High Power EUV Irradiation Tool (HPEUV) Equipped with LPP Source

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LPP Source	Taku Yamazaki Shinji Okazaki Hakaru Mizoguchi	GIGAPHOTON
Main Body	Mikio Kadoi Seiji Takahashi Atsushi Sekiguchi	Litho Tech Japan
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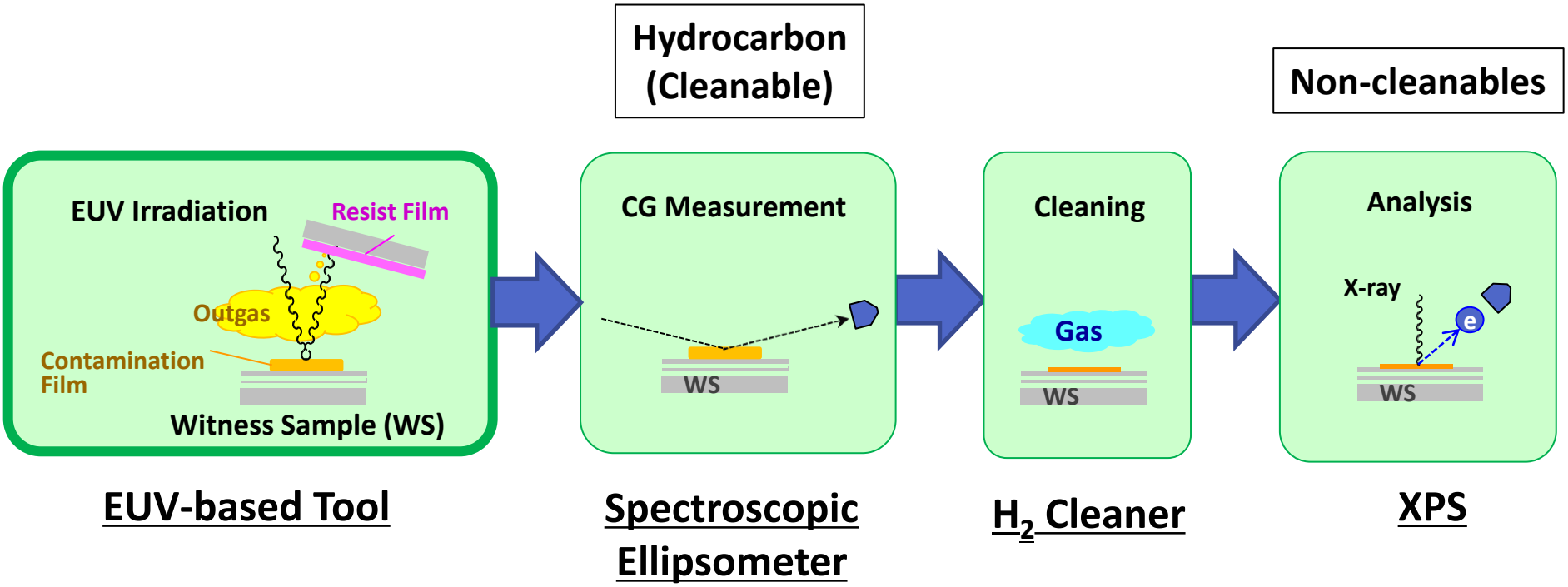
ML Mirrors	Bodo Ehlers Jim Rodriguez Asao Nakano	Rigaku
IR Filter	Yukio Suzuki Kentaro Totsu Shuji Tanaka Masayoshi Esashi	TOHOKU UNIVERSITY

Outline

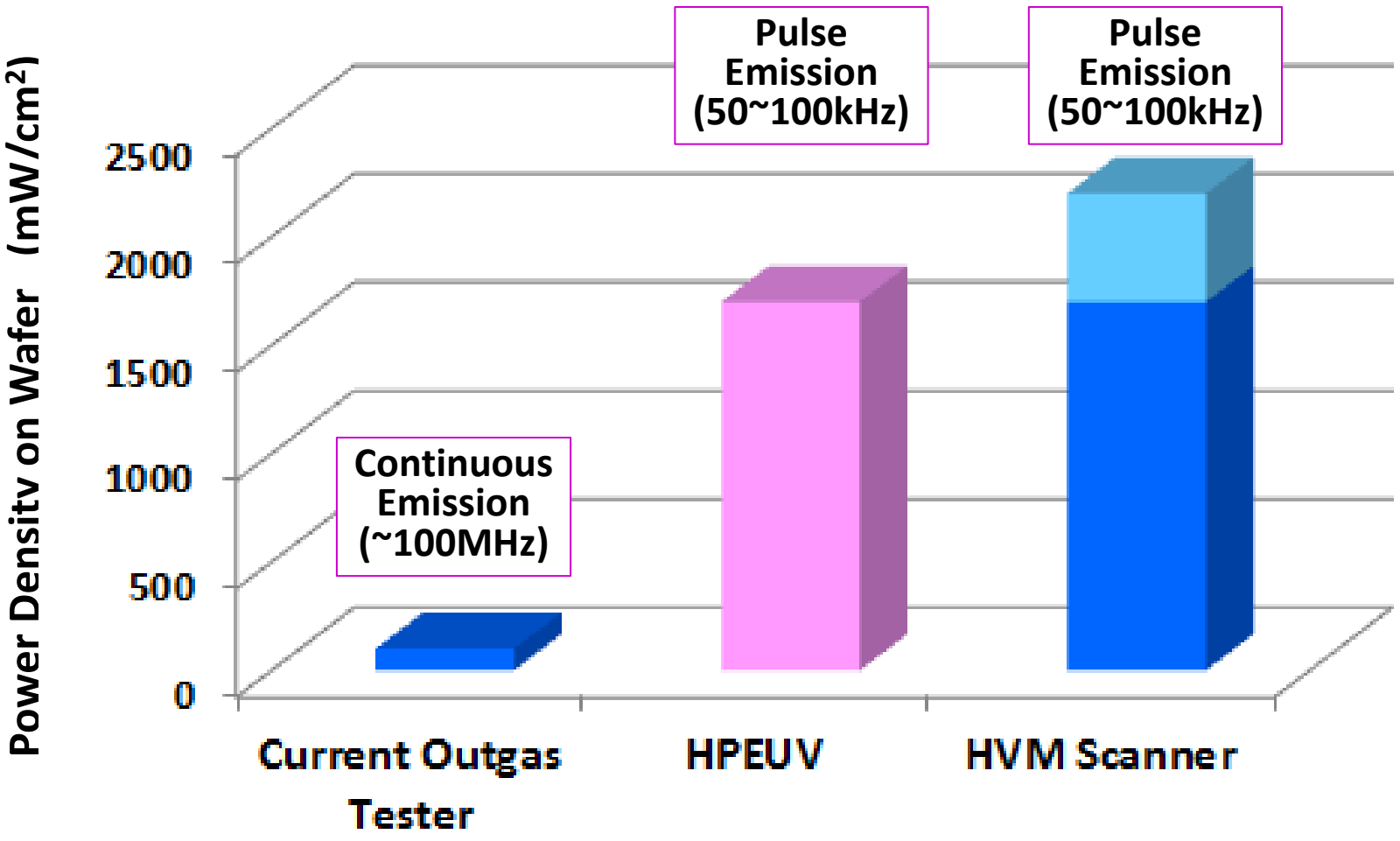
- Background
- Design Concept
- System Configuration
  - ✓ Source
  - ✓ Main Body
- Preliminary Result
  - ✓ Source
  - ✓ Total System
- Summary

