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The Cadmium Telluride Thin Films for Flexible Solar Cell Received by Magnetron Dispersion Method

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For the purpose of creation of thin-film photoelectric converters on the basis of sulfide and telluride of cadmium the pilot studies of process of magnetron dispersion on a direct current of telluride of cadmium and influence of the modes of magnetron dispersion on crystalline structure of films of CdTe are conducted. CdTe films for basic layers of sheet photoelectric converters on flexible polyimide substrate by the method of magnetron dispersion on a direct current are received for the first time. It is experimentally shown that "chloride" processing of the received layers of telluride of cadmium leads to transformation of metastable hexagonal modification of telluride of cadmium in stable cubic. At the same time at the expense of the eutectic recrystallization body height of the sizes of areas of a coherent dispelling much and decrease by 1,5 times of level of microstrains is observed.

Keywords: Sheet photo-electric converter, Sulfide and Telluride of Cadmium, Method of Magnetron Dispersion, Direct current, "Chloride" processing, Hexagonal and Cubic Modification.

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1. INTRODUCTION

Sheet photoelectric converters (PhEC) on the basis of sulfide and telluride of cadmium, as independent sources of electric energy in a land and space environment, represent an alternative to the most widespread silicon crystal PhEC. The modern high effective performance sheet PHEC on the basis of CdS/CdTe are made in a back configuration on a glass substrate through which sunlight comes to a basic layer [1]. In land conditions of PhEC on the basis of CdS/CdTe, according to the optimum width of the forbidden region of telluride of cadmium, possess the greatest theoretical efficiency (E) – 29 %, and in the conditions of space application, thanks to the nature of chemical bonds of CdTe – the greatest radiation resistance [2]. Besides, lower materialo-and power consumption of process of manufacturing of sheet PhEC on the basis of CdS/CdTe provides lower prime cost, in comparison with silicon crystal PhEC. So, in the conditions of the industrial production the First Solar company which releases PhEC on the basis of CdS/CdTe, declared about achievement of "network parity" at which the cost of the electric energy made by PhEC is equal to the cost of electric energy of the electric power made by traditional sources [3]. It should be noted that traditional PhEC on the basis of CdTe significantly concede to PhEC on the basis of crystal silicon on a specific power (the size of the developed electric power on PhEC unit of weight). Replacement of traditional for PhEC on the basis of CdS/CdTe of a glass substrate on a flexible substrate allows to increase mentionedpower by several orders and in this parameter to surpass not only PhEC on the basis of silicon, but also on the basis of the A_3B_5 connections. However at the same time because of lower heat stability of a polyimide substrate it is necessary to reduce precipitation temperature of films of telluride of cadmium below 400 °C that is impossible in traditionally used for receiving of highly effective PhEC on basis of CdS/CdTe methods of sublimation in selfcontained volume [4, 5] and desposition by steam transport [6, 7]. At realization of these methods formation of basic layers of telluride of cadmium is carried out at precipitation temperature at the level of 550 ° C.

The method of magnetron dispersion [8, 9] belongs to the low-temperature technologies of receiving films of telluride of cadmium which can be realized in the conditions of mass production [8, 9]. The main technological problem of receiving semiconductor films by method of magnetron dispersion on a direct current is low speed of body height of films. It is caused by the fact that in the course of dispersion of a low-conductive substrate an accumulation of positive charge which does not manage to flow down takes place. As a result, the counter field braking the argon ions bombarding a substrate that causes decrease in a discharge current is created.

Therefore receiving films of telluride of cadmium for basic layers of flexible photo-electric converters by method of magnetron dispersion on a direct current is an urgent technological problem for the solution of which the pilot studies of process of magnetron dispersion on a direct current of telluride of cadmium and influence of the modes of magnetron dispersion on crystalline structure of films of CdTe were conducted.

