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Investigation of the Gas-Discharge Gap in Ionization Chambers by Probe Method

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Annotation: The article presents the results of studying the current-voltage characteristics of an ionization-type semiconductor photographic system by inserting a metal probe into the region of a gas discharge without disturbing its nature.

Keywords: gas discharge, gas discharge cell, photodetector, current-voltage characteristic, metallicoi probe, Townsend ionization coefficient.

Introduction.

Semiconductor photographic systems and spectral image converters of the ionization type [1-4] have found a fairly wide application for high-speed spatiotemporal photographic diagnostics of laser infrared radiation [5]. Currently, they are one of the most promising types of devices that form the basis of non-silver high-sensitivity photography [6].

Such issues as stabilization of various gas discharge devices, [7] conversion of infrared radiation into visible radiation, image transmission and silver-free photographing [8], etc.are solved using gas-discharge cells with a high-resistance semiconductor electrode. These cells use a narrow gas-discharge gap with a flat metal electrode and a plate made of a high-resistance and photosensitive semiconductor. In such a system, a semiconductor comes into contact with the gas discharge plasma. The presence of this contact significantly affects the properties of a gas discharge and radically distinguishes it from classical obstructed and barrier discharges. There is no unambiguous opinion about the mechanism of stabilization of a discharge with a semiconductor electrode and the physical interpretation of the processes in such a gas-discharge cell. However, the physical processes occurring in the contact between the semiconductor and the plasma play a decisive role in the formation of the discharge.

In [9], the first derivatives of the current-voltage characteristic of a semiconductor probe placed in a neon gas-discharge plasma were measured. Under the influence of external radiation, the derived characteristics are shifted towards the electronic part. The displacement value is interpreted as the depth of penetration of the electric field into the semiconductor. Based on the dependence of the displacement potential of the maximum of the first derivative of the characteristic on the gas pressure at the same illumination, an interpretation of the displacement of the characteristics is given.

In [10], the current-voltage characteristics of a flat semiconductor probe placed in a helium gas-discharge plasma were measured. The effect of post-root radiation on the probe response is studied. It is found that under the action of radiation, the value of the probe current increases strongly, and the floating potential shifts towards the electronic part of the characteristic. The displacement value is interpreted as the depth of field penetration into the semiconductor. The first derivatives of the current-voltage characteristics of the semiconductor probe are also measured. Under the influence of external radiation, the derivatives of the characteristics also shift.

[1] Fergana branch of TATU named after Muhammad al-Khorazmi, assistant
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The purpose of this paper is to verify the correctness of this assumption, i.e., to study the potential distribution in the system elements and to study the current-voltage characteristics of the gas-discharge gap by probe measurements.

2. Experiment.

A schematic diagram of the semiconductor ionization photographic system is shown in Fig.. The photosensitive photodetector (2) is a semi-insulating gallium arsenide, on one of the surfaces of which a translucent nickel contact (1) is filed. The inner surface of the plate is separated from the surface of the recording layer (4) by a gas gap (3). The recording layer (4) is located on a transparent conducting counter-electrode (5), made, for example, of glass a plate covered with a conductive film . When a voltage is connected to the system, a gas discharge breakdown occurs, characterized in that there is a distributed semiconductor resistance in the discharge cell, which contributes to damping current instabilities. The resistance of a semiconductor completely determines the value of the current density over the cross-sectional area, and when the semiconductor is illuminated, it can control the value and distribution of current in the gas gap.

The main elements of ionization-type semiconductor photographic systems are (Fig. 1,a) a semiconductor photodetector (FP), a gas-discharge cell, and a recording medium. In these systems, three types of amplification are implemented: 1) photoelementctelectrical amplification when converting a photon flux into a photocurrent of a semiconductor photodetector; 2) plasma amplification of the photocurrent by power in a gas-discharge gap; 3) chemicaloptical gain in the recording medium exposed to the exposure to gas-discharge plasma.

