DERIVATION OF GOVERNING EQUATIONS OF GAS DISCHARGE PROCESSES IN GAS FLOWS

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Research of glow discharge structure is carried out already about hundred years. The huge experimental material is stored, the great many of the physical-technical and laser devices realizing unique properties of glow discharges are created, theoretical models of discharges are developed. However last years interest to study of glow discharge properties has increased again, already in connection with projects of creation of the hypersonic aircraft, flying at heights 30–40 km, i.e. at air pressures with values about several Torr. It is supposed, that use of electric discharges will allow to operate a stream of rarefied air near to structural components of aircraft and will raise effectiveness of internal processes in ramjet engines.

1. Introduction. Fundamentals of physics of glow discharge. The Engel – Steenbeck theory of cathode layer

The classical glow discharge is characterized by the following parameters:

- Total current through discharge $I \sim 10^{-3} \div 10^{-2}$ A;
- Voltage drop on discharge gap $V \sim 200 \div 5000$ V.

Figure 1 gives the representation of glow discharge place among other types of discharges between two electrodes. The typical values of Voltage and current on gas-discharge gap of classical glow discharge are shown on axes of the figure.

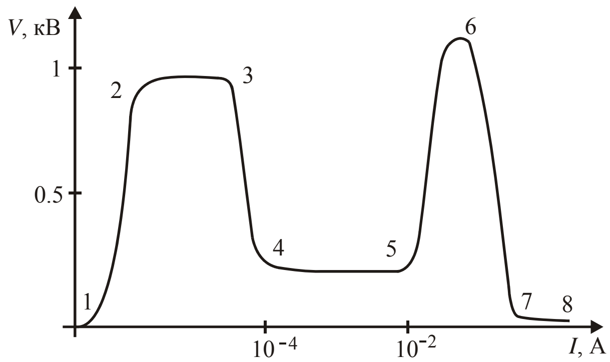

Fig. 1. The diagrammatic representation of Voltage-current characteristic of electric discharges (boundary values of Voltages and currents are approximate): 1-2 – area of non-self-maintained discharge; 2-3 – dark the Townsend discharge; 4-5 – normal glow discharge; 5-6 – anomalous glow discharge; 6-7 – area of transition from glow to arc discharge; 7-8 – arc discharge

The majority of works on experimental and theoretical study of glow discharge has considered the pressure range of $p \sim 1 \div 5$ Torr. However this type of discharge is used commonly enough at raised pressure though in these cases glow discharges are rather unstable (Raizer Yu.P., 1991).

Notwithstanding that the given type of discharges is widely applied in physical devices of various sorts, also in light sources, generators of plasma and in electric discharge optical quantum oscillators (lasers), it is necessary to recognize, that the design-theoretical description of glow discharges is developed in an insufficient degree. First of all it is explained with complicated structure of glow discharge and real lack of the uniform design models allowing to describe all elements of glow discharge structure.

Basic elements of structure of classical normal glow discharge in a gas-discharge tube are shown on fig. 2.

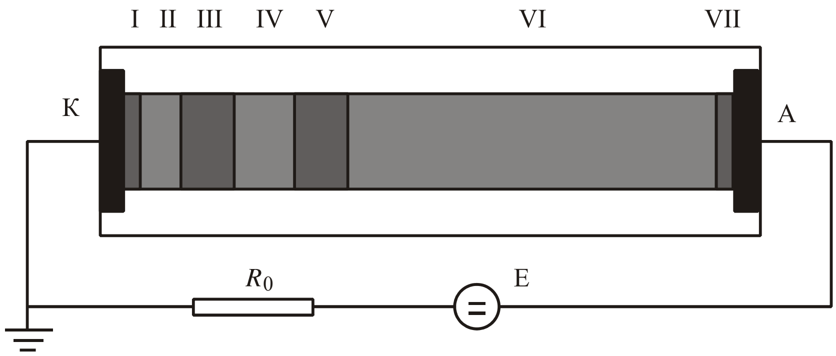

Fig. 2. The scheme and structure of classical glow discharge: I – Aston dark space; II – Cathode luminescence; III – Cathode dark space; IV – Negative luminescence; V – Faraday dark space; VI – Positive column; VII – Anode dark space; K – Cathode; A – Anode; R_0 – Ohmic resistance of external circuit; E – Voltage of power supply

Alternation of relatively light and dark areas on the scheme of discharge corresponds to real alternation of gas luminescence areas in discharge. However, as a rule, areas I – V adjoin the cathode more close.

Typical distribution of electric field strength E and volumetric density of charge $\rho = e(n_i - n_e)$ are shown on fig. 3.

The basic physical processes ensuring existence of glow discharge, are secondary ion-electronic emission of electrons from the cathode, electron acceleration in an electric field and their collisions with neutral discharge particles, which quantity is always by several digits