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## DEVELOPMENT PROGRESS OF THE KEY COMPONENT TECHNOLOGIES FOR A LASER PRODUCED PLASMA EUV LIGHT SOURCE

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# **Gigaphoton LPP-EUV Source System**



#### **Key Components**

#### Sn-droplet Generator

- Minimum-mass target supply to reduce debris
- In-line Sn fuel system to extend the lifetime

### Main/Pre-pulse Laser

 High conversion efficiency without increased Sn plasma energy

### **Debris Mitigation**

 Optimized H<sub>2</sub> gas flow to extend mirror lifetime

### Shooting Control

 High-accuracy spatial and temporal control between lasers and droplets to increase EUV energy stability

### **Pre-pulse laser optimization**

for high CE and low-energy ion plasma generation

- An advanced pre-pulse irradiation technology reduces the high-density part of the "mist" target which absorbs EUV radiation and generates high energy ions when the main-pulse laser is irradiated.
- ✓ Higher CE and Lower ion energy spectrum was confirmed at the research bench.



#### lon energy spectrum



#### Images of Sn-mist and EUV



# **Shooting Control system**

Off-center shooting evaluation

Generation of Sn-fragments depends on laser position offset ΔX.
No Sn-fragments occur under condition of Δx/R below 1.1.
Mie-scattering setup



## **Shooting Control system** Stable EUV radiation and debris reduction

✓ A newly developed in-situ shooting control system optimizes laser conditions.

- $\checkmark$  EUV energy 3  $\sigma$  and dose error 3  $\sigma$  improved by a remarkable 50%.
- ✓ Since ∆x/R is below 0.2 for this new control technology, fragment-free and reflectivity lossfree EUV mirror samples were demonstrated after a mid-term test (~25Billion pulses).



#### Mid-term test results of in-situ shooting system

## Long-life Sn-droplet generator In-line Sn fuel supply development

New Droplet Generator (DG) with in-line Sn fuel supply system has been developed.  $\checkmark$  Stable droplets were generated continuously for over 2,000 hours.

Testing continues and we target a lifetime of 9,000 hours of continuous operation.



#### In-line Sn fuel supply system

### Long-life Sn-droplet generator System evaluation

✓ An In-line Sn fuel supply system has been installed on our EUV source.

✓ Stable EUV emission has been demonstrated during Sn supply phase.



**EUV Systems integration test result** 

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1.4

1.2

0.8

0.6

0.4

0.2

0

energy

**Vormalized EUV** 

## **Summary** Gigaphoton's EUV source system key technologies



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### Key Component Development Status

- Advanced pre-pulse laser technology achieves high conversion efficiency without increasing the energy of the plasma.
- New in-situ shooting control system remarkably improves EUV energy stability.
- As a result, fragment-free and reflectivity loss-free EUV mirror samples were obtained after a 25 Billion pulse operation test.
- An In-line Sn fuel supply system has been successfully installed on our EUV source system.

With these technologies, higher EUV source system availability would be achieved to support HVM EUV lithography industries.







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