Standard Protocol for Resist Outgas Testing

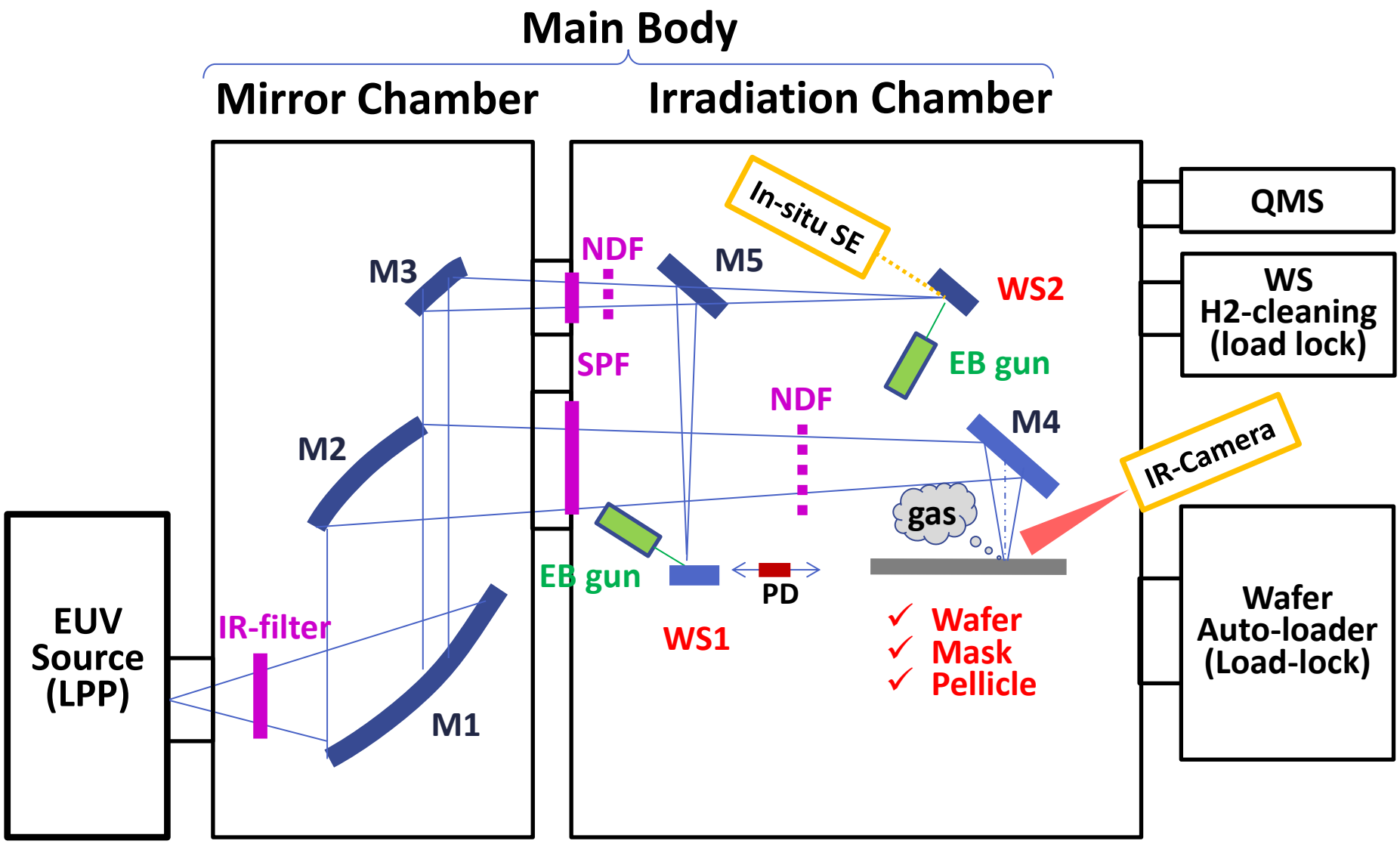


✓ Analyzing contamination growth deposited on witness sample is the standard protocol for identifying the amount of resist outgassing.

