Temporal evolution of plasma density in a pulsed 2-frequency (2/13.56MHz) 2-antenna inductively coupled plasma discharge

N. Sirse[1]*, G. Y. Yeom[2], A. R. Ellingboe[1,2]

[1]*School of Physical Sciences and NCPST, Dublin City University, Glasnevin, Dublin 9, Republic of Ireland*
[2]*Department of Advanced Materials Science and Technology, Sungkyunkwan University, Suwon, South Korea*
**Contact e-mail:* nishant.sirse@dcu.ie

1. Introduction

Pulse-modulated plasma discharges are routinely used in the semiconductor industries to achieve highly selective, anisotropic and charge-free plasma etching [1]. In this contribution we present experimental study of temporal evolution of plasma density in a large-area (substrate holder diameter > 300mm), pulsed, 2-frequency (2/13.56MHz) 2-antenna inductively coupled plasma discharge (figure 1) produced in argon-C_4F_8 (90-10) gas mixtures. 2MHz is pulsed at a frequency of 1KHz and 13.56MHz is applied in CW mode. The discharge operates in a pressure range of 3-50mTorr, 100-600W 13.56MHz power level, 300-600W 2MHz peak power level and the duty ratio are varied from 10% to 90%. The probe is positioned at the centre of the discharge and ~2cm below from the dielectric window.

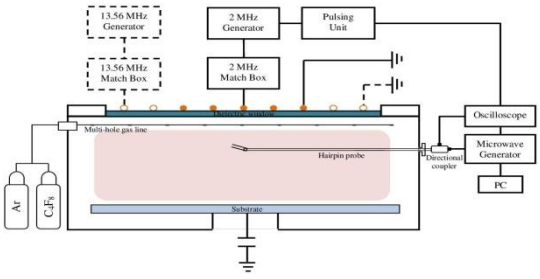

Fig. 1: *2-frequency 2-antenna inductively coupled plasma discharge.*

2. Results

The experimental results reveal that the plasma density in the longer on-phase is greatly affected by the 2MHz power levels and slightly affected by 13.56MHz power levels. It is observed that the plasma density increases by a factor of 2-2.5 on increasing 2MHz power level from 300W to 600W whereas it is increasing by ~20% for 100-600W 13.56MHz power level. Both, the rise time and decay time constant of plasma density are decreasing monotonically with an increase in 2MHz and 13.56MHz power levels. For all the operating conditions, it is observed that the plasma density overshoots in the beginning of on-phase before reaching to a quasi-steady state value. The relative overshoot found to be dependent on 2MHz and 13.56MHz power levels. On increasing gas pressure the plasma density is first increasing, reaching to a maximum value at ~10mTorr gas pressure, and then decreasing with further increasing in gas pressure. Decay time constant of plasma density is pressure dependent (figure 2), it is increasing rapidly up to ~20mTorr gas pressure and then increasing slowly. At a fixed 2/13.56MHz power level and 10mTorr gas pressure the steady state plasma density shows maximum for 50% duty ratio and decreasing with further increase in duty ratio.

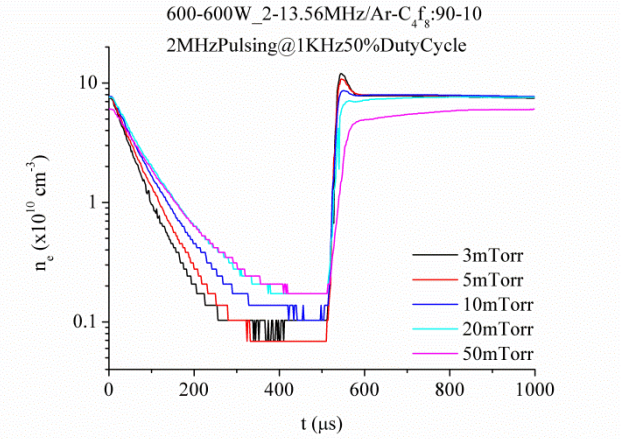

Fig. 2: *Plasma density evolution for different operating gas pressures in Ar-C_4F_8 (90-10) gas mixture. 2MHz peak power level is 600W and pulsed at a frequency of 1KHz. 13.56MHz power level is 600W and applied in CW mode.*

Acknowledgement

This work was supported by the Korea Institute for the Advancement of Technology, Ministry of Knowledge Economy (L-2010-1438-000) Republic of Korea, Enterprise Ireland and the European Regional Development Fund (ERDF) under the National Strategic Reference Framework (NSRF) 2007-2013.

References

[1] S. Samukawa and T. Mineo 1996 *Plasma Sources Sci. Technol.* **5** pp 132