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Production of EUV by using micro wave Plasma
マイクロ波プラズマを用いたEUV光の生成

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The manufacture of the next generation LSI needs the EUV light for the semiconductor lithograhy. The EUV is emitted from the highly ionized Xe plasma. The Xe plasma with the high density and the high electron temperature is produced by the micro-wave (2.45GHz, TM010) amplified by the cavity, where the Q value may be achieved more than 2,000. The vacuum tube penetrates through the center of the cavity and is filled with 100Pa Xe gas. The EUV power 1 W is now observed by the 500W magnetron oscillator which works with the period 60Hz and the duty 20%. More EUV out put is expected by tunning the cavity and optimizing the gas pressure.

1. Introduction

Present day semiconductor technology is capable of manufacturing transistors with 65 nm features. The production of next generation chips with feature as small as 22nm is crucial to the successful development of extreme ultraviolet (EUV) photolithography. Two methods such as Discharge Produced Plasma (DPP) and Laser Produced Plasma (LPP) have been studied for the sake of producing EUV.[1]-[3] A 'debris' is produced along with the EUV. The microwave produced plasma is proposed for the clean EUV light source.

2. Experimental procedure

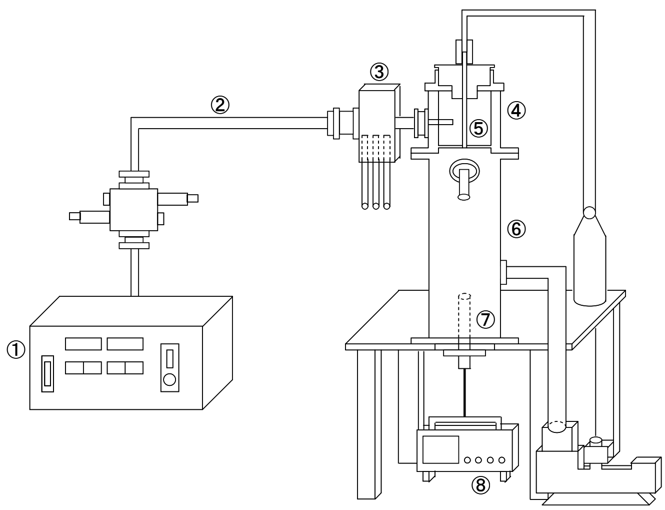
Figure 1 illustrates the experimental facility, which consists of the magnetron, the wave guide, the stab tuner, the cavity, the quarts tube, the vacuum chamber, the EUV detector (photodiode), the amplifier, and the oscilloscope. The Q-value of the cavity is achieved to be 2850 by TM010 mode. The cavity is cylindrical. The height is 6cm and the radius is 3cm. The quart tube is set in the center axis of the cavity. The magnetron output is 500W at the maximum. The repetition cycle and the duty factor are changed 10 to 1 kHz and 5% to 100% by using a function generator. The Xenon gas with the pressure 10-200 Pa. is filled in the vacuum chamber.

3. Experimental results

Figure 2 is the photo of the plasma produced in the quart tube with the diameter of 5mm in the cavity. Figure 3 shows the input power, the reflection power and the out- put voltage of the photodiode. The cavity is tuned in order to minimize the reflection power by the stab tuner. The EUV power (P_{EUV}) is estimated to be 1W from the signal of the photodiode by the following equation.

$$\frac{P_{EUV}}{V} = \frac{4\pi(750)^2}{20} \times \frac{1}{13.3\times10^{-3}\times10^{6}\times0.4} = 66.5[W/V]$$

Distance from plasma to a photodiode: $(750)^2$; Acceptance surface: 20; Quantum efficiency: 13.3×10^{-3}; Resistance of an amplifier: 10^6; Transmissivity: 0.4



1:Magnetoron　2: Wave guide　3: Stab tuner
4: Cavity　5:Quarts tube　6:Vacuum chamber
7:Photodiode　8:Oscilloscope

Fig.1. Diagram of experimental facility

Fig.2. Photo of plasma produced in the quart tube

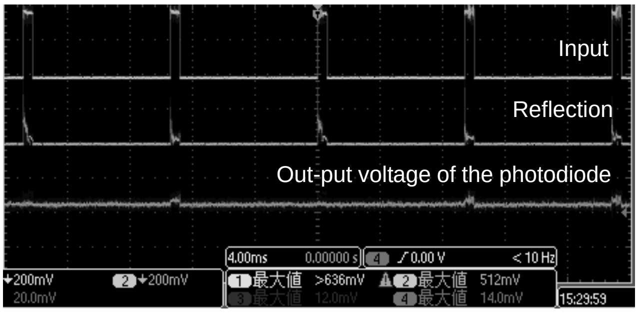


Fig.3. Measurement waveforms

4. Conclusions

The micro wave 2.45 GHz has been demonstrated to produce the clean EUV light in the small cavity with very high Q value. The experiment is the proof of principle of producing the EUV for the lithographic application with the low cost and the small facility. The EUV which satisfies the commercial application may be produced by increasing the magnetron power.

References

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