Power Density on Wafer



Basic Configuration of HPEUV

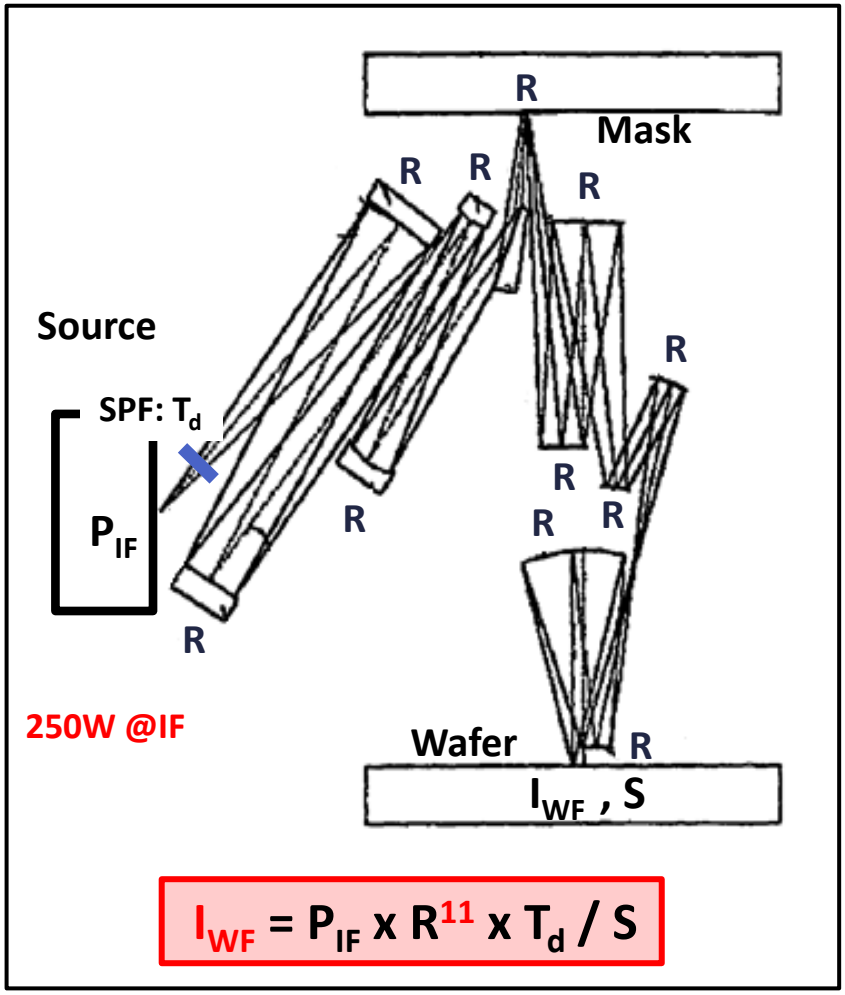


SPF = Spectral Purity Filter NDF = Neutral Density Filter

SE = Spectroscopic Ellipsometer WS = Witness Sample

Desired Source Power for HPEUV

Scanner

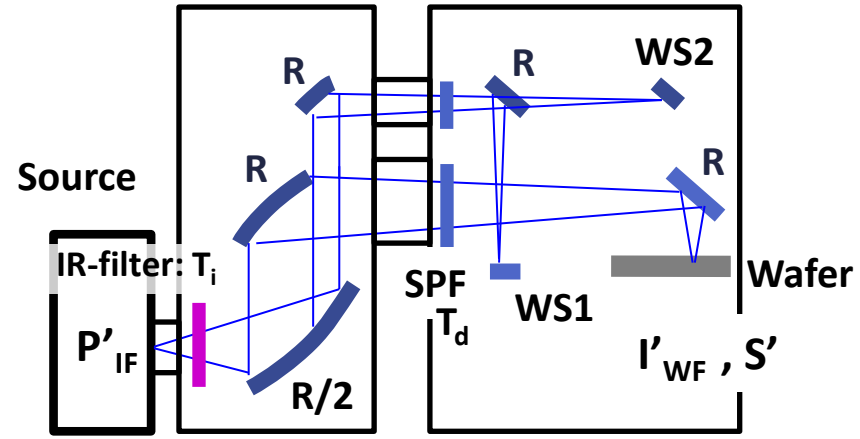


250W @IF

$$I_{WF} = P_{IF} \times R^{11} \times T_d / S$$

S,S' : Area of Exposure Field

HPEUV



10W @IF

$$I'_{WF} = P'_{IF} \times R^3 / 2 \times T_i \times T_d / S'$$

$I'_{WF} = I_{WF}$

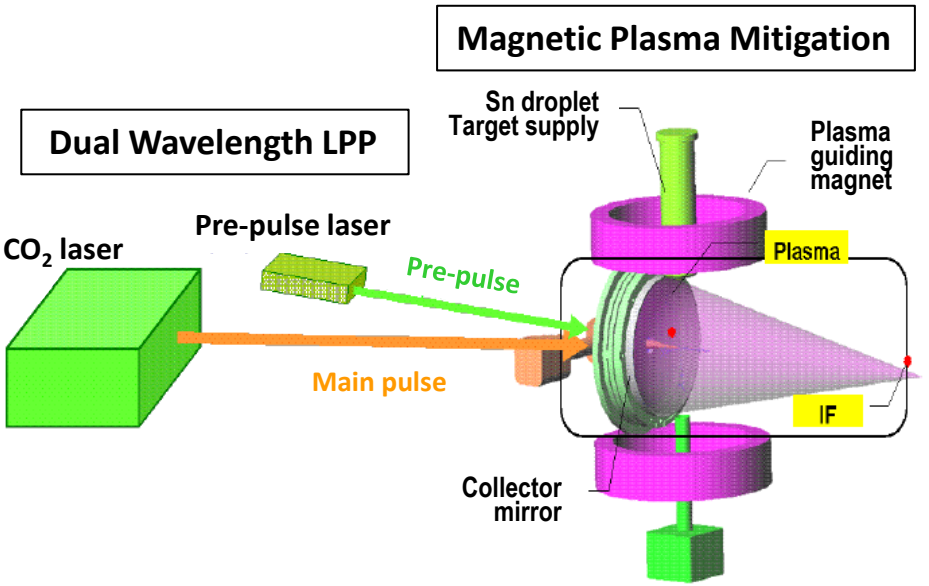
$P'_{IF} = P_{IF} \times R^8 \times 2 / T_i \times (S' / S)$

$P'_{IF} = 250 \times 0.7^8 \times 2 / 0.7 \times \{3.5^2/(26 \times 2)\}$

$P'_{IF} = 250 \times 0.04 = 10$

A 10W source is sufficient for HPEUV to emulate a HVM scanner equipped with a 250W source.

Basic Configuration of LPP Source



Items	Operational Condition	Spec
Performance		
EUV Power @IF	> 10W	25W
CE	4%	←
Pulse Rate	20-50kHz	~50kHz
Technology		
Droplet Generator	20um	←
CO_2 Laser	> 8kW	←
Pre-Pulse Laser	Picosecond	←
Debris Mitigation	Magnetic mitigation	←

- ✓ High ionization rate and CE EUV Sn plasma generated by CO_2 and solid laser dual shooting.
- ✓ Hybrid CO_2 laser system with short pulse, high repetition rate oscillator and commercial cw-amplifiers.
- ✓ Accurate shooting control with droplet and laser beam control.
- ✓ Sn debris mitigation with a super conductive magnetic field.

