For Panel Discussion

2014 International Workshop on EUV Lithography

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2014 EUVL Workshop Panel Discussion

Can EUV deliver patterning solutions for 7nm node? Also, please list your opinion on topics listed below

A: What is the latest status for source power, available for NXE 3300B? What is your opinion on source power requirements for 7 and 5 nm nodes?

B: Will EUV Double patterning be required at 7 nm? What will be required at 5nm node? Do you expect any OPC related issues?

C: Mask: What will be the new material requirements and mask size requirements to accommodate higher NA patterning? Do you expect mask etch complexity with new materials? How ready are masks to support 7 nm manufacturing? What is the status of mask defect inspection and repair tools?

D. Pellicle: Is a no-pellicle approach a show-stopper for HVM insertion of EUVL? What additional restrictions do you expect on inspection due to pellicle?

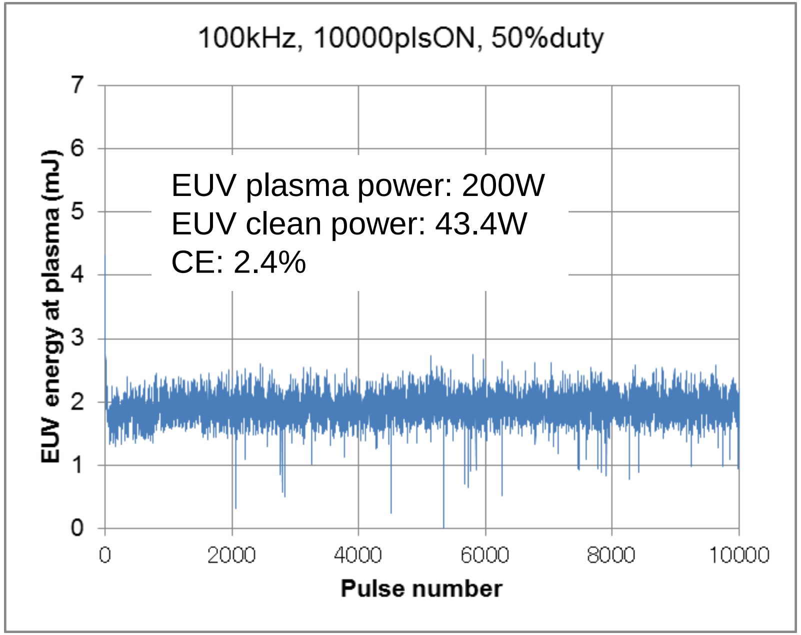
E. What are different device types and lithography needed at various nodes, e.g., 3D NAND, III-V Logic, Post FINFET Era etc.

Agenda

1. Review of Panel Discussion Topics and review of last 2 panel discussion conclusions (Moderators)
2. Panelists
3. Summary

