Estimation of the electric field STRENGTH IN the pre-breakedown wave in long discharge tube at low gas pressures

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In paper [1] it was proposed to use relative intensities of emission of the excited species with essentially different excitation energies to get information on the mean electron energy and electric field strength in discharge. In that work, pulse corona discharge in air was studied and N2 second positive and N2+ first negative bands were used. In paper [2] the similar approach was used for obtaining data on the electric field strength in nanosecond high-voltage pulsed discharge in the form of the fast ionization wave (IW) in air and nitrogen.

In present work, the value of the electric field strength in the slow (pre-breakdown) IW in Ar:Ne and Ar:Hg mixtures was estimated. In the first case it was done by comparison of the measured and the calculated ratio of the intensities of Ar (2p6 – 1s5) and Ne(2p9 -1s5) emission lines. In the case of Ar:Hg mixture the measured and the calculated ratios of the intensities of Ar (2p6 – 1s5) and Ar+ (4p2D5/2 - 4s2P3/2) transitions were compared.

 Experiments with Ar:Ne mixture (25%Ar+75%Ne, gas pressure 1 Torr) were performed in discharge tube with 15 mm of diameter and a distance between electrodes of 80 cm. Experiments with Ar:Hg mixture were performed with the Philips TUV-30W bactericidal lamp with 25 mm of diameter and a distance between electrodes of 80 cm. The tube was filled with argon at a pressure of 3 Torr and mercury vapour at a pressure of 1 mTorr (gas temperature was about 20° С).

The amplitude of (positive) voltage pulses was varied within 1 - 2 kV, the voltage rise time did not exceed 1.5 μs. The diagnostic system allowed one to record the time evolution of the radiation intensity at arbitrary points along the tube axis. The time resolution in optical measurements was less than 10 ns, the axial resolution was 2.7 mm. This system was used to detect the IW and measure its velocity. The spectrum of discharge radiation could also be recorded

The simplest estimate of the electric field strength in the IW can be performed under assumption that the ratio of line intensities is equal to the ratio (*k*1×*A*1×τ1)/(*k*2×*A*2×τ2), where *k*1 and *k*2 are the rate constants for the excitation of the radiating states by electron impact, τ1 and τ2 are the lifetimes of these states, *A*1 and *A*2 are the probabilities of the considered transitions. To do such an estimate we calculated rate constants for the excitation of Ar(2p6), Ar+(4p2D5/2) and Ne(2p9) states by solving electron Boltzmann equation for mentioned above gas mixtures. Calculations were performed in a wide range of the reduced electric field values (*E/N*, *E* is the electric field strength, *N* is the gas number density). Data on lifetimes and transition probabilities were taken from [3].

Comparison of the measured and calculated ratios of line shows that in Ar:Hg gas mixture *E/N* value in the IW decreases with distance from ~ 550 Td (near the anode) to ~ 270 Td (near the cathode). In the case of Ar:Ne gas mixture the *E/N* value in the IW appeared to be about 100 Td.

A more accurate estimate can be obtained if we take into account the probable shape of the spatial profile of the electric field in the IW and the motion of the IW relative to the point at which emission spectrum is recorded.

References

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