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ANALYSIS OF KINETICS OF IMAGE FORMATION ON BISMUTH FILMS UNDER ACTION OF GAS DISCHARGE

Abstract*: This article presents the results of a study of the kinetics of enlightenment and the change in time of some other properties of films under the action of discharge, undertaken to clarify the nature of the processes determining the observed effect.*

Key words*: bismuth film, a counter electrode, gas discharge, gas discharge cell, ionisation systems, photoconductivity, photodiode, silicon filter*

Language*: English*

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Introduction

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A gas discharge cell with a flat semiconductor electrode has found quite wide application in the field of photo electronics when detecting optical and infrared radiation. [1, p.94; 2, p.28]. With a reduction of a gas gap of gas-discharge cell in semiconductor ionization system, area of spatial stabilisation of current is considerably expanded, as in the range of gas pressure and in values of permissible applied voltages [3, p. 44; 4, p. 1330]. A complete picture of processes in a gas discharge cell at small cannot be satisfactorily interpreted within a simple gas discharge theory. [5, p. 244]. The conditions of discharge occurrence in these gaps are quite uncharted.

In the work, it is shown that in such a cell it is possible to reduce images on thin metal and semiconductor films under the action of gas discharge, formed due to illumination of the film directly during the promotion.

I. Purpose of Research

The purpose of this work is to study in detail the interaction of plasma with bismuth film by the kinetics of optical absorption during plasma exposure.

II. Materials and Methods

The scheme of the experimental installation is shown in (figure - 1) to study the image formation kinetics the light from source 1 is focused 2 and evenly illuminates the semiconductor GaAs electrode 3 with a translucent nickel coating 4. Photoactive light, absorbed in a crystal, causes photoconductivity in it. Light, whose wavelength λ > 1 micron, after a slight absorption of the crystal has an intensity of J_0. This intensity of light flux, passing through the gas-discharge gap 5 normally falls on the counter electrode 6 with *Bi* film 7. After absorption in the film *Bi*, the electrode from the Sn02 8, in the output window, the light of intensity *J* passes the silicon filter 9, is modulated 10, and focuses on the input of the silicon photodiode 11. The signal from photodiode after amplification and detection is recorded on self-recorded [6, p.138, 7, p.141]. Thus, a light which is negligible little absorbed in the semiconductor (λ> 1 μm) is "probing" to determine the dynamics of the change in the optical density of the bismuth film during the process. Before switching on the J/J0 ionisation system, the optical density of the applied Bi layer is determined. When the discharge acts on the bismuth film, the J/J0 increases. [8, p.75]

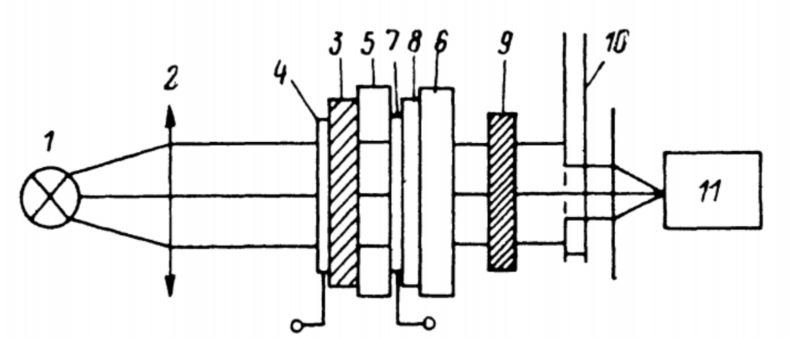

Figure 1. Block diagram of the installation for investigation of image formation kinetics in photographic system of ionization type with semiconductor