2. TECHNIQUE OF CARRYING OUT EXPERIMENT

In work a deposition of films of telluride of cadmium was carried out by method of magnetron dispersion on a direct current. The pilot VUP-5M vacuum unit with systems of original magnetrons which important design feature was the fact that the contour of their cooling covers only magnetic system was for this purpose used. It allowed to vary surface temperature of a target in rather wide limits. The target was made by method of cold pressing of powders of cadmium telluride for semiconductors of the brand "ch" (technical specifications 6-09-01-429-77). Diameter of a target was 76 mm, thickness – 2 mm. At cold pressing of a target the pressure of 100 MPas was created. Dwell time of a target with such pressure made 15 hours. After the process of a molding of a target its vacuum annealing was made with a residual pressure not less than 10 – 4 mm Hg and temperature of 80 °C. At a deposition of layers of CdTe as substrates the thermostable polyimide film of Upilex up to 10 microns thick was used. The flexible substrate settled down in the relative frame of the VUP-5M vacuum chamber in close contact of the frontal surface with the thermocouple. Before process of drawing layers of telluride of cadmium pumping of displacement volume up to the pressure of 10^{-5} Pas was carried out. The blousing of working gas of argon was done by means of the automated system of a blousing of SNA.

Shooting of x-ray diffractogramms, the received cadmium telluride films, was created out by method θ-2θ scannings with focusing after Breggu-Brentano by means of a x-ray diffractometer of DRON-4 with a step 0,01-0,02 degree in K_α-radiation the cobalt anode ($\lambda_{CoK\alpha} = 1.7889$ Å). Under these conditions the diffraction pattern is formed by grains with the parallel to a surface of exemplars reflecting planes (*hkl*) [10]. Identification of phase structure of exemplars was carried out by method of comparison of corners 2θ legiblly revealed peaks received when shooting with reference data of a card file of JCPDS (Joint Committee on Powder Diffraction Standards) which were obtained by means of the electronic PCPDFWIN database, for the corresponding phases. Processing of individual maxima of x-ray diffractogramms (smoothing, separation of background, division of a doublet of $K_{\alpha 1} - K_{\alpha 2}$) and calculation of parameters of a profile of the diffraction lines (position of peak, interplanar distance, integral intensity of peak, integral width) were done by means of the program "New_Profile". Sizing of areas of a coherent scattering (L_i) and level of microstresses (ε) were realised out on a physical broadening of the diffraction peaks (β). An assessment of the diffraction distribution β was calculated by approximation of the diffraction of profiles by means of function of Gauss and Cauchy [10].

For detection of structural features of basic layers of telluride of cadmium also the technique of so-called "slanting" shootings at which in the radiation of the cobalt anode the method 2θ-scannings carried out detection and pointwise registration of the diffraction reflections from those planes of sfaleritny and vyurtsitny modification of telluride of cadmium which can not be found at the way of registation explained above because of a structural of an model [11] was used. For this purpose the model turned rather tentative situation on the corresponding corner (a corner between the plane which formed the most intensive diffraction peak when focusing according to Breggu-Brentano, and the given plane).

3. RESULTS AND THEIR DISCUSSION

3.1 A Research of Process of Magnetron Dispersion on a Direct Current of Telluride of Cadmium

At a research of process of magnetron dispersion on a direct current for receiving films of telluride of cadmium five technological modes (to watch table 1), which differed with pressure of argon (R_{arg}), tension on a magnetron (V) and the modes of heating of a substrate and a target were realized. When carrying out researches dependence of a discharge current of a magnetron (I) from time of dispersion (t) was measured.

It was established that in the course of magnetron dispersion of a target of telluride of cadmium change of a discharge current (Fig. 1) is observed. At realization of the first mode in the beginning at the disconnected magnetron preliminary heating of a substrate to temperature of 200 °C was carried out. At the same time the substrate was taken away from a magnetron. Then on a magnetron voltage of 800 W moved, the pressure of argon was 2.5 Pas and after a substrate was transferred to situation over a magnetron. Measurement of dependence of a discharge current from time of dispersion (Table 1) shows that for the first 4 minutes of dispersion the discharge current did not exceed 1.2 mA. It was visually established that at such discharge current the cadmium telluride film on a surface of a flexible subfrom the since 4th on the 8th minute of dispersion the discharge current increased to 60 mA (a curve 1, the Fig. 1) and then during the subsequent time of dispersion did not change. At the same time on a surface of a substrate the active formation of a film of telluride of cadmium was visually observed.

