Structural and optical properties of CdTe thin films obtained by electrodeposition

Atanas Tanushevski, Dragan Sokolovski
University "Sts. Cyril and Methodius",
Institute of Physics, Faculty of Natural Sciences and Mathematics, Skopje, Republic of Macedonia
Outline

- Introduction
- Materials and methods
- Results and discussion
- Conclusions
Introduction

- Photoelectrochemical cells, which possess certain advantages over cells with p–n junction, are more and more attractive.
- Photoelectrochemical cells can be deposited on large area, defects in the crystal structure of individual layers are not significant, and their efficiency approaches diode solar cells.
- CdTe is a semiconducting compound used in the production process of PV, due to the high value of the absorption coefficient and the optimal width of the band gap of 1.5 eV.
- CdTe in the shape of thin film can be polycrystalline or nanocrystalline, which can contribute towards the change of its characteristics.
Materials and methods

- Cadmium telluride thin films were deposited via the method of electrodeposition on substrates with a SnO$_2$ layer and substrates with SnO$_2$-CdS layers. For electrodeposition of CdTe an aqueous solution of cadmium sulfate, tellurium dioxide and tartaric acid is used.
- CdTe thin film deposited by electrolysis on SnO$_2$ substrates was thermally treated in air at temperatures of $T = 200 \, ^\circ C$, $T = 300 \, ^\circ C$, $T = 400 \, ^\circ C$ and $T = 450 \, ^\circ C$, in order to examine the influence of temperature on its structural and optical properties.
- CdTe film obtained by electrodeposition on substrates with layers of SnO$_2$-CdS was thermally treated in air at a temperature of $T = 400 \, ^\circ C$. 
Results and discussion

- Cyclic voltammetry of aqueous solution of 0.2 M CdSO₄ and 0.8 mM Na₂TeO₃, with the solution temperature at 90 °C and pH = 2.
- The crystal structure and composition of CdTe thin films were determined by x-ray diffraction spectra.

Figure 1. Cyclic voltammetry of as-deposited CdTe thin film.

Figure 2. XRD pattern obtained from as-deposited and annealed CdTe thin films at different temperatures.
Results and discussion

- The morphology of films was determined by AFM (atomic force microscopy), whereby the film surface studied was 1 \( \mu \text{m} \times 1 \mu \text{m} \).
- For determining the optical band gap of CdTe thin films, measurements of the transmission in the wavelength were made.

Figure 3. AFM image of the surface of CdTe film annealed at temperature 450 °C.

Figure 4. Transmission spectra of the CdTe thin films as a function to the substrate temperature.
Results and discussion

- The optical bandgap $E_g$ of the films can be determined by using a graphic presentation of $(\alpha h \nu)^2 = f (h \nu)$
- The determination of the type of electrical conductivity of electrodeposited CdTe thin film is performed by measuring the voltage between the glass/FTO/CdTe-electrolyte (0.1 M Na$_2$S$_2$O$_3$) and graphite.

Figure 5. The dependence of $(\alpha h \nu)^2$ on the photon energy ($h \nu$) of the CdTe thin films at different substrate temperatures.

Figure 6. The PEC signal of the as-deposited CdTe thin film.
Results and discussion

- For characterization of photoelectrochemical cell its $I$-$V$ characteristics are measured in dark and light with light intensity of 50 mW/cm$^2$ and 100 mW/cm$^2$.

Figure 7. $I$-$V$ characteristics of SnO$_2$-CdS-CdTe-graphite solar cell.
Conclusions

- CdTe thin film has been electrodeposited on glass substrates covered with a transparent conductive film of SnO$_2$, at constant voltage of 1.40 V.
- XRD diffraction patterns of as-deposited and thermally treated films show that the films have a cubic crystal structure. The average size of the grains of 74 nm is greatest for films that have a thermal treatment at a temperature of $T = 450$ °C.
- Photoelectrochemical cells of the type SnO$_2$-CdS-CdTe-electrolyte-graﬁte were made with the electrolyte 0.1 M NaOH-0.1M Na$_2$Sx.
- The efficiency of the cells is 0.12 % and can be increased using solid electrolyte and thermal treatment of the layers at a temperature greater than $T = 450$ °C.
Thank You for Your Attention

Questions

Prof. Dr. Atanas Tanushevski
University "Sts. Cyril and Methodius",
Institute of Physics, Faculty of Natural Sciences and Mathematics
e-mail: atanas@pmf.ukim.mk