PARAMETERS OF PLASMA OBTAINED IN THE HYBRID DISCHARGE WHICH IS A COMBINATION OF AN INDUCTIVE RF AND DC DISCHARGES

Alexandrov A.F., Vavilin K.V., Zadiriev I.I., Kralkina E.A., Nekludova P.A., NikonovA.M.

Lomonosov Moscow State University, Moscow, Russia, [nekludova\_pa@mail.ru](mailto:nekludova_pa@mail.ru)

Investigation of hybrid discharge, based on the combination of the inductive RF discharge (RF IC) with external magnetic field and the direct current discharge (DC) is presented in this work. The main attention is devoted to the studying of the mutual influence of these two discharge channels.

The discharge was ignited in a cylindrical plasma source (PS) with diameter 20 cm and length 32 cm. There was a solenoidal antenna on the lateral surface of PS for organization of inductive RF discharge. Two electrodes located at the edges of cylindrical plasma source formed the direct current channel (DC). The cathode (lower edge of plasma source) had negative potential VDC regarding the grounded top electrode. The voltage values were varied between 0 and 800 V. The experiments were carried out in argon and pure air in the pressure range of 0.1–40 mTorr and 60‑200 mTorr, respectively; at the values of the external magnetic fields 0–60 Gs. The RF power was varied at 20–800 W.

The RF inductive discharge can exist in two regions. The first region of low pressures, where ν < ω, and power absorption mechanism is collisionless. The second region where ν > ω, and the absorption mechanism is collisional. Here ν and ω are the collision frequency between electrons and heavy particles and the driving frequency.

Experiments have shown that if ν < ω and VDC is set to 100 W the power PDC coupled through DC channel changes proportional to the power coupled through the inductive channel Ppl, However the absolute values PDC are negligible compared with the values Ppl coupled through inductive channel. The amplitudes of RF magnetic fields increase, however the structure of exited waves is the same. The plasma potential decreases compared with pure inductive discharge, where in the main plasma volume there is equal potential distribution within the error.

In the execution of condition ν>ω and presence DC channel the discharge transition from E- to H-mode is shifted to the area of lower values of RF power. The more power is coupled to the discharge through the DC the greater the shift. The values of ion saturation current in hybrid discharge exceed sufficiently the values observed in pure inductive discharge, if the RF power of generator is less then Р\*,which corresponds to the transfer between E- and H-mode. Moreover, the ion saturation current values are higher than the values, which are the sum of independent RF IC and DC. This is due to the increase in the fraction of power coupled to the discharge through the inductive discharge. The values of ion current in hybrid discharge are less or equal than values in inductive discharge at the pressure higher than Р\*. The axial distribution of ion saturation current becomes similar to the pure inductive discharge. If the electron mean free path is less than the distance between the antenna and the electrode, discharge parameters are determined by inductive channel in the antenna region, and by direct current discharge in the cathode region.