Key components technology update of 100W EUV light source for HVM

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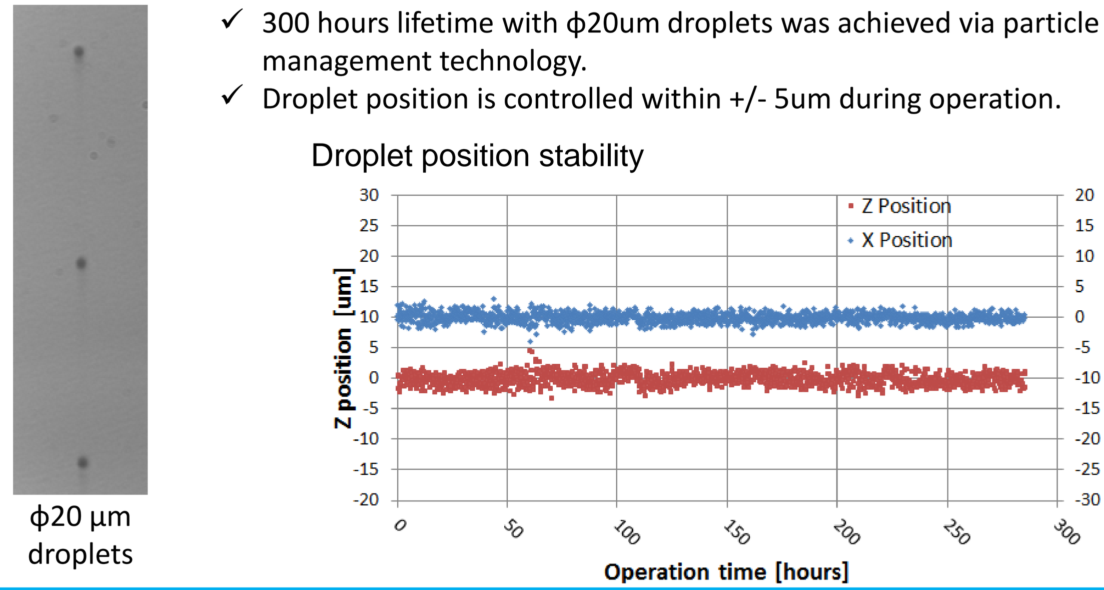
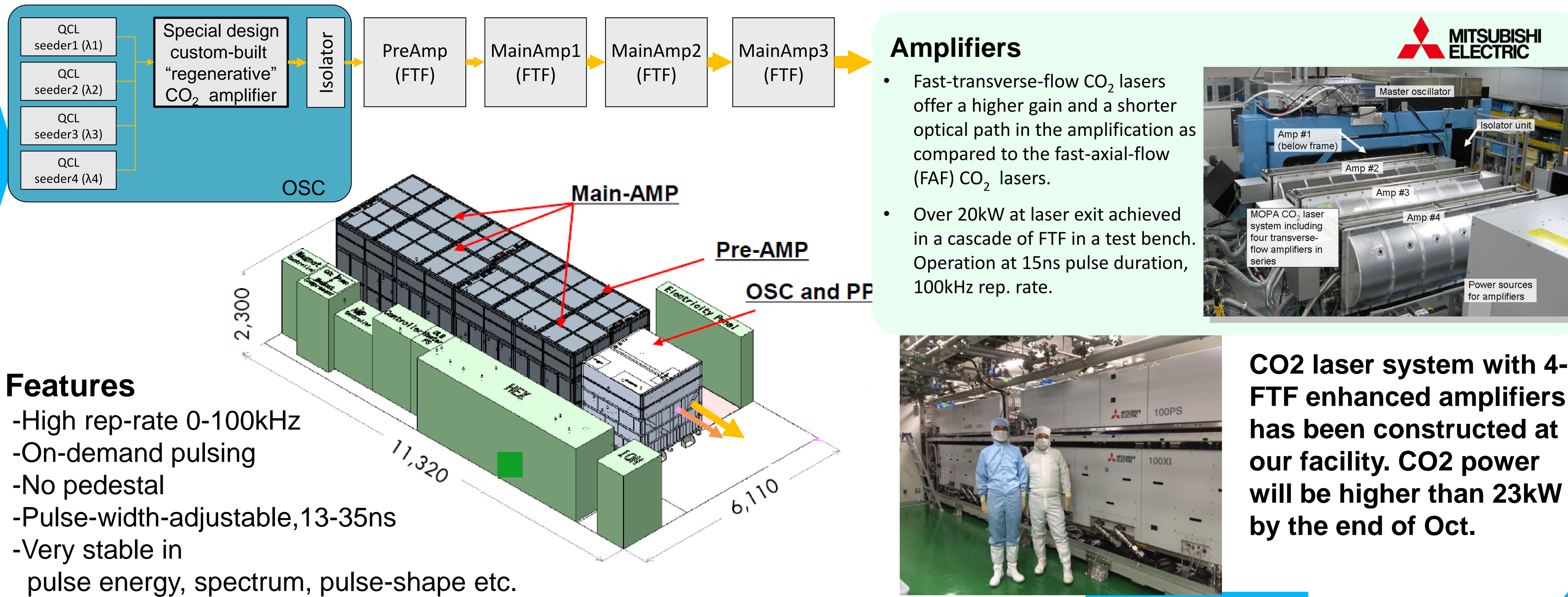
ABSTRACT