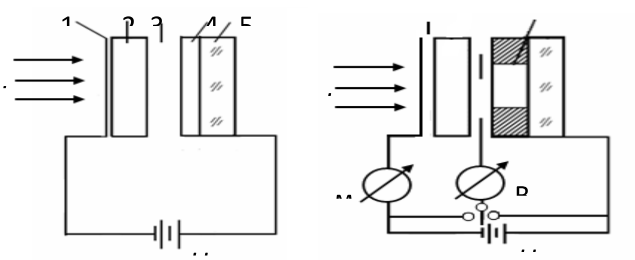

Рис.1. Схема ионизационной системы.1-прозрачный электрод, 2-полупровод- никовый фотоприемник, 3-

The selection of the optimal mode and good coordination of these elements among themselves is the main factor in increasing the sensitivity of the system as a whole. Until now, based on ToIt was assumed that the current-voltage characteristics of the photodetector and the system coincide at $U \geq U_{pr}$. This meant that the current-voltage characteristic of the gas discharge is strictly vertical, the differential resistance of the discharge gap is zero with high accuracy, and no voltage redistribution occurs in the system even in high light conditions. A ring-shaped nickel contact (hereinafter referred to as the probe) with an internal diameter of 11.5 mm was deposited on the surface of the semiconductor on the discharge side. At the same time, replaceable mica gaskets with hole diameters of 10.0 mm, 10.5 mm and 11.0 mm created a gas-calibrated gap and excluded the nickel probe from its direct participation in the discharge process, thus preserving the type of discharge characteristic of the ionization system.

Gradual approximation (in the limit to an infinitesimal distance, d) the use of a discharge gap to a metal ring-shaped probe, sprayed on the surface of the OP from the discharge side, using mica gaskets of different hole diameters that determine the gas-discharge space, is more successful, since it allows you to maintain the constancy of the operating mode when studying the electro-optical characteristics of the system. The VAC of the OP surface always remains linear, so the surface gap of the OP from the probe to the edge of the discharge gap will only change the slope of the VAC of the gas discharge, and with an infinitesimal approach of the probe to the discharge, a VAC close to the true can be observed. For the convenience of comparing the current-voltage characteristics of the system and the photodetector, a scheme with a single gas-discharge gap was chosen (in some variants, the photodetector is placed between two gas-discharge gaps). Otherwise, the solid-state ohmic contact of the OP required to remove the semiconductor's I-V, changes the slope of this line characteristics by damping the input intensity. With the help of a diaphragm, a section of the AF with a diameter of 8 mm was illuminated, which is 2 mm smaller than the the diameter in the mica gasket with the smallest hole. This allows you to limit the intensity of the discharge at the edges of the gap.

The current-voltage characteristics of the semiconductor and the gas-discharge gap of the system were measured according to fig. 1,6 at the entrance lighting $J = 2 \cdot 10^{-2}$ W / cm^2; gas pressure P=50 mm Hg; gap thickness of 40 microns at different distances (750 microns, 500 microns, 250 microns) of the probe edge from the dark ring-shaped section of the gas discharge with a width of 1 mm. The current-voltage characteristic of the system was monitored for all measurements, and it remained virtually unchanged.

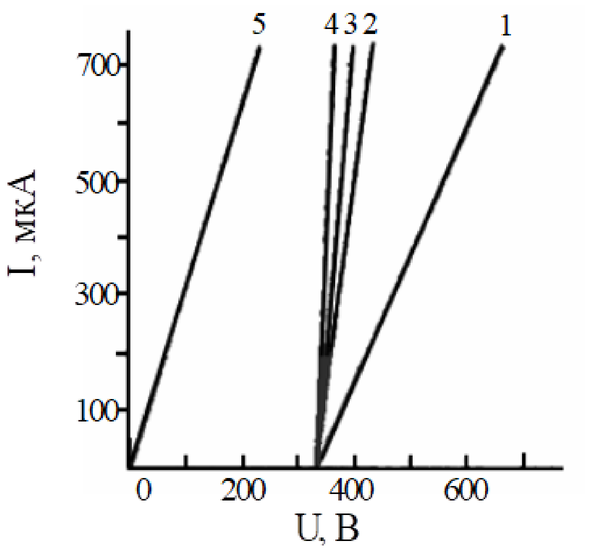

Рис.2. Вольтамперная характеристика:
1-система, 2,3,4-газового разряда, 5-фотоприемника

