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THE EFFECT OF INHOMOGENEITY ON THE EFFICIENCY OF SEMICONDUCTOR PHOTODETECTORS

Annotation: In this article, causes of abnormal photovoltaic voltage (APV), asymmetry in light illumination at the boundary of crystallites, the angle dependence of the APV effect in CdTe thin films are studied. It is shown that the processes of the emergence and diffusion of photocarriers are related to the formation of the priority absorption areas of the light and shadow areas in the angular illumination of the samples.

Keywords: *APV, thin curtains,thermal condensation, molecular flow, columnar structure, roughness, crystallite boundary (CB), surface states, optical phenomena, refraction of light.*

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ВЛИЯНИЕ НЕОДНОРОДНОСТИ НА ЭФФЕКТИВНОСТЬ ПОЛУПРОВОДНИКОВЫХ ФОТОДЕТЕКТОРОВ

Аннотация: В данной статье исследованы причины появления АФН, асимметрия светового освещения на границе кристаллитов, угловая зависимость эффекта АФК в тонких пленках CdTe. Показано, что процессы появления и диффузии фотоносителей связаны с формированием областей приоритетного поглощения световых и теневых участков при угловом освещении образцов.

Ключевые слова: *АФН, тонкие пленки, термическая конденсация, молекулярный поток, столбчатая структура, граница кристаллитов (ГК), поверхностные состояния, оптические явления, преломление света.*

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YARIM O’TKAZGICHLI FOTOQABUL QILGICHLARNING SAMARADORLIGIGA BIR JINSLI EMASLIKNING TA’SIRI

Annotatsiya. Ushbu maqolada, AFKning paydo bo'lishi sabablari, kristalitlar chegarasida nurning yoritilishidagi assimetriyasi, CdTe yupqa pardalarida AFK effektining

burchakka bog'liqliklarini o'rganilgan. Fototashuvchilarning paydo bo’lishi va diffuziyalanish jarayonlari namunalarning burchakli yoritilishida yorug'lik va soya sohalarning ustuvor yutilish sohalarini shakllantirish bilan bog'liqligi ko’rsatilgan.

Kalit so‘zlar: *AFK, yupqa pardalar, termik kondensatsiya, molekulyar oqim, ustunsimon tuzilma, g'adir-budirlik, kristallitlar chegarasi (KCH), sirt holatlari, optik hodisalar, yorug'likning qaytarilishi.*

Introduction

The basis of modern electronics, microelectronics and nanoelectronics, is devices based on semiconductors and semiconductor thin-film structures. Because in microelectronics, semiconductor materials are used to convert various signals, and in energy, to convert one type of energy into another. They are classified according to their function, mode of operation, material, structure and production technology, and field of application [1].

Methods

Photocells made of semiconductors allow the direct conversion of solar radiation energy into electrical energy (solar cells). They are a source of electrical energy without polluting the environment and without using fossil fuels, the reserves of which are running out. Thin films with APV are obtained by thermal condensation of a semiconductor material on a dielectric substrate (e.g. glass) in vacuum [2]. Such thin films grow continuously in the direction of molecular currents and acquire a columnar structure (Fig. 1). Changing the direction of molecular currents, for example by changing the position of the substrate - the growth of crystallites whose plane is not perpendicular to the direction of molecular currents on the substrate, leads to changes in properties that are not exactly the same in different directions.

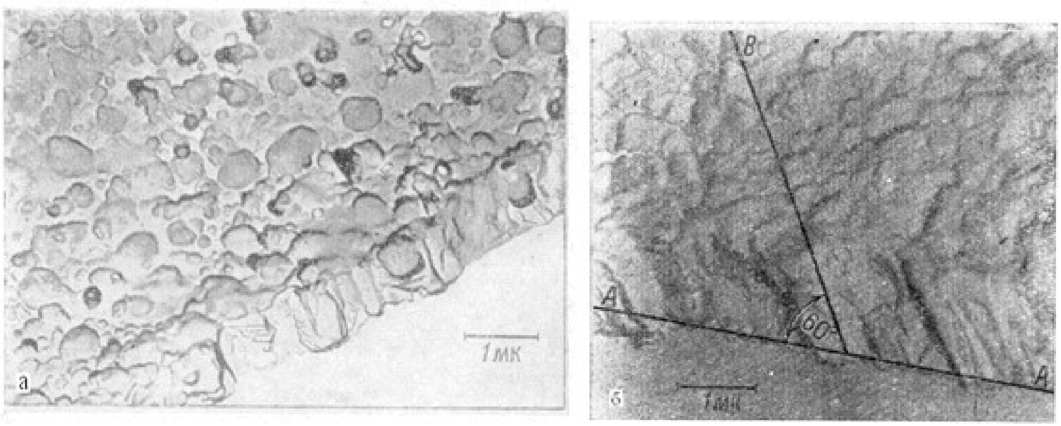


Figure 1. Electron microscopic image of the surface (a) and the fractured side (b) of a thin film of PbS. B - is the direction of molecular flow, AA - is the base surface.

