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Impact of γ-irradition on srtucture and electrophysical properties of CdMnTe

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Abstract: $Cd_{1-x}Mn_xTe$(x=0.05) thin films have been obtained on mica substrates. The surface morphology of samples examined with scanning electron analytical microscope JEOL JSM 7600F and AFM. We obtained $Cd_{1-x}Mn_xTe$ (x=0.05) thin films of high perfection with smooth and glossy surface and having homogeneous composition of Cd, Te, Mn. The crystal structure of obtained samples was investigated by x-ray diffraction method. It has been found that the synthesized samples and films obtained on mica substrates have a polycrystalline structure and indicated on the base of cubic lattice. It has been studied the impact of γ-irradiation on structure of $Cd_{1-x}Mn_xTe$ (x=0.05) thin films. The samples were irradiated by γ-ray 3 times at T=300 K. After irradiation the intensity in X-ray diffraction patterns is changed. The x-ray patterns of non-irradiated samples showed all the characteristic scattering peaks. While, the x-ray patterns of irradiated sample appeared different. The irradiated samples showed less degree of crystallinity as evidenced by fewer peaks of lower intensity. We have investigated the influence of γ-radiation on electrophysical properties of $Cd_{1-x}Mn_xTe$ thin films at T=300 K. Samples were irradiated 3 times by γ-ray at $D_γ$=10−51krad doses. As a result the VAC has changed after irradiation in dependence of γ-irradiation dose. The resistance is changed too. After γ-irradiation till $D_γ$=30krad doses the photosensitivity is increased but the further increasing of doses leads to disappearing of sensitivity.

Keywords: Semimagnetic Semiconductor, Thin Film, Crystal Structure, Substrate, X-Ray Diffraction Method, Sensitivity, Photoconductivity, VAC

1. Introduction

$Cd_{1-x}Mn_xTe$ thin films are considered much perspective and unique materials for optic isolators, infrared, gamma, roentgen and magnetic field detectors, solar cells. It should be noted that considerable work has been done in this area [1-5]. It is obvious that there is a giant Faraday rotation in $Cd_{1-x}Mn_xTe$ thin films and so it makes them to be an indispensable material for optic isolators and one-direction optic amplifiers [6].

$Cd_{1-x}Mn_xTe$ thin films are the most ideal materials for registering γ- and x-ray and being able to operate at room temperature. The working mechanism of these detectors is based on the principle of electric conductivity change under the influence of ionizing rays. The superior feature of these detectors than scintillated ones is - lack of multi-stage mechanism such as transforming energy of particles to electric signal [7].

Another unique application field of $Cd_{1-x}Mn_xTe$ thin films is development of solar cells on their base. These materials being of radiation resistance makes their use perspective in space and space telescopes [8, 9].

It should be noted that today's tendency in the instrument-making industry is going towards the direction of device size reduction. Therefore, we would like to improve parameters – reduction of film thickness, resistance to ionizing radiation, high photosensitivity and etc. For this purpose it is necessary to carry out the researches of physical parameters depending on sample thickness, and ionizing radiation dose.

In this work we have investigated the influence of γ-radiation on structure and electrophysical properties of $Cd_{1-x}Mn_xTe$ thin films.

2. Experimental

$Cd_{1-X}Mn_xTe$ (x=0.05) thin films of 2 thickness have been obtained on mica substrates, in a vacuum 10^{-4}Pa in УВН-71 П3 by the molecular beam condensation (MBC) method during the evaporation of t=10min and t=15min at the source temperature T_{sour}=850˚C and substrate temperature T_{sub}=300˚C. The sputtering installation under a cap consists of the basic and additional source which has been used for evaporation $Cd_{1-X}Mn_xTe$ (basis) solid solution and Te (additional) element, as well as substrate holder (Fig.1).

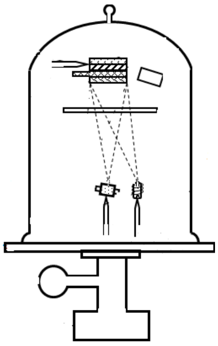


Fig. 1. *Vacuum assembly УВН-71 П3*

The surface morphology of $Cd_{1-X}Mn_xTe$ (x=0.05) thin films examined with scanning electron analytical microscope JEOL JSM 7600F equipped with a backscattered electron detector for imaging and EDS, WDS, EBSD analyzers for elemental analysis. In this method, a focused electron beam is scanned over the sample in parallel lines. The electrons interact with the sample, producing an array of secondary effects, such as back-scattering, that can be detected and converted into an image. The image can then be digitalized and presented to an image analyzer, which uses complex algorithms to identify individual particles and record detailed information about their morphology. We defined that the surface of the studied sample was smooth and glossy (Fig.2).