In a gas-discharge cell, the flat electrodes of which are assembled from glass plates with a transparent conductive coating of SnO2, as one of the electrodes inserted glass plate with sawn with a layer of *Bi*. The discharge was performed when connected to a cell of alternating voltage 1 ÷ 2 kV with a frequency of 7 kHz. To ensure the uniformity of discharge over the area of the electrode, a buffer layer in the form of a gasket thickness of 10 ÷ 30 μm was pressed to the transparent electrode from the discharge side, which served as a distributed reactive resistance and played the same role in the cell as a resistive layer of semiconductor material in a semiconductor photographic ionization system. The LG-75 laser beam passed through the cell. At the output, its intensity was measured by the silicon photodiode FD-24K. In some cases, an incandescent light bulb powered by a stabilized voltage source has been used to provide greater stability in the sensing beam. By changing the intensity of light passing through the cell one could judge about the change in optical density of bismuth layer under the action of gas discharge on it. [9, p.1009]

Light with an intensity of J_0, passing through the plate with thickness X_0, having an absorption coefficient α; weakened by law

$$J = J_0 exp[-\alpha(x_0 - vt)] \quad (1)$$

Where *J*- the intensity of transmitted light, *v* - the rate of change of absorption medium thickness, *t*-time.

Thus, in the simplest case, when only the film thickness decreases as a result of plasma action at a constant rate of *v*, we obtain exponential type curves.

$$J = f(t). \quad (2)$$

Figure 2 shows the volt amp characteristics of the discharge cell at different thickness values of the damping mica layer. Discharge starts at a voltage of about 500 V and the discharge current increases linearly with an applied voltage of up to 3 kV. There is a small capacitive current linearly dependent on voltage in the antitumor section. Also, it is visually noted that the glow of the gas discharge is quite strictly uniform in area, the uniform was the change in the optical density of the bismuth layer sprayed onto the glass with a conductive coating of SnO2. [10, p.580]

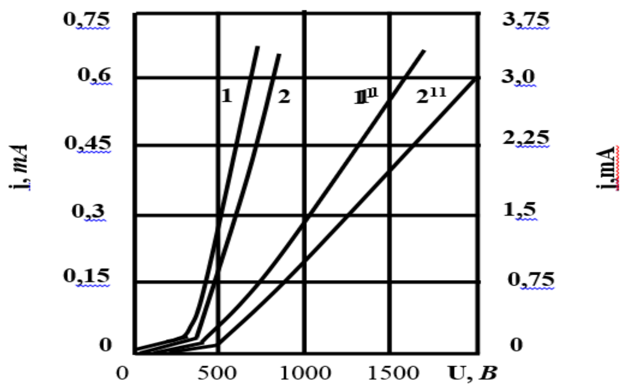

Figure 2. Voltamper characteristics of the gas discharge cell at different thicknesses of the damping mica layer d. d equal: 1 and 1/ - 10μm, 2 and 2/ - 20μm. Curves 1.2 and 1/, 2/ are given for dark and light currents, and therefore they are at different scales. J = 10 -4W/cm2.

On Fig.3. The kinetics of bismuth films enlightenment obtained under special conditions of the experiment is given: at moments t ≈25 min, 45 min and 72 min the gas discharge cell voltage was switched off. During 15 minutes after the voltage was turned off, further illumination of the films was observed, which was saturated after 10 minutes. If only a cathode spray type mechanism were present in this case, the change in bismuth optical density would stop immediately after the applied voltage was turned off. [11, p.199]. The fact that the optical density continues to decrease after the discharge termination indicates the presence of other enlightenment mechanisms. It can be assumed that the active plasma components arising in the discharge are adsorbed on the film surface and react with *Bi* to form transparent oxide compounds [12, p.111].

Thus, enlightenment occurs not only by cathodic spraying but also, apparently, by the chemical interaction of active plasma components with *Bi* atoms.