This paper presents a technology update of key components of a 100W LPP-EUV (laser produced plasma extreme ultraviolet) light source for high volume manufacturing which enables sub-10nm critical layer patterning for semiconductor device fabrication.
Key components of this EUV light source system from Gigaphoton include a magnetic debris mitigation system, a high power short pulse CO2 drive laser system, a unique pre-pulse laser system, a small droplets generator and a laser-droplet shooting control system. All components are perfectly controlled and interact harmoniously to produce a stable plasma and to effectively evacuate the Tin debris from the EUV vessel in order to realize a high power and long lifetime EUV light source system. This paper describes the latest results obtained from our proto systems that are based on key components which support a 100 watt LPP-EUV light source.

1. Droplet generation and Control

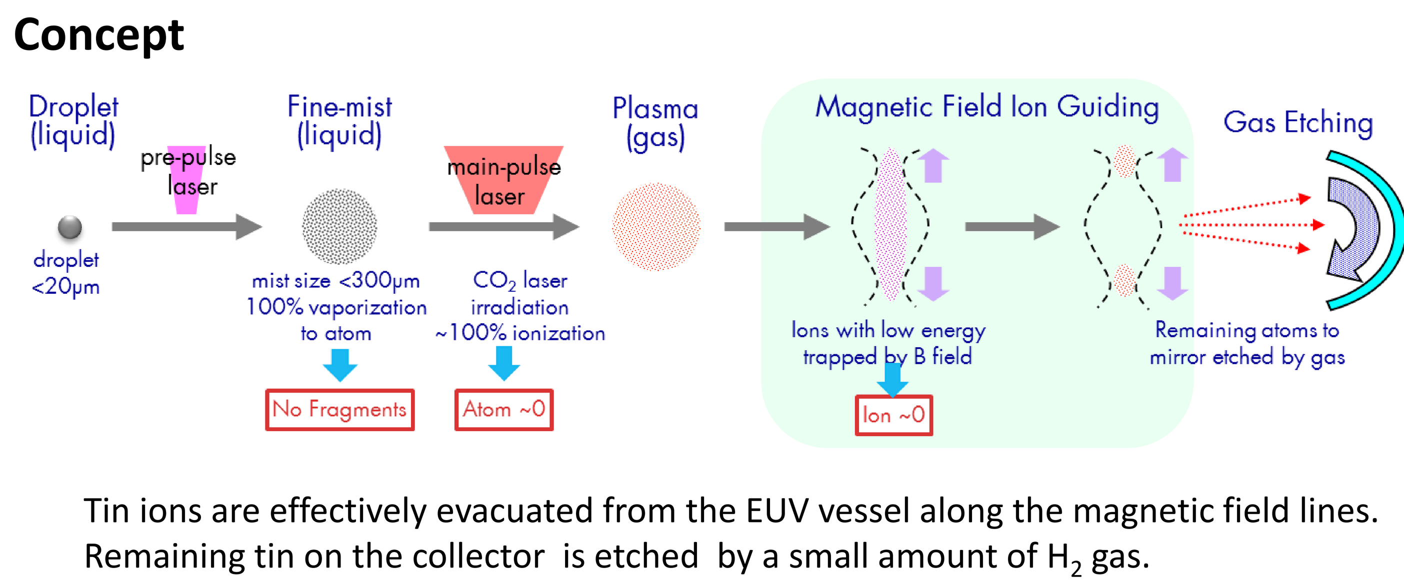


2. Hybrid CO_2 Laser System with short pulse high rep. rate Oscillator and FTF Amplifiers



6. Tin debris mitigation with a superconductive magnet

Concept



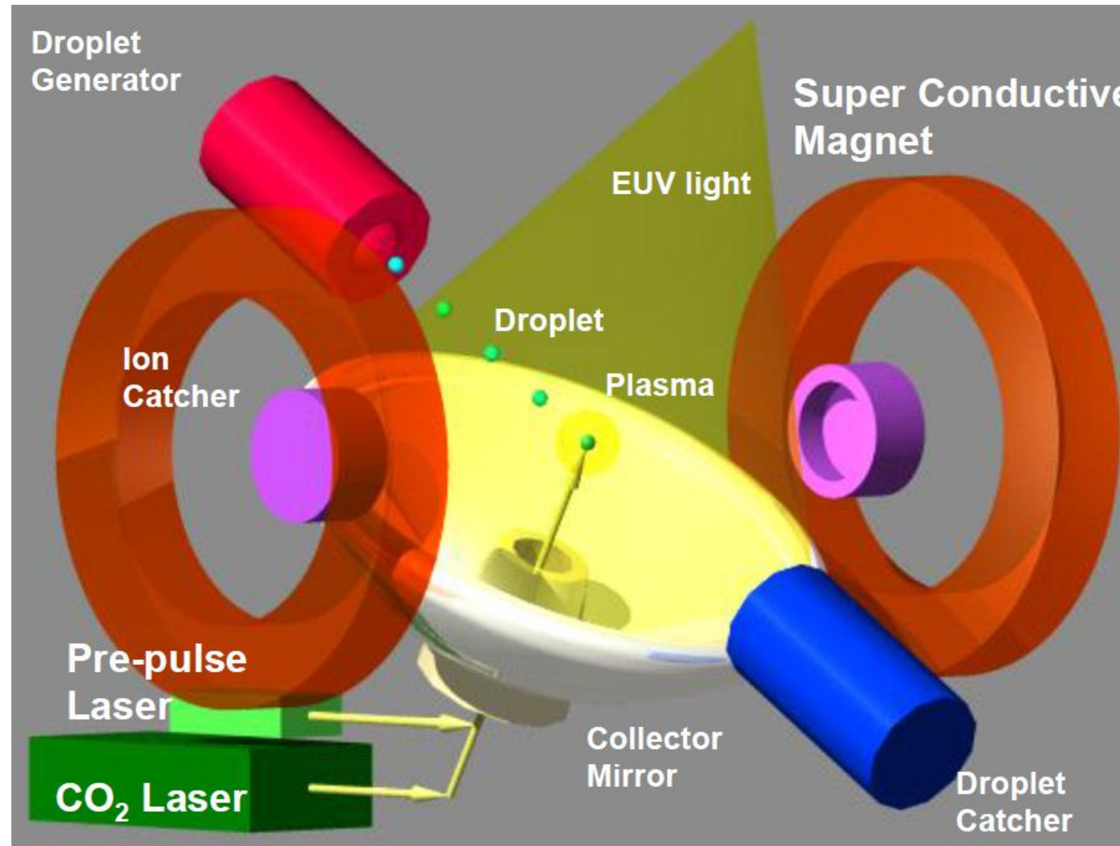
Tin ions are effectively evacuated from the EUV vessel along the magnetic field lines. Remaining tin on the collector is etched by a small amount of H_2 gas.

