ANALYSIS AND INTERPRETATION OF ELECTRIC CHARACTERISTICS OF DRY ETCHING PROCESS FOR THE TFT-LCD FABRICATION

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Keywords : electron density, electron temperature, power balance, Lieberman sheath model

Abstract

In the usual dry etching process for the TFT-LCD fabrication, it is hard to monitor the basic plasma parameters such as density and temperature. However, the basic parameters are easily monitored during the dry etching process. We have simultaneously measured the electric characteristics and basic plasma parameters of the dry etching chamber during the process, analyzed them to interpret plasma parameters. For the Ar plasma discharge case, we could obtain the density and temperature from the electric characteristics using a simple simple sheath model.

1. Introduction

Plasma is widely used in display device manufacturing processes, such as PECVD(plasma enhanced chemical vapor deposition), Sputtering and Dry etch. CCP(capacitively coupled plasma) is commonly used in the PECVD and Dry etch.

Among the plasma parameters, ne and Te are important ones[1,2]. They are easily measured using Langmuir probe to investigate plasma characteristics. However, it is difficult to measure during processes because this method may affect process condition.

V-I probe is so simple that widely used in the plasma process equipment. Usually they are used for simple monitoring and fault detection. Using V-I probe, voltage, current and phase from thepower supply to the plasma chamber are obtained. Because voltage and current are determined from plasma characteristics, V-I probe data can be used as a clue for the plasma characteristics. For the ICP(inductively coupled plasma), a simple method for interpreting V-I probe is proposed[3]. In this study, using a simple model, plasma parameters such as temperature and density are calculated from V-I probe data, and the calculation results are compared to those measured using Langmuir probe to give a interpretation.

2. Experimental

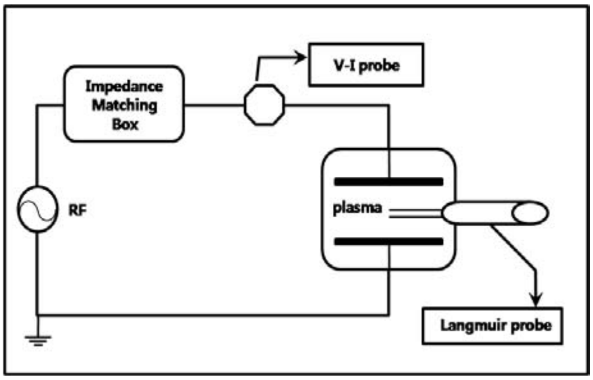

Fig. 1. Method of measurement by V-I probe & Langmuir probe

The chamber has square geometry, which is usual in the display processes. Chamber dimension is 297mmX347mm and the electrode size is 200X250mm. The gap between the upper and lower electrode is 300mm.

In this experiment, Ar gas is used. Pressure is 150-300mT, flow rate is 10sccm, and the input power is used as a variation from 100W to 200W. To measure the parameters such as ne, Te, and Vpp, V-I (voltage Current) probe and Langmuir probe which are shown in Fig. 1 are used .

3. Results and discussion

Correlations among parameters that are ne, Te and Vpp from experimental results shown in following figures.

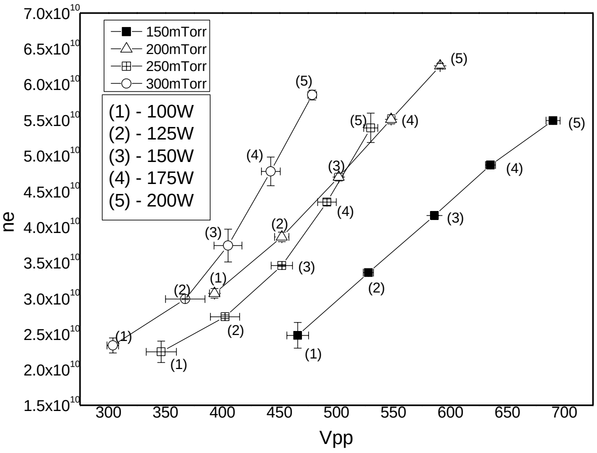

Fig. 2. Vpp dependence of density.