Has been experimentally confirmed that the surface of each crystallite is "rough". This is a relief called "natural rough", which is also due to the minimum free energy requirement. Roughness can be the reason for the appearance of surface at the boundary of crystallites [3].

Considering the individuality of the crystallite surface in thin films , it is necessary to take into account the properties of light transmission through the CB in optical phenomena, in particular its reflection [4]. The roughness of the CB may be the main reason for their reflectivity level (Fig . 2).

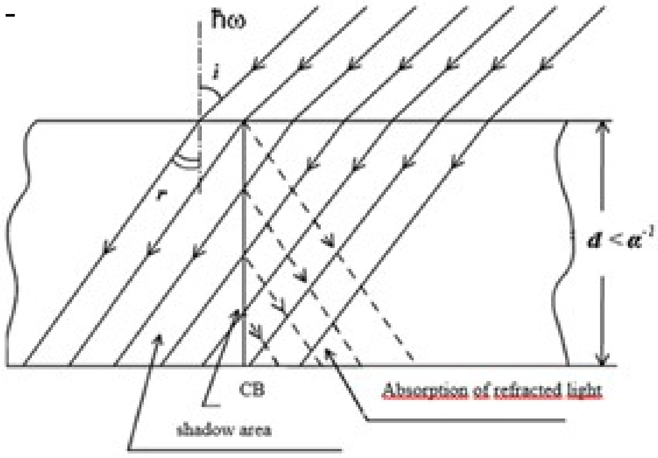


Figure 2. Absorption of a plane-parallel light beam incident on a thin film at an angle, obtained under the condition of the molecular stream incident perpendicular to the base plane. r – angle of refraction; d – thickness of the thin film; α- light absorption coefficient.

The main conclusion that follows from figure 2 is that the absorption of light over the volume of the thin film is not uniform due to the reflection of the light incident on it by the CB. The symmetry that occurs during normal incidence of a light beam is broken when it is illuminated at an angle to the surface and leads to the formation of preferential absorption areas of light and shadow. This is one of the natural reasons for the appearance of APV in such structures. The intensity of the light entering the shadow region through the CB has a lower intensity than the intensity of the primary light incident on the thin film.

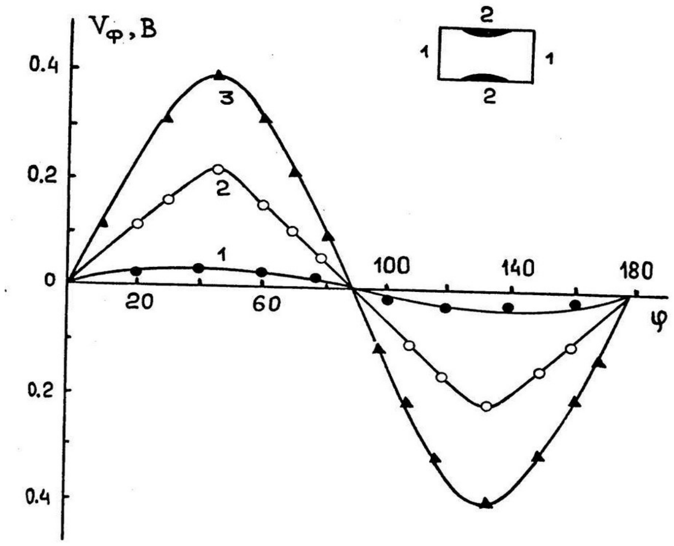
Thus, the reason for the appearance of APV is the asymmetry of the light illumination in the CCH. To clarify the conclusions, we studied the angular dependence of the APV effect φon CdTe thin films . Thin films were obtained by changing the angle of incidence of the molecular stream on the substrate ( ). In this case, an acute angle between $\varphi$the substrate plane and the molecular stream ($0 \leq \varphi \leq 90^0$). The films had a pronounced polycrystalline structure. To change the concentration of SHs in the CCH, the energy spectrum, and other properties, the samples were treated with heating in air.

Figure 3 shows the amplitude of the AFC (V_{APV}) The dependence of the incident light flux angle (α) on the incident light flux for thin films obtained by passing a molecular stream perpendicular to the substrate is shown ($\varphi=90^0$). The angle of illumination varied in the range $0 \leq \alpha \leq 180^0$, so αat = $\varphi=90^0$ light propagates parallel to the CB plane. It can be seen from the figure that the inversion of the sign of V α_{APV} occurs at = $\varphi=90^0$. APV The characteristic V_{APV} (α) is strictly symmetrical with respect to the inversion point (the direction of the molecular current). The amplitude of the effect to the left and right of the inversion point is the same. During heating, only an increase in the amplitude of the effect is observed, which is associated with a change in the electronic properties of the CB due to diffusion processes leading to a change in the SH parameters.

