CATHODE-DIRECTED STREAMER HEAD FINE STRUCTURE

M. M. Nudnova, A. V. Krasnochub, A. Yu. Starikovskii

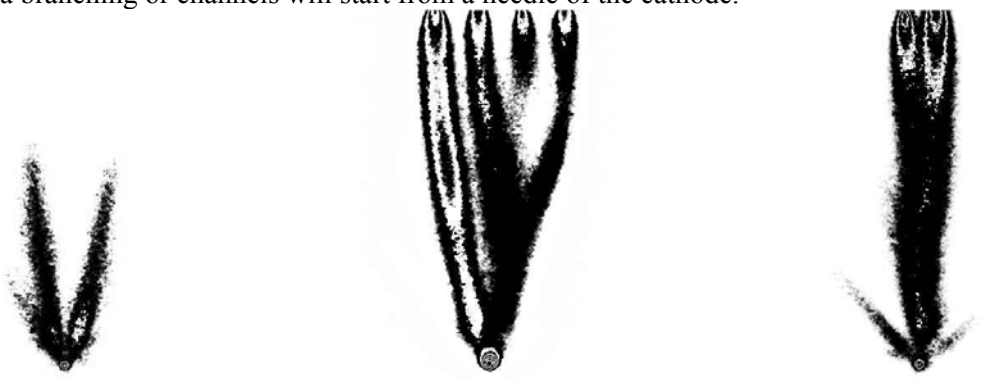
Physics of Nonequilibrium Systems Laboratory, Moscow Institute of Physics and Technology, 9 Institutskii lane, Dolgoprudny 141700, Russia

Abstract

In this paper the experimental results of research of a branching streamer discharge in an mixture (N_2:O_2 4:1) both cathode-direct and anode-direct streamer in plane – plane gap at 26 – 42 kV and pressure 300 - 1200 torr are shown. The experimental data are compared with the results of numerical modeling in the 2D hydrodynamics approximation. The method of measuring the electro-dynamical diameter of the streamer's head is offered. Streamer's head fine structure was restored using emission at 337.1 nm (N_2 second positive 0-0 transition).

Results

Images of a streamer discharge were obtained at electrode voltages of 26÷48 kV and pressures of 300÷1200 torr for both polarities. For the specified voltages in the range of pressures 300÷740 torr 200 photos of anode-direct streamer, typical Fig. 1, were analyzed.. In pictures it is visible that the single streamer channel or some channels starting from an initiating needle can be observed. From 200 images of the anode-direct streamer we received, only in one picture (fig 1b), was obtained the image which can be interpreted as a branching anode-direct streamer, thus in our opinion the indeterminacy is maintained: there was a branching or channels will start from a needle of the cathode.



a) 30 kV b) 36 kV c) 42 kV

Fig.1. Images of the anode-direct streamer in a integral mode at pressure of 740 torr

Thus, for more detailed studying of the mechanisms leading to branching of streamer, it is necessary to synchronize the moment of starting of a streamer, with the beginning of shooting of its spreading and with the moment of recording of a current and the voltage enclosed to a discharge gap. To start with we have investigated the spreading of a streamer in the stroboscopic mode, without synchronization with a current of a streamer.

Velocities of cathode-direct streamer were measured in a wide range of pressures and voltages. Velocity was determined as the ratio of a distance between the positions of the streamer's head to the time with an interval between the exposures. The distance between the positions of the streamer's head was determined by the maximum or minimum of the intensity of a side view of radiation. In article [1] we supposed the accumulation time of the active particles happens exclusively on the head of a streamer. In a spectrum of radiation N_2-O_2 at the influence of nanosecond discharge in a visual range the basic contribution imports radiation of the second positive system of nitrogen in transition $N_2(C^3\Pi_u \rightarrow B^3\Pi_g)$.

Observationally filed radiation with the ICCD camera is proportional to the concentration of emissive transition $N_2(C^3\Pi_u)$ (Fig. 2). In Fig. 3 is shown the instantaneous image of the concentration of excited states $N_2(C^3\Pi_u)$ for the pressure P=740 torr U=30 kV obtained by means of the numerical model [2].

Whereas the concentration of the fissile particles is proportional to the quantity of a field on the streamer's head, the diameter of the streamer's head is determined on a location of maxima of radiation.

