East European Journal of Physics. 4. 256-261 (2024)
DOI:10.26565/2312-4334-2024-4-26 ISSN 2312-4334

VOLT-AMPERE CHARACTERISTICS OF HETERO FILM PHOTOSENSITIVE STRUCTURE Au-CdS-nSi-CdTe-Au

Sharifa B. Utamuradova[a], Khodjakbar S. Daliev[b], Shakhrukh Kh. Daliev[a], Sultanpasha A. Muzafarova[a]*, Kakhramon M. Fayzullaev[a], Gulnoza A. Muzafarova[a]

[a]*Institute of Semiconductor Physics and Microelectronics, National University of Uzbekistan, 20 Yangi Almazor st., Tashkent, 100057, Uzbekistan*

[b]*Branch of the Federal State Budgetary Educational Institution of Higher Education "National Research University MPEI", 1 Yogdu st., Tashkent, Uzbekistan*

**Corresponding Author e-mail: samusu@rambler.ru*

Received July 5, 2024; revised September 2, 2024; accepted September 16, 2024

The results of studies of the current-voltage characteristics of a photodiode heterostructure are presented. Au-nCdS-nSi-pCdTe-Au, in forward and reverse directions. Photodiode heterostructures with an area of 29 mm^2 were created, which were obtained by vacuum evaporation in a quasi-closed volume by depositing layers of cadmium sulfide and cadmium telluride onto a single-crystalline silicon substrate with resistivity ρ = 607.47 Ohm·cm. A distinctive feature of the resulting photodiode Au-nCdS-nSi-pCdTe-Au structures is two-way sensitivity, where impurity complexes are formed. In the structures, the rate of recombination of nonequilibrium carriers at low excitation levels is determined by simple local centers in the boundary transition layers. The band diagram of a multilayer photodiode structure Au-nCdS-nSi-pCdTe-Au has been constructed.

Keywords: *Resistivity; Intensity; Current; Heterojunction; Photodiode; Structure; Junction; Microinterferometer; Vacuum; Capacitance; Band diagram*

PACS: 07.30.-t, 52.25.Mq, 61.72.jd, 61.72.uj, 66.70.Df

INTRODUCTION

In recent years, integrated circuits have almost reached the limit of the degree of integration of electronic components and speed. The use of optical interconnects to connect individual circuit elements will significantly increase the speed of signal transmission. For this purpose, the development of optoelectronic components necessary for the creation of photonic integrated circuits is actively underway for the purpose of efficient generation, modulation and detection of optical radiation [1-7]. The use of CdTe and CdS semiconductor compounds to create optoelectronic components operating in the near-IR wavelength range is a promising direction in the development of silicon optoelectronics and integrated photonics. However, the number of photonic components on modern integrated circuits is only approaching the ten thousand marks. Optical systems for transmitting and receiving information, being an alternative to cable transmission, are beginning to become widely used. Their important elements are receiving optical modules, the functions of which include converting the optical signal received by the photodetector into an electrical one, which is processed by electronic devices. At the same time, the photodetector is required to capture even a very weak optical signal, low inertia and noise [7-9]. Phototransistors and photodiodes without charge accumulation meet these requirements to a certain extent. However, the time constant of a phototransistor is longer than that of a photodiode, which limits its application in communication systems [1,8]. The above problem can be solved by creating structures with two Schottky barriers based on silicon. The appeal to silicon is due to the fact that it is the most technologically proven, well-developed material, however, photodiode structures with two barriers and based on it remain poorly studied. In a photodiode structure, the creation of a second or third barrier helps to reduce its capacitance, enhance the primary photocurrent and increase the frequency range and speed of operation [10-13].

This article presents the results of a study of the current-voltage characteristics of MSM photodiode structures with silicon-based potential barriers in the forward and reverse directions at 300 K.

EXPERIMENTAL PART

The heterojunction photodiode structure Au-nCdS-nSi-pCdTe-Au was obtained in a quasi-closed volume by vacuum thermal evaporation of CdS and CdTe powders onto a single-crystalline n-type silicon substrate with film thickness d = 0.55 μm, determined with an MII-4 microinterferometer.

The substrate is single-crystal n-type silicon of the KEF-600 brand according to TU 48-4-295-82 with a thickness d = 130 μm and a diameter D = 42 mm with a resistivity of 607.47 Ohm·cm, oriented in the crystallographic direction (111) and concentration of the main carriers' component $N_n = 7 \cdot 10^{12}$ cm^{-3}.