Recent result

Pulse number	152 Mpls	527 Mpls	1513 Mpls	4531 Mpls
Debris in Center of collector (SEM x10,000)	Improved	stays clean with increasing pulse number		
Sn deposition rate	0.5 nm/Mpls	<0.002 nm/Mpls	<0.0007 nm/Mpls	<0.0004 nm/Mpls

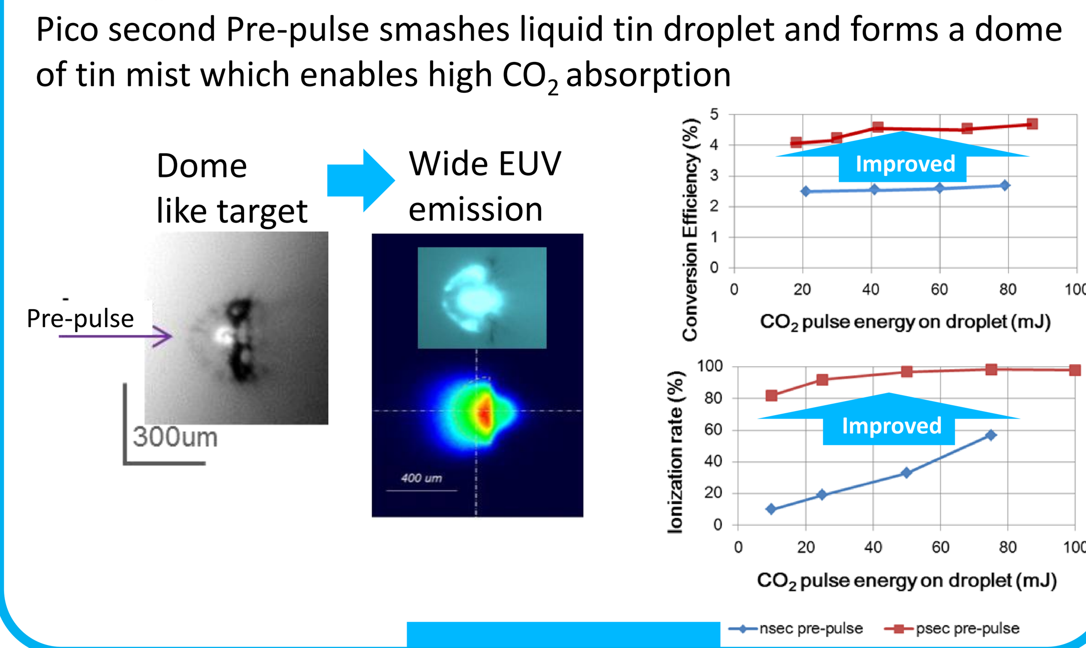
Works well with small droplets and a small amount of H_2 gas.

