5th EUVL Symposium, October 15~18, 2006, Barcelona, Spain, S0-149

Axial Dynamics of Z-pinch Plasmas Driven by 100 ns-long Current Pulses

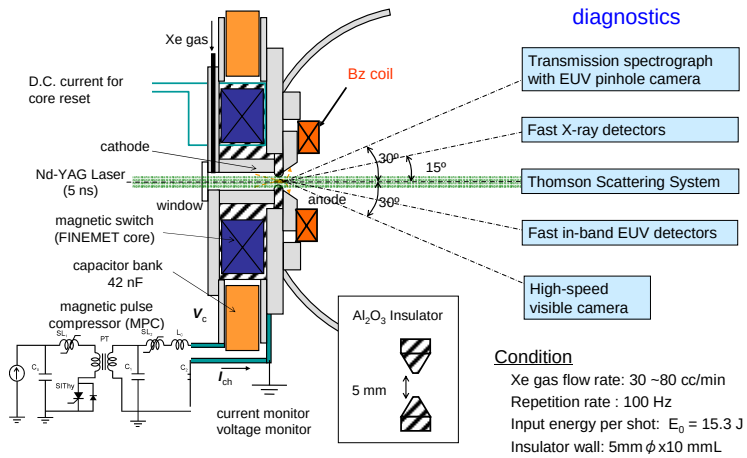
Graduate School of Science and Technology, Kumamoto University
Sunao KATSUKI, Hidenori AKIYAMA, Takashi SAKUGAWA, Takao NAMIHIRA, Hideki IMAMURA, Nobufumi TOMIMARU, Yoshihiro KONDO
Kyushu University
Kenichiro TOMITA, Shunji ARAKI, Kiichiro UCHINO

1. Introduction

In order to find a direction to improve the conversion efficiency from the discharge energy to EUV yield (CE), it is important to understand the plasma dynamics and EUV radiation mechanism. This paper discusses the dynamics of Z-pinch plasmas driven by a fast rise-rate current, which is based on time-resolved measurements including

1. visible imaging
2. EUV imaging
3. Thomson scattering (Ar plasmas)

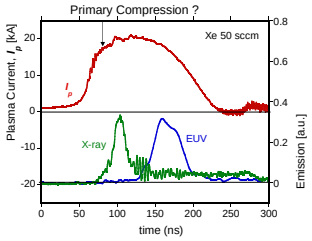
2. Z-pinch Device



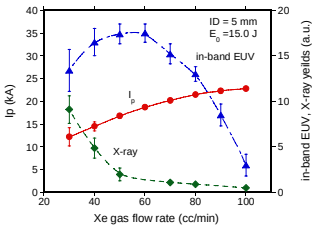
Condition

Xe gas flow rate: 30 ~80 cc/min
Repetition rate : 100 Hz
Input energy per shot: E_0 = 15.3 J
Insulator wall: 5mm ϕ x10 mmL

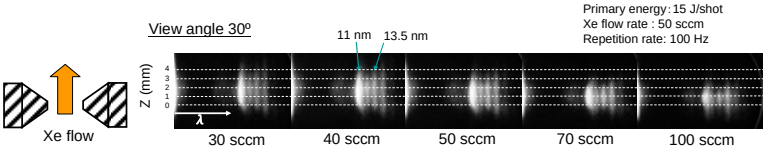
3. EUV Emission Dependent on Xe Gas Flow Rate