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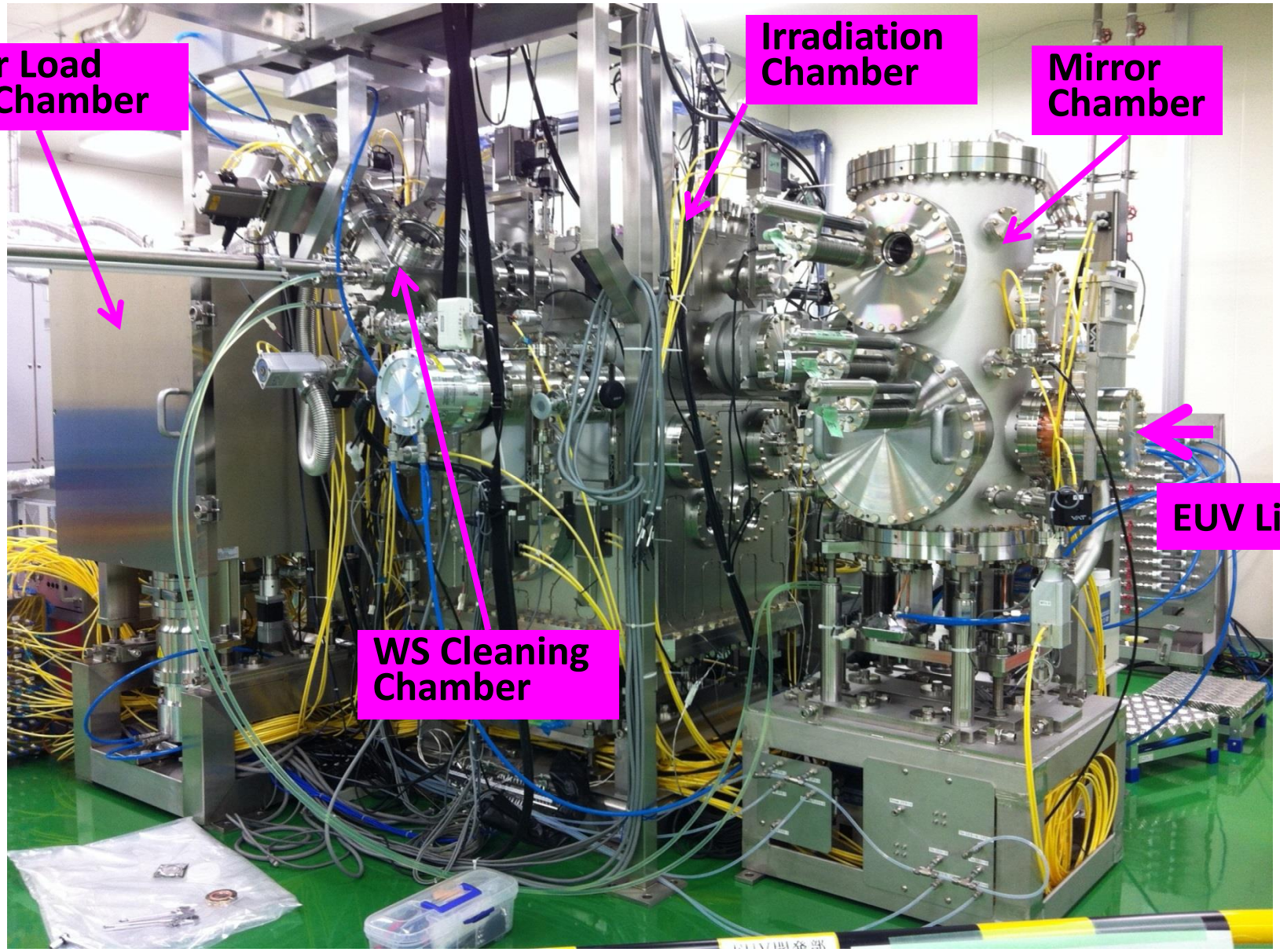
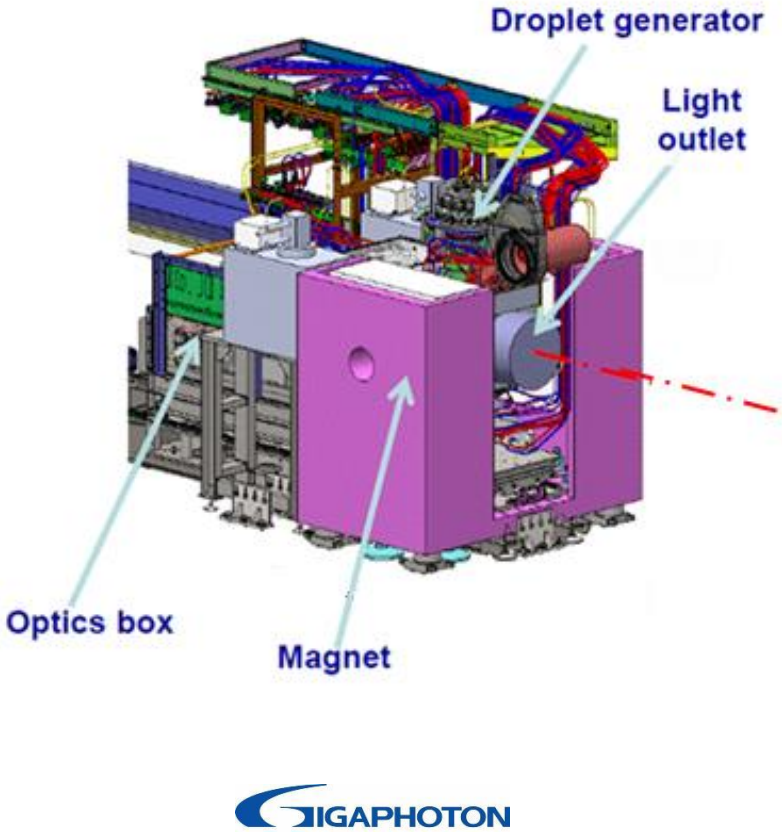
Main Body Outlook



3D CAD Model for HPEUV

LPP Source



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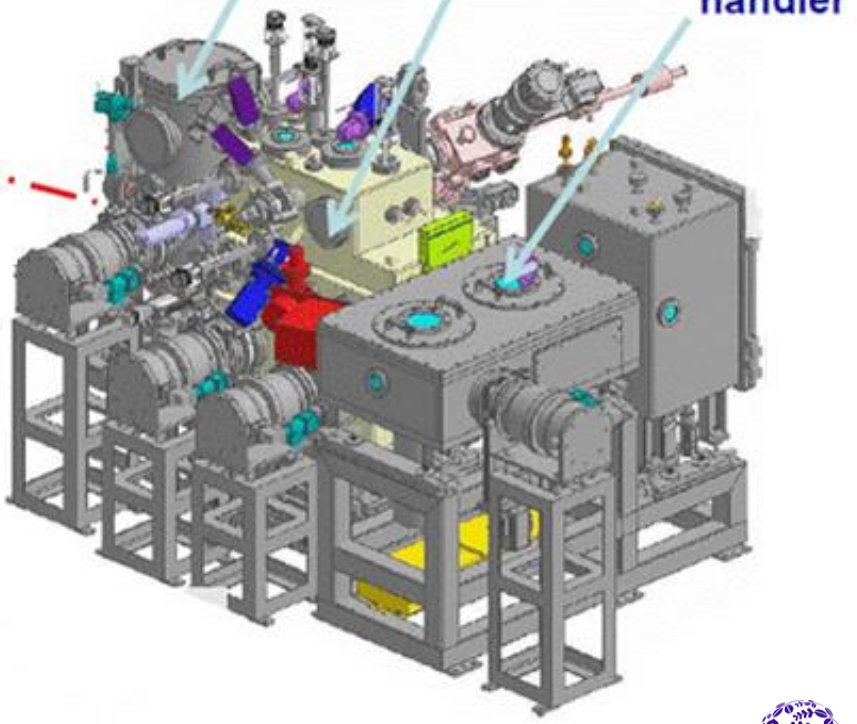
Main Chamber



