§9. Characterization of High-pressure H_2 Plasma Produced by Microwaves

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1. Introduction

Hydrogen (H_2) plasma is widely used for scientific and industrial field. For instance, negative ion in H_2 plasma is used as a negative ion source for the NBI heating of fusion plasma. On the other hand, atomic hydrogen in silane and methane plasma with a large amount of hydrogen dilution plays an important role for the thin film growth of silicon and carbon, respectively. In these applications, there are strong requirements for understanding of the characteristics of H_2 plasma, especially under high gas pressure where the reactions between particles become more complicated.

In this study, we investigated the composition of positive ions (H^+, H_2^+, H_3^+) and evaluated negative ion (H^-) as a first step in understanding high-pressure H_2 plasma.

2. Experimental

60 MHz VHF plasma was used instead of 915 MHz plasma due to the malfunction of the power source. This alternation of the excitation frequency has little influence on the plasma characteristics due to gas-phase reactions. The temperature and density of electrons were measured by Langmuir probe. The composition and energy distribution of positive ions were measured by a quadrupole mass spectrometer (Q-mass, HIDEN EQP-500). For the estimation of negative ion, Langmuir probe was used again.

3. Results and discussion

Figure 1 shows the composition of positive ions as a function of gas pressure. As the pressure was increased, H_3^+ greatly increased above 50 mTorr, and reached more than about 98 % at 1 Torr. It is thought that the collisions between ions and neutrals became frequent and the following reactions were especially promoted judging from the reaction data [1].

$$H_2^+ + H_2 \rightarrow H_3^+ + H \qquad (1)$$

$$H^+ + 2H_2 \rightarrow H_3^+ + H_2 \qquad (2)$$

Figure 2 shows a result of Langmuir probe measurement. A steep and local increase in the probe current was found in the vicinity of 50 V. From the comparison with Ar plasma, it is considered that this increase is caused by a large amount of negative ions.

4. Conclusion

It was observed that most positive ion was H_3^+ and a large mount of negative ions H^- were generated.

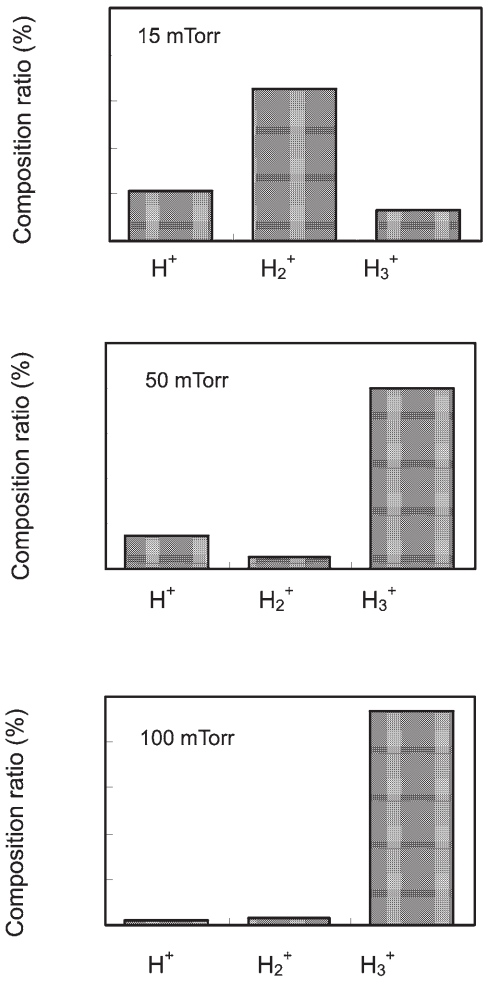

Fig. 1. Dependence of the composition of positive ions on the gas pressure.

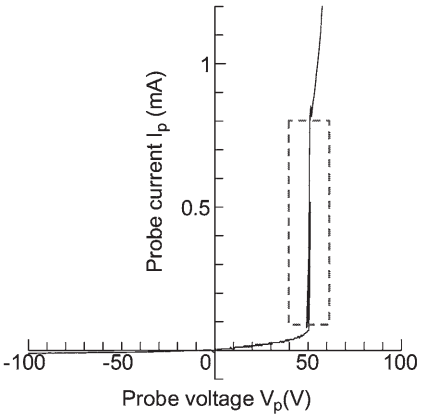

Fig. 2. I-V curve measured by Langmuir probe.

[1] Phelps, A. V., *J. Phys. Chem. Ref. Data*, **1990**, *19*, 653.