S1-1 EUV Light Source Development for Next Generation Lithography
ﾘｿｸﾞﾗﾌｨ用 EUV 光源開発

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Abstract The main technological challenge of future extreme ultraviolet (EUV) light source is the required average power of 115W at the intermediate focus. High repetition rate plasma sources both discharge produced plasma and laser produced plasma are very promising to face this challenge. Source is the most essential part of future Extreme Ultraviolet Lithography apparatus. This paper describes the present status and critical issues of high power EUV light source development. There have been put a lot of effort to both LPP and DPP EUV light sources. In order to obtain an innovative technology for EUV source, it should be noted the important collaboration of EUVA project with Leading project. This collaboration will benefit the understanding the underlying physical processes and should lead to the high volume manufacturing (HVM) goal.

1. Introduction

Extreme ultraviolet lithography (EUVL) is the main candidate for the next generation lithography to be introduced at the 45nm node. The EUV light source power is very high demanding output power of 115W and the energy stability of 0.3%. This paper describes the present status and critical issues of high power EUV light source development. In order to obtain an innovative technology for EUV source, it should be noted the important collaboration of EUVA project with Leading Project of MEXT (Ministry of Education, Culture, Sports, Science and Technology).

2. EUV Light Sources

In 1988, a synchrotron radiation (SR) was used as the lithography light source in a pioneer work of the EUV lithography carried out in Japan(1). For the HVM semiconductor industry application, very high demanding output power of 115W and the energy stability of 0.3% are required. Two kinds of EUV sources of LPP and DPP have been studied to fulfill these requirements. Comparing these sources, LPP source has the advantages, such as a large solid angle of about 5sr to be realized at the collector mirror, the lower debris production resulting in extended component/collector mirrors lifetime and the high repetition rate operation for improved dose accuracy. It has been shown that with a Sn GDPP it would be possible to get the required photons at IF. But we have not solved the debris problem yet and this can be a showstopper.

3. ＥＵＶ Power at Source and Intermediate Focus (IF)

At EUVL symposium at Miyazaki, power of Sn-GDPP were reported to be 257 W / 50 W at source / IF respectively from Philips Extreme, 700 W / 60 W from Cymer and 400W / 50-75 W from Xtreme technologies. Whereas the power of Xe-LPP were 9.1W / 4 W were from EUVA and 7 W / 2.3 W from Xtreme technologies and 7 W / 3 W from PowerLase.

４. Target Materials

Philips estimated in Xe case fast ion generation and electrode erosion are five times as large as those of Sn. In addition conversion efficiency and collection efficiency of Sn are larger than those of Xe. Therefore as is shown in Table 1, it was estimated that Xe is limited to about 15W. γ-tool specifications are only achievable with Sn source! Sn is the most promising candidate as fuel (target) material for the generation of light at 13.5nm in sources in next step EUV lithography. Xe is presently used in most gas discharge plasma(GPP) and laser produced plasma (LPP) sources. Compared with Xe, Sn has the advantages of less out-of band emission yielding in much higher conversion efficiency into the

13.5nm emission (2). However, debris problem is not solved yet.

Table 1 Limits of power scaling of DPP (Philips)(3)

Material	Xe	Sn
conversion efficiency (% of 2Pi)	0.5	2
pinch size (mm)	2	<1
collector opening (sr)	1.8	3
collector + mitigation efficiency (%)	50	40
collection efficiency (% of 2 Pi)	20	45
limit of power input (kW)	30	30
inband power limit 2nd focus (W)	15	108

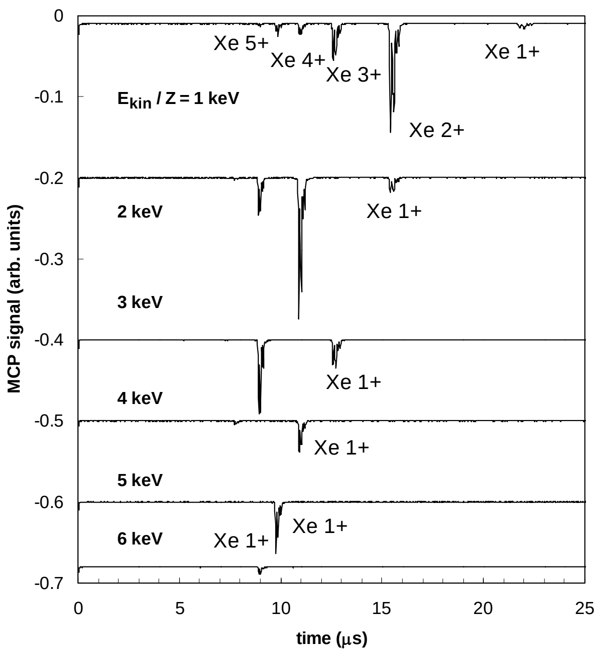

Fig. 1 Typical ESA signal with an 8-ns, 100-mJ laser

5. Collaboration with MEXT Leading Project

A five-year long project for LPP EUV Light source development has been started as a Leading Project promoted by MEXT. The project aims at understanding physics of EUV for practical use in collaboration with METI project (EUVA). The project includes high performance laser development, plasma experiments, theory and simulation and target fabrication and providing database and guideline.

6. Ion Damage Analysis on EUV Collector Mirrors

Collector mirror lifetime evaluation and damage prevention are important technical challenges for the EUV light source development. Related future collector lifetime considerations, fast ions from liquid jet xenon plasma measurement were made for the first time at EUVA. A time-of-flight (TOF) measurement combined with an electrostatic energy analyzer (ESA) was used. In Fig.1, typical ESA signals are shown. Though up to Xe5+ ions are observed, Xe2+ is the main observed charge state.(4)

7. Exposure Tool Applications

In 2002, an early prototype of the Philips hollow cathode discharge plasma source was installed in an experimental setup at the ASML EUV laboratory in Veldhoven. The source emits roughly 0.2 W in-band EUV at intermediate focus of the source and condenser.(5).First prototype GDPP sources of XTREME technologies of the type XTS-35 with 35W power in 2 pai sr have been integrated into micro-exposure tools (MET) from Exitech, UK. Experience of integration as well as data about component and optics lifetime will be presented near future (6).

References

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