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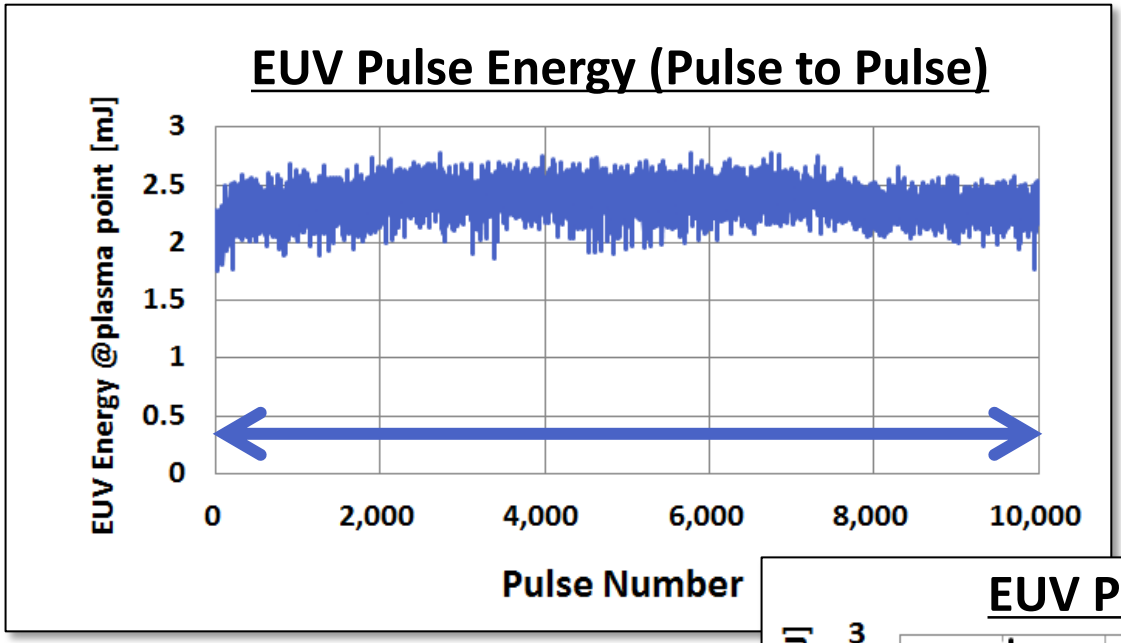
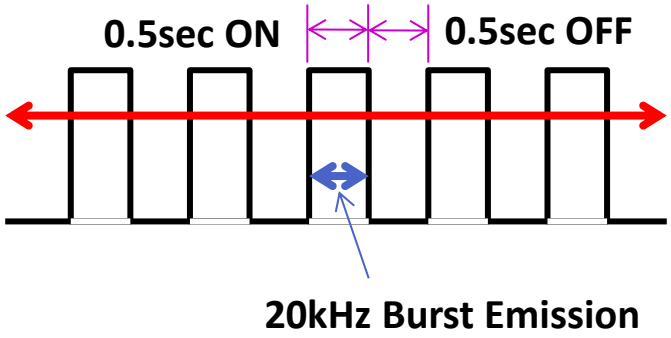
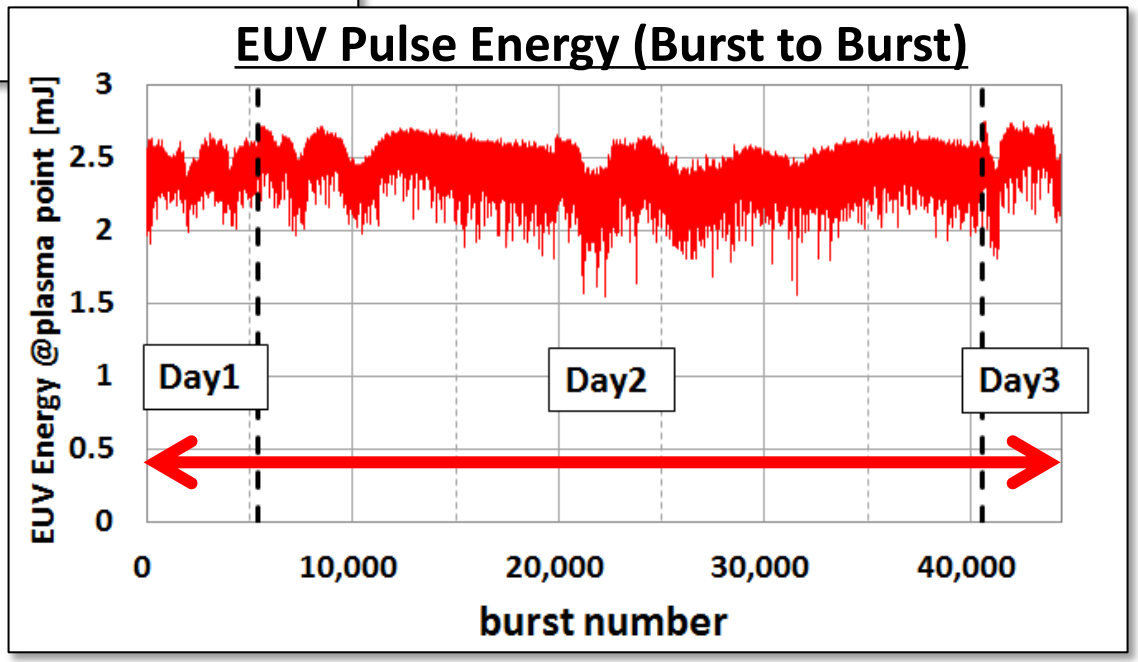
Basic Performance of LPP Source