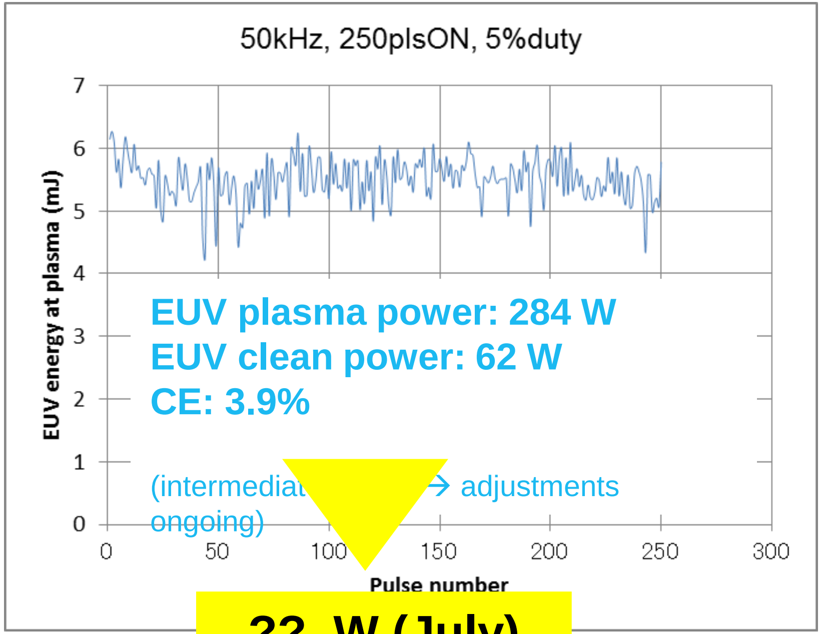
High Power EUV Light Source

2014 Jan



EUV plasma power: 200W
EUV clean power: 43.4W
CE: 2.4%

2014 May



EUV plasma power: 284 W
EUV clean power: 62 W
CE: 3.9%

(intermediat → adjustments
ongoing)

?? W (July)

Power-up Scenario of HVM Sources

Next target is 12 kW by upgrading the pre-amplifier (installation is on going now)

	Target at Plasma	System	Oscillator	Pre-Amplifier	Main Amplifier		
Current Proto #1	5kW	Endurance Testing Platform	GPI GPI	R R	T T	T T	 T
Current Proto #2	8kW	Power Up Testing	GPI	M	T	T	T
	>12kW	Power Up Testing	GPI	M	M	M	M
		Customer					

🟦 Validated performances at system

Power-up Scenario of HVM Sources

We are achieving **solid** and **steady** progress towards realizing our HVM EUV source

New Data Available Very Soon!

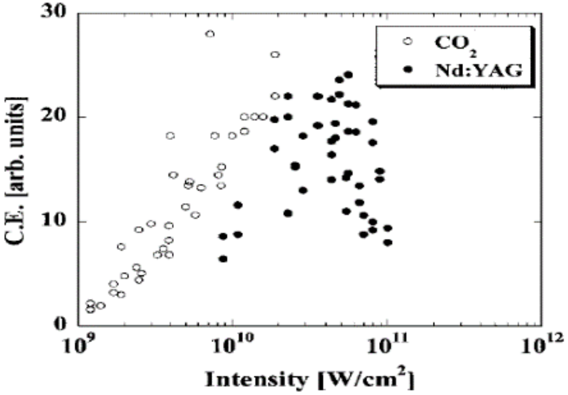
Next Target

EUV clean power	25W	43W	**??W**	150W	**250W**
Target	2013, Q4	2014, Q1	2014,Q2	2014,Q4	2015,Q2
CO_2 power at plasma	5kW	8kW	14kW	>14kW	> 20kW
CE	2.5%	3%	**??%**	4%	> 4.5%
Plasma to IF clean	21.7%	21.7%	**??%**	26.7%	26.7%
CO_2 laser	2 main amp. system	3 main amp. system	Mitsubishi pre. amp.	Mitsubishi pre. amp	Mitsubishi main amp. system
Pre-pulse laser	ps-laser	ps-laser	ps-laser	ps-laser	ps-laser
Collector mirror	V3 type	V3 type	V5 type	V5 type	V5 type

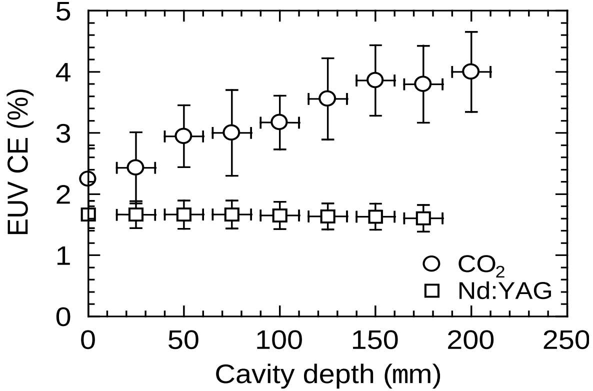
🟩 Performance was confirmed at 100kHz system

