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PHYSICAL AND OPTICAL PROPERTIES OF THE FILMS Bi_2Te_3-Bi_2Se_3

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ABSTRACT

Results of researches show, that film p-n the structures received by a method of discrete thermal evaporation in a uniform work cycle, are suitable for use in low-voltage devices. As a result of work are received p-n heterojunctions in thin-film execution, described by high values of differential resistance. Show that, thermo endurance - T_0 maybe using as characteristic of thermo endurance of optic materials. If heating flow, destruction temperature and internal surface temperature is measured during test, it is possible to determine value T_0 and other necessity characteristics. As a result of the taking test was lead to comparison evaluation of considered materials. Working range of heating flow and up level heating embark have been determined.

Keywords

Semiconductor materials; monocrystals; photoelectrical propesties;mathematical models; solar energy.

INTRODUCTION

The volt–ampere and volt–farads characteristic in an interval of temperatures 77-300K are investigated. With this purpose the structure p-Bi2Te3 - n-Bi2Se3 also was mounted in vacuum cryostat, where furnace and the sensor of temperature were in a landing place of a sample. The temperature regulator provided maintenance of temperature with accuracy ±10C.

Obtaining knowledge about solidity and heating endurance of materials is tremendous important during material selection for preparation optical details which work under intense heating

Lens and filters of projectors, heating equipment's of optic covered are considered as optical details. There isn't this information for many new materials. The reason of this situation is not only unique view to methodology of defining category of thermo endurance but also specifying of the materials. Comparatively low thermo endurance and solidity, weaker resistance to extraction rather than pressing include this specification. By this reason, traditionally extraction methods (for example: for various temperature) complicate process identification of characteristics for embedding optic materials. In this situation direct test thermo endurance of optic materials become more important.

As mentioned above, specification of optic materials during their testing highly require heating base and method of their transferring. As specific factor base stable equal heating pollute additive and contactless with foreign substances, ordinary deformation and other similar requirements are demanded. In this view, it presents huge interest testing of one side heating of free placing flatness layers. As a source of heating, concentrating radiation and also solar radiation are utilized.

SYNTHESIS AND PRODUCTION OF MATERIALS

Breezy samples possessed straightening properties; the factor of straightening on occasions reached value 10^2 at displacement 0,2V and temperature 80K. Straightening character volt–ampere characteristic is kept down to temperature 300K.

In this job, methods and some results of thermo endurance research are commented during heating optic materials in solar equipment's. Length of the equipment is based of parabolic concentrator which consists of 40 cm length and 30 cm focal distance organic glass. Thermocouple sample is located in focal zone of concentrator. Changing of heating parameters is implemented through breaking of sample focuses. This obtains with help of replacement of thermocouples sample by axis of mirror.

Sample which is provided with thermocouple and entire registration located on focal surface of concentrator. Replacement of heating parameters is obtained by breaking of focuses of sun ray which reflection on sample, because moving sample through mirror. Following concentrator of sun is implemented with help of azimuthally-zenithal photoelectric system which consist optic photo head, automat block and electric engine. Duration of experiment is registered via stopwatch.

Maximum capability of density of radiation on this equipment is 14KV/m^2. It is sufficient requirement for surplus practical cases. As sample for testing were using epocsed and optic glue materials. Elements are bordered by metal frames and provided complete and temperature sensors. Moreover, they registered separate moment and internal surface temperature of sample. Free settled sample surface happens with stretch-deformation during non-straight heating which characterize as whole bending. Its internal surface has extensibility tensions which undesirable issue [1].

Spreading of energy on focal surface and through concentrator axis is learned with help of colorimeter which cooled with water, imitated absolutely black matter.

PHYSICAL PROPERTIES OF THE FILMS Bi_2Te_3-Bi_2Se_3

With increase in temperature direct currents are limited to more high-resistance layers $Bi_2Te_{3-x}Se_x$ heterojunction, reverse currents grow more intensively and consequently at temperatures T> 200K the factor of straightening appreciably decreases.

At voltage more than 30mV straight lines volt–ampere characteristic are described by function of a kind $I = I_0 \exp(qV/\beta kT)$, with factor of ideality β =2-2,5 characteristic for a current, limited recombination's of carriers in a layer of a volumetric charge.