Using the method of vacuum evaporation in a quasi-closed volume [14] makes it possible to obtain layers with thicknesses ranging from several hundred angstroms to several tens of microns. At the same time, homogeneity and maximum frequency of the material are achieved, and film growth conditions are easily controlled.

Cite as: Sh.B. Utamuradova, Kh.S. Daliev, Sh.Kh. Daliev, S.A. Muzafarova, K.M. Fayzullaev, G.A. Muzafarova, East Eur. J. Phys. 4, 256 (2024), https://doi.org/10.26565/2312-4334-2024-4-26

N-type CdS powder with a particle size of 120 μm and a purity of 99.99 % was used as the starting material to obtain the Au-nCdS-nSi-pCdTe-Au photodiode structure. 60 μm p-type CdTe with 99.999% purity from Advanced materials (China). The resistivity of CdTe is $\rho \approx 10^4 \div 10^6$ Ohm·cm, and the resistivity of CdS $\rho \approx 10^2$Ohm·cm. The concentration of the main carriers of CdTe is $N \approx 10^{12} \div 10^{14}$ cm^{-3}, CdS = 10^{18} cm^{-3} [15]. CdS and CdTe films were deposited by vacuum evaporation on the silicon surface of an AVP-05 unit, at a pressure in the chamber $P = 1.8 \cdot 10^{-5}$ mmHg.

When depositing CdS films on the surface of a silicon substrate, the evaporator temperature was varied in the range T_e=750÷800 °C, necessary for congruent evaporation of CdS particles, in which the temperature of the silicon substrate was simultaneously maintained in the range T_e=200÷250 °C. At a low temperature of the silicon substrate, fine-grained and randomly oriented grains are formed in the polycrystalline film. CdTe films were deposited on the back side of the substrate at an evaporator temperature T_e= 550°C.

During the deposition of CdTe films, the substrate temperature was T_s = 270÷290°C. The film growth time is t = 5 minutes at a rate of υ = 16.7 Å/s, at which the thickness of each film is 0.55 μm. The thickness of the films was measured with a Linnik MII-4 microinterferometer. The data obtained when studying the surface using a MII-4 microscope showed that a thin layer of CdS deposited on the surface of the n Si substrate consists of columnar crystallites, misoriented in azimuth and oriented in the direction of film growth [16].

To obtain a rectifying contact on the surface of the film layers of the heterostructure, metal-semiconductor transitions obtained by sputtering gold (Au) with a thickness d = 100 Å in a VUP-4 vacuum station at a temperature t = 435°C. Next, the resulting heterojunction structure Au-nCdS-nSi-pCdTe-Au scribed into discrete samples with an area of 29 mm^2 (Fig. 1)

Figure 1. Cross section of a photosensitive multilayer double heterostructure Au-nCdS-nSi-pCdTe-Au

RESULTS AND DISCUSSION

Studying the current-voltage characteristics of heterostructures solves two problems at once:

- first, is directly related to the determination of the most important characteristics of semiconductor devices;
- second, performs in the role of feedback in further increasing the efficiency of the structures under consideration, allowing, if necessary, to adjust the parameters of the formation of heterostructures in the event of observing degradation of the electrical characteristics of diodes based on them.

Au-nCdS-nSi-pCdTe-Au heterojunction photodiode structure was obtained by sequential vacuum thermal evaporation of CdS and CdTe powders onto a substrate - the surface of a monocrystalline n-type silicon wafer.

In Fig. 2 the direct (I) and reverse (II) branches of the current-voltage characteristics (CV characteristics) of the heterojunction are presented Au-nCdS-nSi-pCdTe-Ag structures, which were measured at room temperature and plotted on a log-log scale.