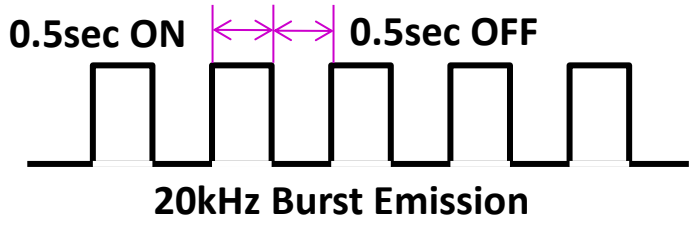
- Frequency: 20kHz
- 10,000 pulses in a burst

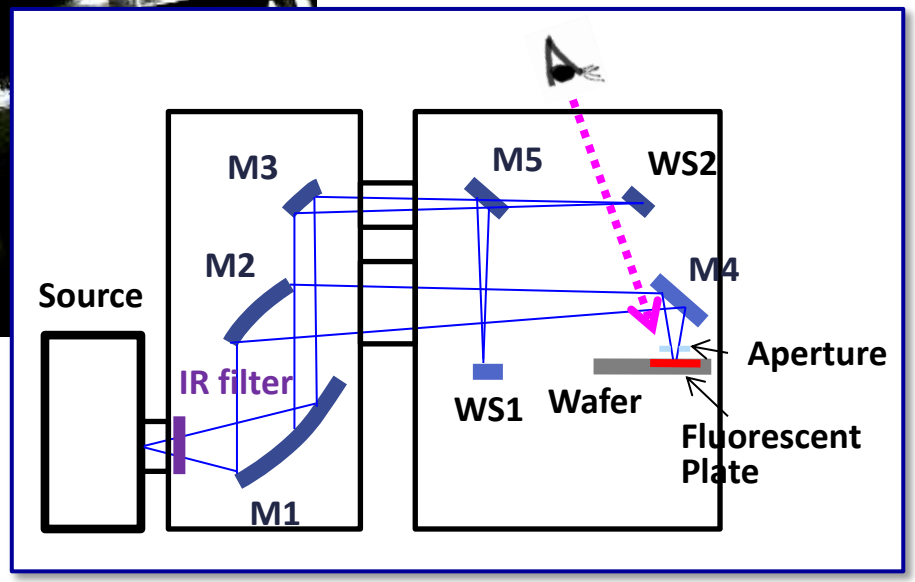
- 444Mpls in total
- 0.5 sec ON - 0.5sec OFF
- Total operation time: 12hours
- Ave. EUV @ IF: 10.6W
  (with DUV & IR filtration)



