ACADEMICIA
An International Multidisciplinary Research Journal
(Double Blind Refereed & Peer Reviewed Journal)

ISSN (online) : 2249 –7137
ACADEMICIA
An International Multidisciplinary Research Journal
published by:
South Asian Academic Research Journals.
A Publication of CDL College of Education
(Affiliated to Kurukshetra University
Kurukshetra,India).

DOI: 10.5958/2249-7137.2021.01243.X

INVESTIGATION OF BACKGROUND RADIATION AND THE POSSIBILITY OF ITS LIMITATION IN A SEMICONDUCTOR IONIZATION SYSTEM

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ABSTRACT

The article presents the results of experimental studies of the phenomenon in a flat gas-discharge cell with a semiconductor electrode. The possibility of limiting the background, which is an obstacle to increasing the contrast of the output image, is shown.

KEYWORDS: *Image Converter, Semiconductor Electrode, Ionization Chamber, Gas-Discharge Gap, Semi-Insulating Gallium Arsenide, Photodetector, Current-Voltage Characteristic, Photocurrent, Pulse Duration, Pulse Voltage.*

INTRODUCTION

A semiconductor photographic system of the ionization type, in which one of the electrodes is a plate made of a high-resistance and photosensitive semiconductor, has found practical application in recent years. On its basis, so-called photoionization systems have been created, which are used for high-speed IR photography [1-2], silver-free photography, as IR image converters [3-4], as devices for visualizing electrical and structural defects in high-resistance semiconductors, as a source of uniform UV radiation over a large area, as a system where dissipative structures are formed in a gas plasma [5].

The semiconductor ionization system [6] operates in two modes: waiting and gating. In the standby mode, high-resistance semiconductors with p ≥ 107 om cm at direct current are mainly used. In the gating mode, relatively low-resistance photodetectors are also used in the pulse mode. In the second case, the dark current and thus the background radiation on the output screen of the semiconductor ionization chamber is much larger.

The study of the dependences of the average current on various values (photocurrent, pulse duration, pulse voltage, gas pressure, etc.) in the system is of considerable interest not only for understanding the physical mechanism of phenomena, but also has applied significance.

Recent research suggests that a new approach to a flat gas-discharge cell with a semiconductor photosensitive electrode will lead to a new class of devices. In our next works, we will show that changing the configuration and location of the cell elements, as well as the use of new photodetectors, allows us to create a unique photographic system, or rather a modern type of night vision devices.

This paper presents the results of experimental studies of the phenomenon in a flat gas-discharge cell with a semiconductor electrode. As part of this work, the possibilities of limiting the background, which is an obstacle to increasing the contrast of the output image, and in general improving the characteristics of the system, are shown.

SCHEMATIC DIAGRAM OF THE SYSTEM

The schematic diagram of a semiconductor ionization photographic system is shown in Fig.1. The photosensitive photodetector (2) is a semi-insulating gallium arsenide $(\rho \cong I0^{8}\,\text{Ом.см})$, 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 a glass plate covered with a conducting film . When connected to the voltage system, a gas discharge breakdown occurs, characterized in that there is a distributed resistance of the semiconductor in the discharge cell, which contributes to the damping of current instabilities.

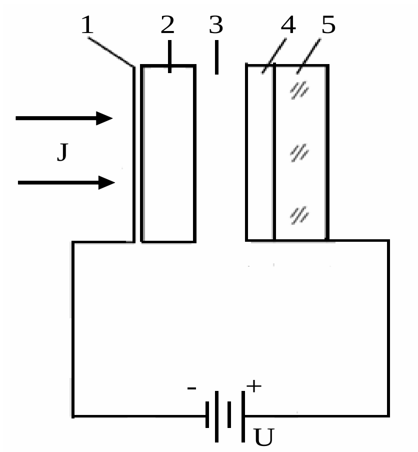

Fig. 1. Schematic-ionization system .

1 – translucent electrode, 2-semiconductor photodetector,

3-gas-discharge gap, 4-recording layer, 5-transparent counter electrode.

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 the current in the gas gap.[7]

For the measurements, the usual scheme of an ionization system with a semiconductor photodetector made of compensated gallium arsenide with a dark resistivity p = 108 om·cm was used. Providing output voltage pulses with a duration of 0.5 – 30 ms, up to 1.6 kV. The measurements were performed at two values of the gas discharge gap-40 microns and 100 microns-and an air pressure of 0.2 atm.

RESULTS AND DISCUSSIONS

When a rectangular voltage pulse is applied to a cell consisting of a gas – discharge gap contacting, on the one hand, a semiconductor electrode and on the other, a counter electrode, a gas breakdown occurs. The appearance of current pulses – the presence of an easily recorded delay time θ relative to the moment of switching on the voltage. Another feature of current pulses is the presence of a statistical spread of the breakdown delay value χ relative to some of its values.