The size β increases up to 3 at 100K.

At the big voltage linear dependence $I(V)$ operates. The size diffusion's site of the volt – ampere characteristic in the field of the big currents makes 0,095-0,100V.

In temperature dependence of an inclination of straight lines $\ln I \cong V$ three intervals of temperatures are allocated: 77-100; 100-300K.

With growth of temperature is higher 100K an inclination changes, and is lower 100K remains to constants, and at temperatures 77-100K initial sites of the volt–ampere characteristic is not described by expression $I = qSNd \exp\left|-q(V_{D_n} \cdot V)\right|$. Temperature dependence of a current on a voltage is much weaker, than it is necessary to expect from generations–recombination's model. In a temperature range (77-100K) had a constant inclination (fig. 1, curves 1-2) more often, and the exponential site was well described by expression, characteristic for a tunnel current $I = I_0 \exp(BT)\exp(AV)$, where A and B - constants, not dependent on temperature and voltage.

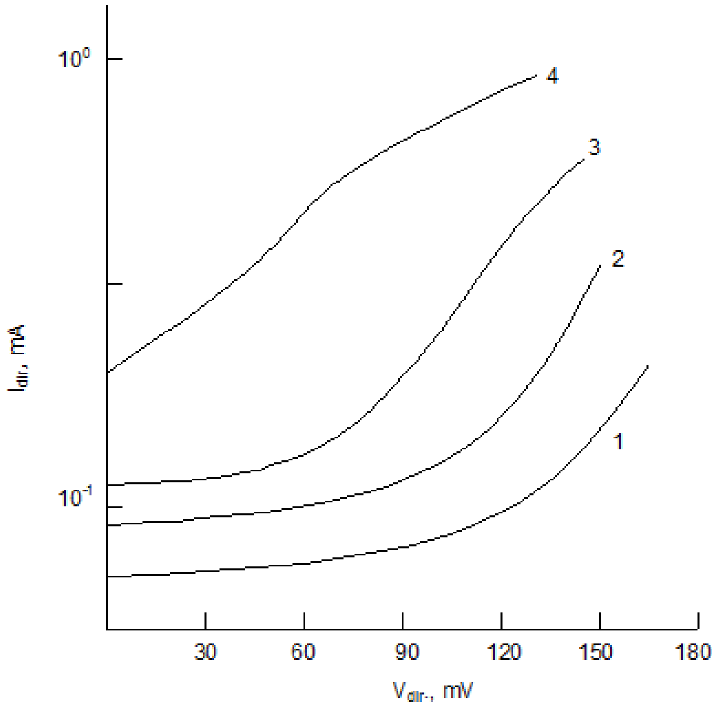

Fig. 1: Dependence of direct currents on the enclosed voltage at various temperatures.

(1 - T=77K; 2 - T=100K; 3 - T=160K; 4 - T=300K)

In this case Fermi's levels lay in a zone of conductivity and in a valent zone accordingly for n-Bi_2Se_3 and p-Bi_2Te_3. It allows assuming, that at low temperatures the prevailing mechanism of passage of a current through structures is tunneling carriers "zone-zone". Weak temperature dependence of a direct current, constancy dI/dV at change of temperature and great value of a current of saturation specifies such opportunity. At high temperatures the tunnel current also exists, but because of stronger temperature dependence a generations–recombination's current tunneling gives the small contribution to the common current.

Hence, in the field of temperatures (100-300K) course of a current is limited to a generations–recombination's current on border of the unit (fig. 1, curves 3-4). At higher temperatures (200-300K), prevailing become activity processes. The inclination a exponential site became temperature-dependent, experimental points well to be lying on straight lines in coordinates $\ln I \cong T^{-1}$.

Proceeding from the tunnel mechanism of carry of a current, in double logarithmic scale dependence of a current on a voltage can look as sedate. At small displacement (20-30mV) reverse branches submit to the sedate dependence, which can be connected to presence of superficial outflow or the complex mechanism of tunneling [1], [2].