Results and Discussion

As can be seen from these data, the geometric factor is clearly evident in the experimental manifestation of the effect:

1) the inversion of the effect is again observed when the molecular stream and the plane-parallel light directions on which it falls coincide; in the geometry of our experiments, $\varphi$when the condition + $\alpha=180^{0 \text{ is met}}$ (Figure 4);



α, deg

after treatment with heating in air at 200 and 300 $^{0\,C}$, respectively.

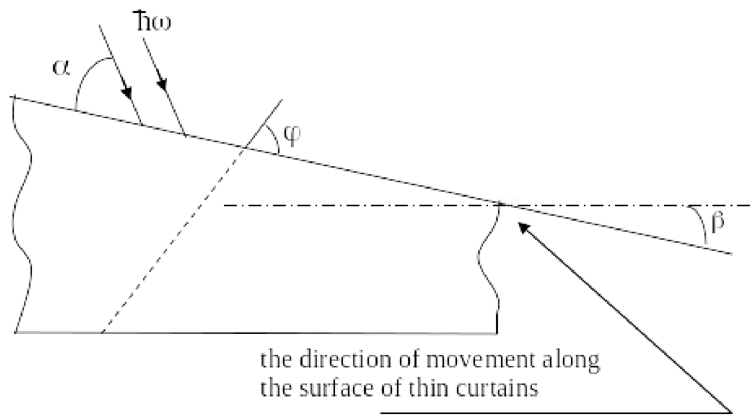


Figure 4. Geometry of the experiment

2) the angular characteristics of the molecular stream at each angle of incidence are asymmetric with respect to the point of inversion of the sign of the effect (primarily, this concerns the amplitude of the effect); This is due to the fact that when illuminated from the right, a significant part of the volume of the thin curtain in our terminology becomes a shadow area;

3) the angle of incidence of light at which the maximum amplitude of the effect is observed follows the angle of incidence of the molecular stream; In addition, the APV The maximum will have an empirical dependence on the angular position.

On the left $\alpha_{is\,1}\left(V^{MAX}_{APV}\right)\approx(180-\varphi)/2$ and on the right is $\alpha_2\left(V^{MAX}_{APV}\right)\approx\varphi/2$, so $\alpha_1\left(V^{MAX}_{APV}\right)+\alpha_2\left(V^{MAX}_{APV}\right)=90^{0}$.

The AFC effect produces photoelectrons that diffuse into an adjacent potential barrier in a thinner part of the thin film (Figure 5).

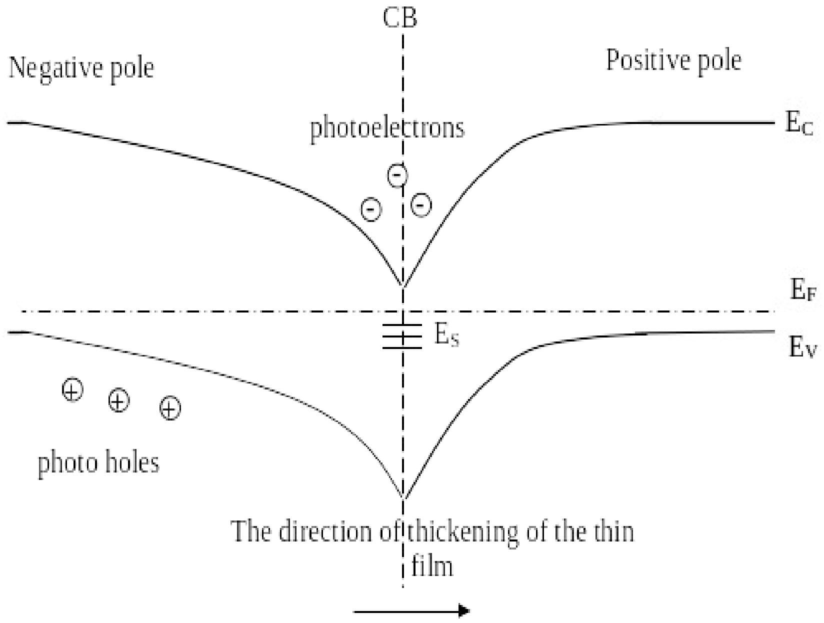


Figure 5. Zone structure of an illuminated p-CdTe thin film

Conclusion

The increase in the amplitude of the effect during heating (curves 2, 3) is associated with a change in the height of the potential barrier in the CB due to the oxygen SC formed by the diffusion of oxygen atoms along the CB. An increase in the amplitude of the Zons bending in the inversion channel leads to an increase in the electron concentration, which, as a result, leads to a decrease in the share of photoelectrons in the total number of electrons in the channel. Ionized electrons repel photoelectrons, which leads to a decrease in the amplitude of the APV effect.

APV for newly planted and lightly tilled thin grasses (α) The maximum value of V APV on the left and right sides of the connection. The appearance of additional peaks is probably due to the contribution of the main photocarriers to the effect. Their appearance and diffusion processes are associated with the formation of preferential absorption zones of light and shadow areas under angular illumination of the samples. Thus, the theoretical considerations presented here show almost complete agreement with the experiments discussed here. The simplicity of the mechanism and its compatibility with other phenomena indicate its viability.

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