§10. Control of Ion Composition in H_2 ECR Plasmas

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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 selective production of ions and radicals in H_2 plasma.

In this study, we investigated ion composition (H^+, H_2^+, H_3^+, H^-) and their spatial distributions in H_2 ECR plasma by comparison between the experiments and a numerical simulation.

2. Experimental and simulation

All the experiments were performed using 915 MHz ECR plasma at a gas pressure of 10 mTorr, 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 negative ion, Langmuir probe was alternatively used due to some trouble of the Q-mass. On the other hand, the simulation was made using a fluid model [1] in which physical and chemical reactions in the H_2 plasma were fully considered.

3. Results and discussion

Figure 1 indicates the magnetic filed configurations. The A-type and B-type were used for the fundamental and the second harmonic ECR plasma, respectively. Figure 2 shows the composition ratio of the positive ions at the measuring position of z = 400 mm. H^+ was great majority in the both cases.

Next, we carried out the numerical simulation for the magnetic field configuration of B-type. As a result, the electron temperature was almost uniform (about 2 eV) and the electron density had a maximum value of 2×10^{17} m^{-3} around z = 300 mm. Figure 3 shows spatial distributions of the ion density. It was found that each ion has a specific profile. The difference seems to result from the difference of each mobility in the main. The negative ion density was about 3×10^{15} m^{-3} at z = 400 m. These results were almost consistent with the experimental ones.

4. Conclusion

It was found that the model presented here can considerably reproduce the plasma parameters around 10 mTorr. The investigation of ion composition of H_2 plasma in the higher pressure of Torr regime is future work.

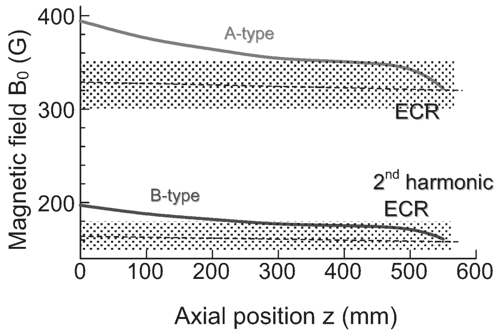

Fig. 1. The magnetic field configurations.

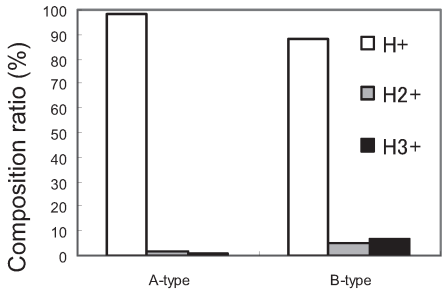

Fig. 2. The composition of positive ions.
(z = 400 mm)

(a)

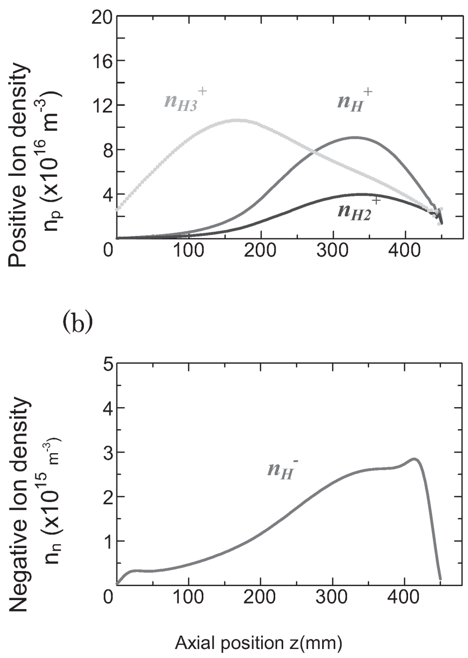

Fig. 3. Simulation results.

1) Muta, H., Tanaka, M. Y., Kawai, Y.,: Proc. of the ninth international symposium on sputtering and plasma processes, pp 503-506 (2007).