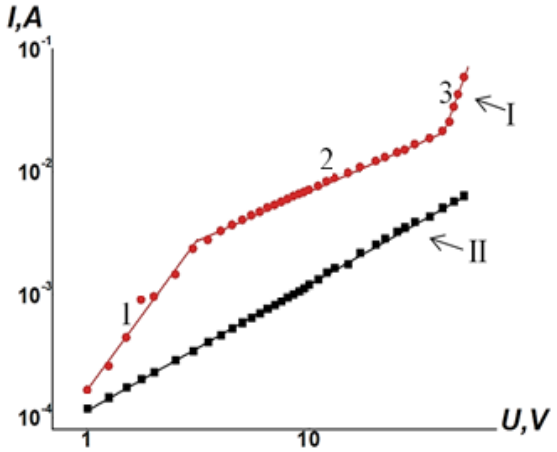

Figure 2. Current-voltage characteristic Au-nCdS-nSi-pCdTe-Au heterostructures in the voltage range from zero to 3 V – $J \propto V^{2.44}$ (1), in the range from 5 to 40 V – $J \propto V^{0.78}$ (2), in the range from 43 to 50 V – $J \propto V^{5.55}$ (3)

The direct branch of the current-voltage characteristics of Au-nCdS-nSi-pCdTe-Au structures (Fig. 2) is well described by power-law dependences of the type – $I = AV^{\alpha}$ with different values of the exponent α. Analysis of the direct branch of the current-voltage characteristic shows that at room temperature there are three pronounced sections in the voltage range from zero to 3 V - $J \propto V^{2.44}$ (1), in the range from 5 to 40 V – $J \propto V^{0.78}$ (2), in the range from 43 to 50 V – $J \propto V^{5.55}$ (3).

According to theory [5], diode structures have a power-law dependence of current on voltage of the type $J \propto V^{\alpha}$, ($\alpha \geq 2$), including a region of sharp increase in current when complex defect-impurity complexes are involved in recombination processes along with point defects, within which electron exchange occurs [17].

$$U = N_R \frac{c_n c_p (pn - {n_i}^2)}{c_n(n+n_1)+c_p(p+p_1)+a\tau_i pn}, \quad (1)$$

where N_R is the concentration of recombination centers (complexes), n, p are the concentrations of electrons and holes, n_i is the intrinsic concentration in the semiconductor, c_n, c_p are the capture coefficients of electrons and holes, n_1, p_1 are the equilibrium concentrations of electrons and holes under conditions, when the Fermi level coincides with the impurity level (the so-called static Shockley-Read factors), τ_i is the time that takes into account certain processes of electron exchange within the recombination complex, a is a coefficient that depends on the specific type of impurity or defect-impurity complexes.

The nCdS-nSi-pCdTe structure under study may contain point defects - vacancies of both cadmium (Cd) atoms and sulfur (S) or tellurium (Te) atoms.

In the sublattice of cadmium atoms, their singly and doubly charged vacancies V_{Cd}^{-}, V_{Cd}^{2-} are easily formed. Doubly charged vacancies of cadmium atoms in most cases form complexes with positively charged impurities of the type $(V_{Cd}^{2-}\ D^{+})^{-1}$ and neutral sulfur atoms of the type $(V_{Cd}^{2-}\ S^{*})^{-2}$[10]. In addition to these complexes, there is a high probability of the formation of such defect-impurity complexes as - "negatively charged acceptor + positively charged interstitial ion" or "positively charged donor + negatively charged vacancy" [18], which play a decisive role in recombination processes.

Despite the difference in the type of complexes, one general pattern can be traced in them - the recombination of nonequilibrium electrons and holes in nCdS-nSi-pCdTe occurs with a delay, and taking into account the inertia of electron exchange inside the recombination complex causes the appearance of the last term in the denominator of formula (1), which, when sufficiently a high level of arousal can become decisive. In this case, the current-voltage characteristic has the following analytical expression in the voltage range from 0 to 4 V:

$$V = A + B\sqrt{J} - \frac{D}{\sqrt{J}}, \quad (2)$$

where A, B and D are constants depending on the properties of the material. The value of the coefficients A = 2,464 V, B = 11.4 V $A^{-1/2}$ and D = 4.4 10^{-4} V·$A^{-1/2}$.

Dependence (2) allows us to describe any value of the slope of the current-voltage characteristic of the type $J \propto V^{\alpha}$, including for sections with a sharp increase in current. As the voltage increases, we can very clearly see the sublinear nature of the dependence of the current on the voltage, which clearly indicates that an injection depletion effect is observed. It is known that the appearance of a sublinear section is usually associated with the imperfection of one of the transitions in the npn or p - n - n^{+} structure. In our case, in the Au-nCdS-nSi-pCdTe-Au structure, since it does not limit the current through the np junction.