At realization of the second mode at the same time with the beginning of heating of a substrate which was away from a magnetron on a magnetron voltage of $V = 600$ V moved at R_{arg} of $= 2$ Pas. Temperature of preliminary heating of a target was 200 °C. Then without interruption of the category of a magnetron the substrate was transferred to situation over a target. It was established that process of magnetron dispersion began at an initial discharge current 3,1 mA. At increasing of the time of dispersion up to 4 minutes body height of a discharge current to 20 mA was experimentally recorded, then with a further growing of time of dispersion up to 8 minutes the discharge current increased to 85 mA (a curve 2, the Fig. 1). At further increasing of the time of dispersion from 8 minutes to 20 minutes slight decrease in current by 10 % was observed.

At the realization of the third mode in situation when the substrate is taken away from a magnetron in the beginning its warming up to 200 °C was carried out, then for 3 minutes the substrate got warm in situation over a magnetron. Then on a magnetron voltage of 600 V moved with a pressure of argon of 1.8 Pas. Such change of the operating conditions led up to 55 mA (table 1) to increase of an initial discharge current. In the course of dispersion slight monotonic decrease of a discharge current to 50 mA (a curve 3, the Fig. 1) was observed.

In comparison with the third technological mode, at realization of the fourth mode heating temperature of a substrate as aside a magnetron as over a surface of a magnetron was increased to 230 °C. On a magnetron voltage of 600 V moved with a pressure of argon of 1.7 Pas. As a result of realization of such mode the initial discharge current increased to 62 mA (table 1). In the course of dispersion slight monotonic decrease of a discharge current to 60 mA (a curve 4, the Fig. 1) was observed.

At the realization of the fifth mode heating temperature of a substrate was increased to 240 °C, and time of preliminary warming up of a substrate was increased over a target surface – up to 5 minutes. It led to increase in initial current up to 75 mA (table 1) at a voltage of 600 V and pressure of argon 1.5 Pas. In the course of dispersion the monotonic decrease of a discharge current to 60 mA (a curve 5, the Fig. 1) was observed.

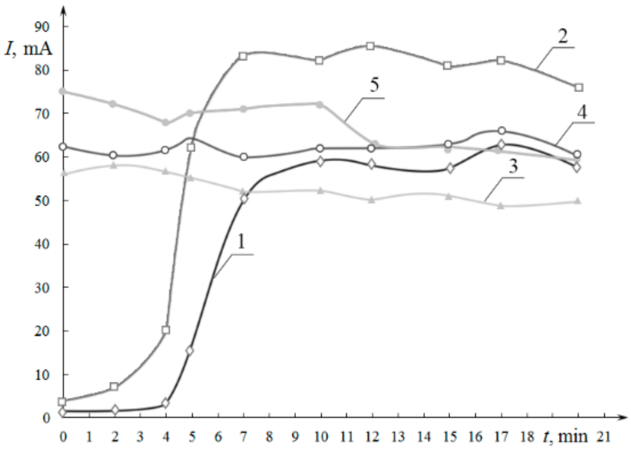

Fig. 1 – Dependence of a discharge current on the time of dispersion for various technological processes

The conducted research of process of magnetron dispersion on a direct current of a target of telluride of cadmium showed that change of current of magnetron dispersion in a precipitation process of a film of telluride of cadmium is bound to a warming up of a surface of material of a target. Experiments show that it can come at the expense of a caloradiancing from a substrate surface. It is really experimentally shown that with body height of temperature of a substrate and, first of all, time of its heating over a surface of a target increase in an initial discharge current from 1.2 mA to 75 mA (table 1) is observed. Surface temperature of a target also increases at increase in time of magnetron dispersion due to bombing of a target ions of working gas. It is confirmed experimentally by existence of sites of rapid growth of a discharge current from a discharge time (to watch the modes 1 and 2 in table 1).