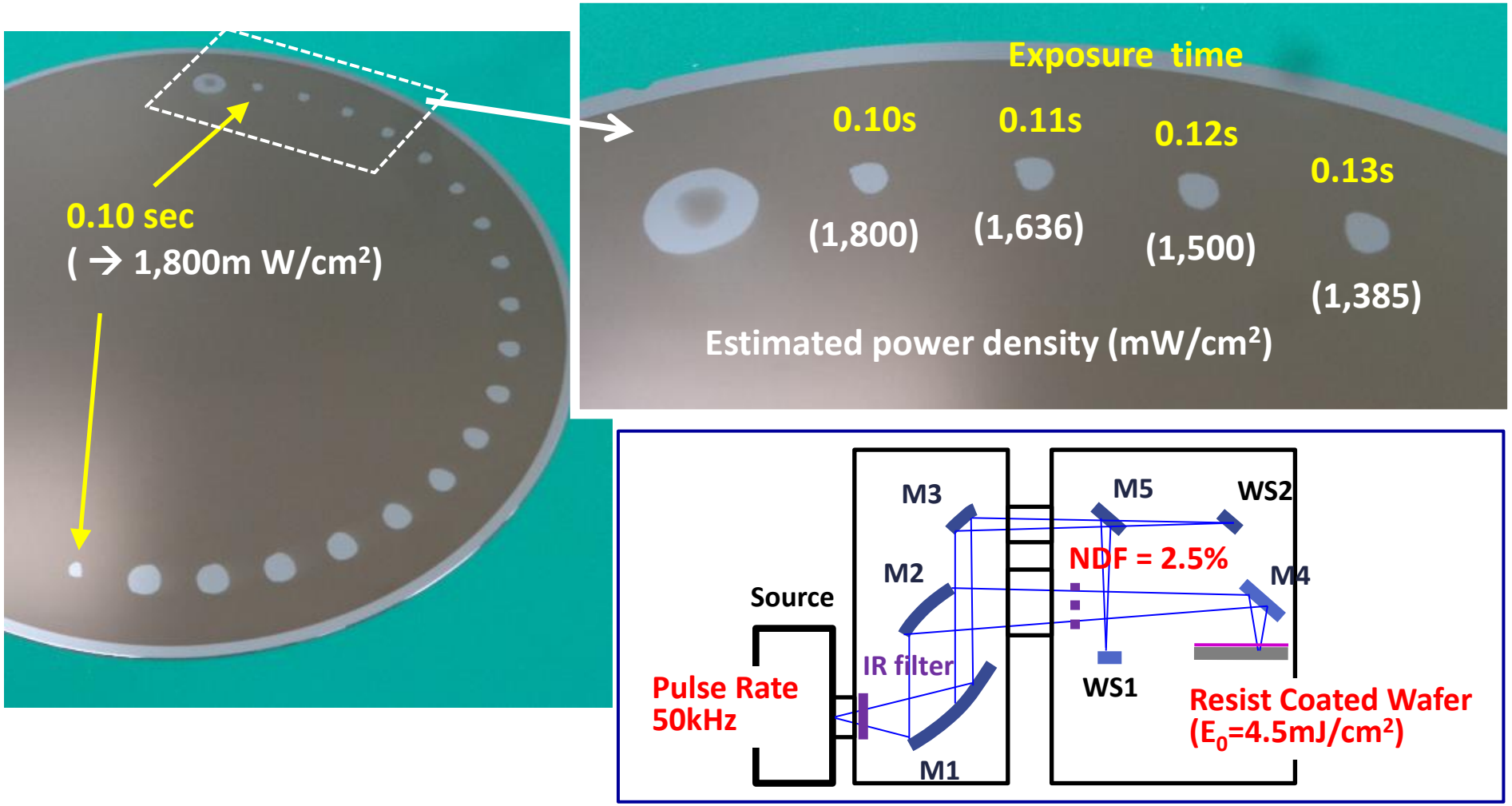


Burst Mode EUV Irradiation on Wafer Plane



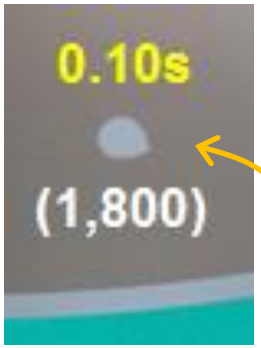


EUV Power Density Measurement on Wafer



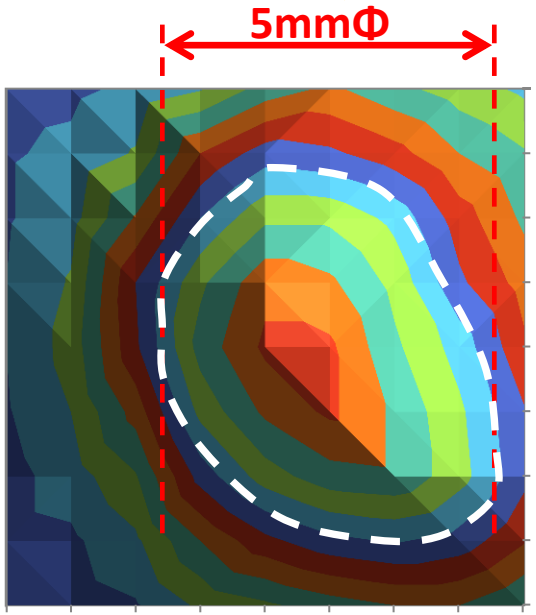
- ✓ The power density on wafer was estimated by flood exposure tests using a resist with known EUV sensitivity.
- ✓ >1,800 mW/cm² power density on wafer plane confirmed.

EUV Beam Profile Measurement



Circle edge intensity = 1,800mW/cm²
Circle size = 5mmΦ

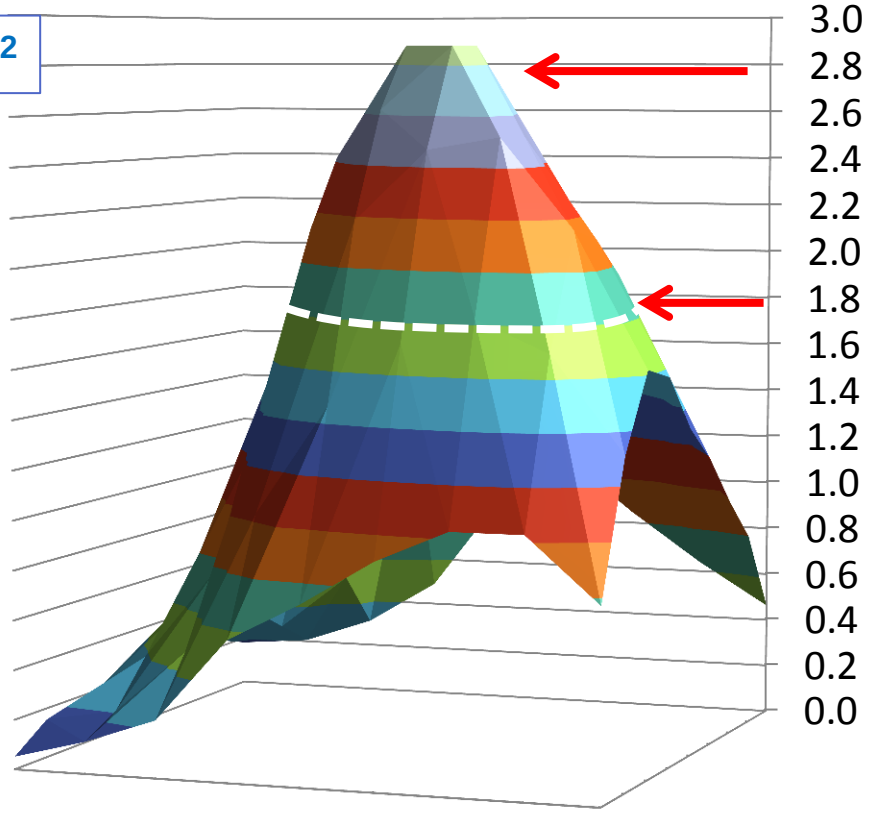
a.u.: 0.035 → 1,800mW/cm²



Intensity [a.u.]

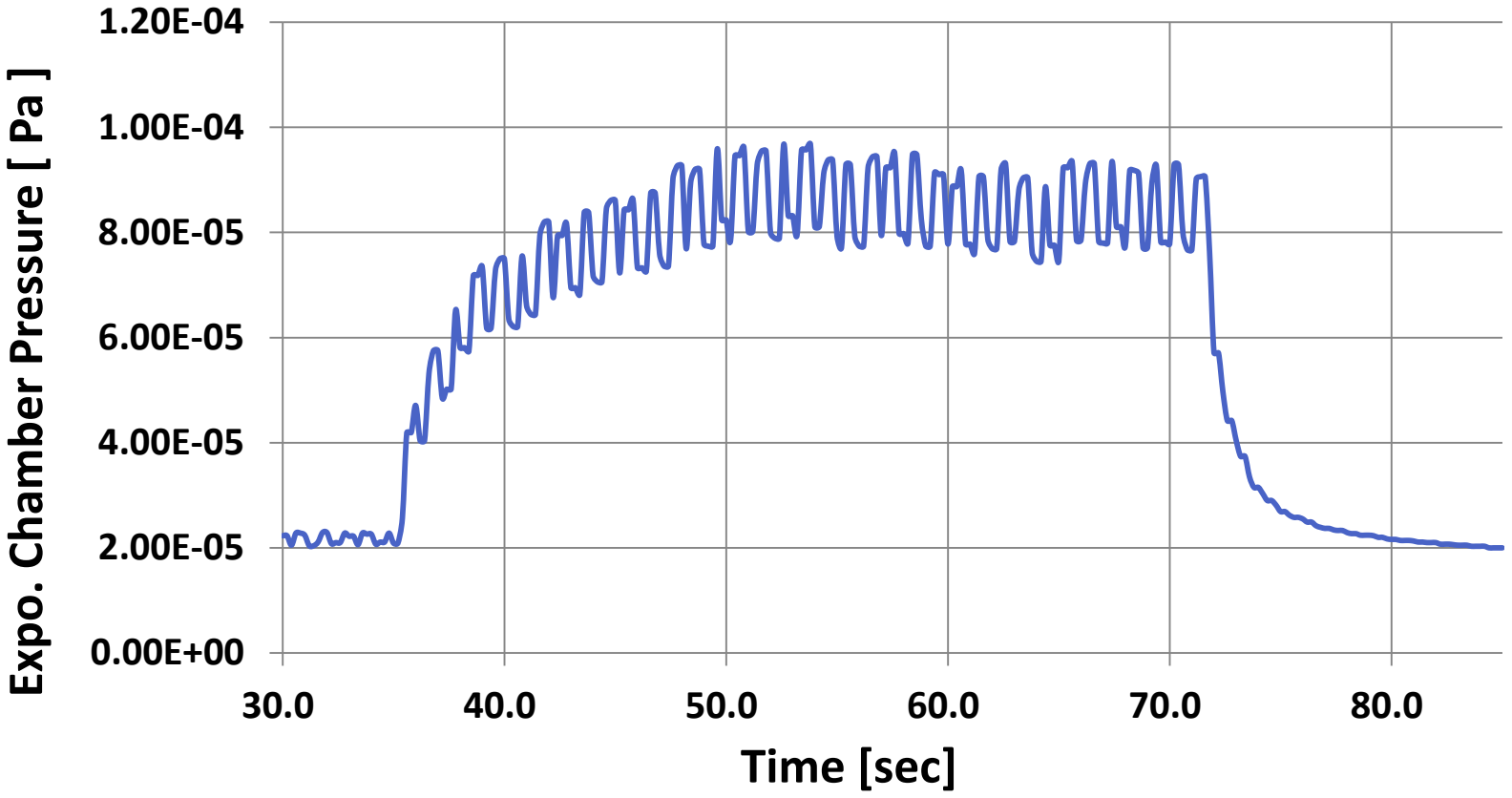
- 0.055-0.06
- 0.05-0.055
- 0.045-0.05
- 0.04-0.045
- 0.035-0.04
- 0.03-0.035
- 0.025-0.03
- 0.02-0.025
- 0.015-0.02
- 0.01-0.015
- 0.005-0.01
- 0-0.005