In the forward bias direction near the pCdTe-Au-contact, electrons, as well as holes, are accumulated to maintain electrical neutrality due to a high potential barrier of the order of 0.843 eV, which promotes the accumulation of nonequilibrium charge carriers and the appearance of a positive gradient $dn / dx > 0$. As a result, the diffusion and drift flows of carriers are directed towards each other and, starting from a certain value of the bias voltage (5V), these flows are mutually compensated, increasing the base resistance and forming a sublinear dependence [20].

According to the theory given in [18,19] in structures with developed accumulation, a sublinear part of the current-voltage characteristic appears when the conditions $Ja\ d \geq 2$ are met. This shows that for samples of structures based on CdTe-Si-CdS the value $Jad = 3$, at T = 300 K.

This section of the current-voltage characteristic can be well described within the framework of the above theory of the effect injection depletion:

$$V = V_0\, exp(\, aJd), \quad (3)$$

where $a = \frac{1}{2kT\mu_n N_t}$ is a parameter that depends only on the mobility of the majority carriers - electrons (μ_n) and the concentration of deep impurities - N_t. Using expression (3), you can determine the value of the parameter “a” directly from the sublinear section of the current-voltage characteristic, as shown in Fig. 2.
Au-nCdS-nSi-pCdTe-Au with forward and reverse bias on a logarithmic scale:

$$a = \frac{S \cdot ln(V_2/V_1)}{(I_2 - I_1)\cdot d}. \quad (4)$$

The value of the parameter "a" in expression (4), determined on the basis of experimental data on the current-voltage characteristics of the Au-nCdS-nSi-pCdTe-Ag structure was at room temperature $a = 5.22 \cdot 10^4$ cm/A then, accordingly μ_n - $N_t = 2.31 \cdot 10^{15} V^{-1} \cdot cm^{-1} \cdot s^{-1}$. The mobility of the majority carriers was $\mu_n \approx 500$ cm^2/*Vs*, and minority carriers $\mu_p \approx 60$ cm^2/*Vs*, therefore, the concentration of deep impurities leading to the injection depletion effect is $N_t \approx 4.62\ 10^{12}$ cm^{-3}.

With further increase in voltage, as can be seen from Fig. 1. starting from U = 43 V, a sharp increase in current is observed, and the exponent $\alpha \approx 5.55$. This section is called pre-breakdown. In this case, the third term in the denominator of expression (1) becomes significant and the recombination rate no longer obeys the Shockley–Reed statistics. In this case, according to [19], the current-voltage characteristics of the system under consideration take the form:

$$J = \frac{q^2(b+1)^2 N_r d^3}{\varepsilon \tau_i^2 c_p (V_0 - V)}. \quad (5)$$

Where, ε is the dielectric constant and

$$V_0 = \sqrt{\frac{q(b+1)N_r d^4}{2\varepsilon \tau_i \mu_p}} = const. \quad (6)$$

From (5) it is clear that the denominator decreases with increasing voltage, i.e. the increase in current in the voltage range (43÷50) V is described by a dependence like (5). First-principles calculations of band electronic structure based on density functional theory [16,18]. In accordance with the original material data given in Table 4.3 of the multilayer heterojunction Au-nCdS-nSi-pCdTe-Au - structures can be constructed with a high-quality energy band diagram in an equilibrium state.

Table 1. Data on the physical parameters of the studied multilayer heterofilm photosensitive Au-nCdS-nSi-pCdTe-Ag structure

No	Name of parameters		Heterofilm layers		Substrate
			nCdS	pCdTe	nSi
1	Material thickness, W (μm)		0.55	0.55	130
2	Band gap, E_g (eV)		2.42	1.45	1.12
3	Dielectric constant, ε/ε$_0$		9.0	9.4	12
4	Resistivity, ρ (Ohm·cm)		$2 \cdot 10^2$	10^5	600
5	conductivity, σ(Ohm·cm) $^{-1}$		$0.5 \cdot 10^{-2}$	10^{-5}	$0.83 \cdot 10^{-3}$
6	electron affinity, χ(eV)		4.5	4.28	4.01
7	Mobility, cm^2/(V·s)	μ_c	350	500	1200
		μ_p	50	60	500
8	Own concentration of charge carriers, N (cm^{-3})		$1.1 \cdot 10^{18}$	$2.0 \cdot 10^{14}$	$3.6 \cdot 10^{12}$
9	Charge carrier concentration, (cm^{-3})	N_c	$1.8 \cdot 10^{19}$	$7.5 \cdot 10^{17}$	
		N_v	$2.4 \cdot 10^{18}$	$1.8 \cdot 10^{18}$	