From our point of view the warming up of a surface of a target causes body height of intensity of a thermal emission of secondary electrons from a target surface in a zone of the magnetron category and decrease of resistance of a target as a result of thermal oscillation of majority carriers of a charge. Increase in concentration of secondary electrons increases probability of ionization of molecules of argon that in turn causes intensity of an ionic bombardment of argon of a surface of a target and, accordingly, a speed of dispersion of a target. Oscillation of majority carriers of a charge reduces a specific resistance of a target and reduces the intensity of process of accumulation of positive charge which leads braking accelerated argon ions bombarding a target to formation of an electric counter field. Existence of process of accumulation of a charge is confirmed by the decrease in a discharge current observed experimentally (to watch, for example, the mode 5). Observed experimentally stabilization of a discharge current independently of a technological diagram in the course of magnetronic dispersion demonstrates approach of the mode of the heat balance of a target.

3.2 Research of Influence of the Modes of Receiving on Crystalline Structure of Films of Telluride of Cadmium

On the basis of the carried-out analysis of process of magnetron dispersion of films of telluride of cadmium on a direct current the deposition modes which provided intensive dispersion of a target were chosen. For this purpose preliminary heating of a substrate to 410 – 420 °C was carried out. After the achievement of the specified temperature the relative frame was transferred to the mode over a target and as a result of wich a target warming up for 5 – 8 minutes was carried out as well. On a magnetron tension moved and the precipitation process of films of telluride of cadmium began. At the same time for different samples by changing of power of a magnetron from 600 V to 650 V and fractional pressure of argon from 0.8 Pa to 1 Pa the discharge current from 40 mA to 100 mA (Table 1) was varied. At the same time in the course of dispersion the discharge current practically did not change. Substrate temperature at a deposition also was almost invariable and it was 300 °C. Duration of process of drawing films made from 15 to 25 minutes.

Table 1 – Technological modes of receiving films CdTe

Sample	t, min	P_{arg}, Pas	U, V	I, мА	D, nm	V, nm/min
CdTe3	25	0.8 – 1,	600	40	1030	41
CdTe4	25	0.8 – 1	600	60	2360	94
CdTe6	25	0.9 – 1	650	80	5200	208
CdTe7	15	0.8 – 0,9	650	100	5500	367

The increasing of average speed body height of films of telluride of cadmium from 41 nm/mines to 367 nanometers/min. was experimentally established at increasing in a discharge current from 40 mA to 100 mA, thus the chosen duties of a magnetron do not get to the area of saturation that provides good process control and speed of drawing a film, sufficient for the organization of quantity production.

The crystalline structure of films of telluride of cadmium by the method of a roentgen diffractometry was investigated. Roentgen diffractogramm of exemplars 3 and 6 are given in the Fig. 2. Analytical processing of the experimental roentgenograms allowed to define position of the diffraction peaks, their intensity and half-width.

Two double peaks on corners 2θ 27.05° and 91.05° which can belong to both hexagonal, and cubic modification of CdTe are allocated on all the roentgendiffractogramms: reflection (002) and (006) - a vyurttsita and reflection (111) and (333) – sfalerit, accordingly. High intensity of these peaks indicates that films possess a preferred direction. Such direction is [111] in case of sfalerit modification of telluride of cadmium or [0001] in case of vyurtsit modification of CdTe. As on the rentgendifraktogrammakh reflections of peaks on corners 2θ 49.890, 78.980 which can belong to the planes (103) and (105) of a vyurtsit are observed, becomes apparent that the studied films of telluride of cadmium have hexagonal modification.

