VOLT-AMPERE CHARACTERISTICS OF THE PARTIALLY CONstricted GLOW DISCHARGE IN Ar:N$_2$ MIXTURES

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It is known that at intermediate gas pressures the increase of the discharge current leads to the constriction of the positive column of the diffuse glow discharge and formation of the bright filament. In some cases the visible diameter of the positive column diminishes gradually with current increase, but in most cases it looks like step-wise transition after the discharge current $I$ exceeds some critical value. The critical discharge current for the constriction is usually higher than that for the reverse transition, i.e. the hysteresis effect takes place. It was shown in [1-3] that in some cases the so-called steady-state partially constricted glow discharge can be realized, in which diffuse and constricted forms of the positive column coexist in the same discharge tube. In present paper the procedure for the obtaining of the steady-state partially constricted glow discharge is described and the measured Volt-Ampere characteristic (VAC) of this form of discharge is presented.

The discharge was maintained in cylindrical molybdenum glass tube, 2.8 cm i.d., the distance between cylindrical tantalum electrodes was about 75 cm. Gas mixture was pumped through the set of liquid-nitrogen cooled traps and then through the discharge tube at a flow rate of $\sim 100$ sccm (residence time in the discharge $\sim 1$ min). A 10 kV DC power supply could maintain discharge current up to $I \approx 100$ mA. The discharge current could be changed by varying the power supply voltage $V_s$ or changing ballast resistance $R_b$.

Fig. 1(a) shows VACs of the discharge in Ar (99.998% purity) and in Ar:N$_2$ mixtures with a small addition of N$_2$ measured at pressure $P = 40$ Torr. It follows from this figure that for all gas mixtures under consideration the pronounced step-wise constriction as well as hysteresis effect takes place, the higher is the N$_2$ percentage the higher is the critical current value. Let us also note that the addition of nitrogen to argon leads to the noticeable decrease of the voltage drop across electrodes ($U$) at low currents when discharge operates in diffuse form. It means that the ionization mechanism in Ar:N$_2$ mixtures with a small addition of N$_2$ differs from that in pure argon.

According to our observations, the constriction of the positive column in Ar:N$_2$ mixtures (after the discharge current exceeded critical value) arose near one of the electrodes and the boundary between constricted and diffuse parts moved to the other electrode. The reverse transition occurred in a similar manner. It was found that the time of the transition from diffuse to constricted discharge as well as the time of the reverse transition can be as long as $\approx 1$ s. If the value of $V_s$ and $R_b$ is not changed during transition, then the corresponding part of VAC is a straight line (load characteristic) $U = V_s - IR_b$, see lines AB and CD in Fig. 1(b).
It appeared that the velocity of the motion of the boundary between diffuse and constricted parts of the positive column can be decreased down to 0 by variation of $V_s$ (or $R_b$) during transition. In this case the boundary is stopped at some intermediate point between electrodes, i.e. steady-state partially constricted form of discharge is realised. Such a form can exist for a long time if there is no further variation of $V_s$ (or $R_b$).

![Graph](image)

**Fig. 1 (a).** VACs of the discharge in Ar and Ar:N$_2$ mixtures ($P = 40$ Torr).

(b). VAC of the discharge in Ar + 0.02% N$_2$ mixture ($P = 42$ Torr, $R_b = 157$ k$\Omega$). DABC is the hysteresis loop measured without variation of the external electric circuit parameters during transition from diffuse to constricted (AB) and from constricted to diffuse (CD) forms of discharge. CEF is the VAC obtained by increasing of the power source voltage $V_s$ during transition from constricted to diffuse discharge. Point E corresponds to the steady state partially constricted glow discharge.

The VAC measured in the case of the variation (increasing) of $V_s$ value during transition from constricted (point C) to diffuse (point D) form of discharge is shown in Fig. 1(b) (curve CEF). In point E the velocity of boundary became equal to 0, i.e. this point corresponds to the steady-state partially constricted discharge. The further increase of $V_s$ leaded to the backward motion of boundary and positive column returned to constricted form (point F).

It follows from our studies that the transition time in pure Ar is 1.5-2 orders of magnitude shorter than that in Ar:N$_2$ mixtures with small percentage of N$_2$. For this reason the formation of steady-state partially constricted discharge in Ar is rather difficult problem.

To understand the reasons for the observed difference between Ar and Ar:N$_2$ discharge parameters additional experimental and theoretical studies are needed. Recently we have developed discharge model for pure Ar [4], and at present we are developing discharge model for Ar:N$_2$ mixtures with small percentage of N$_2$. According to estimations, in such a mixture at intermediate gas pressures a very high degree of vibrational excitation of nitrogen molecules is expected. Results of modeling and newest experimental data will be presented in the report.

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**References**


