Development of a CO_2 Laser Produced Xenon Plasma for EUV Lithography

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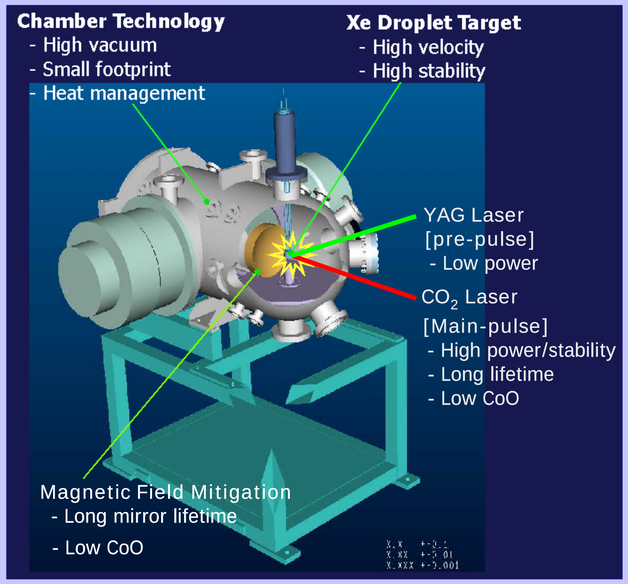
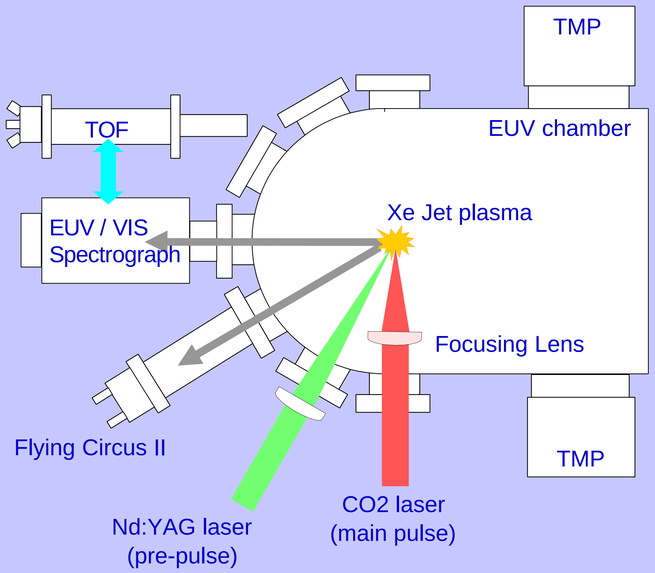
Abstract

Fundamental concept of the EUV light source currently being developed by EUVA is the combination of Xe target, i.e. low debris target, with CO_2 laser. Beside its lower initial cost, CO_2 laser has much higher wall-plug efficiency than other lasers considered for EUVL, thus reducing the power consumption of a light source system tremendously. In order to increase the CE we use a pre-pulse laser that optimizes the target density at the moment of CO_2 irradiation. Currently 0.6% CE (2% bw, 2π sr) are obtained with a 25ns, 100mJ CO_2 laser and a 8ns (150ps), 5mJ pre-pulse laser.

Concept of EUV Light source



Experimental setup



■Nd:YAG Laser (pre-pulse)
Wavelength : 1064nm
pulse energy : 5mJ
Pulse width : ~8ns (fwhm)
Rep. rate : 10Hz

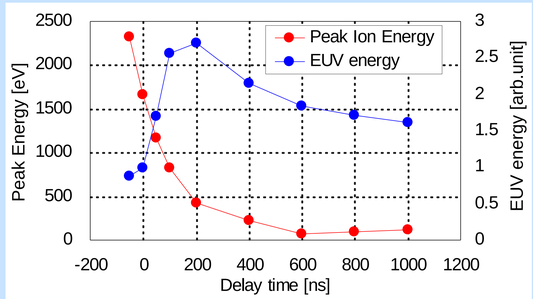
■CO_2 Laser (main-pulse)
Wavelength : 10.6um
pulse energy : ~ 300mJ
Pulse width : ~25ns (fwhm)
Rep. rate : 10Hz

