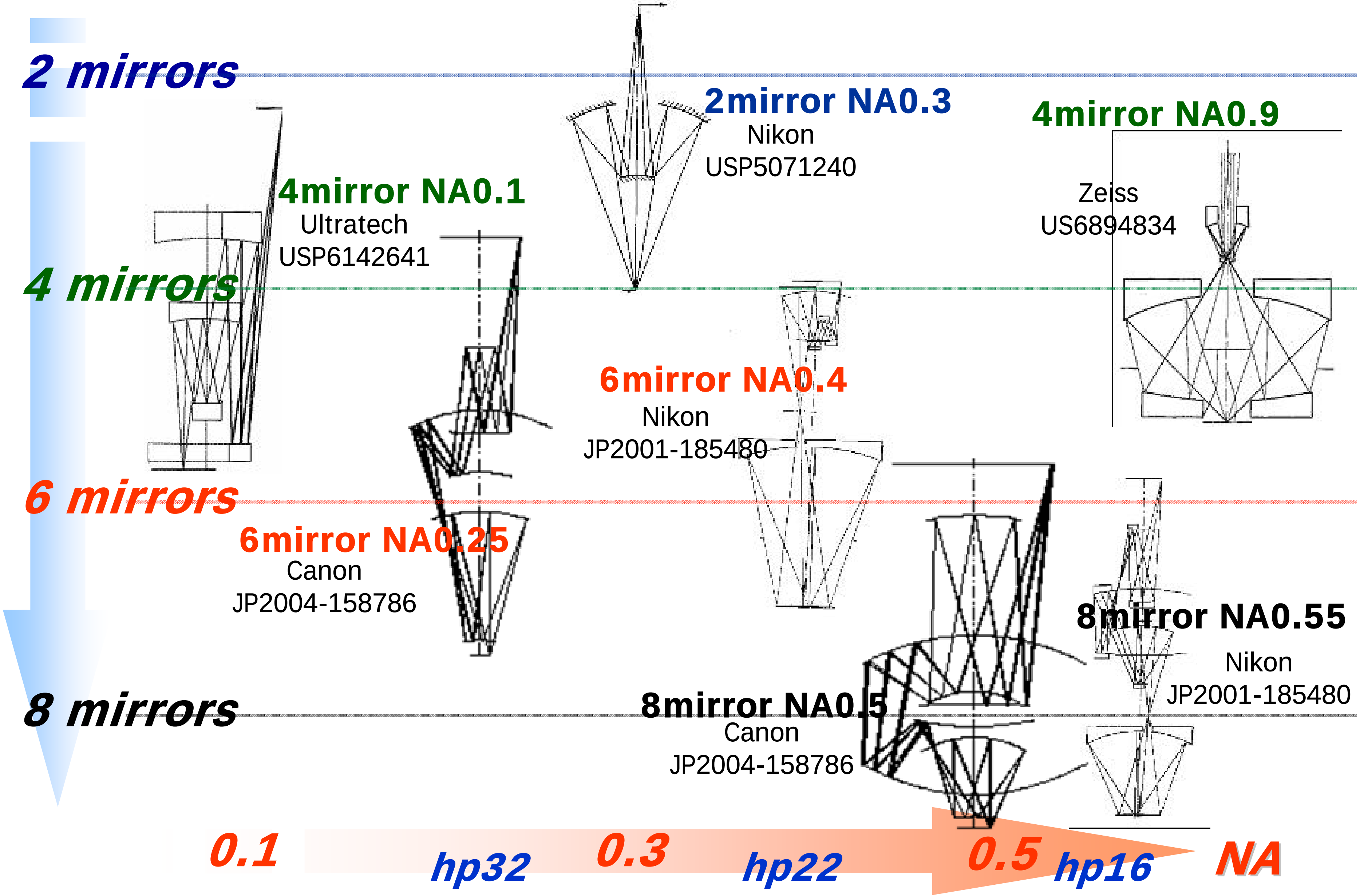
Requested NA and Resolution



EUVL will have long lifetime <22nm



2 mirrors

4 mirrors

6 mirrors

8 mirrors

2mirror NA0.3
Nikon
USP5071240

4mirror NA0.9
Zeiss
US6894834

4mirror NA0.1
Ultratech
USP6142641

6mirror NA0.4
Nikon
JP2001-185480

6mirror NA0.25
Canon
JP2004-158786

8mirror NA0.55
Nikon
JP2001-185480

8mirror NA0.5
Canon
JP2004-158786

0.1 *hp32* *0.3* *hp22* *0.5* *hp16* *NA*

EUVL Development Status

Pre-production tool will be ready in 2010 at best case.

* Completion time is not yet fixed (will be fixed at 2007E).
* System design and 6-PO production started.
* Machining tools are ready.
* All units for tool will be ready in 2009.

Collaborative research with Selete is on-going.

* HVM Specification study (ex. PSD vs flare)
* Chemical contamination on mirror surface
* Mask handling

Consortium works encourage every developments in the EUV lithography field.

* Source, resist, mask.
* CAD tool with flare compensation.

Acknowledgment

Some Exposure results are quoted from Selete presentations.

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END

Thank you for your attention!