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Research Article

ANOMALOUSLY HIGH DIOTOVOLTAIC EFFECT IN THIN FILMS OF GALLIUM ARSENIDE

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ABSTRACT

The current-voltage characteristics of APN elements manufactured by vacuum anisotron evaporation have been studied. It was found that there are inhomogeneities in a series of successive p–n–p transitions.... The dependence of the current-voltage characteristics of oxygen-enriched environments on temperature and illumination was tested.

KEYWORDS

APV element, amnisatron evaporation, potential barriers, photoconductivity, microcrystallites, filling centres, point, shear resistance, electrical neutrality condition, photo, thermal conductivity concentration, clusters, capture, photovoltage, photovoltage, photocarriers.

INTRODUCTION

The theoretical physicist in the field of solid state physics, Doctor of Physical and Mathematical Sciences, and member of the Academy of Sciences of Uzbekistan Adirovich E.I. et al [1] obtained semiconductor thin films from gallium arsenide (GaAS) with anomalously high photovoltage. (~100 V) using a simple thermal evaporation method. Later in [2], an anomalously high photovoltage (~5 V) was also observed in thin films of series semiconductors belonging to the AIIIBV group. Karpovich [3] experimentally established that the magnitude of the anomalous photovoltaic voltage and its direction vary depending on the angle of incidence of light on the

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surface of the sample. In their opinion, it is possible to find a direction in which, when illuminating a sample with this direction, the anomalously high photovoltage (APV) approaches zero, and then the photovoltage changes polarity. Later it became known that this state corresponds to the direction of growth of its microcrystals during the formation of thin GaAS films [4]. Studies of thin films of gallium arsenide and other semiconductors have shown that anomalous diagrams of the dependence of photovoltage on the angle of illumination are one of the defining characteristics. These studies make it possible to determine the physical nature of the anomalously high photovoltages generated in APV elements. According to Figelsky [5], photovoltage (abnormally high) occurs at the boundary of microcrystals with localized conditions in the form of surfaces or dislocations in a semiconductor polycrystalline thin film. These states are charged and form a potential barrier. Electron and hole photocarriers, inert under the influence of light, are generated on one side of the potential barrier and separated by the barrier medium [6-11]. They create a potential difference in neighbouring microcrystals (Fig. 1). In this case, the following expression is suitable for the elementary microphotovoltage.

$$V_{\phi} = \frac{\kappa T}{q} \frac{\Delta \eta_{ч}}{\eta_{н}} \left(\frac{J_n}{J_n + J_{cc}} \right) \qquad (1)$$

$\eta_{н}$-concept of non-primary charge carriers,
$\Delta\eta_{ч}$ – concentration of charge carriers formed under the influence of light.

The photovoltage reaches its maximum value when the ratio of the currents of the majority charge carriers and minority charge carriers Jn in the expression for micro photovoltage is Jos: Jn <<1. This state means the presence of structural systems of the p–n–p or n–p–n-type at the boundary of veil-shaped crystallites. One of the factors causing anomalously high photovoltage is photodiffusion processes in homogeneous areas of a thin film (Dember effect) [6,7]. In the experimental samples, there are "oxide" areas between the microcrystals of the curtain, and their resistance is quite high. These boundary regions prevent the exchange of intercrystalline-free carriers. Because the resistivity of the material evaporated in a vacuum differs from the resistivity of the thin film obtained from it (much, several times less).

MATERIALS AND METHODS

Quite a lot of work has been published on the nature of formation, production technology, features and areas of application of abnormally high photovoltage (APV) [9]. The mechanism of the effect in APV technology - the production of elements from any semiconductor material - is a sufficient task that requires a solution. These problems cause differences in the characteristic parameters of the element. As a result, the imperfection of practical and theoretical criteria that clarify the experimental characteristics causes certain difficulties in the areas of practical application of APV elements. For these reasons, it is necessary to deepen and expand the scope of work in this area. To do this, let's try to clarify the essence and characteristics of the APV - the

