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Fig. 1

Figure 1: Fig. 1

Fig. 2

Figure 2: Fig. 2

Abstract

Full Text

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PHYSICS

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OPTICAL METHOD FOR FORMING A p—n JUNCTION

(Presented by Academician A. A. Lebedev on 7 December 1964)

We have established that, in order to achieve a high rectification coefficient and substantial photosensitivity in certain film heterojunctions, special light forming is necessary. Below are given the results of a study of the p—n junction between films of cuprous oxide and cadmium sulfide. Cadmium sulfide, doped with indium (0.01%), was deposited by thermal evaporation in vacuum onto an oxidized copper substrate. The CdS films had a thickness of 2.5 μ and a specific resistivity of 0.1 ohm · cm. The ohmic contact on the cadmium-sulfide side was made in the form of a ring-shaped indium (or aluminum) electrode. Measurements were carried out at room temperature. Freshly prepared samples, before light forming, had nearly ohmic current-voltage characteristics and exhibited a slight photovoltaic effect.

Fig. 1. Change in the short-circuit current $I_{\text{k.z}}$ of a Cu_2O−CdS photoelement for several successive 30-minute light pulses and dark intervals of the same duration

Fig. 2. Envelopes for the maxima (1) and minima (2) of the short-circuit current of a Cu_2O−CdS photoelement over all light pulses in the process of light forming. n is the number of pulses, $\Delta t = 30$ min

Light forming consists in periodic illumination of the samples followed by dark intervals. The process of light forming is shown in Fig. 1. It is evident from the

Fig. 3. Current-voltage characteristics of a Cu_2O—CdS p—n junction: a—freshly prepared, unformed sample; b—half-formed sample; c—fully formed sample. Division value of the vertical axis: 1 mA; of the horizontal axis: 1 V.

Figure 3: Fig. 3. Current-voltage characteristics of a Cu_2O—CdS p—n junction: a—freshly prepared, unformed sample; b—half-formed sample; c—fully formed sample. Division value of the vertical axis: 1 mA; of the horizontal axis: 1 V.

figure that, after "rest" in the dark, with the application of each subsequent light pulse, the value of the short-circuit current generated by the element increases noticeably relative to the value observed at the initial moment of exposure.

of the preceding pulse. This figure also shows that, in the sample being formed, photoelectric "fatigue" is simultaneously observed; it is expressed in a drop of the short-circuit current during the duration of the light pulse to a certain stationary value. The increment of $I_{s.c.}$ from one forming cycle (light—dark) to the next cycle becomes ever smaller, which ultimately leads to the attainment of a certain maximum sensitivity of the photocell (Fig. 2). By the final stage of the light-forming process, the fatigue disappears.

By periodically illuminating the photocells with pulses of 30 min duration (20-30 pulses), it was possible to increase their sensitivity by hundreds of times. At the same time, the rectifying properties of the Cu_2O—CdS p—n heterojunction improved. This was expressed in a change in the current-voltage characteristics of the samples during light forming, from ohmic to diode-like (the rectification coefficient increased from 1.5—2 to 10^4), as shown in Fig. 3. The ohmic character of the metal—semiconductor contacts was not disturbed.

Fig. 3. Current-voltage characteristics of a Cu_2O—CdS p—n junction: a—freshly prepared, unformed sample; b—half-formed sample; c—fully formed sample. Division value of the vertical axis: 1 mA; of the horizontal axis: 1 V.

The qualities of the p—n junction obtained as a result of light forming do not deteriorate with time, and the junction proves to be stable under the action of external factors.

The effect of light forming can be explained by recharging of metastable trapping centers present in cuprous oxide,[1,2] on which photoelectrons that have passed from cadmium sulfide can become localized. This is confirmed by the sign of the photo-e.m.f.: under illumination, the electrode located on the cuprous-oxide side is positive.

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Note: Figure translations are in progress. See original paper for figures.