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CdTe-SiO2-Si-Al HETEROSTRUCTURE PHOTOSENSITIVITY CONTROL WITH DEEP IMPURITY LEVELS UNDER EXTERNAL FACTORS

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Abstract: The ability to control photosensitivity under the influence of external factors is demonstrated. It has been established that, with an increase in the potential of the corona discharge and the electric field, the spectra are mixed into the short-wave region of the spectrum, while the activation energy of the deep level of 0.70 eV changes significantly due to the Poole-Frenkel effect. The electric field strength in the vicinity of the defect $E = 10^5$ V/cm was found.

Keywords: photoconductivity, so short circuit, deep levels, corona discharge, electric field.

Despite the rather complex dependences of the short-circuit current density ($I_{sc}$) and the open-circuit voltage ($V_{oc}$) on the technological conditions for obtaining the heterostructure, there are optimal substrate temperatures and deposition rates, as well as optimal concentrations of introduced impurities, and this leads to an improvement in its electrophysical parameters, at which maximum efficiency of the resulting heterostructure.

In this regard, a promising pair was created based on cadmium telluride obtained on the oxidized silicon surface doped with boron [1]. In this case, CdTe is doped with an impurity of silver, copper, which give deep levels in the band gap of CdTe. With the introduction of impurity atoms, the photosensitivity expands into the ultraviolet region up to infrared radiation, while in fine-grained polycrystalline films of p - CdTe with an increase in the concentration of deep impurities, not only the short circuit current ($I_{sc}$) increases, but also the efficiency ($\eta$) [2].

Here we consider the effect of an external field in a static mode and in a corona discharge applied between the CdTe layer and an oxidized boron-doped Si crystal plate on the photosensitivity of the CdTe film in the light wavelength range of 0.4-3.1 $\mu$m. The spectral dependences of the short-circuit current ($I_{sc}$) and the specific photoconductivity of the CdTe films were measured.

Fig. 1 spectral dependences of the short-circuit current ($I_{sc}$) of the CdTe layer are presented for various values of the corona discharge intensity, which were carried out by a contact and an electric probe contact to the surface of the CdTe semiconductor.

It can be seen that in the absence of external influences in the spectra $I_{sc}$ ($\nu$), an inversion of the sign of $I_{sc}$ is observed in the vicinity of the value of the photon energy equal to $h\nu = 1.21$ eV (curve 1).
Fig. 1. Spectral dependences of $I_{sc}$ for the CdTe-SiO2-Si structure on the value of the corona discharge potential: $\varphi_{cr} = 0$ V (curve 1), 40 V (2), 70 V (3). The inset shows the photosensitivity spectra of the impurity light absorption region on a logarithmic scale.

The inclusion of the surface potential of corona discharge between the CdTe layer and silicon leads to a significant change in the spectral sensitivity short-circuit current ($I_{sc}$). When the surface potential changes within its value from 0 to 100 V, the position of the inversion of the sign of the short-circuit current is mixed into the short-wavelength region of the spectrum. In this case, the maximum photosensitivity $I_{sc}$ is mixed into the short-wavelength region of the spectrum in the range from 0.93 eV to 1.5 eV. The position of the value of the maximum $I_{sc}$ increases by more than 1000 times at $U_{cr} = 70$ V (curve 3).

It is shown that the $I_{sc}$ spectra have pronounced maxima (1.06 μm for one polarity and 0.7 μm for the other polarity of the photo-EMF). With an increase in the corona discharge voltage ($U_{cr} > 100$V) and the static electric field ($U_{in} > 300$V), the photosensitivity at the maximum increases from 100 to 1000 times, and the inversion frequency $I_{cr}$ shifts to the short-wavelength region of the spectrum and the inversion gradually disappears.

It is noted that these changes occur under the influence of a charge built into the oxide layer or the interface between the Si layer and semiconductor CdTe.

For a qualitative description of the mechanism of the electron transfer phenomenon occurring in the structure of CdTe-SiO2-Si-Al under conditions of an applied external constant electric voltage. In which the stationary current is from the flux of tunneling electrons from the conduction band of the CdTe semiconductor to the conduction band of the Si semiconductor through the SiO2 oxide layer and from the conduction band of the semiconductor to the deep level in the dielectric.
Tunneling infiltration of current carriers from a CdTe film into deep levels of a silicon oxide dielectric leads to a change in the filling degree of both slow surface states and deep traps. And this, depending on the magnitude of the built-in charge, modifies the potential relief of the film of the structure under study and, therefore, the photogeneration rate will depend on the magnitude of the built-in charge, i.e., on the strength of the external electric field polarizing the dielectric. This means that the magnitude of the photo-EMF, due to the degree of asymmetry of the potential relief of the CdTe film, can be controlled by the transverse external electric field and corona discharge.

For a qualitative description of the physical nature of the kinetic phenomenon in the structure of the semiconductor CdTe - oxide semiconductor SiO₂ - semiconductor Si, we can consider a model based on the theory of MIS (metal-insulator-semiconductor) - transistor. In this case, we mean that in a thin (~0.4 μm) oxide layer, the main mechanism of current flow is determined by the Fowler – Nordheim model [3] and the corresponding current is denoted as

\[ j_{FN} = aE^2 \exp \left( \frac{-b\phi^{3/2}}{E} \right) \]

where \( i \) is the emission current density, \( E \) is the electric field strength, \( \phi \) is the output work, functions \( a \) and \( b \) depend on the geometry and work function, for example, the degree of asymmetry, height, and width of the potential barrier. The current carrier flux should arise: a) due to the increasing (due to the Poole - Frenkel effect) with an increase in the potential of the corona discharge by thermionic emission through the potential barrier (\( j_{FN} \) electrons), b) due to the field emission of current carriers captured in the semiconductor oxide into the conduction band CdTe (\( j_{FN} \)). Since the contributions to the total current from the above currents are different in magnitude, the continuity of the current is disrupted at the interface. Thus, the excess (nonequilibrium) current carriers appearing in this case lead to the accumulation of charge at the interface. This leads to a redistribution of the internal electric field, which is essential in the formation of a potential barrier relief.

The proposed CdTe-SiO₂-Si-Al heterostructure can operate as a separate photodetector (in the range of 0.4-3.1 microns), as well as a component of a matrix device, which makes it possible to control both the spectral photosensitivity and the value of the maximum sensitivity thin CdTe films with retention of selectivity.

This opens up new opportunities in information processing, since it provides reception of signals from its output with different spectral photosensitivity, matching with the emitter, which is important when creating, with fundamentally new capabilities, semiconductor devices with a variable spectral characteristic in a wide range of received electromagnetic radiation. In addition, film heterostructures have high spectral photosensitivity near the infrared region of the spectrum.

References
2. Goldman E.I., Zhdan A.G., Chucheva G.V. Transport of free ions along the insulator layer and the effects of electron-ion exchange at the semiconductor-insulator interface during thermostimulated ion depolarization of Si-MOS structures, Semiconductors. 1999, no. 8, p.2024.