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element of the current voltage characteristic (CVC). The point is that if there are potential obstacles in the heterogeneity of the FSA element, then in its current-voltage characteristic nonlinearities of various shapes are observed (deviation from Ohm's law). As a result of studying the APV element of the current-voltage characteristic, it will be possible to determine a criterion that will clarify the mechanism of formation of APV [10]. To determine the ROS mechanism, an alternating voltage is applied under the influence of light, such as the current-voltage characteristic. Voltage is applied to the vertical deflection plate (electrode) of the oscilloscope through a load resistor. It is proportional to the voltage passing through the sample. The voltage applied to the sample is applied to the horizontal electrode plate of the oscilloscope. As a result, a CVC chart for one period will appear on the screen. The oscillogram is studied by taking a photograph (computer image) from the screen. Nonlinearity in CVC is not noticeable at low illumination and area but appears at large values of area and illumination. Based on the purpose of the study, the absolute value of voltage and current in the current-voltage characteristic is important, and not the absolute (real) value, because the nature of the current-voltage characteristic curves is shown on the oscillogram. The sign and magnitude of the photovoltage associated with illumination depend on the asymmetry of the current-voltage characteristic in accordance with the direction of the external voltage applied to it. As the field approaches 3.103 V/cm, a sharp increase in current is observed. In conventional units, the CVC of samples selected by the anisotron method of thermal evaporation for unlit (V = 0, Fig. 2-a) and illuminated (V = 0, Fig. 2-b) conditions are shown in Fig. 1. From the figure it can be seen that the approximate slope of CVC obtained for the case of CVC is x v. If potential barriers "shrink" under the influence of light, then at high values of luminous intensity (or illumination), the potential barriers disappear and the current-voltage characteristic rectifies (representing the classical OM connection). This situation occurs at $\Delta n = \frac{N_0 \chi}{\lambda}$ where N_0 is the concentration of donors and acceptors, for GaAS about 10^{18} cm, $^{-3}$ d is the thickness of the thin film of the AFC element when it is 1 μm, the concentration of photoelectrons occurs at $\Delta n = 4 \cdot 10^{18}$ cm.

Measuring the current-voltage characteristic of a thin film

To study the current-voltage characteristics, thin GaAS films obtained by anisotronic thermal evaporation in a vacuum were used. Before starting the measurement process, the sample is subjected to high-temperature and low-temperature heat treatment in an oxygen environment and enriched with oxygen. It is also possible to use the classical scheme [4] of step-by-step continuous measurement (current and voltage) to perform current-voltage measurements. This method requires lengthy, complex (labour-intensive) measurements. Therefore, there is a need to optimize the measuring circuit with high resistance (>109 Ohm). At the same time, the current-voltage characteristic can also be studied oscillographically using technical means of

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information technology (garnograph). To do this, you can sample at a low frequency (~50Hz). At the beginning of the initial (-slant) linear coordinate in CVC, the connection expands (increases) with increasing illumination. However, complete CVC correction is not observed until 105 lux. Photoconductivity can be determined by the quality of the difference in slope tangents in CVC (tgλ1-tgλ2=τ). Linearity does not change with changes in temperature and illumination (Fig. 3). Fig. Figure 4 shows the temperature dependence of the electrical conductivity of samples subjected to heat treatment at high temperatures $\frac{10^3}{T} < 3.2$ in an oxygen environment.

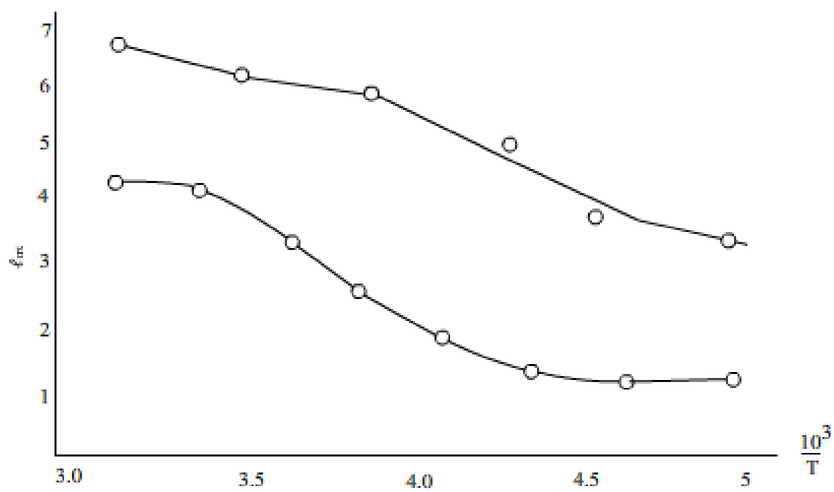

Fig. 1. Temperature dependence of the conductivity of samples obtained in an anisotron evaporator and subjected to high-temperature heat treatment. (Permeability in additional units)

1 – transmittance for an unilluminated sample
2 – transmittance under illumination 5.

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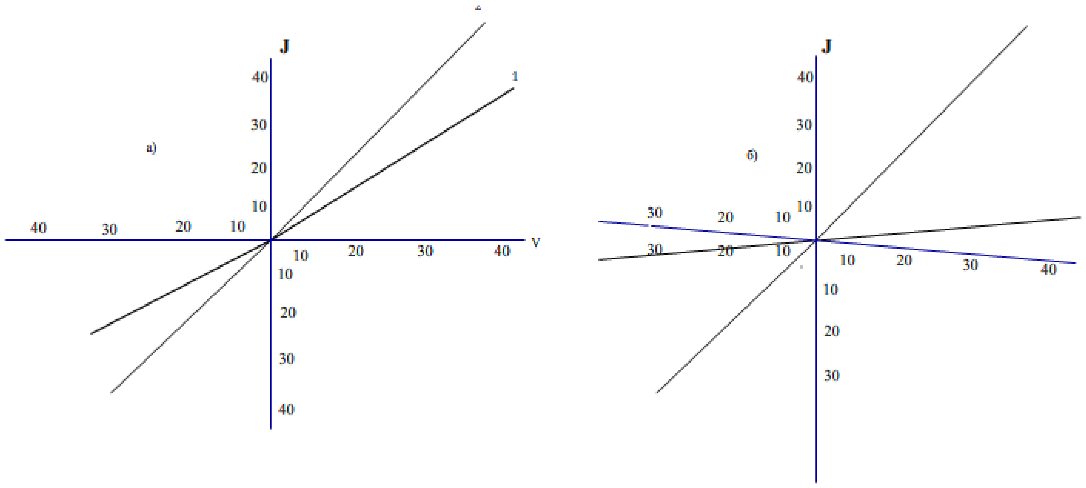

