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EUV radiation characteristics of Xe cluster ensemble irradiated by lasers

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Introduction

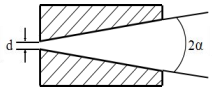
Laser Produced Plasmas (LPP's) EUV source based on Sn droplet is one of the leading sources of EUV radiation for the application in EUVL. Xe was also a widely used target material for generation of EUV radiation from early reaseach. Although it is less efficiency comparing with Sn droplet, but due to its less polluting, it still have attracted much attention. The history of EUVL tells us that the most important things in developing EUV sources are getting a high efficiency and suppressing contamination of surrounding optics by debris and ions. It is shown that clusters ensemble greatly can enhance the absorption of laser energy than in gas-jet scheme. The cluster target scheme maybe the promising way to EUV source which the ultimate high CE is achieved and contamination of the plasma is ultimately minimized. In the Shanghai Institute of Optics and Fine Mechanics (SIOM), we are on the way of developing LPP-EUV sources for recent years. Some experimental investigations of EUV radiation of Xe cluster jet irradiated by lasers have been done, and the Sn droplet target based EUV source is also in construction.

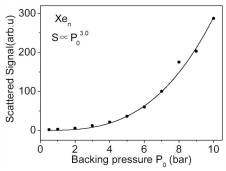
Experimental setup

Laser used

- Wave length: 532nm
- Energy : < 500mJ
- Pusle duration: 7.5ns

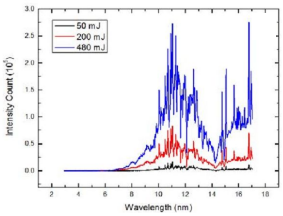
Cluster ensemble jet Generation



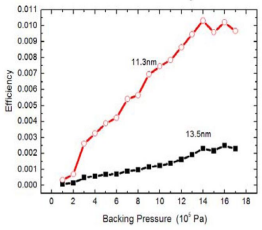


A conical nozzle of d=300μm and α=7.97° was used to generate cluster ensemble. Large rare gas clusters of (Xe)n were produced in the process of supersonic adiabatic expansion. Rayleigh scattering method is used to diagnose the cluster size. The average cluster size (atoms per cluster) was estimated from 10^2-10^6 for (Xe)n gas cluster .

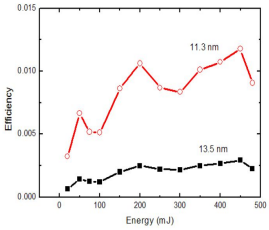
Results



The spectrum of EUV from Xe clusters at varius irradiated laser pulse energy. The EUV radiation get its maximum at 11.3nm



EUV conversion efficiency at 13.5nm and 11.3nm (2% in band) versus the backing pressure. It's shown the CE of EUV increased greatly when the pressure got higher (clusters become larger).



EUV conversion efficiency at 13.5nm and 11.3nm (2% in band) versus laser pulse energy. The CE increased with the laser energy, but it is almost unchanged while laser energy great than 200mJ.

Conclusions

When irradiated by laser pulse, EUV was excited more efficiently by Xe cluster ensemble target than Xe gas-scheme. Large clusters may enhance the CE of EUV. In future, more works will be done on cluster scheme with different laser pusles changing wavelength and pulse duration to improve CE.

Future work

In Shanghai Institute of Optics and Fine Mechanics (SIOM), A project has been suggested to develop a scalable EUV source for basic research. Researches mainly focus on the improvement of conversion efficiency. Progresses for preparation of the experimental conditions are undergoing.

Driven lasers

- CO_2 laser :
  10.6 μm, 80mJ, 50ns, 100Hz
- Nd-YAG laser:
  1.06 μm, 800mJ, 10ns, 10Hz
- short-pulse laser:
  800nm, 7mJ, 30fs, 1kHz

Progress of Droplet Generator

Photograph of droplet generator and the generated water droplets

- Water droplet diameter: 120μm
- Repetition rate: 20KHz
- More test work and measurements are undertaking. Sn droplet generating is also in plan recently.

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