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# Plasma Deionization Features in Gas Discharge Device

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**Abstract**—Results of plasma excess conductivity investigations of gas discharge device under conditions of plasma decay have been presented. This case involves the need of taking into account the recombination of charged particles both on the device electrodes and in its volume. It was established that the volume recombination of charged particles at the stage of plasma excess conductivity materially affects the duration of plasma excess conductivity and modifies the pattern of its decay.

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## 1. INTRODUCTION

Plasma deionization in gas discharge devices (GDD) is an important process because it determines the working frequency range of device and its application field. The real gas discharge devices (high-power switches) are divided into two classes: devices with glowing cathode and low-pressure gas where during the calculation of deionization processes it is possible to neglect the volume recombination (thyratrons), and devices with cold electrodes and high-pressure gas where the volume recombination cannot be neglected (pseudo-arresters, arresters). That is why each class of such devices has its own peculiarities of deionization.

GDD with low-pressure gas nowadays are widely used as switches for all types of metal vapor lasers and also the excimer and chemical lasers. Since lasers generate nanosecond pulses, only gas discharge devices (thyratrons and tacitrons) with small time of deionization can ensure their operation [1]. In addition, radars for short-range detection make use of thyratrons that generate ultrashort pulses, the frequency of which depends on the time of deionization of the filler gas: the less is deionization time, the higher is the frequency.

The issue of deionization has been especially acute in recent years also for devices and appliances with high-pressure gas medium, such as flip-flop (toggle) arresters, lightning arresters and limiters, high-voltage switches (oil and elegas). Such devices are used for emergency cutoffs at nuclear power stations, in cases of phase mismatch, load mismatch, short circuits, etc., where the speed of circuit-breaker opening is determined by the rate of gas medium deionization. These devices are filled with gas medium at high pressure. For example, high-power switch produced by Mitsubishi Company with rated voltage of 30 kV and rated current of 275 A is filled with elegas at pressure 1.5 Pa. The mass of gas contained in this switch amounts to 25 kg [2]. That is why deionization of such devices is characterized by specific peculiarities.

A system with cold electrodes is considered in classical studies on deionization [3, 4], where the effect of bulk recombination of particles during the deionization process is neglected. In other papers [5, 6] the investigation of decay of excess plasma takes is performed by taking into account only the effect of ambipolar diffusion of charged particles on electrodes with subsequent recombination at these electrodes. Let us consider the run of these processes in different devices.

## 2. PHYSICAL BACKGROUND OF OCCURRENCE OF EXCESS CONDUCTIVITY

Deionization of the interelectrode gap occurs during the pause time between current pulses passing through the device with glowing cathode, when the cathode continues to emit electrons. In this case, the so-called excess (high) conductivity of plasma is created in the interelectrode space. The existence of excess conductivity of discharge gap for a long time during the deionization period is possible when the following conditions are satisfied:

– current that can be obtained from plasma is much more than the current tapped into external circuit;
– glowing cathode operates in the saturation (space-charge) mode;
– voltage source is connected with positive polarity in relation to cathode.