Figure 2 shows a diagram of oscillograms of successive current pulses, illustrating the nature of the manifestation of the statistical spread of the moment of ignition of the discharge. Oscillograms of successive current pulses were taken in a semiconductor ionization chamber, illustrating the nature of the manifestation of the statistical spread of the discharge ignition moment.

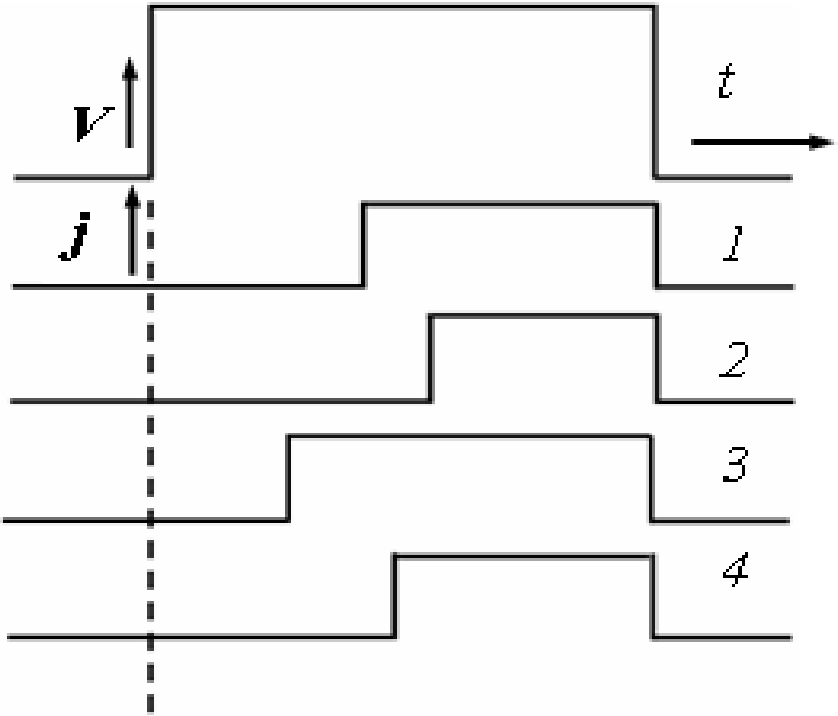

Fig. 2. Diagram of the breakdown current j waveforms with voltage pulses V applied in series.

Since the photographic effect on the recording medium is determined by the value of the average amount of electricity, we were interested not only in the values of the charge in each individual current pulse, but also in the average values of the charge and current over the period. Therefore, the first experimental task was to determine the average current averaged for each moment of time by the total number of pulses during exposure.

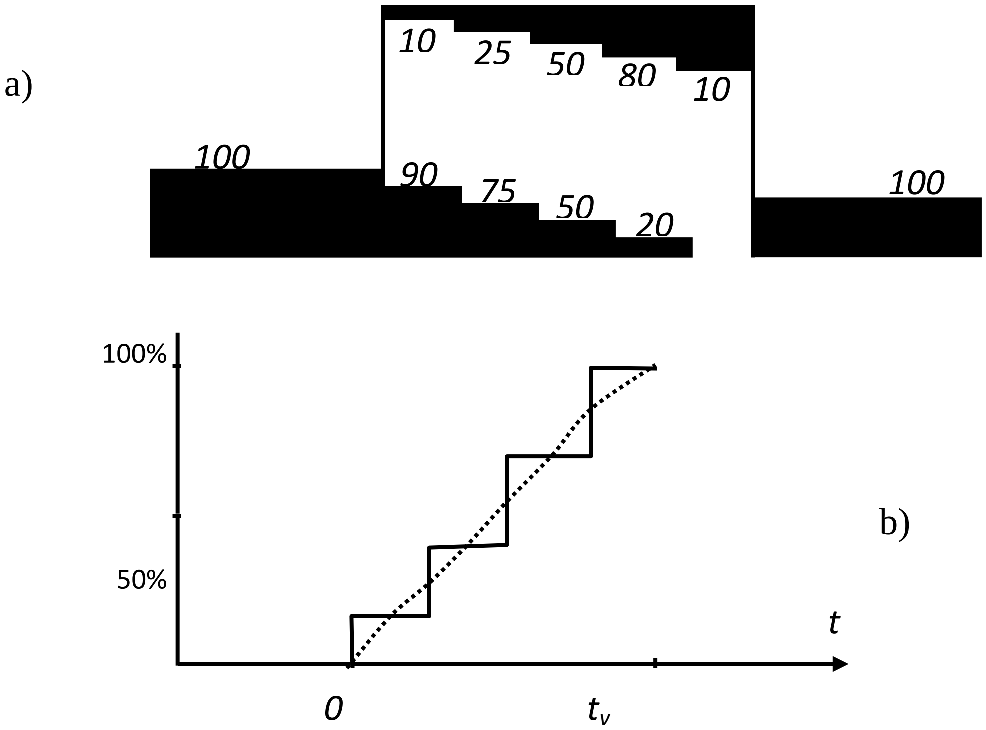

Fig. 3. a). Schematically – the distribution of the optical density of blackening on the current pulse waveform. b). the time dependence of the average current obtained from the waveform (a).