Based on the data calculated from the experimental results, a band diagram was constructed Au-nCdS-nSi-p CdTe-Au heterostructure, which is shown in Fig. 3. From the band diagram of the heterostructure it is clear that forward and reverse currents are limited by the resistance of the space charge layer at the interface of the nCdS-n Si and n Si-pCdTe heterojunction. This space charge consists of negatively charged mobile and immobile donor centers, which are located in the nCdS and – p CdTe layer adjacent to silicon, respectively, since the donor concentration in nSi is ten orders of magnitude greater than the carrier concentration in these layers.

In this structure, the contact between Si and nCdS also gives a contact potential difference of U=1.1 eV, however, an enriched layer of space charge appears at the interface of the Si and nCdS layer, since the work function of the metal (Au) present in large quantities in n CdS layer is less than the work function of the semiconductor - Si.

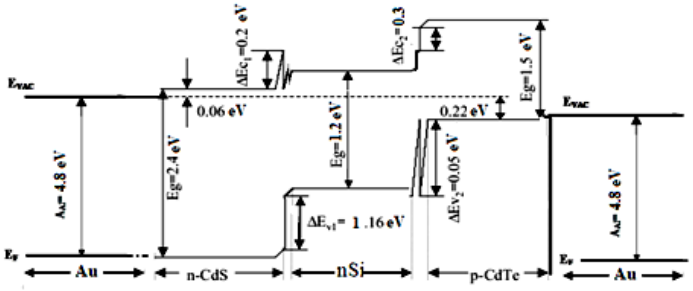

Figure 1. Energy band diagram of the Au-nCdS-nSi-pCdTe-Au structure in the equilibrium state

When illuminated from Au-nCdS-nSi-p CdTe-Au heterojunctions from the rear sides, photogeneration of film carriers of chalcogenide compounds nCdT e and pCdS occurs. The main current carriers diffuse into the n-layer of silicon, where they are separated by the transition field with further acceleration of the carriers by the applied external field, sufficient for impact ionization of Si atoms, which leads to the development of the avalanche process.

It is obvious that the introduction of films of chalcogenide compounds CdT e and CdS into the active region of the diode leads to the following results: firstly, there is an expansion of the spectral range of photosensitivity into the near-IR region below the optical absorption edge of silicon to 1.4 μm, which corresponds to the optical band gap for films of chalcogenide compounds CdT e and CdS at room temperature 300 K [16]; secondly, the photo response in this region has increased by more than two orders of magnitude, including at wavelengths corresponding to the transparency windows of quartz optical fibers, which are used for telecommunications; thirdly, there is an almost tenfold increase in sensitivity near and above the band gap of Si in the region λ = (1.0÷1.4) μm, which is also associated with the contribution to photon absorption and carrier generation in films of chalcogenide compounds CdTe and CdS .

Therefore, the external potential applied to the structure, including the contact potential difference, mainly falls on the space charge layer of the structure boundaries. Moreover, surface states (N_{SS}) at the interface of contacting semiconductors - cadmium sulfide and silicon, can affect the height of the potential barrier. The nature of these surface states is associated with the difference in the crystal lattice constants n CdS and n Si, as well as p CdTe and n Si. The properties of the multilayer diode structure of Au-n CdS-nSi-pCdTe-Au heterojunctions depend on the technological parameters and method conditions.

CONCLUSIONS

The conducted studies show that the current-voltage characteristic of Au-nCdS-nSi-pCdTe-Au structures has three sections: power-law - $I \propto V^{2.44}$, sublinear $V \propto \exp(Jad)$, and prebreakdown dependence – $I \propto V^{5.55}$, arising in nCdS-nSi-pCdTe layers with a change in current density at a constant temperature due to a change in the type of recombination processes. Recombination of nonequilibrium carriers at low current densities occurs through point local centers (defects), and at high current densities, complex complexes are responsible for the recombination processes, within which electron exchange occurs.

Based on the data obtained, it was established that in the layers nCdS-nSi-pCdTe photosensitive Au-nCdS-nSi-pCdTe-Au structure, impurity complexes (defects) are formed, in which the rate of recombination of nonequilibrium carriers at low excitation levels is determined by simple local centers in the boundary transition layers. A band diagram of a multilayer photodiode structure Au-nCdS-nSi-pCdTe-Au has been constructed, which can be schematically described as Au-nCdS-nCdS-nSi-nSi-pCdTe+pCdTe-Au.

