Influence of small additions of argon on properties of strongly non-uniform reduced pressure hydrogen microwave discharge

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Gas additions to the main plasma gas provide to change the plasma parameters and can be used for plasma diagnostics. These problems are practically unstudied for strongly non-uniform discharges. Electrode microwave discharge (EMD) is one of representatives of such discharges [1]. Earlier the EMD was studied in nitrogen with addition of argon and in nitrogen with addition of hydrogen [2, 3]. This paper presents the results of study of influence of small argon additions on the properties of hydrogen EMD on the base of experiments and 2D self-consistent modeling. Experimental conditions were: the total gas pressure 1 Torr, hydrogen flow rate (fH2) 50 sccm, ratios of argon flow rate fAr to fH2 were in the range fAr/fN2= 0-0.05, incident microwave power 90 W.

Experiments showed that addition of several percents of argon to hydrogen decreases the maximum values of emission intensities of hydrogen atom lines.

The 2D self-consistent model is based on the joint solution of the Maxwell equation, the Poisson equation, the Boltzmann equation and the balance equations for charged and neutral plasma particles. Results of modeling are in the qualitative agreement with results of experiments.

Analysis of calculated spatial distributions of ions (Н2+, Н3+, Ar+), distributions of DC field near the antenna, and the total ion flux to the antenna surface allows to determine the mechanism of influence of small argon addition on the parameters of hydrogen discharge. In spite of the fact that ion Ar+ took small part in the totalbalance of charged particles, the role of this ion is noticeable in the vicinity of the antenna. Additional, as compared with the discharge in pure hydrogen, ion changes the field of charge separation. The field is changed in such manner that the total ion flux to the antenna surface is decreased. As the electric field strength of the field maintaining the plasma (microwave field) is determined by the balance of charged particles, the decreasing of the ion flux to antenna causes the decreasing of the rate of its generation. Ionization is determined by the electron impact and thus depends on the microwave field strength. This is why the argon addition has to decrease the microwave field and intensities of hydrogen atom emission.

Results illustrate the role of discharge non-uniformity in discharge physics.

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References

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