CHARACTERIZATION OF INDUCTIVELY COUPLED ARGON PLASMAS

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ABSTRACT

In this experiment we analysed the DC bias voltage (VDC) in Inductively Coupled Plasmas (ICP), for this two different types of coil were used.

At first, it was used the coil placed inside the reactor chamber in direct contact with the plasma, this type of coil is called internal coil. In a second part of the experiment, the coil was insulated by a thick borosilicate plate (external coil).

With characterizations of DC bias voltage we may analyse the influence of coil power in the plasmas and differentiate between internal and external coil in plasma process.

1. INTRODUCTION

Inductively Coupled Plasmas (ICP) are used for most etching processes in integrated circuit manufacturing. Although they are very frequently used, their characteristics are not well known, because they are relatively difficult to characterise, because of the varying magnetic field in the plasma. In this paper simple characterizations were done with two types of reactor configurations: an internal coil and an external coil.

2. EXPERIMENTAL

A standard Reactive Ion Etching (RIE) system was transformed into an ICP system by adding a coil. In a first configuration, a coil was placed inside the reactor chamber, i.e. there is direct electric contact between coil and plasma. In a second configuration, the plasma was insulated from the coil by a 10 mm thick borosilicate plate. RF power was applied through a special matching network to the coil. Independently, another RF generator - matching network set delivers RF power to the 6-inch diameter, aluminium electrode. This system also measures the DC self bias voltage. Gas flows and process pressure can be controlled independently.

3. RESULTS & DISCUSSION

The DC bias voltage (VDC) was measured at the electrode as a function of power levels applied to both electrode and coil, pressure and coil configuration. The results are shown in figures 1 and 2.

The DC bias voltage becomes more negative when the electrode power is increased. Increasing the power on the coil does make VDC less negative, it may even become positive in some cases. For the same plasma conditions, with the two different coil configurations, VDC was more positive for the internal coil. In this configuration, VDC is much more sensitive to the coil power.

When decreasing the pressure, the DC bias voltage becomes more negative, for all coil configurations.

For the external coil, the place where the coil was grounded (centre of coil or side of coil) did not interfere in the plasmas. For the internal coil, the plasma depended on the fact if the centre of the coil was grounded or if the border of the coil was grounded. The second configuration proved to generate more stable plasmas, hence this configuration was used for the plasma characterizations.

The observed phenomena can be explained when the following model is used. Power increase to the electrode increases somewhat the plasma density but mainly the electron energy. Hence, more negative self bias voltage is necessary to repel the electrons from the electrode. Power applied to the coil, in all configurations, mainly increase the plasma density. The decrease of bias voltages is a strong indication that the electron temperature decreases with increase of coil power. This is the only way to explain the trends observed for the external coil.

In the case of the internal coil, there is electric contact between plasma and coil. The plasma potential has to be more positive than the coil voltage. As the DC voltage on the coil is zero, the mots positive voltage on the coil reaches tens of volts. Hence the plasma potential becomes very positive. The force, which repels the electrons, is proportional to the difference between plasma potential and DC self bias voltage. As the plasma potential becomes more positive, the DC bias voltage also becomes more positive.

4. CONCLUSIONS

Bias voltages were measured on the cathode of an ICP system. They become more negative if the pressure decreases, the cathode power increases and the coil power increases. If an internal coil is used, the DC bias voltage becomes more positive than with an external coil, probably due to the increase of the plasma potential. The decrease of the electron temperature with external coil power can explain the increase in DC self bias voltage in this case.

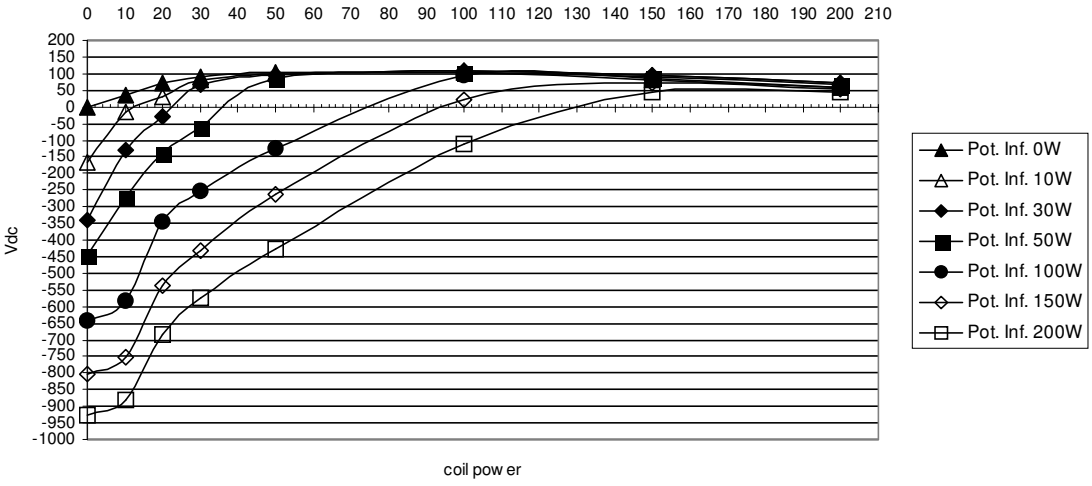

Figure1- *DC bias voltage as function of coil power at 10 mtorr and internal coil*

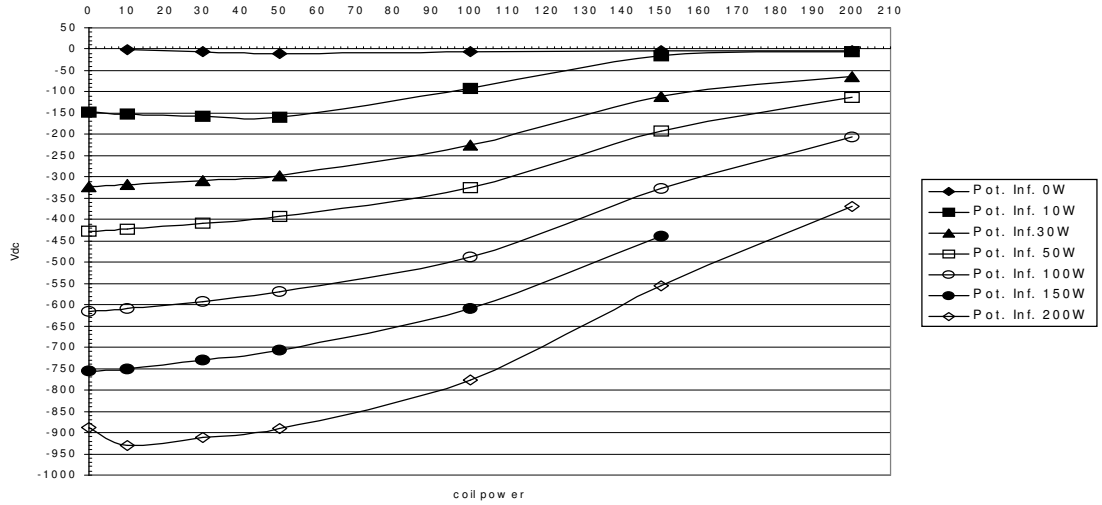

Figure 2- *DC bias voltage as function of coil power at 10 mtorr and external coil.*