ORCID

Sharifa B. Utamuradova, https://orcid.org/0000-0002-1718-1122, **Khodjakbar S. Daliev,** https://orcid.org/0000-0002-2164-6797
Shakhrukh Kh. Daliev, https://orcid.org/0000-0001-7853-2777; **Sultanpasha A. Muzafarova,** https://orcid.org/0000-0001-5491-7699
Kakhramon M. Fayzullaev, https://orcid.org/0000-0001-7362-1439; **Gulnoza A. Muzafarova,** https://orcid.org/0009-0002-1773-920X

REFERENCES

[1] M. Bass, *et al*., editors, *Handbook of optics*, Vol. 2. (New York, McGraw-Hill, 1995).
[2] Z.T. Azamatov, M.A. Yuldoshev, N.N. Bazarbayev, and A.B. Bakhromov, "Investigation of Optical Characteristics of Photochromic Materials," Physics AUC, **33**, 139-145 (2023). https://cis01.central.ucv.ro/pauc/vol/2023_33/13_PAUC_2023_139_145.pdf
[3] K.S. Daliev, Sh.B. Utamuradova, J.J. Khamdamov, and M.B. Bekmuratov, "Structural properties of silicon doped rare earth elements ytterbium," East European Journal of Physics, (1), 375–379 (2024). https://doi.org/10.26565/2312-4334-2024-1-37
[4] Z.T. Azamatov, Sh.B. Utamuradova, M.A. Yuldoshev, and N.N. Bazarbaev, "Some Properties of Semiconductor-Ferroelectric Structures," East Eur. J. Phys. (2), 187-190 (2023). https://doi.org/10.26565/2312-4334-2023-2-19
[5] N.A. Sultanov, Z.X. Mirzajonov, F.T. Yusupov, and T.I. Rakhmonov, "Nanocrystalline ZnO Films on Various Substrates: A Study on Their Structural, Optical, and Electrical Characteristics," East Eur. J. Phys. (2), 309-314 (2024), https://doi.org/10.26565/2312-4334-2024-2-35
[6] A. Heintz, B. Ilahi, A. Pofelski, G. Botton, G. Patriarche, A. Barzaghi, and A. Boucherif, "Defect free strain relaxation of microcrystals on mesoporous patterned silicon," Nature Communications, **13**(1), 6624 (2022). https://doi.org/10.1038/s41467-022-34288-4
[7] Z.L. Wang, Y. Liu, and Z. Zhang, *Handbook of nanophase and nanostructured materials II*, (Kluwer Academic Plenum, 2003).
[8] H.S. Nalwa, *Photodetectors and Fiber Optics*, (Academic Press, 2001).
[9] Sh.B. Utamuradova, A.V. Stanchik, K.M. Fayzullaev, and B.A. Bakirov, "Raman scattering of light by silicon single crystals doped with chromium atoms," Applied Physics, (2), 33–38 (2022).
[10] Y. Liu, Y. Li, Y. Wu, G. Yang, L. Mazzarella, P. Procel-Moya, A.C. Tamboli, *et al.*, "High-efficiency silicon heterojunction solar cells: materials, devices and applications," Materials Science and Engineering: R: Reports, **142**, 100579 (2020), https://doi.org/10.1016/j.mser.2020.100579
[11] Sh.B. Utamuradova, and D.A. Rakhmanov, "Effect of Holmium Impurity on the Processes of Radiation Defect Formation in n-Si<Pt>," Annals of the University of Craiova, Physics, **32**, 132–136 (2022). https://cis01.central.ucv.ro/pauc/vol/2022_32/15_PAUC_2022_132_136.pdf
[12] M.H. Abdullal, R.A. Jaseen, and A.H. Resan, "Annealing effect on the optical energy gap of (CdTe) thin films," J. Pure Sciences, **7**(3), 205-213 (2011), https://www.iasj.net/iasj/pdf/ccf116d82c221e01
[13] Sh.B. Utamuradova, D.A. Rakhmanov, A.S. Doroshkevich, Z. Slavkova, and M.N. Ilyina, "Impedance spectroscopy of p-Si<Pt>, p-Si<Cr> irradiated with protons," Advanced Physical Research, **5**(1), 5–11 (2023). http://jomardpublishing.com/UploadFiles/Files/journals/APR/V5N1/Utamuradova_et_al.pdf
[14] T.M. Razikov, S.A. Muzafarova, R.T. Yuldoshov, Z.M. Khusanov, M.K. Khusanova, Z.S. Kenzhaeva, and B.V. Ibragimova, East Eur. J. Phys. (1), 370-374 (2024). https://doi.org/10.26565/2312-4334-2024-1-36