Fig. 2. Current-voltage dependence for samples subjected to low-temperature heat treatment $\frac{10^3}{T} > 4$ in an oxygen environment.

(graphically in conventional units)

a) – taken at room temperature, 1 – without lighting 2 – B = 5,10³ lux.·

b) – sample at liquid nitrogen temperature, 1 – without illumination, 2 – B = 5,10³ lux.·

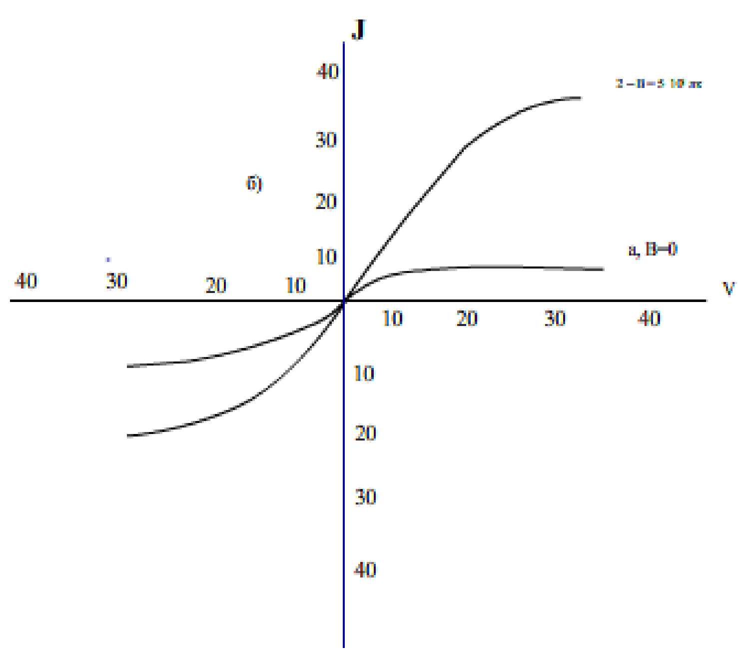

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Fig. 3. CVC for a sample that has undergone heat treatment in an oxygen atmosphere at high temperature.

CONCLUSIONS

The non-standing form of CVC indicates the presence of shunt currents shunting the pn junctions. According to the condition of electrical neutrality for the current, we can write the expression J = Js*tgλ tan V.

This expression can be compared with the experiment by introducing $J\frac{J}{Js}th\frac{\tau V}{Js}\ \tau = \frac{dJ}{dV}|_{v=0} = \lambda J_s$ corresponds to the permeability of the curtain. If the $\frac{J}{Js}\oint(2V)$ connection is used for the BAX of the illuminated sample, then its graph looks like this (Fig. 4).

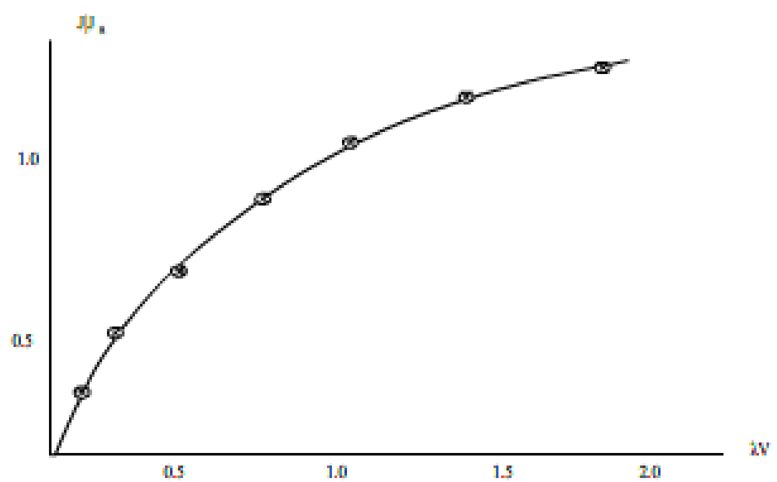

Fig. 4. CVC for burning state

At sufficiently high temperatures, CVC in the illuminated state and CVC in the unilluminated state, the curtains correspond to a hyperbolic tangent, which means the presence of p-n-p or n-p-n junctions in the curtain. The degree of asymmetry of adjacent junctions causes the appearance of photoelectric voltage (E.M.F.).

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