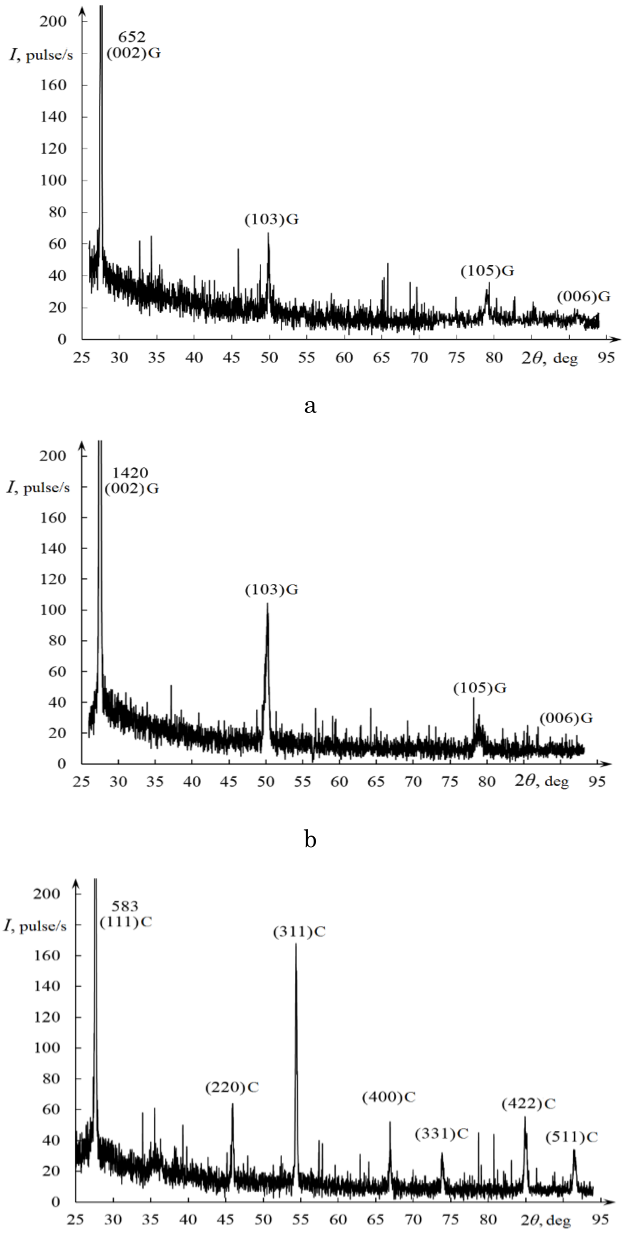

Fig. 2 – Roentgendiffractogramm of CdTe films: a – I = 40 mA, b – I = 80 mA, c – I = 80 mA after "chloride" processing

To define whether there is a sfalerit modification at the studied cadmium telluride layers "slanting" shootings were carried out. For carrying out "slanting" shootings on formulas (1) and (2) corners between the planes (111) and (620) for cubic modification and (002) and (105) and (002) and (515) hexagonal modifications were calculated:

$$CosJ_1 = \left(h_1h_2 + k_1k_2 + l_1l_2\right) / (h_1^2 + k_1^2 + l_1^2 \times h_2^2 + k_2^2 + l_2^2)\ ,(1)$$

where h_1, k_1, l_1-indexes of the plane (111), h_2, k_2, l_2 – indexes of the plane (620)

$$CosJ_2 = \left(h_1h_2 + k_1k_2 + 1/2\left(h_1k_2 + h_2k_1 + 3/4\left(a^2/c^2\right)\ l1l2\right)\right)/$$
$$\left(h_2^2 + k_2^2 + h_2k_2 + 3/4\left(a^2/c^2\right)\ l22\right)^{1/2})$$
$$/(\left(h_1^2 + k_1^2 + h_1k_1 + 3/4\left(a^2/c^2\right)\ l12\right)^{1/2} \times$$

where h_1, k_1, l_1-indexes of the plane (002); h_2, k_2, l_2 – indexes of the plane (105) or (515); a, c – parameters of a hexagonal lattice of telluride of cadmium.

Calculations show that the corner between the planes (111) and (620) of a cubic phase makes 43.08^o, a corner between the planes (002) and (105) and (002) and (215) of a hexagonal phase – 20.7^o and 78.46^o, accordingly. Proceeding from for definition of phase structure discharged films shootings of roentgenograms on corners 2θ 72-85o were carried out at turn of an exemplar on a corner 20.7 ^{o}. The choice of value of an angle of rotation of an exemplar was caused by what the corner between the direction [001] and [105] of hexagonal modification makes 20.68^o, and corners between the directions [331] and [422] with the direction [111] make 22 ^{o} and 19,47 ^{o}. Therefore at the specified turn reflection [105] of hexagonal modifications and reflections of [331] and [422] cubic modifications have to reveal. Results of sloping shootings are given in the figure 3. For the studied films on site 2θ 72-85^o only the diffraction peak (105) of a hexagonal phase is observed, and the diffraction peaks (331) and (422) cubic modifications do not reveal. Thus it is possible to make a conclusion that the studied films in this case are created by hexagonal modification of CdTe and further calculations were carried out for this phase.

