Extraction of neutral particles from a gas discharge

A A Rykov, M I Yurchenkov, A A Lisenkov

Department of electronic instruments and devices, Saint Petersburg Electrotechnical University “LETI”, 197376, Saint Petersburg, Russia

E-mail: rikov247@gmail.com

Abstract. In this paper a version of the extraction of neutral particles from a gas discharge using a gas-distributing disk is proposed, which allows creating a pressure drop between the source volume and the working zone of the vacuum chamber. The gas distributor ensures a uniform supply of gas to the ionization zone and resonant charge exchange, which will make it possible to achieve uniform combustion of the discharge in the entire volume of the source. Also the gas distributor allows to increase the speed of gas flow, due to pressure drop. An increase in the rate of gas flow in the volume of the source makes it possible to increase the number of ionization events per unit of time. Consequently, it makes it possible to increase the number of ions generated in the gas discharge, that is, the ionization coefficient of the working gas increases. In turn, an increase in the number of ions generated in the discharge leads to an increase in the number of neutral atoms in the output beam.

1. The first section in your paper

The main task in the application of coatings on dielectric surfaces with the use of ion-plasma technological systems is the preliminary preparation of this surface [1-3]. For this purpose, to optimize the process of removing residual gases and activating the surface, a preheating technological operation is used before the coating is deposited. Then ion-plasma cleaning of dielectric substrates on the basis of a controlled gas-discharge source of fast neutral particles is used for final cleaning [4].

If there is a working gas in the source volume and a negative voltage on the main cathode (Udiss), a gas discharge is ignited, occupying the internal volume of the source. In the gas discharge, ions are generated, accelerated by the cathode voltage drop. Neutralization of charged particles occurs mainly in the reflection of ions from the main cathode. As a result of neutralization, an accelerated directed flux of neutral particles is formed.

To maintain the pressure difference between the input volume (1) and the gas source of the neutral particles (2), a gas distribution disk (4) was used (1 mm thick with different, radially located openings with a diameter of 1-2 mm). The total gas conductivity of the holes is an order of magnitude less than the conductivity of the inlet channel. The gas distributor allows to increase the gas flow rate by providing a pressure difference between the volume of the source (2) and the working volume (3) of the vacuum post (neutralizer 5 - dielectric 6). The distribution of the pressure of the working gas in the transportation area (3) decreases (figure 1).
To obtain the maximum ionization coefficient, the maximum pressure in the volume of the gas-discharge source was provided (\(pd = 10\)). On the other hand, for transporting neutral particle beams, the pressure in the working chamber must be minimal in order to minimize the probability of a collision between the flow of fast neutral particles and the atoms of the residual gas.

If the vacuum chamber is continuously evacuated and the gas is allowed to flow into the source, it is possible to create a pressure difference (\(p_1 - p_3\)) between the source volume and the vacuum chamber.

In the course of the source study, the dependences of the pressure difference between the vacuum chamber and the source volume were obtained using two different gas-distribution disk samples. The obtained dependences are shown in Figure 2.

Thus, the use of the gas distribution disk allows creating a pressure difference between the source volume and the working area of the vacuum chamber: the pressure in the source is 3.5 times higher than the pressure in the vacuum chamber.

The difference in pressures in the gas supply zone \(p_1\) and the transport zone for the neutral particle fluxes \(p_3\) can differ very significantly, with \(p_1 > p_3\). The pressure in the ionization and resonance charge-exchange region \(p_2\) changes linearly in the first approximation, and the average

Figure 1. Diagram of variation of working gas pressure (p): 1 - area of argon supply to the volume of gas discharge source, limited by anode and distribution disk 4; 2 - gas discharge region; 5 - cathode with neutralization channels oriented at angle \(\alpha\); 3 - flow transport area neutral particles outside the source volume from the neutralizer 5 to the workpiece 6; \(S_0\) - vacuum pumping out

Figure 2. Pressure in the volume of the source from the pressure in the vacuum chamber
pressure value is calculated by the formula \( \overline{p_2} = 0.5 \cdot (p_3 + p_4) \). As already mentioned, the working gas supply zone is limited by a gas distribution element, which is a plate with a plurality of radial holes. The total gas conductivity of the holes is an order of magnitude smaller than the conductivity of the inlet openings. The gas distributor ensures a uniform supply of gas to the ionization zone and resonant charge exchange, which will make it possible to achieve uniform combustion of the discharge in the entire volume of the source. Also the gas distributor allows to increase the speed of gas flow, due to pressure drop \( p_1 \) and \( p_3 \).  

An increase in the rate of gas flow in the volume of the source makes it possible to increase the number of ionization events per unit time, and consequently, it makes it possible to increase the number of ions generated in the gas discharge, that is, the ionization coefficient of the working gas increases. In turn, an increase in the number of ions generated in the discharge ultimately leads to an increase in the number of neutral atoms in the output beam.

References

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