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PHOTOELECTRIC PROPERTIES OF THE STRUCTURE Cr-ZnSe WITH SCHOTTKY BARRIER

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Explored the structures based on the ZnSe single crystal with a semitransparent layer of chromium. The current-voltage and capacitance-voltage characteristics of the structures indicate that Cr-ZnSe contact is a lock and close in its properties to the Schottky barrier. The calculated equilibrium barrier height is 1.22 eV. In the structures in the reverse biased direction to the detected occurrence of photosensitivity wavelength region of the spectrum up to 230 nm wavelength. This is due to the deterioration of conditions for the recombination of photoexited carriers in fast recombination centers in a strong electric field in the surface region of the reverse bias pin barrier. Calculated from critical frequency of the photocurrent spectrum contact barrier height value of 1.18 eV goes with the results obtained from the C-V characteristics.

1. INTRODUCTION

In recent years, especially acute problem of reception and quantifying ultraviolet (UV) radiation. One of the most promising types of UV photodiode receivers is the Schottky barrier. Surface potential barrier provides effective separation of charge carriers born in this area as a result of absorption of energy quantums significantly larger than band gap. For the manufacture of such detectors wide semiconductor compounds are used mainly [1, 2].

The literature contains information about the photo detectors based on the contact Ni-ZnSe [3, 4], having a sufficiently high sensitivity in the range of 0,25-0,5 microns. Other possible metals suitable for the manufacture of zinc selenide with a Schottky barrier may be an element of the same group of the periodic table - chromium. Optical characteristics of the semitransparent film of chromium in the aforementioned spectral region is not worse than the thin films of nickel. The films show good adhesion of chromium to the surface of the zinc selenide crystal. However, increasing the work function of chromium (4,6 eV) than that of nickel (4,4 eV) allows us to expect that the potential barrier in contact Cr-ZnSe is higher than in contact Ni-ZnSe. This should yield higher intensity of the internal electric field in the surface region of the contact barrier and, finally, lead to increased photosensitivity of photodetector in the near UV - spectrum [5]. In this paper, on the chemically polished surface of low-resistivity single crystals of zinc selenide were deposited translucent chromium films. Purpose of the research was to determine the parameters of the contact barrier Cr-ZnSe, the study of its electrical and spectral characteristics and finding the possibility of using such a structure as a photodetector in the near-UV - spectrum.

2. EXPERIMENT AND DISCUSSION

Figure 1 shows the current-voltage characteristics of the structure of Cr-ZnSe, measured at opposite polarities of bias. As can be seen, the contact shows rectifying properties (rectification ratio at 0,8 V voltage reaches 10^7). This indicates that in the Cr-ZnSe contact exists a sufficiently high potential barrier. Under reverse bias (Fig. 1, curve 2) current-voltage characteristic obeys to dependency $I \sim V^{1/2}$, which is typical for "thick" Schottky barrier.

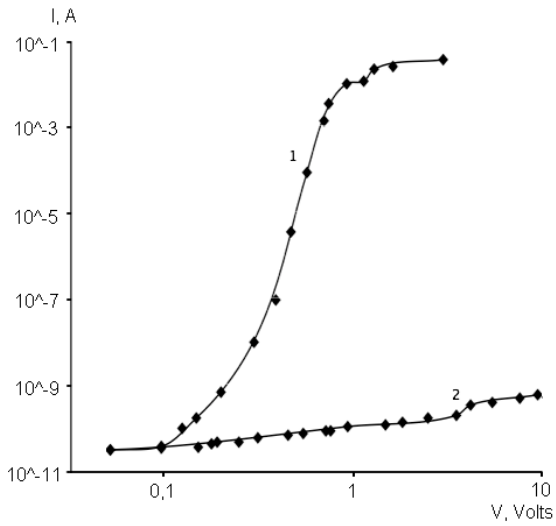

Fig. 1. The current-voltage characteristics of the Cr-ZnSe contact, measured by direct (1) and reverse (2) bias.

With direct polarity of the applied bias (Fig. 1, curve 1) current-voltage characteristic is described by I~exp (e·V/ß·k·T), as evidenced by its straightening in coordinates lnl ÷ V.

ß ideality factor was ß ≈ 1,47. The obtained value of ß, significantly greater than one, allows to conclude that in Cr-ZnSe contact a thin oxide layer is present, as well as a sufficiently high density of surface states.

Figure 2 (curve 1) shows the capacitance-voltage characteristics of the test contact. Curve 2 shows the dependency C-V, built in the coordinates $(S/C)^2$-V, typical for the Schottky barrier [6]. Extrapolation of this dependence on the voltage axis (Fig. 2, curve 2) allows to determine the equilibrium height of φ barrier for electrons from the semiconductor. It is equal to φ ≈ 0,98 eV.

Using the numerical value of the capacitance at zero bias (Fig. 2, curve 1) was estimated the equilibrium barrier thickness (L ≈ 2,8 μm). The numerical value of the slope of the curve 2 (Fig. 2) allowed to calculate the equilibrium of concentration of free electrons in the ZnSe crystal ($n_0 \approx 1,2*10^{14}$ cm^{-3}) and the energy separation of the equilibrium of Fermi level from the bottom of the conduction band in the semiconductor (E_f=0,24 eV). In the calculations for zinc selenide were accepted the values of the relative permittivity ε= 9,1 and electron mobility μ_n = 500 cm^2/V·s.

