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Experimental and theoretical study of radial profiles of the Ar metastable atom density in diffuse and constricted dc discharges

G. Grigorian[1], N. Dyatko[2], I. Kochetov[2]

[1]*St. Petersburg State University, St. Petersburg 199034, Russia*
[2]*Troitsk Institute for Innovation and Fusion Research, Pushkovykh Str. 12, 108840 Troitsk, Moscow, Russia*

In the present work the radial profiles of the number density of metastable Ar($1s_5$) atoms in a dc glow discharge in argon at intermediate gas pressures were studied both experimentally and theoretically under the following conditions: discharge tube radius R_{tube} = 2.0 cm, gas pressure P = 40 Torr – 100 Torr, discharge current I = 10 mA – 50 mA. For gas pressures under study a step-wise transition from diffuse to constricted form of discharge was observed after the discharge current had exceeded some critical value. Radial profiles were measured and calculated in diffuse as well as constricted discharges. Measurements were performed using optical absorption technic, and in calculations the self-consistent 1D axial-symmetric discharge model was used. Results of calculations were in a reasonable agreement with the experimental data.

It is known that at intermediate gas pressures the increase in the discharge current leads to the constriction of the positive column of the diffuse glow discharge. In most cases it looks like step-wise transition after the discharge current exceeds some critical value, herewith the transition is accompanied by the noticeable decrease in the electric field strength E in the positive column. The constricted positive column looks like a narrow bright cord at the discharge tube axis.

In the present work the radial profiles of the number density of Ar($1s_5$) metastable atoms were measured and calculated in the diffuse discharge as well as in the constricted discharge. Measurements were performed using optical absorption technic, experimental setup and procedure were nearly the same as in [1]. In calculations the self-consistent 1D axial-symmetric discharge model was used [2].

The measured $E(I)$ dependences and the calculated ones in argon discharge at P = 60 Torr are shown in fig. 1. One can see that, in this case, the measured critical current value for the step-wise transition from diffuse to constricted discharges is about 37 mA. The calculated $E(I)$ curve agrees rather well with the measured one.

In fig. 2 there are normalized radial profiles of the number density of Ar($1s_5$) metastable atoms. These profiles were measured and calculated in diffuse (I = 20 mA) and constricted (I = 50 mA) discharges. As one should expect, the profile of metastable atoms in the constricted discharge is essentially narrower than that in the diffuse discharge. The number densities of Ar($1s_5$) atoms measured at the tube axis are 8.53×10^{10} cm^{-3} (I = 20 mA) and 6.1×10^{11} cm^{-3} (I = 50 mA).

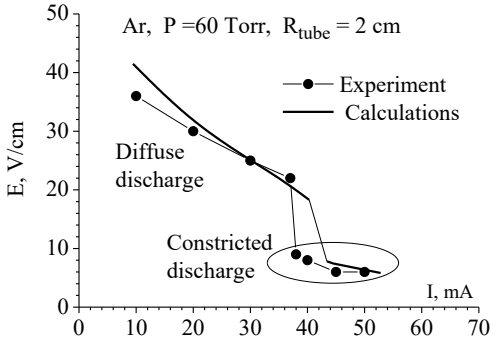

Fig. 1. Measured and calculated values of the electric field strength in the positive column.

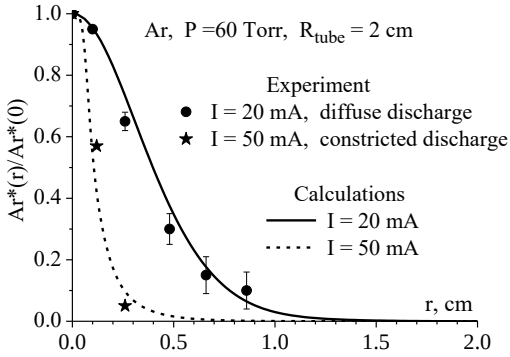

Fig. 2. Measured and calculated normalized radial profiles of Ar($1s_5$) metastable atoms.

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References

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