Power Density [W/cm²]



- Pin-hole sensor tests show shows the EUV beam profile [arb.units].
- Based on this, calculated power density profile showed a peak of 2,800mW/cm² in 1 mmΦ.

Pressure Rising by Resist Outgassing of Main Chamber during Exposure



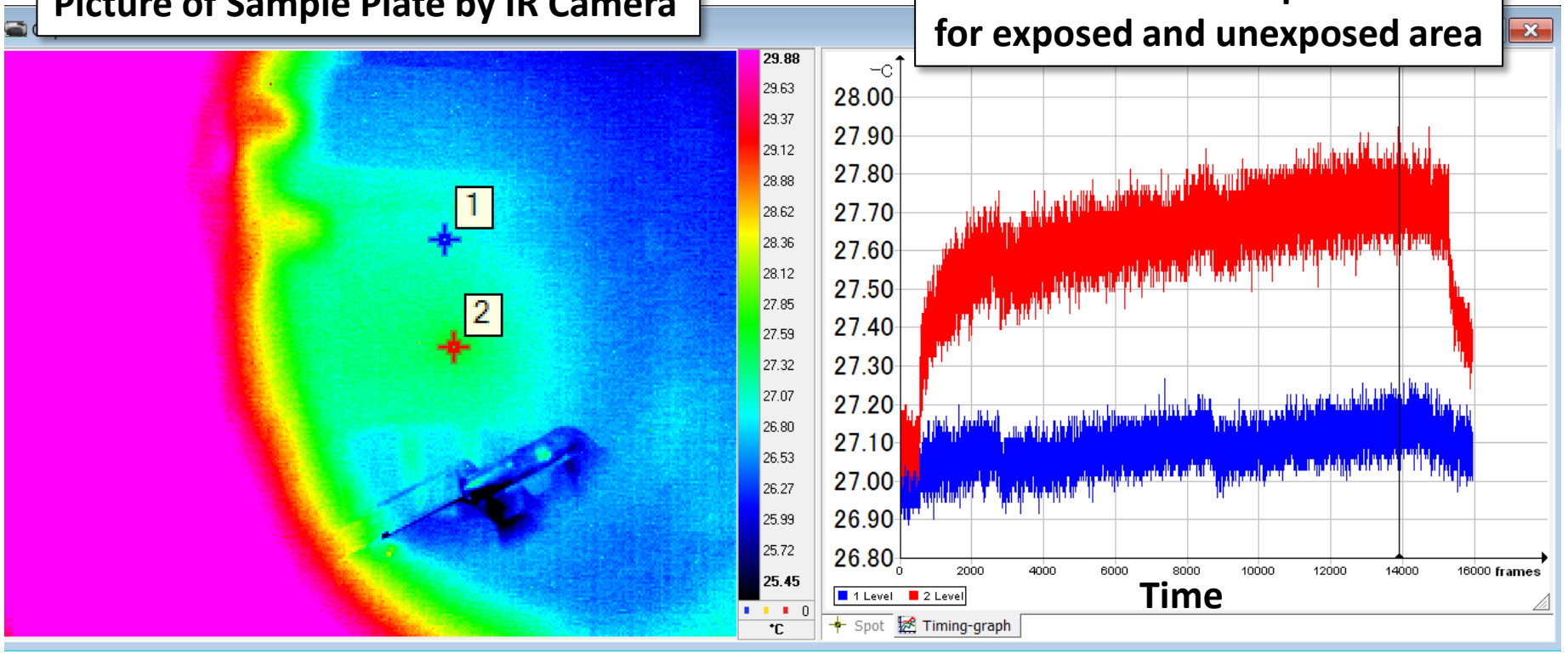
- ✓ Frequency of pressure undulation matches that of the burst emission.
- ✓ Proper operation of HPEUV tool was validated with further precise tool qualification underway

Temperature Rise of EUV Mask Blank

During Exposure Measured by IR Camera

Picture of Sample Plate by IR Camera

Transition of Temperature for exposed and unexposed area



Temperature Raise at

1	Unexposed Area:	~0.1 deg
2	Exposed Area:	~0.5 deg

Summary

- ✓ A High Power EUV irradiation tool (HPEUV) equipped with an actual LPP source and relay mirror optics has been designed and constructed.
- ✓ Fewer relay mirrors compared to present EUV scanners facilitated to emulate a power density on the sample plane equivalent to what is expected in future HVM EUV scanners.
- ✓ Extremely high power density (>> 1,800mW/cm^2) on the sample plane compared with present tools has been successfully obtained.
- ✓ Pressure rise due to resist outgassing in the main chamber and temperature rise of EUV mask blanks have been demonstrated as initial results of the HPEUV.
- ✓ The impact of higher power and pulsed irradiation on outgassing and damage of blank/pellicle is currently being pursued.

Acknowledgements

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Thank you !

LPP Source Outlook