▨ Performance was confirmed at 10Hz source or parts level

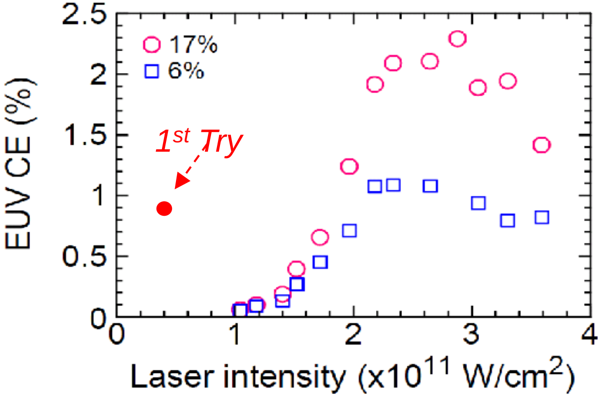
History of LPP Source Development in Japan



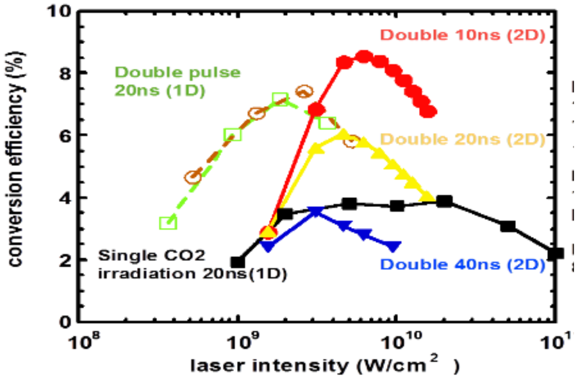
Kyusyu Univ. /
H. Tanaka et al.
/ Appl. Phys.
Lett. 87,041503
(2005)



EUV conversion efficiency (solid target) demonstrated in EUVA (2005)



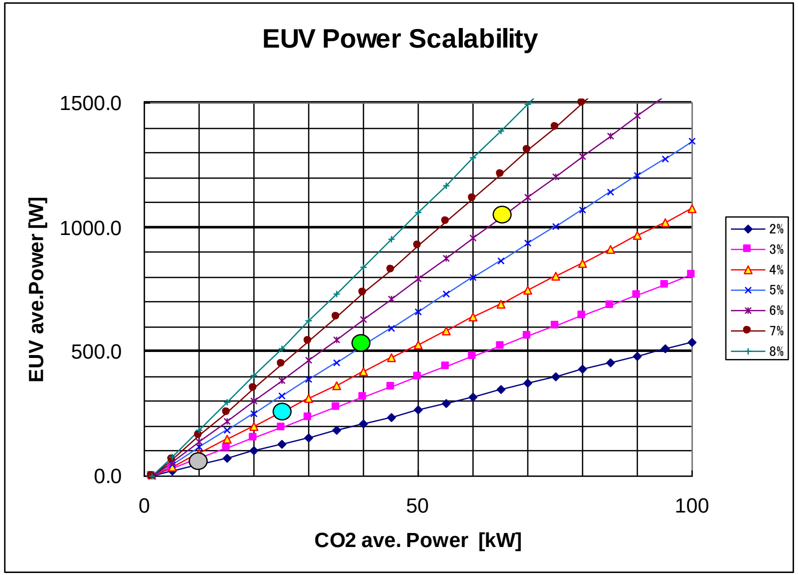
Miyazaki Univ. / T. Higashiguchi et al. / SPIE Microlithography 2006, 6151-146 (2006)



EUV conversion efficiency simulation by Osaka Univ. team (2006)

Extendibility to 1kW EUV Power (1)

Feasibility study of EUV Output Power vs. CO2 Input Power



Feasibility study of extendibility to 1kW

- Conversion efficiency is Key. At least achievement of CE＞4% is essentially important. If not, CO2 laser will become >100kW.
- At least >50kW CO2 laser power must be realized. Even in best case of CE=8%.
- I believe; 1000W EUV source is feasible in future, from the technical data (experiment of CE and CO2 laser) and technical expectations at present.

