Functional Materials 16, No.2 (2009) © 2009 — STC "Institute for Single Crystals"

Contact electrodeposition of CdTe thin films

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Received October 28, 2008

The effect of contact electrodeposition conditions on the impurity content in CdTe films has been studied. Stoichiometric single-phase CdTe layers of cubic modification have been obtained. The films are not texturized, and are characterized by the coherent-scattering region size of about 30 nm and the relative micro-strain values of about $5 \cdot 10^{-3}$.

Изучено влияние условий контактного электроосаждения на содержание примесей в пленках CdTe. Получены стехиометрические однофазные слои CdTe кубической модификации. Пленки не текстурированы, характеризуются размером областей когеррентного рассеяния $\simeq$ 30 нм и значениями относительных микродеформаций $\simeq 5 \cdot 10^{-3}$.

Cadmium telluride (CdTe) is now a leading base material for the thin film solar cells [1], including those with extremely thin (80–500 nm) CdTe absorbers (so-called η-solar cells) [2, 3]. Up to date, the CdTe deposition for the η-solar cells was realized using either vapor phase epitaxy under dynamical vacuum [2] or by electrodeposition [3].

In this work, we investigate contact electrodeposition, a new technique for preparing of thin CdTe films. The prototype technique proposed in [4] for the CdTe deposition did not provide the deposition of stoichiometric single-phased cadmium telluride layers. The CdTe films [4] contained free tellurium as an impurity. In order to solve the deposition problem of the single-phased CdTe layers, we have studied the electrochemical processes occurring during current-free electrolysis in sulfate solutions at different $CdSO_4$ concentrations and acidity values, as well as the film phase composition and structure.

The electrodeposition of CdTe films was performed onto glass plates coated with magnetron-sputtered indium/tin oxide (ITO) transparent conducting films. These substrates were immersed in a bath containing 0.5 M $CdSO_4$, 0.0002 M TeO_2 and diluted H_2SO_4 (pH was 2 to 4). The solution temperature was 95°C, the deposition duration was 10–15 min. The obtained film thickness was not exceeded 500 nm.

X-ray investigations (XRD) of the film crystal structure were carried out using a DRON-4M diffractometer in CoK_α characteristic emission (λ = 1.78892 Å) according to θ–2θ scheme with Bregg-Brentano focusing. The identification of the phases of obtained compounds were identified by comparison of experimental data with parameters of crystal lattice for CdTe of cubic (sphalerite) and of hexagonal (wurtzite) modifications in accordance with JCPDS No.19-193 and No.15-770, respectively, with parameters of ITO (JCPDS 39-1058), γ-$Cd(OH)_2$ (JCPDS No.20-0179), and some other most probable cadmium and tellurium compounds. The coherent-scattering region sizes and relative microstrain values for CdTe phase were estimated under approximation of isotropic crystallite properties according to [5].

To prevent the sursaturation of CdTe films in cadmium observed in [4], the first cadmium telluride samples were deposited in slightly acidic solution (pH 4) at a great excess of cadmium ions (0.5 M $CdSO_4$). However, no stoichiometric single-phased films have been obtained in those conditions. X-ray diffraction spectra have shown a commensurable amount of cadmium hydroxide γ-$Cd(OH)_2$ impurity along with cadmium telluride and ITO substrate reflections (Fig. 1,a).

To reduce the cadmium hydroxide impurity content in the CdTe films, the following conditions of tellurium electrochemical reduction should be provided:

$$Cd^{2+} + TeO_2 + 4H^+ + 6e^- \rightarrow CdTe + 2H_2O \quad (1)$$

A stoichiometric CdTe film has been obtained at 0.2 M $CdSO_4$ and pH 2.

The comparison of the XRD patterns shown in the Fig. 1, b has revealed that both samples exhibit the ITO sublayer reflections and (111), (220), and (311) reflections of the cubic CdTe. The intensity and shape of the CdTe phase reflections are quite identical for both sample, thus evidencing that the salt concentration variation in the electrolyte does not result in any significant changes in the CdTe layer thickness and structure. The relative intensity of CdTe peaks correlates essentially to the JCPDS 19-193 data that points to absence of specific orientation of the phase grains. The estimated coherent-scattering area size and relative microstrain of the CdTe phase amounted about 30 nm and $5 \cdot 10^{-3}$, respectively. So small coherent-scattering regions seem to be caused by a high density of package defects that is typical of film structures. The microstrain values are

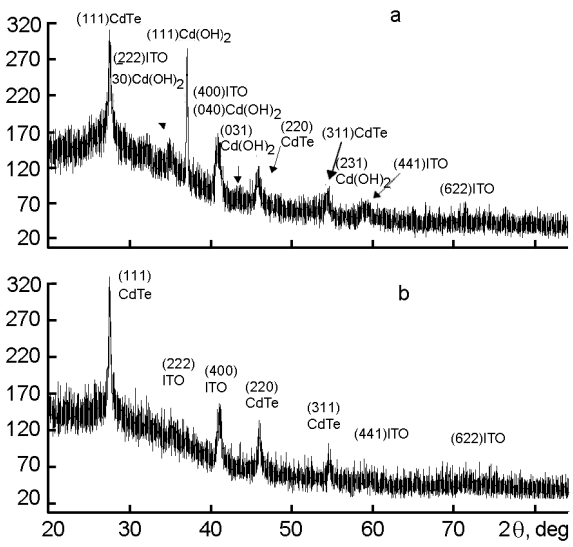

Fig.1. XRD patterns for electroless-deposited CdTe films onto ITO substrates in solutions: *a* — 0.0002 M TeO_2; 0.5 M $CdSO_4$ (pH 4) ; *b* — 0.0002 M TeO_2; 0.2 M $CdSO_4$ (pH 2).

in agreement with those for cadmium telluride films deposited by vacuum methods at temperatures below 100°C.

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Контактне електросадження тонких плівок CdTe

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Досліджено вплив контактного електроосадження на вміст домішок у плівках CdTe. Одержано стехіометричні однофазові шари CdTe кубічної модифікації. Плівки є нетекстурованими і характеризуються розміром областей когерентного розсіювання≃ 30 нм та значенням відносних мікродеформацій" ≃ $5 \cdot 10^{-3}$."