[15] A.J. Mawat, M.H. Al-Timimi, W.H. Albanda, and M.Z. Abdullah, "Morphological and optical properties of $Mg_{1-x}CdS_x$ nanostructured thin films," AIP Conference Proceedings, **2475**(1), 090019 (2023). https://doi.org/10.1063/5.0103955
[16] F.A. Giyasova, "Study of the spectral and temporal characteristics of a heterofilm photosensitive Au-nCdS-nSi-pCdTe-Au structure," Scientific journal "Physics of Semiconductors and Microelectronics", **4**(1), 42-50 (2022).
[17] Sh. B. Utamuradova, A.S. Achilov, R.R. Kabulov, and S.A. Muzafarova, "Effect of temperature on the current transfer mechanism in the reverse I-V characteristics of the n-CdS/i-CdS_x Te_{1-X} / p-CdTe heterostructure," Modern Physics Letters B, **37**(33), 2350162 (2023). https://doi.org/10.1142/S0217984923501622
[18] A.S. Saidov, K.A. Amonov, and A.Yu. Leiderman, "Study of the dependence of the current-voltage characteristic p-Si–n-$(Si_2)_{1-x-y}(Ge_2)_x(ZnSe)_y$-structures on temperature," Computational nanotechnology, **6**(3), 16-20 (2019). (in Russian)
[19] Sh.B. Utamuradova, S.Kh. Daliev, S.A. Muzafarova, and K.M. Fayzullaev, "Effect of the Diffusion of Copper Atoms in Polycrystalline CdTe Films Doped with Pb Atoms," East Eur. J. Phys. (3), 385 (2023). https://doi.org/10.26565/2312-4334-2023-3-41
[20] A.H.H. Asal, and S.N.T. Al-Rashid, "Effects of Quantum Confinement Energy on the Transmittance of Cadmium Telluride (CdTe) Within the Near Infrared Region (700-2500nm)," East. Eur. J. Phys. (3), 329 (2023), https://doi.org/10.26565/2312-4334-2023-3-33

ВОЛЬТ-АМПЕРНА ХАРАКТЕРИСТИКА ФОТОЧУТЛИВОЇ ГЕТЕРОПЛІВКОВОЇ СТРУКТУРИ Au-CdS-nSi-CdTe-Au

Шаріфа Б. Утамурадова[a], Ходжакбар С. Далієв[b], Шахрух Х. Далієв[a], Султанпаша А. Музафарова[a], Кахрамон М. Файзуллаев[a], Гульноза А. Музафарова[a]

[a]Інститут фізики напівпровідників і мікроелектроніки Національного університету Узбекистану, 100057, Узбекистан, Ташкент, вул. Янги Алмазор, 20

[b]Філія ФДБУ «Національний дослідницький університет МПЕІ», Йогду, 1, Ташкент, Узбекистан

Наведено результати досліджень вольт-амперних характеристик фотодіодної гетероструктури. Au-nCdS-nSi-pCdTe-Au, в прямому і зворотному напрямках. Створено фотодіодні гетероструктури площею 29 мм^2, отримані методом вакуумного напарювання у квазізамкнутому об'ємі шляхом нанесення шарів сульфіду кадмію та телуриду кадмію на підкладку монокристалічного кремнію. з питомим опором ρ=607,47 Ом·см. Відмінною особливістю отриманих фотодіодних структур Au-nCdS-nSi-pCdTe-Au є двостороння чутливість, де утворюються домішкові комплекси. У структурах швидкість рекомбінації нерівноважних носіїв на низьких рівнях збудження визначається простими локальними центрами в граничних перехідних шарах. Побудовано зонну діаграму багатошарової фотодіодної структури Au-nCdS-nSi-pCdTe-Au.

Ключові слова: *питомий опір; інтенсивність; струм; гетероперехід; фотодіод; структура; перехід; мікроінтерферометр; вакуум; ємність; смугова діаграма*