According to the provision of the diffraction peaks a calculation of interplanar distances (Table 3) was carried out. The analysis of data shows that at the beginning with body height of a discharge current from 40 mA to 80 mA the increasing in interplanar distances for all identified planes is observed. Further body height of a discharge current from 80 mA to 100 mA leads to decrease in interplanar distances. On a physical broadening of the diffraction peaks the path of approximation of their profiles by means of function of Gauss and Caushy investigated the influence of the modes of magnetron dispersion on the size of areas of a coherent scattering (a.c.s.) and the level of microstresses (Table 2) of the grains focused in the direction (002) was investigated. It was established that with a growth of current of dispersion from 40 mA to 80 mA increasing in the sizes a.c.s. is observed from 52 nanometers to 132 nanometers. From our point of view, it first of all is bounded with increasing of the thickness of a film of telluride of cadmium from 1,0 microns to 5.2 microns at increase in growth rate of films that is caused by body height of current of dispersion. Increase in the sizes a.c.s. on a measure of increasing in thickness of a film is natural physical process. Traditionally at a deposition of films of telluride of cadmium on not focusing substrates the cryptocrystalline defect layer in which grains have the arbitrariest crystallographic orientations is formed in the beginning.

Then in process of body height of thickness of films because of the different growth rate of grains with various crystallographic orientation there is a formation of the bar structure to the grains focused in the crystallographic directions which are characterized by the maximal growth rates [12]. At the same time body height of grains with other crystallographic orientation is suppressed.

For hexagonal modification of telluride of cadmium the crystallographic direction has the maximal growth rate (002). According to results of structural researches, the received films of telluride of cadmium are focused in this crystallographic direction that confirms high values of intensity of the corresponding diffraction peaks and existence of the multiple peaks (004). For the bar structure to body height of thickness there is an increase in aggregate size between which borders are high-angular. Besides, in grains because of decrease of degree of deficiency also degree of development of

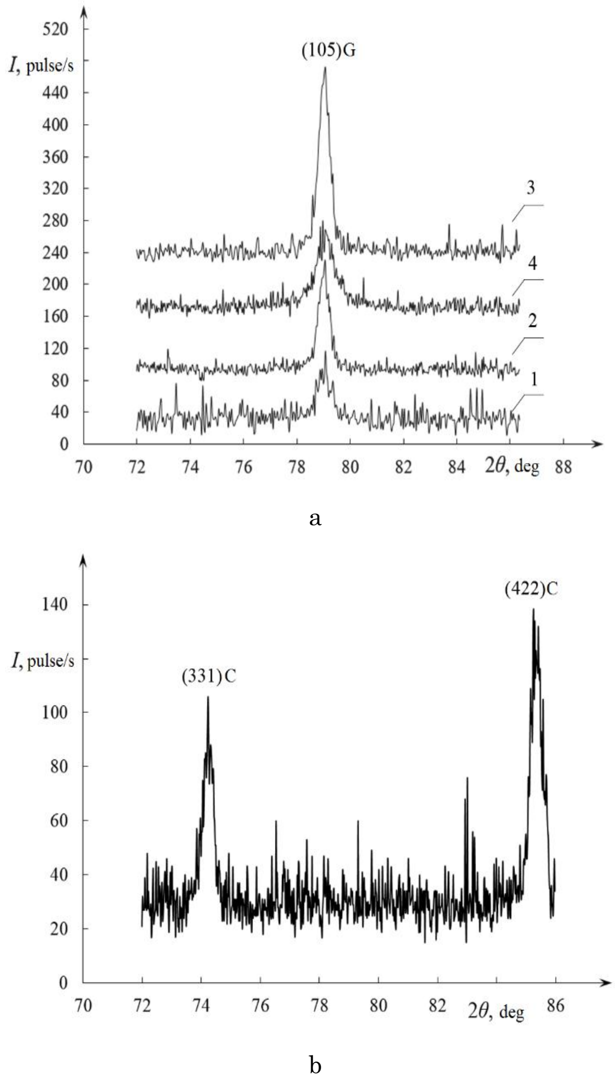

Fig. 3 – Roentgenogramms of basic layers of CdTe when carrying out "sloping" shootings: a) 1 – I = 40 mA, 2 – I = 60 mA, 3 – I = 80 mA, 4 – I = 100 mA; b) I = 80 mA, after "chloride" processing