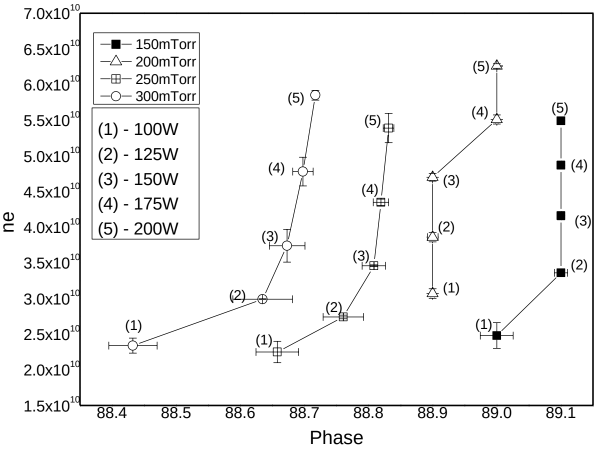

Fig. 3. Correlation between density and phase.

In Fig. 2, Vpp and ne are changed with changes of process conditions that are power and pressure. Interrelation among three parameters that are ne, Vpp and phase is found in Fig. 3, comparing the identical value of ne with Vpp and phase in each process condition.

In Fig. 4, Te are also changed with changes of process conditions that are power and pressure. In Fig. 5, comparing the identical value of ne with Vpp and phase in each process condition, interrelation among three parameters that are Te, Vpp and phase is found.

Correlation among Vpp, ne, Te and phase are confirmed from the result of experiment in accordance with process condition.

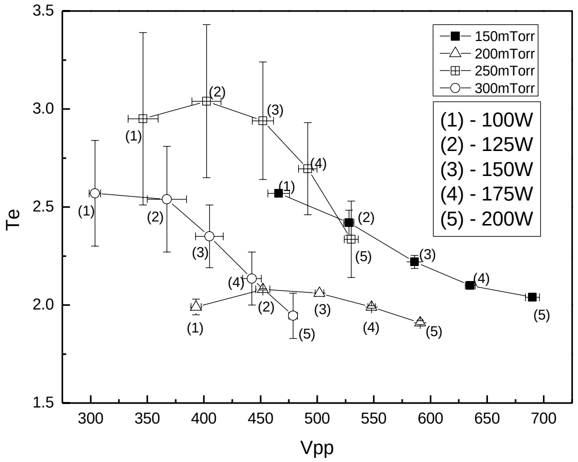

Fig. 4. Vpp dependence of electron temperature.

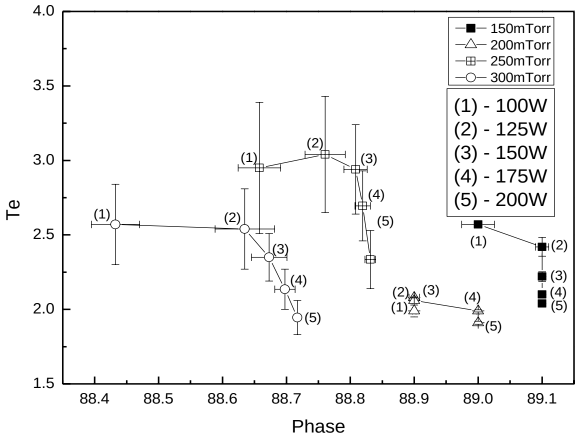

Fig. 5 Correlation between phase and electron temperature.

ne is calculated from (1) assuming the steady state power balance equation[4].

$$n_e = \frac{P_{abs}}{\Omega}\frac{1}{(\nu_i \varepsilon_i + \nu_l \varepsilon_l)} \qquad (1)$$

, where ν_i is ionization frequency of the plasma density, and ν_l is axial loss frequency of the plasma density. ε_i is ionization energy and ε_l is mean energy of escaping electrons. P_{abs} is absorption power and Ω is volume of the reactor chamber.

Vpp can be calculated from the sheath model[5] as follows.

$$V_{pp} = \frac{s_0^2}{\lambda_D^2} T_e \left[1 + \frac{s_0^2}{\lambda_D^2} \left(\frac{5}{12} - \frac{512}{675\pi^2} \right) \right] \qquad (2)$$

, where λ_D is electron Debye length and s_0 is mean sheath thickness.

Te is determined from the eq. (2)

$$T_e = \frac{V_{pp}}{\frac{s_0^2}{\lambda_D^2}\left[1 + \frac{s_0^2}{\lambda_D^2} \left(\frac{5}{12} - \frac{512}{675\pi^2} \right) \right]} \qquad (3)$$

From Eqs. (1) & (3), ne and Te are calculated with successive iterations.