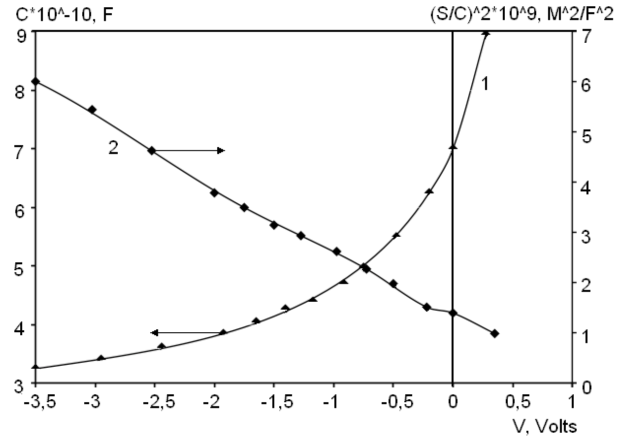

Fig. 2. Capacitance-voltage characteristics of Cr-ZnSe contact.

Point values of E_f and *φ* allowed us to construct the energy diagram of the Cr-ZnSe test contact, which in the absence of applied bias is shown schematically in Fig. 3.

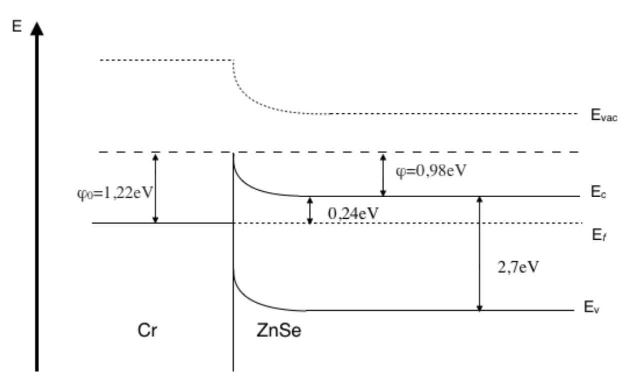

Fig. 3. Energy diagram of the Cr-ZnSe contact balance.

Figure 4 represents the spectral characteristics of photocurrent at different bias conditions of the structure. Curve 1 (Fig. 4) shows the photocurrent spectrum in direct applied voltage V=+l V, i.e. in an environment where the potential barrier φ is practically “smoothed”. Therefore, the curve 1 actually reflects the spectral photosensitivity of the total volume of the ZnSe crystal. Slump photosensitivity in the wavelength region of the spectrum due to the fact that the incident light rays with energies, greater than the band gap, are absorbed in a thin surface layer of the crystal, where is a high density of surface fast recombination centers. Depending on this, apart from its own high photosensitivity (λ_{max} = 460 nm), there are also two bands of impurity photoconductivity. These are a mild band with a maximum at a wavelength at λ_{max} = 530 nm and a broad band with a maximum at λ_{max} = 800 nm. Nature of these bands is known and associated with associative defects ($V_{Zn}Al_{Zn}$).

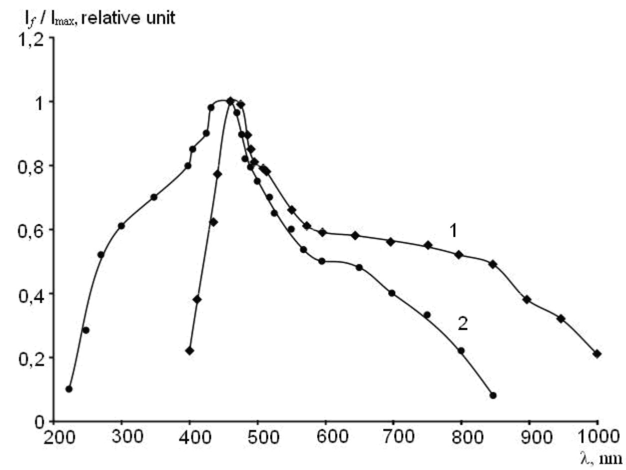

Fig. 4. Spectral dependence of the photocurrent structure of Cr-ZnSe and a forward bias V=+1 V (1) and a reverse bias V=-5 V (2).

Curve 2 (Fig. 4) shows the photocurrent spectrum measured under reverse bias contact V=-5V. A significant increase in photosensitivity short wavelengths up to wavelength $\lambda \approx 230$ nm can be seen. It is due to the fact that the surface in the excited electrons of the semiconductor layer under the influence of the field in the region of the barrier are moved from the illuminated surface into the sample without time to recombine with holes.

Maximum on the graph corresponds to transitions, when the incident photon energy is close to the band gap. Also on the schedule (curve 2) can be seen a lingering long-wavelength tail, which can be explained by the photoemission of electrons from the metal. If the energy of the incident quantum is not less than the height of the barrier, the electrons to overcome barriers contribute to the photocurrent, leading to an increase in the photocurrent. If the quantum energy is less than the height of the potential barrier, the electrons are no longer able to overcome it and the photocurrent decreases, which explains the long-wavelength limit.

