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Discharge plasma to produce EUV by using a rotating magnetic field of 13.56MHz

13.56MHzの回転磁場による放電プラズマを用いた極端紫外（EUV）光の生成

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The 13.56 MHz rotamak is studied for the purpose of producing the Xe plasma which radiates EUV light for the semiconductor lithography. The resonant conditions to maximize the antenna current are obtained in the circuits including the impedance of the antenna, the cable length and the internal impedance of the power supply. The current more than 40 A is realized and the small rotamak plasma is produced.

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', however, is produced along with the EUV. The rotamak has produced the clean EUV more than 66W by the Xe plasma with the diameter 70 mm by using the oscillator with 200 kHz and 75 kW.[4)] The smaller plasma formation is studied by 13.56 MHz oscillator and the smaller chamber in order to satisfy the condition for the lithography.

2. Experimental facility

The facility is shown in the diagram given by Fig.1.

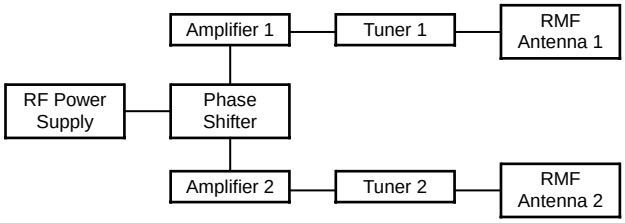

Fig.1. Diagram of experimental facility.

The power supply branches two circuits consisting of the amplifier and tuner and the antenna. The phase shifter gives the phase difference of 90 degree to the currents. Two couple antennas attach directly on the glass vacuum chamber as shown in Fig.2.

Fig.2. Photography of vacuum chamber with antenna of rotating magnetic field.

3. Tuning the circuit and Current in the antenna

The frequency 13.56 MHz is high enough to include the cable length connecting the power supply and the antenna in obtaining the resonant condition of the circuit. Figure 3 shows the current versus tuning capacitance for the various cable lengths. The maximum current is obtained in the cable length 0.75 m. When tuning the circuit by changing the capacitance the currents are 40 A and possess 90 degree phase difference. The input power 1.2 kW is supplied to each antenna.

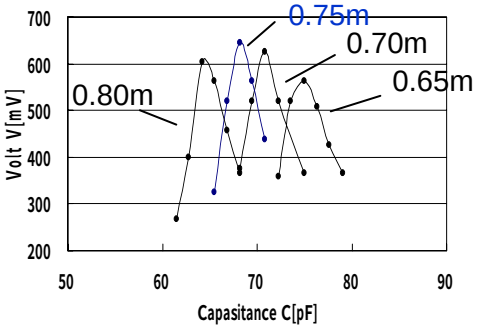

Fig.3. Current versus tuning capacitance for the various cable lengths.

Figure 4 shows the Xe plasma produced in the chamber with the diameter 16 mm. The strong light is emitted, but no EUV is observed by the photodiode.

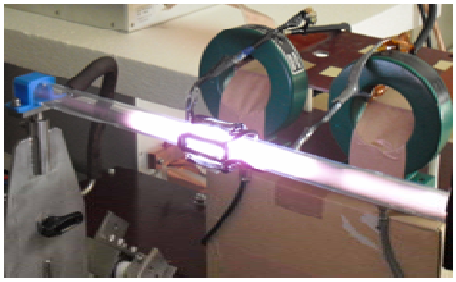

Fig.4. Xe plasma produced in the chamber with the inner diameter 16 mm.

4. Conclusions

The plasma is formed by 13.56 MHz oscillators which are 90 degree out of phase. The antenna currents are more than 40A. The axial magnetic field is now being applied for reducing the electron loss. The higher electron temperature will be obtained to observe the EUV radiation.

References

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