Extendibility to 1kW EUV Power (2)

Possible scale up scenario of EUV Output Power vs. CO_2 Input Power

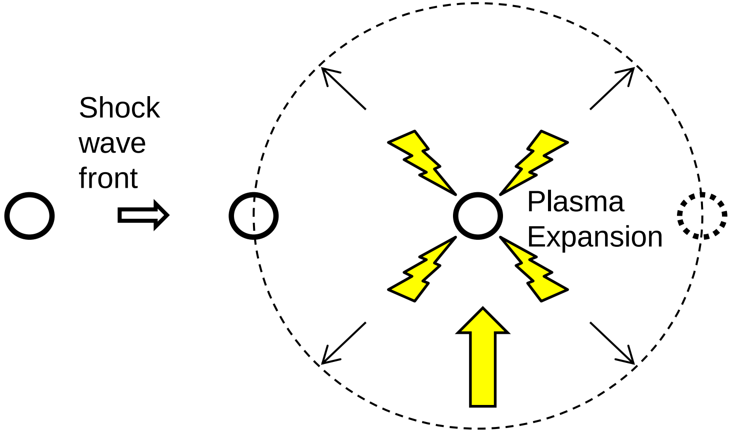
EUV ave.Power[W] @100kHz		Conversion Efficiency [%]						
CO2 laser Energy [mJ]	CO2 laser ave. Power [kW]	2%	3%	4%	5%	6%	7%	8%
15	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50	5	19.1	28.7	38.2	47.8	57.3	66.9	76.4
100	10	46.4	69.6	92.8	116.0	139.2	162.4	185.6
150	15	73.7	110.6	147.4	184.3	221.1	258.0	294.8
200	20	101.0	151.5	202.0	252.5	303.0	353.5	404.0
250	25	128.3	192.5	256.6	320.8	384.9	449.1	513.2
300	30	155.6	233.4	311.2	389.0	466.8	544.6	622.4
350	35	182.9	274.4	365.8	457.3	548.7	640.2	731.6
400	40	210.2	315.3	420.4	525.5	630.6	735.7	840.8
450	45	237.5	356.3	475.0	593.8	712.5	831.3	950.0
500	50	264.8	397.2	529.6	662.0	794.4	926.8	1059.2
550	55	292.1	438.2	584.2	730.3	876.3	1022.4	1168.4
600	60	319.4	479.1	638.8	798.5	958.2	1117.9	1277.6
650	65	346.7	520.1	693.4	866.8	1040.1	1213.5	1386.8
700	70	374.0	561.0	748.0	935.0	1122.0	1309.0	1496.0
750	75	401.3	602.0	802.6	1003.3	1203.9	1404.6	1605.2
800	80	428.6	642.9	857.2	1071.5	1285.8	1500.1	1714.4
850	85	455.9	683.9	911.8	1139.8	1367.7	1595.7	1823.6
900	90	483.2	724.8	966.4	1208.0	1449.6	1691.2	1932.8
950	95	510.5	765.8	1021.0	1276.3	1531.5	1786.8	2042.0
1000	100	537.8	806.7	1075.6	1344.5	1613.4	1882.3	2151.2