Figure 2 shows the following characteristics: 1-current-voltage characteristics of the system; 2,3,4-probe potentials as a function of the system current, respectively, for d= 750 microns, 500 microns, 250 microns; 5-VAC OP.

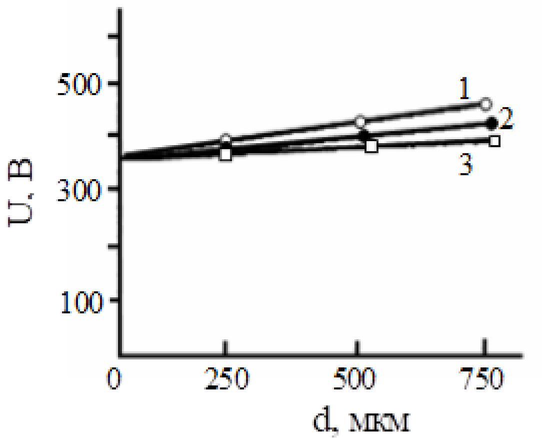

Рис.3. Зависимость потенциала зонда от расстояния до разрядного промежутка при токе системы: 1 - 700 мкА; 2 - 500 мкА; 3 - 300 мкА

In Fig.3 reconstructed from graphs 2,3,4 of the previous figure, the dependences of the probe potential on d for three system current values: (l-I=0,7 mA, 2-0. 5 mA, 3-0.3 mA).

A comparison of the current-voltage characteristics of the system as a whole, the photodetector and the discharge gap (Fig.2) indicates that at currents of i > 150 UA all characteristics of the photodetector and the system are almost identical, the slope of the current-voltage characteristic of the discharge decreases d 2), and the curves intersect the stress axis at the point 340 V (Fig. H), which coincides with the gas breakdown voltage (for this case Upr it is determined by the point of intersection of the CVC of the system with the stress axis (Fig. 2, curve 1).

It should be noted that in ionization systems, a transparent electrode in the form of glass with a conductive layer is usually used as a counter electrode Sn02, which usually has a surface resistivity of the order of 100÷400 ohms. cm.

The slight discrepancy between the slopes of the current-voltage characteristic of the photodetector and the system, as well as the deviation of the current-voltage characteristic of the gas discharge (Fig.2) from verticality, is most likely explained by the shielding of the electron flow by the volume charge formed on the counterelectrode surface. When using metal plates, for example, Si, Ta, A, as a counterelectrodel et al., the current-voltage characteristic of the system strictly coincides with the slope of the current-voltage characteristic of the OP.

Analyzing these results, it can be stated that by approaching the probe to the discharge edge, the value of the breakdown voltage can be determined Upr for these parameters of the bit gap, which remains constant. It should be noted that when the input illumination changes, the slope of the VAC of the gas-discharge gap does not change, i.e. the value of Upr it remains constant. The steepness of the CVC of the system in the post-breakdown area increases with increasing light intensity.

Conclusion.

Summing up these results, we can conclude that the semiconductor electrode performs two functions simultaneously: it locally controls the current density of the gas-discharge gap and suppresses the instability of the uniform current distribution that is undesirable for the system operation. The range of observed currents and the verticality of the current-voltage characteristic of the gas-discharge gap indicate that the systems operate in the region of a normal glow discharge. However, as already mentioned, the current lacing characteristic of this stage of discharge is absent in our case.

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