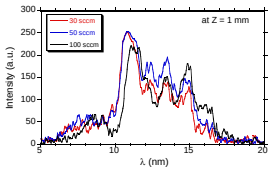


Typical waveforms of plasma current, X-ray and in-band EUV emissions

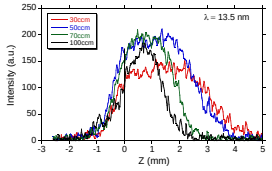


Amplitude of Plasma current and in-band EUV and X-ray yields versus Xe flow rate

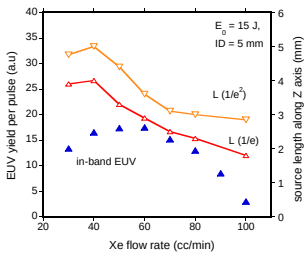




EUV spectra at Z = 1 mm



Spatial distribution of 13.5 nm emission

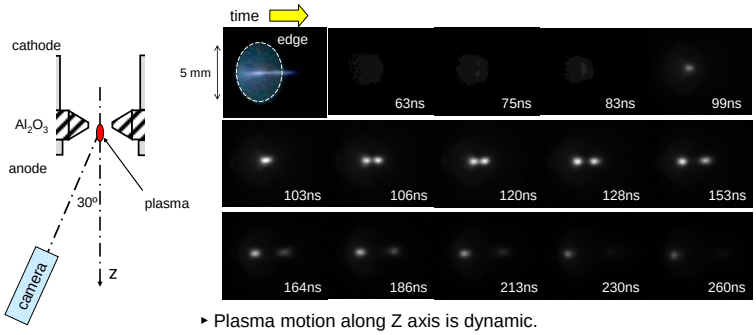


Source length as a function of Xe flow rate

- X-ray radiation occurs in the case of a small flow rate of Xe gas. No EUV emission is observed during the X-ray radiation.

  → Primary compression of rarefied gas ???
- X-ray yield is decreased with increasing the gas flow rate.
- EUV spectrum and source length is varied with the Xe flow rate.
- The variation of the EUV spectra indicates the plasma temperature is decreased with increasing the Xe flow rate.

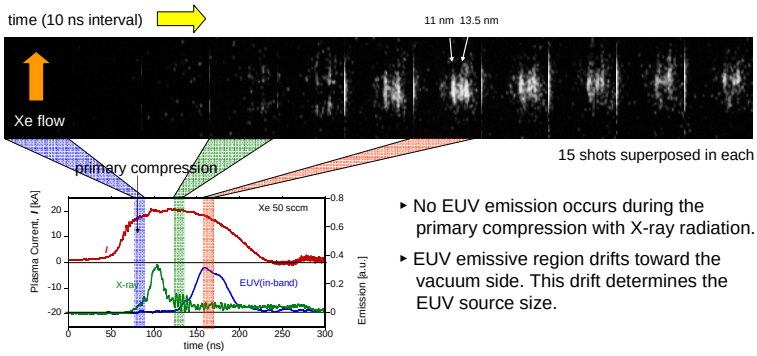
4. Time-Resolved Visible Imaging



- Plasma motion along Z axis is dynamic.
- After the first compression, plasma split into two parts and they move in opposite direction in Z axis.

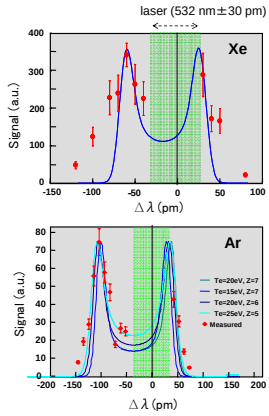
5. Time-Resolved EUV Imaging

- A micro channel plate used as a detector of the pinhole camera was driven by pulsed voltages. Time resolution determined by the pulse width is 5 ns.

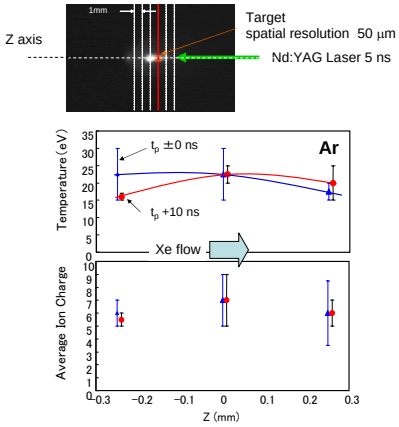


- No EUV emission occurs during the primary compression with X-ray radiation.
- EUV emissive region drifts toward the vacuum side. This drift determines the EUV source size.

6. Thomson Scattering Measurement of Xe and Ar Plasmas



Scattered Spectra (ion term)



Spatial Distribution of Temperature, Average Ion Charge along Z axis (Ar plasmas)

- The ion term peak shift due to thermal motion of Xe plasmas is not sufficiently large to estimate the plasma parameters.
- Spectrum shift indicates the plasma drift.
- High temperature region drifts to the vacuum side, which coincides with the motion of EUV radiant region.

7. Conclusion

- Plasma is dynamic not only in the radial direction but in the axial direction.
- EUV radiant plasma drifts toward the vacuum side together with high temperature region.
- This plasma dynamics determines the EUV source size.

Acknowledgements : This work was supported by NEDO, EUVA, and The 21 Century COE Program on "Pulsed Power Science".

Kumamoto University 熊本大学 Pulsed Power Laboratories EUVA NEDO