Gigaphoton's Concept

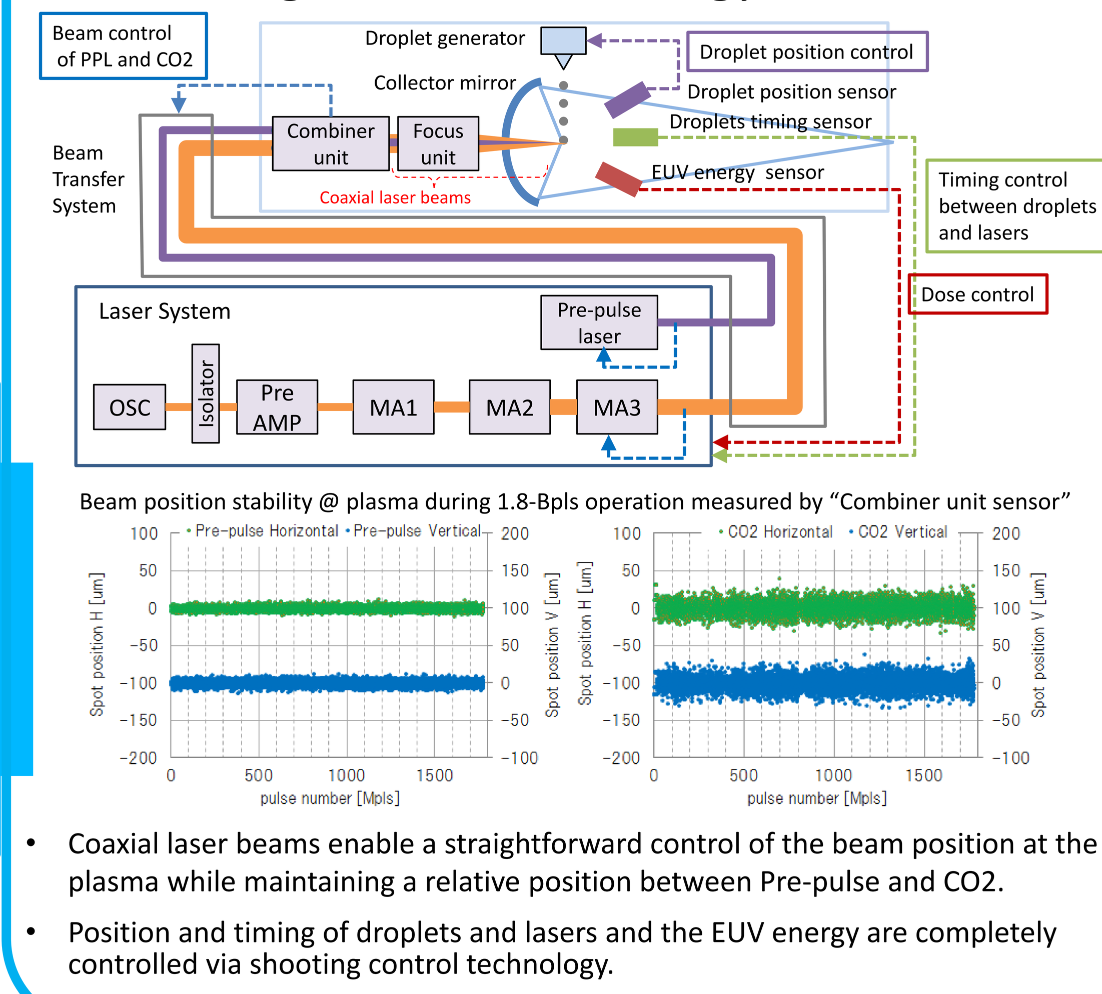


3. Pre-pulse Technology for High CE and High Ionization Rate

Pico second Pre-pulse smashes liquid tin droplet and forms a dome of tin mist which enables high CO_2 absorption



