Measurement of Monodisperse Particle Charging in Unmagnetized and Magnetized Plasmas

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1. Introduction

Particle charging in a plasma precess is very important in terms of contamination control in semiconductor processes. Several research groups [1-4] have been tried to understand and measure the particle charge that is generated in a plasma process. However, their research results are sometimes unrealistic or does not measured the particle size distribution and its concentrations.

In this research, the known size and known concentration of particles are introduced into a plasma chamber and the plasma properties and the particle charge are measured in the magnetized and unmagnetized DC plasma to understand the particle charging characteristics.

2. Experiment

2.1 Experimental Set-up

Fig. 1 shows a schematic diagram of the experimental set-up. It consists of three major parts, i.e., the monodisperse particle generation part, the plasma chamber, and the particle concentration and charge measurement part. The test particles (NaCl or Al_2O_3) are generated with atomizer and then these polydisperse particle are classified with differential mobility analyzer(DMA) to extract the monodisperse particles. Before the introduction of this monodisperse particles into the plasma chamber that is operated at 1.17 torr, the particle concentration is monitored by the condensation particle counter (CPC). The particle flowen into the chamber will be exposed into the plasma region. After passing the plasma region the particles will be carried into the Faraday cup by the vacuum pump. If the particles are charged the induced current will be detected by the Keithley 6517A electrometer. These particle concentration and the current are monitored and recorded by a personal computer for further data analysis.

2.2 Experimental results and Analysis

Fig. 2 shows the plasma and floating potential as the plasma potential changes. These potentials are increasing as the plasma voltage increases. Fig. 3 shows the raw data of the particle concentration and the current as a function of time when 0.05μm Al_2O_3 particles are introduced into the plasma chamber. It clearly shows a very strong relationship between the current and the particle concentration. It also indicate that the particles are negatively charged. Fig. 4 and Fig. 5 show the number of elementary charge for Al_2O_3 and NaCl particles. As the particle size becomes larger the number of charge increases. However, the number of charge for Al_2O_3 and NaCl particles is about one order of magnitude different for the same size particles. This may be caused by the NaCl particle size reduction by the evaporation on the surface during the plasma exposure. The melting point of NaCl is 800.7°C.

Fig. 6 shows 0.05μm Al_2O_3 particle charge variation as the magnetic field strength changes. The number of elementary charge increases as the applied magnetic field strength increases. The particle charge for each particle increases very rapidly up to about 4.8 Gauss and then it seems like the charge reached the saturation limit.

3. Conclusions

The known size particle charge measurement system in a DC magnetic plasma is successfully developed. As one can expect the number of charge of particle is dependent on particle sizes and magnetic field. The larger the particle size the more charge is attained. The measurement also shows that the magnetic field strongly affects on the particle charging. It is believed that the ExB drift of electrons by the external magnetic field gives high chance of collision with particles. This will eventually increases the particle charging.

Acknowledgments

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References

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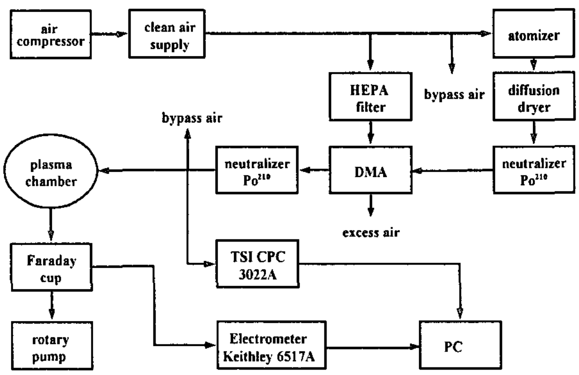

Fig. 1 Experimental set-up for particle charge measurement in DC plasma.

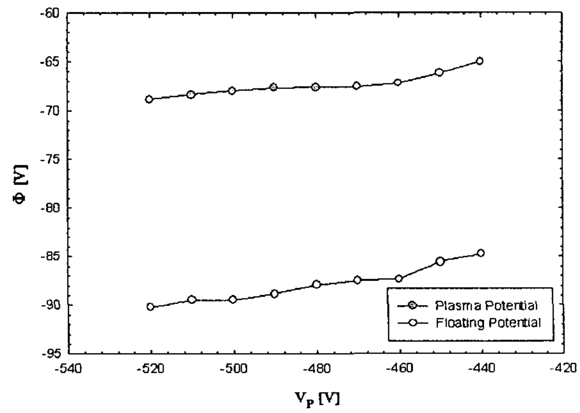

Fig. 2 Plasma and floating potential with plasma voltage.