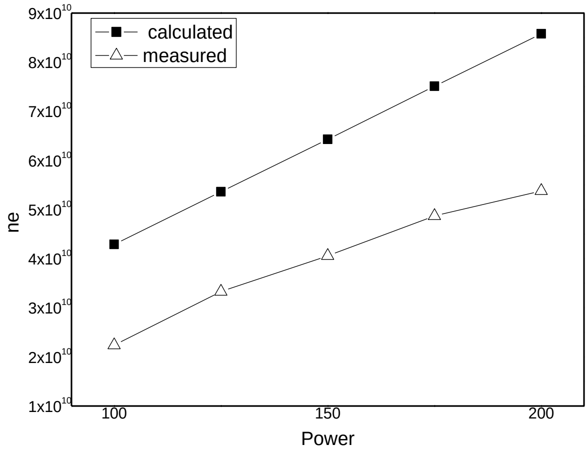

Fig. 6. Comparison of calculated and measured process parameters; ne vs. power.

In Fig. 6, calculation and measurement of ne according to various power are compared on the process condition that is 150mT.

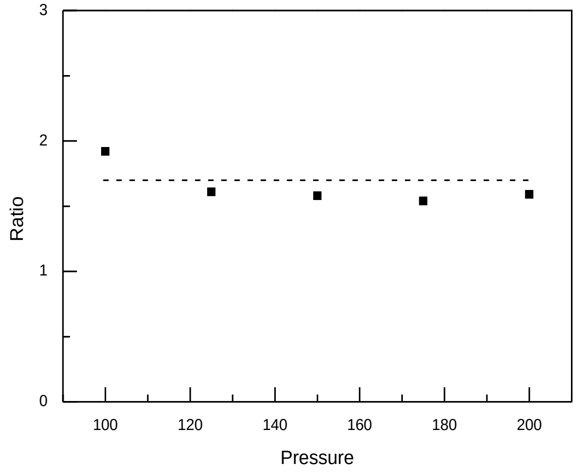

Fig. 7. Ratio of calculated and measured ne; ne(ca.)/ne(me.)

Ratio of calculated and measured ne is shown in Fig. 7 and it is nearly constant. It shows that there is some differences between calculation and measurement, which might be from the simple global model used in this calculation.

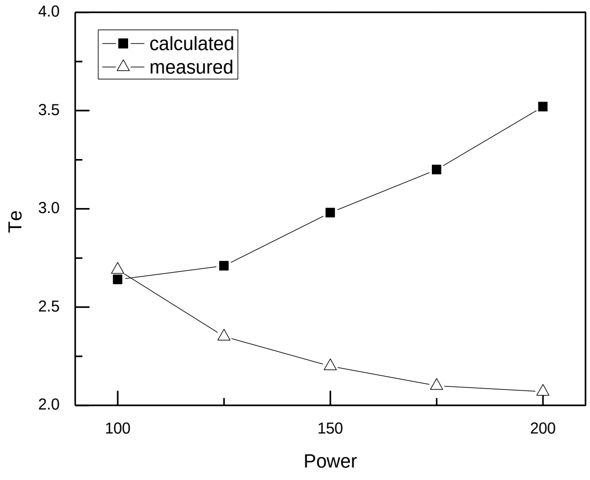

Fig. 8. Comparison of calculated and measured process parameters; Te vs. power.

In Fig. 8, calculation and measurement of Te according to various power are compared on the process condition that is 150mT.

As power is increased, calculated Te increased but measured Te decreased. Even though there is difference between the calculation and the measurement, Te is regarded as uniform according to various power condition because the differences are about 1eV.

4. Summary

In this work, interrelation and comparison among parameter data obtained from Langmuir probe and V-I probe are confirmed. Thus, Vpp, Ipp and phase that is simple monitoring parameter is interpreted as an important plasma parameter.

This interpretation will be developed considering additional monitoring parameters such as Vdc and Ipp with various sheath models.

5. Acknowledgments

This work was supported in part of a project for base construction of vacuum technology carried out at the Korean Research Institute of Standards and Science and by the "SystemIC2010" project of the Korea Ministry of Commerce, Industry and Energy.

6. References

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