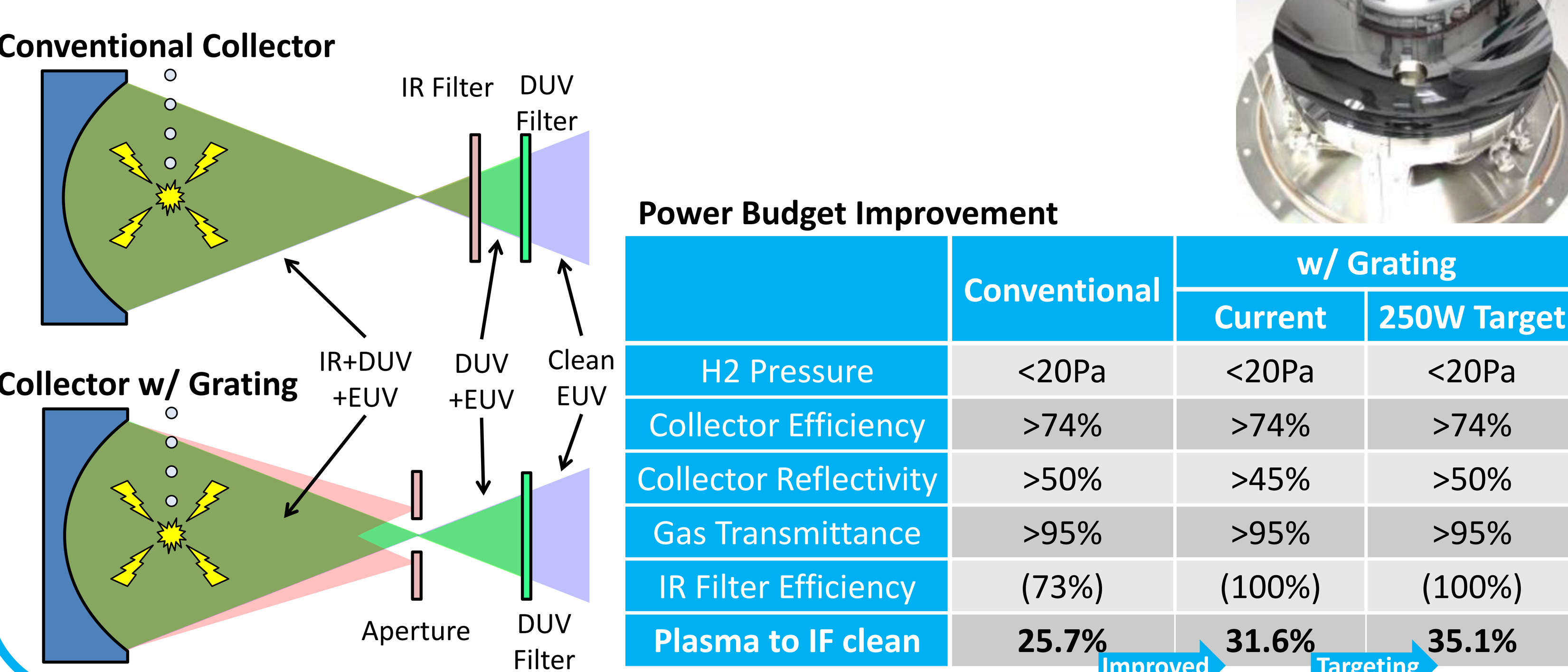
4. Shooting Control Technology



- Coaxial laser beams enable a straightforward control of the beam position at the plasma while maintaining a relative position between Pre-pulse and CO2.
- Position and timing of droplets and lasers and the EUV energy are completely controlled via shooting control technology.

5. Collector Mirror with grating structure for highly efficient out of band light reduction

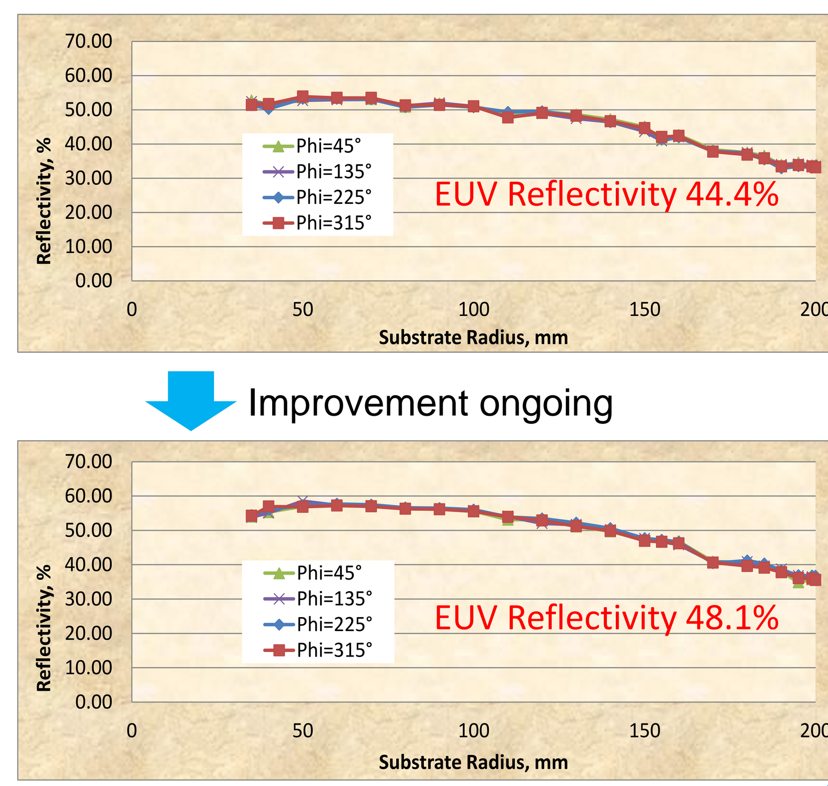
Collector with grating improves the power budget from EUV plasma to IF clean.