The method for obtaining the average current kinetics from densitometry of waveforms is schematically explained in Fig. 3, a, where the optical density on the waveform is conventionally represented by lines of different thickness, and the smooth curve in Fig. 3, b shows the resulting average current kinetics.

Thus, the total delay time is determined by two components: the delay time of the discharge gap capacitance through the illuminated semiconductor and the time of the statistical breakdown delay at a given voltage in the gap.

To determine the value of the stationary voltage, the stationary VAC was removed (Fig. 4), from which it follows that the value of the breakdown voltage is 500 V with a gap length of 100 microns. The value of the resistance under illumination varies from 50M to 790K.

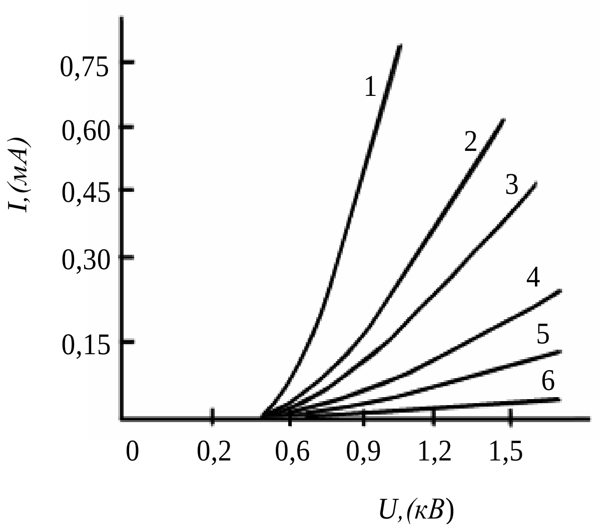

Fig. 4 Stationary VAC systems at different values of the semiconductor illumination. The light intensity is equal to (in rel. units.): 1 – 100%, 2 -72, 3 – 50, 4 – 25, 5 – 10, 6 – 0%.

Figures 5a and b show the dependences of the average current in the pulse on the light intensity at different values of the voltage pulse duration. A characteristic feature of the curves is the " threshold" the type of these dependencies, which is a consequence of the breakdown delay effect. With an increase in the duration of the voltage pulse, the threshold value of the illumination intensity decreases, below which the conduction current in the system, and therefore the discharge glow, is absent. Note also that starting from the threshold value, the current, as well as the past charge, sharply increase with increasing light intensity. Received " threshold values" the dependences of the average amount of electricity passed and the value of the average current with the adjustment of the threshold value are of considerable interest, being in principle a new method of background discrimination. Such a possibility of dynamic background discrimination is undoubtedly realized in independent gas-discharge cells with a distributed resistance of the semiconductor electrode in a semiconductor photographic system of the ionization type.

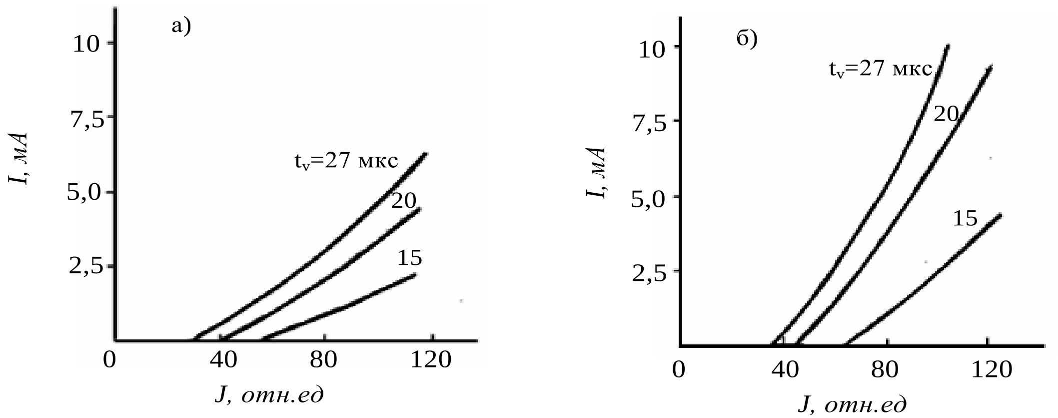

Fig. 6. a). Lux-ampere characteristics of the system at different values of the voltage pulse duration with a gap thickness d = 40 mm. b). The same is true for the gap thickness d = 100mkm.

Studies of the dynamic background discrimination mode with photographic image registration at different values of the breakdown delay and different illumination of individual areas of the semiconductor photosensitive electrode area are carried out

CONCLUSION

Thus, the shown breakdown delay in a gas-discharge cell with a semiconductor electrode during electrical and photovoltaic measurements generally confirms the possibility of implementing dynamic background restriction at a given level.

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