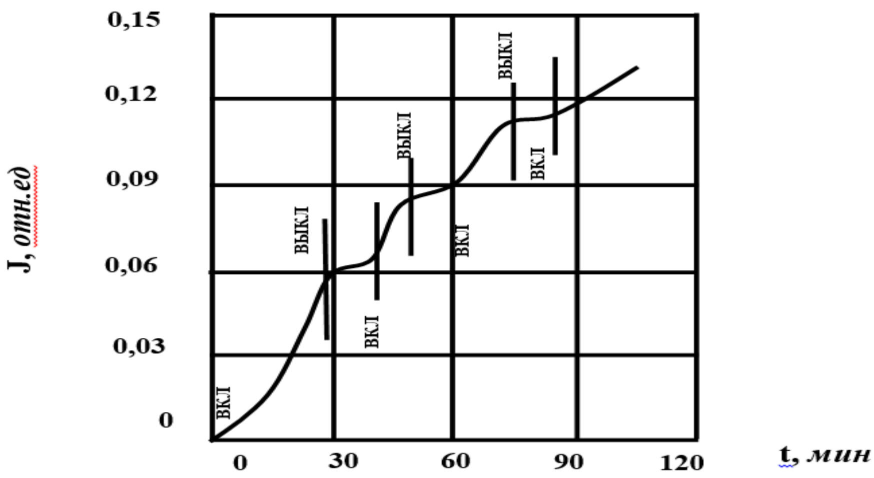

Figure. 3. The kinetics of bismuth film enlightenment.

The material of the substrate on which the bismuth layer has been sawed has a significant effect on the illumination rate. Figure 4 shows the illumination kinetics curves of the same optical density Bi films sprayed onto the SnO_2 surface, the polystyrene lacquer layer (2 μm) covering the SnO_2 surface and the polystyrene film.

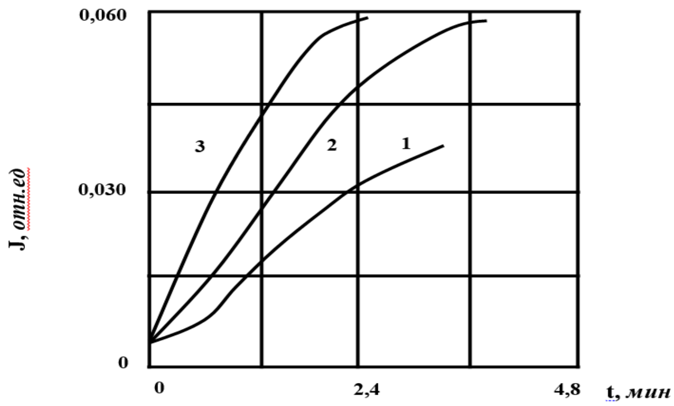

Figure. 4. Enlightenment kinetics of Bi films at equal optical density, sprayed 1 - on the SnO_2 surface, 2 - on the polystyrene lacquer layer covering the SnO_2 surface, 3 - on the polystyrene film

It can be seen from the curves that only for the first case at the initial sites kinetics is close to the calculated one. In the second and third cases, the rate of enlightenment is much higher and at the initial site, it changes almost in a jump-start manner. The average values of αv for these three cases are - $2{,}9\cdot10^{-2}\ c^{-1}$, $3{,}3\cdot10^{-2}\ c^{-1}$, $6\cdot10^{-2}\ c^{-1}$, respectively. The effect of the substrate on the properties of thin films is manifold.

Conclusion

Thus, in the simplest case, when only the film thickness at a constant rate *V* decreases as a result of the plasma action, we obtain curves of exponential type

$$J = f(t). \tag{3}$$

It seems to us that in this case, the heat sink from the bismuth layer plays a significant role in the enlightenment process. Any processes leading to enlightenment - cathodic spraying, chemical reactions and thermal evaporation of bismuth atoms - intensify with increasing temperature. The thermal conductivity of polystyrene is much lower than SnO_2 and glass. The temperature of the layer is highly dependent on the thermal conductivity of the substrate. Apparently, this is the reason for the increase in the rate of enlightenment on thermally insulating polystyrene substrates.

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