Power Budget Improvement

	Conventional	w/ Grating Current	w/ Grating 250W Target
H2 Pressure	<20Pa	<20Pa	<20Pa
Collector Efficiency	>74%	>74%	>74%
Collector Reflectivity	>50%	>45%	>50%
Gas Transmittance	>95%	>95%	>95%
IR Filter Efficiency	(73%)	(100%)	(100%)
Plasma to IF clean	25.7%	31.6%	35.1%

Improved / Targeting



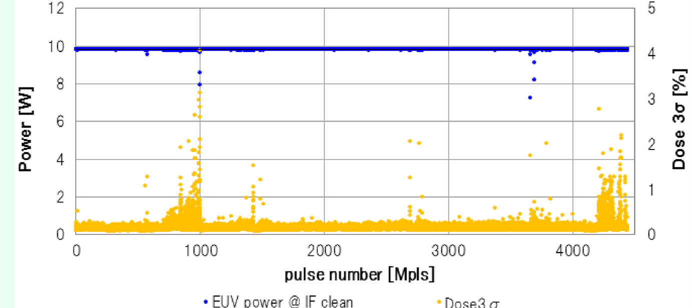
7. Proto system performance

Target Specification		Proto #1	Proto #2
Purpose		Magnetic Mitigation	High power and stable operation
Performance	EUV Power	25 W	150 W
	CE	3.5%	3.5%
	Pulse rate	50 kHz	100 kHz
	CO_2 laser	> 3kW	> 17kW
	Dose overhead	20%	
	Pre-pulse	Pico second	
	Debris mitigation	1 month	

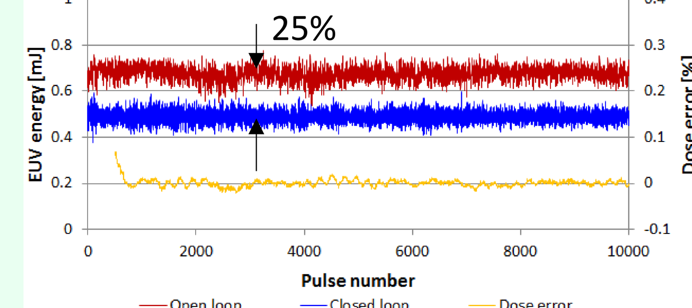
Proto#1

Dose controlled EUV power :**10W**
-pulse number: **4.5-Bpls** (total)
Incl. unattended operation
-Dose error 3σ : **<0.2%**
-Dose overhead : **25%** constant
(Target : 20%)

20kHz Operation (Closed loop)



