THE ROLE OF MERCURY IN THE PROCESS OF THE APPEARANCE OF ANOMALOUS PHOTO-CONDUCTIVITY OF AMORPHOUS SELENIUM

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Abstract

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Academician of the Academy of Sciences of the Kazakh SSR M. I. KORSUNSKII,
A. D. VOLCHEK,
K. S. TARGER, V. V. KLIMENKO

THE ROLE OF MERCURY IN THE PROCESS OF THE APPEARANCE OF ANOMALOUS PHOTOCONDUCTIVITY OF AMORPHOUS SELENIUM

It is known that in films of amorphous selenium, under certain conditions, anomalous photoconductivity (a.p.) is observed (^1). The magnitude of the quasi-dark photocurrent in the state of a.p. depends on the wavelength of the monochromatic light (color memory) and does not depend on the intensity of the radiation incident on the sample (^{2};3). A.p. in amorphous selenium was observed only after the samples had been held for a certain time in mercury vapor, cooled to a temperature of 100–150° K, and subsequently illuminated (formed) with white light (^4).

The phenomenological theory of the phenomenon of a.p. (^2) assumes the presence in films of amorphous selenium of special centers of long traps (l.t.), possessing the property that a nonmajority current carrier entering them is retained in the dark for an indefinitely long time. In this case, the release of a carrier from an l.t. is possible only as a result of absorption of a photon of sufficient energy. On the basis of the data of work (^5) it was found that the l.t. are located in the near-surface layer of the amorphous selenium film.

Despite the fact that a.p. was observed in films of amorphous selenium only after they had been exposed to mercury vapor, the role of the latter in the observed phenomenon remained unexplained.

Two assumptions were advanced (^6):

1. L.t. arise as a result of the process of adsorption of mercury on the surface of a film of amorphous selenium.
2. L.t. in the layer of amorphous selenium are present even before exposure to mercury vapor, but their presence is not manifested because of the existence in the layer of a large photoinactive resistance. As a result of adsorption of mercury vapor, the photoinactive resistance decreases

Figure 1

Figure 1: Figure 1

Fig. 2

Figure 2: Fig. 2

sharply, and regions of the layer containing l.t. begin to play an essential role in the conduction process.

Fig. 1. Spectral distribution of the photoconductivity of amorphous selenium.
I –distribution of the light-induced photoconductivity;
II –conductivity level after the light is switched off

To determine which of these two assumptions is valid, a study was made of the spectral distribution of the photoconductivity of selenium films before exposure to mercury vapor (pure amorphous selenium) at room temperature and at temperatures lowered to ~100° K. The measurements were carried out both before illumination of the sample with white light and after such forming. Then the selenium film was exposed to mercury vapor, and the entire measurement cycle was repeated. The magnitude of the photoconductivity was determined by means of a potentiometric circuit. A millivoltmeter was used as the recording instrument–

an electrometer of type V2-5 with a high-resistance input, which made it possible to measure conductance down to 10^{-17} Ω^{-1}.

In pure selenium the spectral distribution of photoconductivity proved to be the same both at a temperature of ~ 300°K and at a temperature of ~ 100°K (Fig. 1, *I*). The results obtained are in agreement with the data given in Ref. ([7]). It was also found that the phenomenon of a.p. does not arise in pure selenium even after prolonged forming with white light.

Fig. 2. Spectral distribution of the photosensitivity of amorphous selenium after exposure of the specimen to mercury vapor. *I*, *III*–quasi-dark values of the conductivity, respectively before forming of the specimen with white light and after forming; *II*, *IV*–light values of the conductivity, respectively before forming of the specimen with white light and after forming

If the film under investigation is placed for some time in a closed volume with a definite vapor pressure of mercury, the total resistance can be lowered by many orders of magnitude, down to several ohms. We brought the resistance of the specimens to values of $\sim 10^{10}$ Ω. The photosensitivity of such specimens at room temperature is practically absent, but appears when the temperature is lowered.

Figure 2 gives curves of the spectral distribution for the light (*II*) and dark (*I*) values of photoconductivity for a specimen cooled in the dark. It is seen that the action on the layer of mercury vapor leads to a substantial change in the character of the spectral distribution of photoconductivity. As a result, an additional photosensitivity appears in the long-wavelength part of the spectrum, the maximum of which, for different specimens, lies within the limits from 900 to 1000 mμ. At the same time an effect appears of memorizing the photoconductivity level after the light is switched off. In pure selenium the dark level of conductivity (Fig. 1, *II*) is the same for all wavelengths of the investigated spectral range.

Subsequent illumination (forming) of the specimen with white light (from an incandescent lamp) leads to a change in photosensitivity both in the short-wavelength and in the long-wavelength regions of the spectrum. The amplitude of the maximum in the region $900 \div 1000$ mμ increases both for the light (Fig. 2, *IV*) and for the dark (Fig. 2, *III*) values of the photocurrent. At the same time the maximum in the region 450 mμ, characteristic of pure selenium, disappears completely. The general form of the spectral distribution obtained in the visible part of the spectrum for a specimen subjected to the action of mercury and to forming with white light agrees with that known previously for a.p. (^{8}). The independence of the stationary value of the dark conductivity from the intensity of monochromatic light was checked from 380 mμ up to the maximum of the spectral distribution of photoconductivity, i.e., up to 900–1000 mμ.

It should be noted that the given form of the spectral distribution (Fig. 2, *III*) does not undergo substantial changes when the specimen is heated from 100 to 230°K. Heating of the specimen leads only to a change in the relative magnitude of the long-wavelength maximum, which decreases exponentially with increasing temperature.

Thus, in pure selenium the centers responsible for A.P. are absent. The assumption that the amorphous selenium samples studied contain large non-photoactive resistances must be rejected, since appreciable photosensitivity is present in the absence of "memory."

It may be asserted that D.L. arise as a result of adsorption and condensation of mercury vapor on the surface of amorphous selenium. Nothing definite can yet be said about the nature of these centers. However, if mercury forms colloidal inclusions on the surface, then it is precisely these that may play the role of D.L. (^{9}).

A.P. is observed against the background of the sample's own conductivity, which is small at the temperature of liquid nitrogen. Therefore, as the temperature is raised, the relative contribution of A.P. to the total conductivity decreases.

Institute of Nuclear Physics
Academy of Sciences of the Kazakh SSR

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