Morphology and Growth Mechanisms of CdTe Thin Film

Nykyruy L.I.[1], Yavorskyi R.S.[1], Wisz G.[2], Sawicka-Chudy P.[2], Vakaliuk I.V.[1], Naidych B.P.[1], Yavorskyi Ya.S.[1]

[1] Vasyl Stefanyk Precarpathian National University, T. Shevchenko Str. 57, Ivano-Frankivsk-76018, Ukraine.

e-mail: ivanna.maliarska@pnu.edu.ua

[2] Institute of Physics, College of Natural Science, University of Rzeszów, 1 Pigonia Street, 35-317 Rzeszów, Poland.

Introduction

The photovoltaics is a popular and actively developing industry. The most common are materials based on Silicon in the amorphous, nanocrystalline, polycrystalline phases and polycrystalline chalcogenide (sixth group) semiconductor compounds. The third class of new compounds is based on organometallic dyes and polymers [1]. The main characteristic that determines the parameters of the photovoltaic cell is the electrical efficiency. This parameter depends on the length and intensity of the incident sunlight, the type of photovoltaic cells, composition materials, and the components used in the solar module. Among chalcogenide materials, CdTe has higher temperature and radiation stability [2]. This makes the material suitable for use at higher operating temperatures and resistant to ionizing radiation.

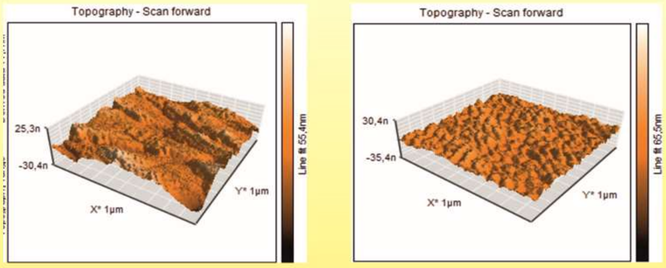
Methods

Thin films were grown on glass (sample 23) and (100) silicon (sample 43) substrates by PVD (Physical Vapor Deposition) technique at constant evaporation and substrate temperatures. The thickness determines by the time of condensate deposition: τ = (30–570) sec.

Morphological and structural properties of CdTe thin films were studied using Atomic Force Microscope (CSM Instruments) in periodic contact mode and Scanning Electron Microscope (Vega 3 Tescan). The central part of the samples was selected for research, and serial Veeco MNSL-5 silicon probes (with a radius of curvature of the tip up to 5 nm) were used. Determination of film thickness was carried out using a 2D Profilometer Bruker Dektak XT.

Results

The surfaces of the films have a "scaly" shape with size in normal dimensions of about 25 - 45 nm, which are more clearly distinguished on glass substrates. Analysis of the surface morphology of CdTe films indicates Stransky-Krastanov growth mechanism. After the growth of several layers of material, the formation of individual islands becomes predominant and then their growth continues.



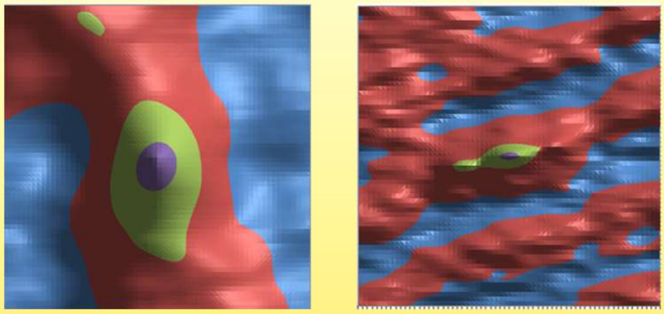
a) b)

Fig. 1. AFM image of CdTe thin films: a) sample 23/glass, T_S = 473 K, T_E =823 K, τ = 120 sec, d = 335 nm; b) sample 43/Si, T_S = 473 K, T_E =843 K, τ = 120 sec, d = 1080 nm.

The crystal lattice of CdTe thin films is cubic with preffered (111) orientation, the space group is F-43m. Films characterized by higher values of crystal lattice constants consist of smaller crystallites.

A two-dimensional autocorrelation function was used to determine the periodicity of the location and symmetry of objects on the film surface.

The surface of films is formed with parallel rows of formations the sizes of which depend on the temperature of the evaporator. The smaller objects formed on the surface, the shorter distance between the parallel rows that they form.



a) b)

Fig.2. Image of 2D auto-correlation functions of AFM images of CdTe thin films on a) glass (sample 23 T_E = 823 K, d = 335 nm) and b) silicon substrates (sample 43 T_E = 843 K, d = 1080 nm). The size of each side of square images is 0.5 µm.

Conclusions

The analysis of films of different thickness and obtained at different temperatures of the evaporator shows that thin films of Cadmium Telluride grow according to the Stransky-Krastanov mechanism.

A strong dependence of the surface properties of the films on the thickness is observed. No such regularity was found regarding the substrate material.

References

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