As the reverse current with growth of a voltage changes under the reverse law $I \cong \sqrt{V}$, at 30-130mV direct displacement the direct current is described by dependence $I = I_0 \exp(qV/\beta kT)$, where β ~2. Thus, it is possible to conclude, that in an interval 77-130K at V_{direct} =20-130mV and $V_{reverse}$=40-120mV. Thus the reverse current through transition is basically generations, and a straight line – recombinations.

At temperatures from above 200K, the exponent becomes more than 1.

Measurement of capacity p-n transition depending on a voltage allows to determine such major parameters, as the width of area of a volumetric charge, diffusion potential, concentration of acceptors and donors in the field of a volumetric charge, structure of a locking layer, the mechanism of straightening, etc.

Results of measurements testify to sharpness of transition of the volt - farad characteristic resulted on fig. 2.

As is known for a barrier the metal - semiconductor, as well as for sharp asymmetrical transition, the width of the impoverished layer is expressed by the following formula

$$W = \sqrt{2\varepsilon_S (V_B - V - kT)q / N_d} \qquad (1)$$

The specific capacity of the impoverished layer is defined by the formula

$$C = \sqrt{q\varepsilon_S N_d (2(V_B - V - kT)q)} \qquad (2)$$

Whence

$$N_d = (2 / q\varepsilon_S)\left[-1/(d(\frac{1}{C^2})/dV)\right] \qquad (3)$$

The analysis of the volt - ampere characteristic of structures Bi_2Te_3 – Bi_2Se_3 carried out.

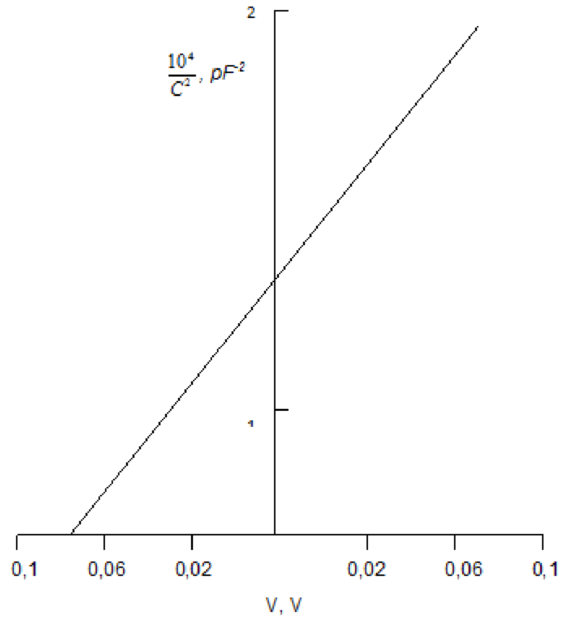

Fig. 2: The volt - farad characteristic of structure p-Bi_2Te_3 - n-Bi_2Se_3

The schedule of dependence on negative voltage is constructed. Apparently from figure 2 dependence $C^{-2} \cong V$ has linear character up to 0,1V. Concentration ionized centers N_d in a barrier, determined on an inclination $C^{-2} \cong V$ makes $4 \cdot 10^{15}$cm^{-3}.

The diffusion potential determined by extrapolation of resulted dependence is equal ~ 0,08-0,09V.

Influence of an intermediate layer on capacity is in details analyzed on the basis of Bardin's model [3]. At presence of a thin high-resistance layer by superficial charges on border undressed dependence C^{-2} from $V_{reverse}$ remains still linear with an inclination $2 / q\varepsilon N_d$, as well as for the diode without an intermediate layer, but the point of crossing of this dependence with axis $V_{reverse}$ is displaced aside higher values.

SOLAR RADIATION EXPERIMENTAL PROCEDURE

Changing of radiation density through concentrator axis is exhibited in figure 3. Theoretically, the concentrator's focal shadow is guessed to be approximately 10 mm but it is 50mm in fact because it geometrically shape is non-precise. That is why maximal radiation density has had 200kkal/m^2 which is sufficient meet requirements of some practical cases. Using of focus breaching is seemed as correct method in regulation heating parameters because flow of heating less changed through concentrator axis [4].