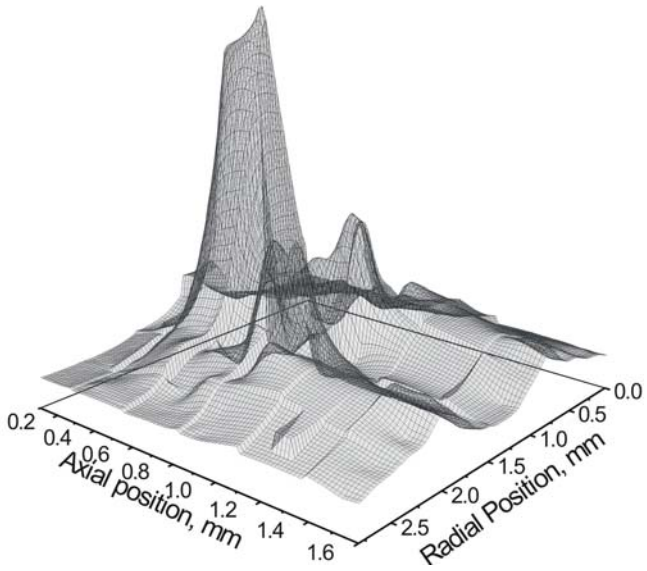


Fig. 2. A picture of radiation of the streamer's head, restored on lateral views of radiation in different sections of the streamer's head. P=740 torr U=30 kV

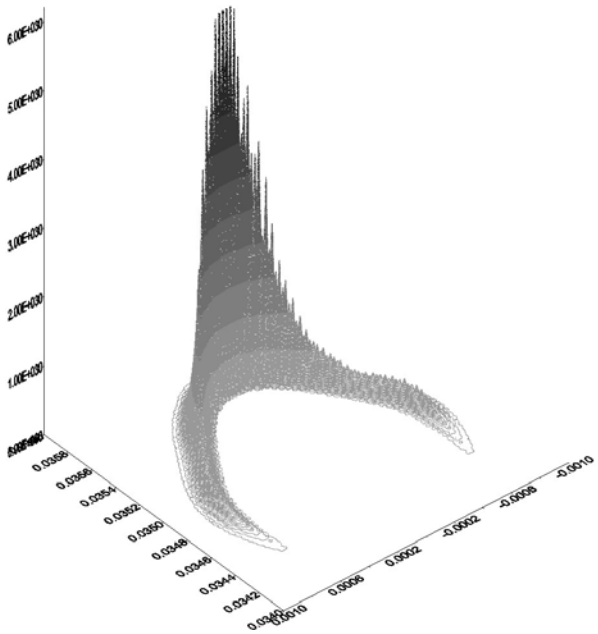


Fig. 3. The instantaneous image of concentration of excited states $N_2(C^3\Pi_u)$ for pressure P=740 torr U=30 kV, constructed by means of numerical model [2]

Conclusions

In this work the data on branching of a streamer are obtained at electrode voltages of 26÷42 kV and pressures 300÷1200 torr for both polarities. It is shown that the anode-direct streamer does not branch. Comparison of the experimental values of the velocity distribution, the diameter of a streamer is found from the results of numerical modeling [2]. .It is shown that the numerical model may predict the velocity (radius, diameter) of a streamer in a wide range of pressures and voltages.

Profiles of radiation of the streamer's head obtained in the stroboscopic mode of operation of the high-speed camera prove the guess that in basic points the operating time of the active particles occurs on a surface to the streamer's head. Also it is shown that the numerical model offered before also allows predicting truly the structure of the streamer's head.

Acknowledgments

The work is supported in part by grants of Netherlands Organization for Scientific Research/RFBR "Pulsed Corona Discharges for Plasma Chemical Treatment of Gases" (03SRF08), and EOARD/CRDF "Plasma Assisted Combustion" Project (PR0-1349-MO-02).

References

[1] Pancheshnyi S.V., Sobakin S.V., Starikovskaya S.M., Starikovskii A.Yu. Discharge Dynamics and the Production of Active Particles in a Cathode-Directed Streamer. Plasma Physics Reports, 2000. V.26. N.12. P.1054.

[2] Pancheshnyi S.V. and Starikovskii A.Yu. Two-Dimensional Numerical Modeling of the Cathode-Directed Streamer Development in a Long Gap at High Voltage. Journal Physics D: Applied Physics, 2003. V. 36. pp.2683-2691.