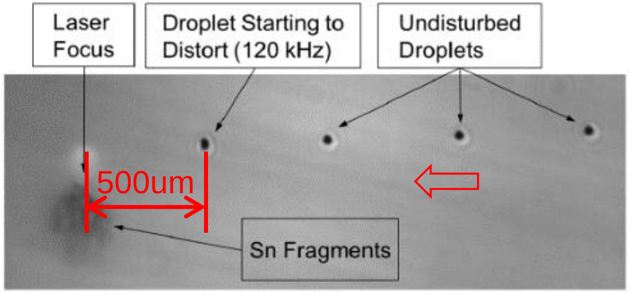
Our possible scale-up scenario

	HVM (1st)	HVM (2nd)	HVM(3rd)
EUV power	250W	500W	1000W
CE	4%	5%	6%
Pulse rate	100 kHz	100kHz	100kHz
Pre-pulse laser	Pico-s	Pico-s	Pico-s
CO2 laser power	25kW	40kW	65kW
# of main amps	3	5	8

Debris Mitigation Technology

Issue with previous gas mitigation techniques





100Pa Droplet 30um

Proc. of SPIE Vol. 8322 83222N (2012)

The Vicious Circle of Mitigation and Output Power

Higher Power

Gigaphoton has broken this vicious circle by developing the **Magnetic Debris Mitigation** system

Increase fragment and deposition

Increase Hydrogen pressure to compensate

Debris Mitigation Technology

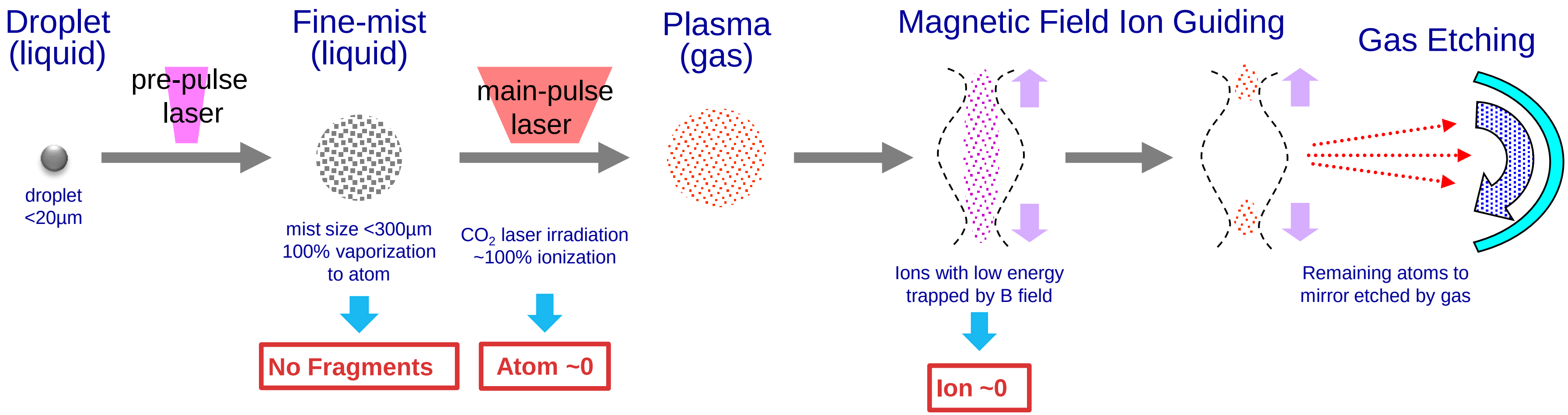
Gigaphoton’s Magnetic Debris Mitigation concept

Higher CE and Power

- Optimum wavelength to transform droplets into fine mist
- Higher CE achievement with ideal expansion of the fine mist

Long Life Chamber

- Debris mitigation by magnetic field
- Ionized tin atoms are guided to tin catcher by magnetic field



Droplet (liquid)

droplet <20µm

pre-pulse laser

Fine-mist (liquid)

mist size <300µm
100% vaporization to atom

No Fragments

main-pulse laser

CO$_2$ laser irradiation
~100% ionization

Atom ~0

Plasma (gas)

Magnetic Field Ion Guiding

Ions with low energy trapped by B field

Ion ~0

Gas Etching

Remaining atoms to mirror etched by gas

Thank You

GIGAPHOTON