Spreading of temperature on focal surface and its parallel surfaces per concrete case is implemented with help of thermo couple. Because used colorimeter type diaphragm is defined radiation density due to size. This measure is indicated that exceeding of temperature was not greater than 10% in whole researched diapason breaching of focusing in 40 mm shadow which is absolutely reasonable [5-10].

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Circle samples have been tested which have been made by optic materials with 3-8 mm thickness and 30-50mm diameter. Layers made free settlements in metal frame. It provides with thermo couples and special completing registration which fix temperature of unheated inside layer and destruction moment of sample. Outside surface of sample was covered with swallow layer by 15 mkm thickness due to obstacle reflection radiation energy of sample. Obviously, during the period balanced heating of free settlement circle layer surface there happens tension-deformation case which is clear bend. This period happen pulling tensions in internal layer which cause serious danger.

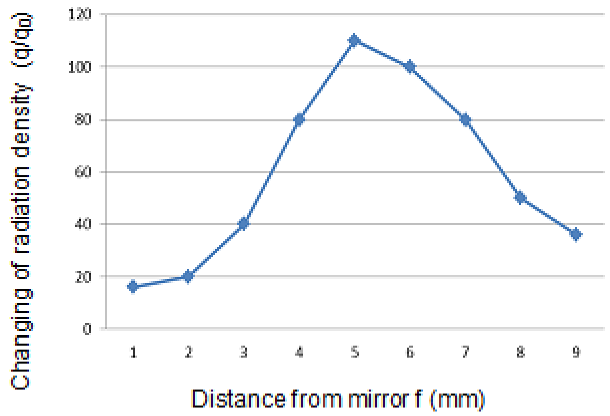

Fig 3: Changing density of radiation energy through concentrator axis (q_0, ray – heating flow on focal plane)

It is presented that obvious accepting thermo-physic characteristic of material possible to define solid level from pulling due to heating flow of layer surface, temperature of internal surface and destruction period.

Indeed, thermo-flexibility theory of thin circle layer causes that given tensions, deformation of layer equal [5]:

$$\sigma = -\frac{\alpha E(t_U - t_i)}{1-\nu}, \varepsilon = \alpha t_U \quad , \quad t_U = \frac{1}{h}\int_0^h t(x)dx, \qquad (4)$$

If during some period tension or deformation reach to own limited value then get from (4).

$$\frac{\sigma_0 (1-\nu)}{E} = T_{kr} - \alpha t_i, \ \varepsilon_0 = T_{kr} \qquad (5)$$

Here σ_0, ε_0 - solidity border to pulling top level deformation to pulling respectively. From first approach of (4) resulted that

$$T_0 = \frac{\alpha q_0 \tau_0}{hc\rho} \quad , \quad (T_0 - t_i)/\alpha = \sigma_0 (1-\nu)/E\alpha \qquad (6)$$

So, T_0 may be using as characteristic of thermo endurance of optic materials. Resulted from (5) that T_0 is function of temperature. However, (6) following result: If heating flow, destruction temperature and internal surface temperature is measured during test, it is possible to determine value T_0 and other necessity characteristics.

CONCLUSION

As a result of work are received p-n heterojunctions in thin-film execution, described by high values of differential resistance. Results of researches show, that film p-n the structures received by a method of discrete thermal evaporation in a uniform work cycle, are suitable for use in low-voltage devices.

It can be seen from results of tests that optic ceramic is the best endurance to heating. If T_0 which is calculated during concrete period for known heating flow during heating of internal detail's surface is placed on or above appropriate curve or then this material are not useful.

Consequently, T_0 would be used as thermo endurance characteristics of optic materials. If heating flow, splitting period and temperature of in internal surface is measured then T_0 indicator would be determined too. As a result of researches compared measures of thermo endurance for tested materials are found. Working diapason of heating has been determined.

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Gurban Akhmedov was born in Balaken, Azerbaijan, 1960. He received the M.S.E. degrees in Physics in 1982 from Azerbaijan State University, Baku and the Ph.D. degree in Physics & Mathematics from Institute Physics of National Academy of Sciences (Baku, Azerbaijan), in 1992. Currently, he is Senior Research Scientist in Institute Physics, Baku, Azerbaijan. His research interests are of thermodetectors, Semiconductor materials and devices. His publications are more than 50 articles.

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