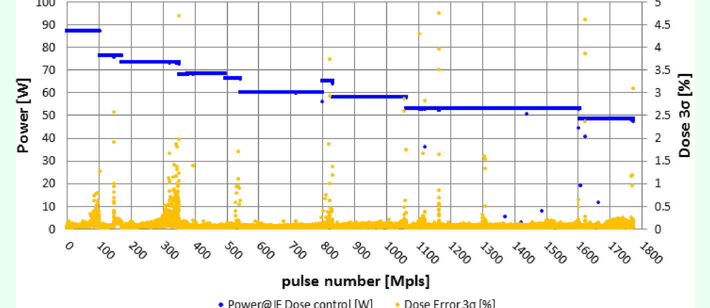
Typical pulse to pulse data

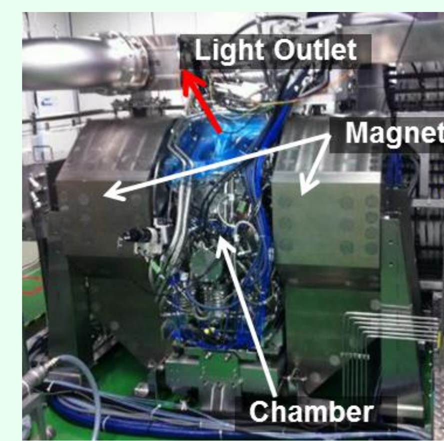


Proto#2

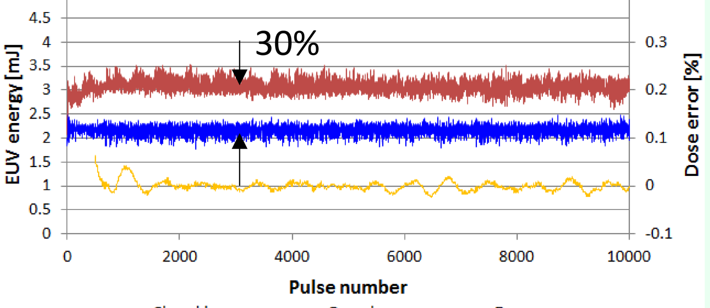
Dose controlled EUV power :**49~87W**
-pulse number: **1.8-Bpls** (total)
Incl. unattended operation
-Dose error 3σ : **<0.2%**
-Dose overhead : **30~55%**
(Target : 20%)

35kHz operation (Closed loop)





Typical pulse to pulse data

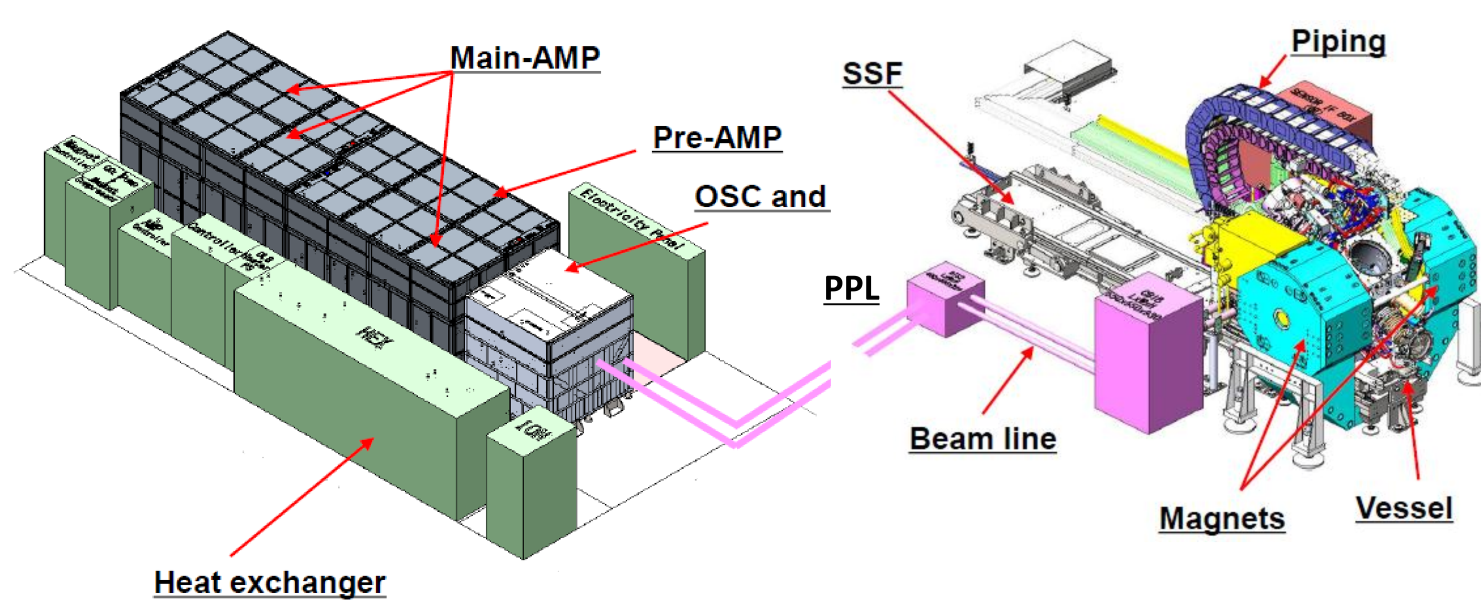


The current target is the evaluation of the intermediate focus (IF) and far field (FF).

8. Pilot system status

Pilot: Construction in progress

Target Specification	
EUV Power	250 W
CE	4.0%
Pulse rate	100 kHz
Availability	> 80%
CO_2 laser power	>23 kW
Dose overhead	20%
Pre-pulse	Pico second
Debris Mitigation	> 1 month



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