According to the Fowler formula [7], a long wavelengths photocurrent under reverse bias can be transformed into coordinates $I_{\phi}^{1/2}$- (hv), in which this dependence should rectify (Fig. 5). By extrapolating the resulting line on the energy axis the height of the barrier from the metal φ_0’ can be determined. It proved to be φ_0’= 1,18 eV, which goes well with the results obtained from the energy diagram (Fig. 3) φ_0 = 1,22 eV.

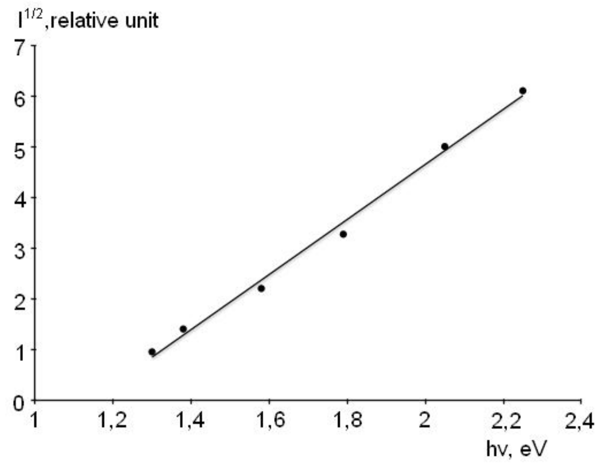

Fig. 5. Long wavelengths photocurrent under reverse bias V =-5 V, built in coordinates $I_f^{1/2}$-(hv).

3. CONCLUSIONS

The results show that the locking contact Cr-ZnSe shows sufficient photosensitivity in spectral region of wavelengths $\lambda \geq 0{,}23$ microns. It can be used in the development of radiation detectors in the near-UV region of the spectrum.

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Abstract

Explored the structures based on the ZnSe single crystal with a semitransparent layer of chromium. The current-voltage and capacitance-voltage characteristics of the structures indicate that Cr-ZnSe contact is a lock and close in its properties to the Schottky barrier. The calculated equilibrium barrier height is 1.22 eV. In the structures in the reverse biased direction to the detected occurrence of photosensitivity wavelength region of the spectrum up to 230 nm wavelength. This is due to the deterioration of conditions for the recombination of photoexited carriers in fast recombination centers in a strong electric field in the surface region of the reverse bias pin barrier. Calculated from critical frequency of the photocurrent spectrum contact barrier height value of 1.18 eV goes with the results obtained from the C-V characteristics.

Key words: Schottky barrier, UV receiver, photosensitivity, fast recombination centers.

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ФОТОЕЛЕКТРИЧНІ ВЛАСТИВОСТІ СТРУКТУР Cr-ZnSe З БАР'ЄРОМ ШОТТКИ

Резюме

Досліджено структури на основі монокристалів ZnSe з напівпрозорим шаром хрому. Вольт-амперні та вольт-фарадні характеристики структур свідчать, що контакт Cr-ZnSe є запірним та близьким за своїми властивостями до бар'єру Шоттки. Розрахована рівноважна висота бар'єру складає 1,22 еВ. В структурах, зміщених у зворотньому напрямку, виявлено виникнення фоточутливості в короткохвильовій області спектру аж до довжини хвилі 230 нм. Це зумовлено погіршенням умов для рекомбінації фотозбуджених носіїв на центрах швидкої рекомбінації в сильному електричному полі у приповерхневому шарі зворотньо зміщеного контактного бар'єру. Розраховане із довгохвильової межі спектру фотоструму значення висоти контактного бар'єру 1,18 еВ добре узгоджується з результатами, отриманими із C-V характеристик.

Ключові слова: бар'єр Шоттки, УФ-приймач, фоточутливість, центри швидкої рекомбінації.

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ФОТОЭЛЕКТРИЧЕСКИЕ СВОЙСТВА СТРУКТУР Cr-ZnSe С БАРЬЕРОМ ШОТТКИ

Резюме

Исследованы структуры нас основе монокристаллов ZnSe с полупрозрачным слоем хрома. Вольт-амперные и вольт-фарадные характеристики структур свидетельствуют, что контакт Cr-ZnSe является запорным и близким по своим свойствам к барьеру Шоттки. Рассчитанная равновесная высота барьера составляет 1,22 эВ. В структурах, смещенных в обратном направлении, обнаружено появление фоточувствительности в коротковолновой области спектра вплоть до длины волны 230 нм. Это связано с ухудшением условий для рекомбинации фотовозбужденных носителей на центрах быстрой рекомбинации в сильном электрическом поле в приповерхностной области обратно смещенного контактного барьера. Рассчитанное из длинноволновой границы спектра фототока значение высоты контактного барьера 1,18 эВ хорошо согласуется с результатами, полученными из C-V характеристик.

Ключевые слова: барьер Шоттки, УФ-приемник, фоточувствительность, центры быстрой рекомбинации.