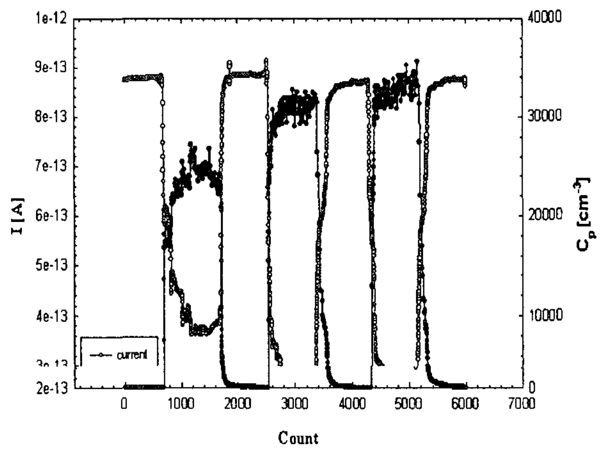

Fig. 3 Current variation with particle concentration (Al_2O_3 particle, -440V, 0.05μm).

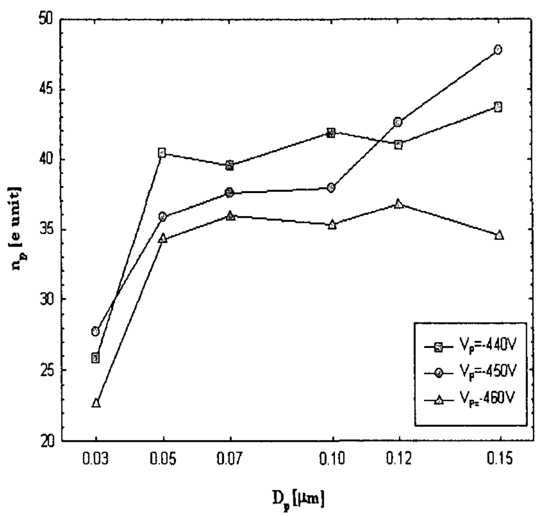

Fig. 4 Number of charge for Al_2O_3 particles.

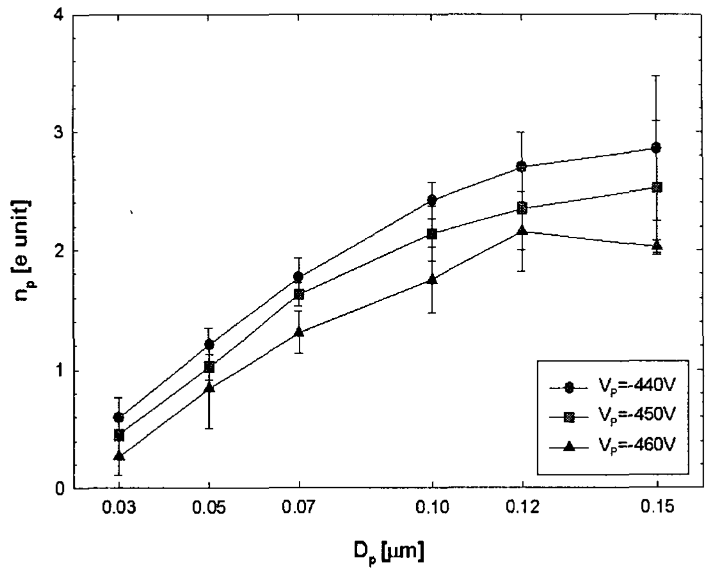

Fig. 5 Number of charge for NaCl particles.

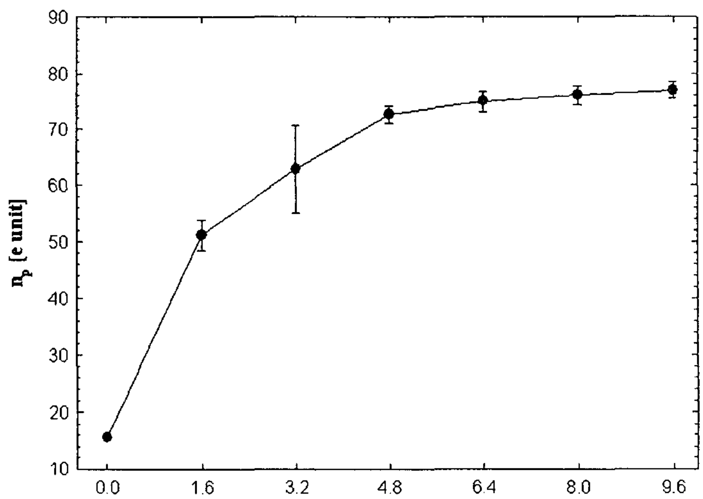

Fig. 6 Number of charge of 0.05μm Al_2O_3 particle in the magnetic field.