■Target
Xenon jet

■Evaluation
EUV energy (CE)
Spectrum (EUV,VIS)
EUV image
Fast ion

Characteristics of Xe ion

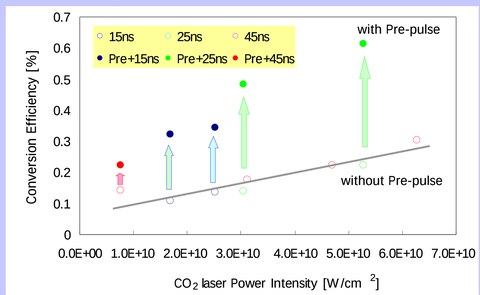
■Delay time dependence of Xe ion energy



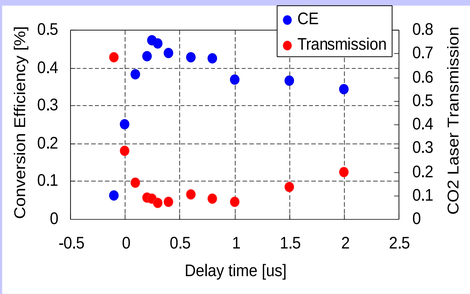
Experimental Results

■Conversion Efficiency

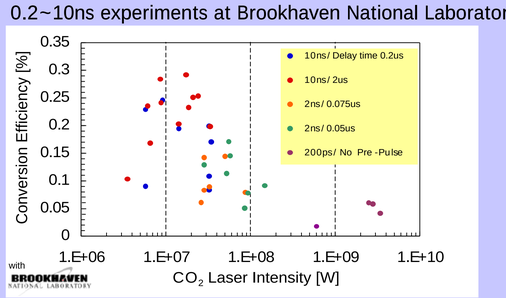
15~50ns experiments at Hiratsuka R&D center



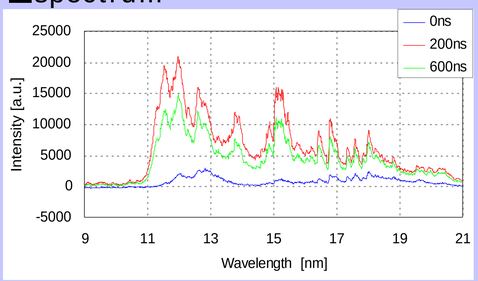
Delay time dependence of 25ns CO_2 Laser



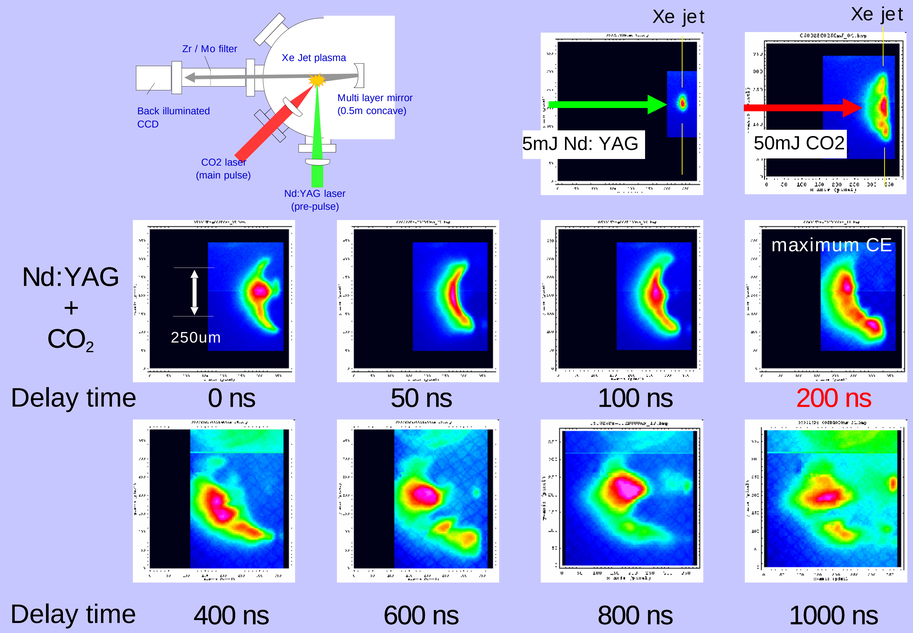
0.2~10ns experiments at Brookhaven National Laboratory



■spectrum



■EUV image



Conclusion

■Pre-pulse laser increases CE ~3times.

■Laser parameters for high CE determined, laser pulse widths for pre-pulse and CO2 laser are : ~8ns and ~25ns,respectively.

■Best CE is 0.6%. (2%BW 2π sr)

■Best CE observed for 200ns delaytime between pre-pulse and CO_2 laser

■Development of 10W CO_2 laser produced EUV source is the next step ("Development of CO_2 laser produced plasma EUVL source for Microlithography" by Dr. H. Mizoguchi, invited speaker)

Acknowledgments

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