Table 2 – Results of calculation of the size of areas of a coherent scattering (L_i) and level of microstresses (ε)

Sample	Approksimation according to Caushy		Approksimation according to Gauss		Mean value	
	L_i, Å	ε	L_i, Å	ε	L_i, Å	ε
CdTe3	55	$7\cdot10^{-2}$	48	$8.5\cdot10^{-2}$	52	$7.8\cdot10^{-2}$
CdTe4	120	$5\cdot10^{-2}$	95	$5.3\cdot10^{-2}$	108	$5.2\cdot10^{-2}$
CdTe6	165	$4\cdot10^{-2}$	98	$7\cdot10^{-2}$	132	$5.5\cdot10^{-2}$
CdTe7	105	$5\cdot10^{-3}$	87	$5.5\cdot10^{-3}$	96	$5.3\cdot10^{-2}$

low-angle borders decreases that leads to body height of the sizes о.к.р. Further body height of current of dispersion from 80 mA to 100 mA leads to decrease in the sizes о.к.р. from 132 nanometers to 96 nanometers, despite the continuing body height of thickness of a film of telluride of cadmium to 5.5 microns. It demonstrates increase in degree of deficiency of the growing layers at increase in current of dispersion. From our point of view, the increase in growth rate of films identified experimentally at the same time from 208 nm/mines to 367 nanometers/min. leads to decrease in mobility of the besieged atoms on a substrate that in turn increases number of dot structural defects. Body height of density of defects leads to increase in the free energy of system in such degree that becomes thermodynamic favorable formation in the growing layer of low-angle borders which are a drain of dot structural defects.

Researches of level of microstrains show that with body height of current of dispersion from 40 mA to 60 mA there is a decrease in level of microstrains, and then the level of microstrains practically does not change.

Thus, from the point of view of receiving films of telluride of cadmium with minimum number of structural defects the discharge current 80 mA is optimum. Just for the film of telluride of cadmium received in these modes "chloride" processing, traditional for formation of basic layers of telluride of cadmium for sheet high performance PhEC on their basis, was carried out [13]. For carrying out "chloride" processing on a surface of films of telluride of cadmium the method of vacuum evaporation without heating of a substrate applied cadmium chloride layers. Then there was an annealing on air at a temperature of 430 °C for 25 minutes [14]. According to literary data [15] at such temperature there is a recrystallization of basic layers of telluride of cadmium without liquation due to existence in the $CdTe$-$CdCl_2$ system of the low-temperature eutectic.

On a cadmium telluride film diffractogram after "chloride" processing peaks which belong to cubic modification of CdTe (Fig. 3, Table 5). On the diffractogram received by method of "slanting" shootings in the angular range 2θ from 72.5° to 87.5° at an exemplar turn on 20,5° only peaks (331) and (422) cubic modifications are observed, and the peak (105) hexagonal modifications does not come to light. Thus, after "chloride" processing the film of telluride of cadmium does not contain a hexagonal phase. At "chloride" processing decreasing of width of peaks (111) and (333) in comparison with peaks (002) and (006) hexagonal phase in samples before "chloride" processing is also observed (table 5). Calculations of the sizes a.c.s. and the level of microstrains showed increasing a.c.s. to 230 nanometers and decreasing in level of microstresses to $3 \cdot 10^{-2}$.

Table 3 – Results of the machining of the diffractogramm $CdTe_6$ sample after "chloride" processing

Position of peak, degree	Index (*hkl*)	Interplanar, distance, Å	Intensity of peak, imp/s	Half width, degree
27.59	(111)	3.751	402	0.15
45.88	(220)	2.295	34	0.19
54.35	(311)	1.959	128	0.15
66.89	(400)	1.623	20	0.23
73.83	(331)	1.489	18	0.22
84.90	(422)	1.325	76	0.25
91.44	(511)	1.249	40	0.32

4. CONCLUSION

For the first time on flexible polyimide substrates the method of magnetron dispersion on a direct current, at the expense of a target surface warming up for an intensification of a thermal emission of secondary electrons in a zone of the magnetron category and decrease of resistance of a target as a result of thermal oscillation of majority carriers of a charge, received films of telluride of cadmium of hexagonal modification 1-5 microns thick which allows to use them as basic layers of sheet photo-electric transformers.

It is established that at increasing of current of the magnetron category up to 80 mA body height of the sizes a.c.s., which is caused by increase in thickness of the films of telluride of cadmium possessing the bar structure is observed. Further body height of current discharge leads to the decreasing of the sizes a.c.s., that is caused by thermodynamically by favorable formation of low-angle borders which are compensating physical mechanism of increasing of radiation dot defects at an intensification of the process of magnetron dispersion. It is shown that decrease of the level of the microstrains is observed with a growth of a discharge current to 60 mA, and further body height has no significant effect.

It is experimentally shown that the "chloride" processing of the received cadmium telluride layers which is carried out by drawing films of chloride of cadmium with the subsequent annealing on air at a temperature of 430 °C for 25 minutes leads to transformation of metastable hexagonal modification of telluride of cadmium in stable cubic. At the same time at the expense of the eutectic recrystallization body height of the sizes a.c.s. is observed, much and decrease by 1,5 times of level of microstrains.

For receiving films of telluride of cadmium of hexagonal modification on the flexible polyimide substrates used as basic layers of sheet photo-electric converters back the method of magnetron dispersion on a direct current in which the intensification of a thermal emission of secondary electrons in a zone of the magnetron category is provided at the expense of a target surface warming up was realized for the first time. It is established that the optimum size of current of the magnetron category is in range of 60 – 80 mA. It is shown that carrying out "chloride" processing of the received cadmium telluride layers, leads to transformation of metastable hexagonal modification of telluride of cadmium in stable cubic, and also to body height of the sizes a.c.s. much and to decrease by 1.5 times of level of microstrains.

Тонкі плівки телуриду кадмію для гнучких сонячних елементів, отримані методом магнетронного розпилення

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З метою створення тонкоплівкових фотоелектричних перетворювачів на основі сульфіду та телуриду кадмію проведені експериментальні дослідження процесу магнетронного розпилення на постійному струмі телуриду кадмію і вплив режимів магнетронного розпилення на кристалічну структуру плівок CdTe. Вперше на гнучких поліамідних підкладках методом магнетронного розпилення на постійному струмі отримані плівки CdTe для базових шарів плівкових фотоелектричних перетворювачів. Експериментально показано, що «хлоридна» обробка отриманих шарів телуриду кадмію призводить до трансформації метастабільною гексагональної модифікації телуриду кадмію в стабільну кубічну. При цьому за рахунок евтектичною перекристалізації спостерігається зростання розмірів областей когерентного розсіювання на порядок та зниження в 1,5 рази рівня мікродеформацій.

Ключові слова: Плівковий фотоелектричний перетворювач на основі сульфіду та телуриду кадмію, Метод магнетронного розпилення на постійному струмі, «Хлоридна» обробка, Гексагональная і кубічна модифікація.

Тонкие пленки теллурида кадмия для гибких солнечных элементов, полученные методом магнетронного распыления

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С целью создания тонкопленочных фотоэлектрических преобразователей на основе сульфида и теллурида кадмия проведены экспериментальные исследования процесса магнетронного распыления на постоянном токе теллурида кадмия и влияние режимов магнетронного распыления на кристаллическую структуру пленок CdTe. Впервые на гибких полиимидных подложках методом магнетронного распыления на постоянном токе получены пленки CdTe для базовых слоев пленочных фотоэлектрических преобразователей. Экспериментально показано, что «хлоридная» обработка полученных слоев теллурида кадмия приводит к трансформации метастабильной гексагональной модификации теллурида кадмия в стабильную кубическую. При этом за счет эвтектической перекристализации наблюдается рост размеров областей когерентного рассеивания на порядок и снижение в 1,5 раза уровня микродеформаций.

Ключевые слова: Пленочный фотоэлектрический преобразователь на основе сульфида и теллурида кадмия, Метод магнетронного распыления на постоянном токе, «хлоридная» обработка, Гексагональная и кубическая модификация.

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