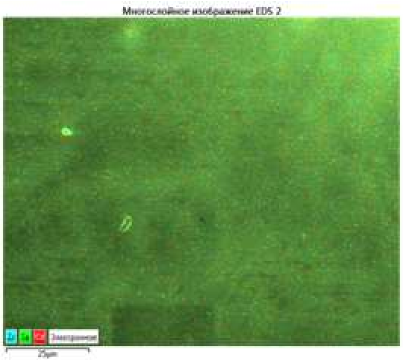
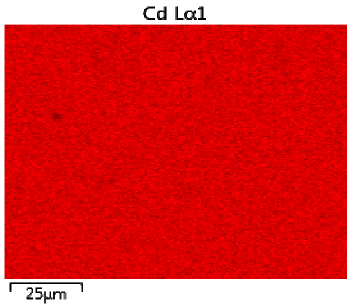
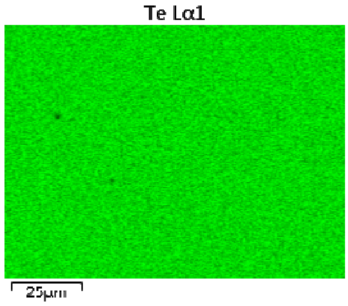


Fig. 2. *a) Scanning electron microscopy pictures of $Cd_{1-x}Mn_xTe$ (x=0.05) thin film surface b) histogram*

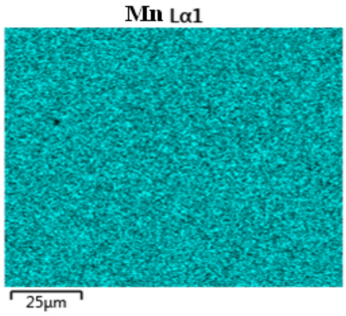
The elemental analysis of $Cd_{1-x}Mn_xTe$ (x=0.05) thin film was examined with scanning electron analytical microscope JEOL JSM 7600F. We have defined that thin film have homogeneous composition of Cd, Te and Mn (Fig.3).



a)



b)



c)

Fig. 3. *Elemental Analysis of $Cd_{1-x}Mn_xTe$ (x=0.05) thin film: a) Cd in the sample content b) Te in the sample content c) Mn in the sample content*

We have studied surface morphology by atomic force microscopy (AFM) too (Fig.4).

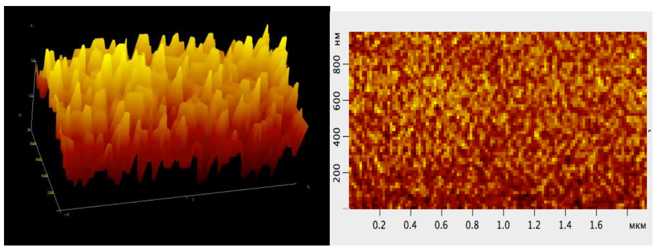
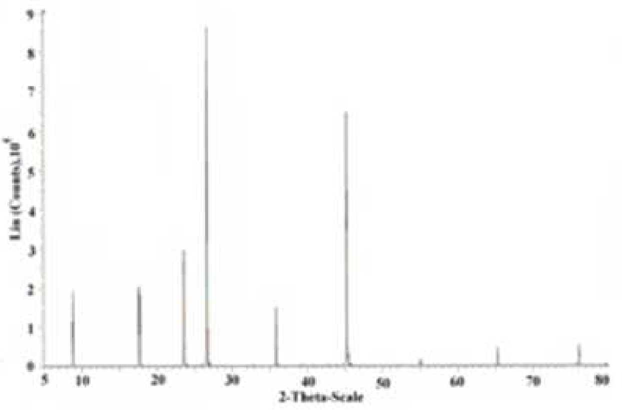


Fig. 4. *AFM images of $Cd_{1-x}Mn_xTe$ (x=0.05) thin film*

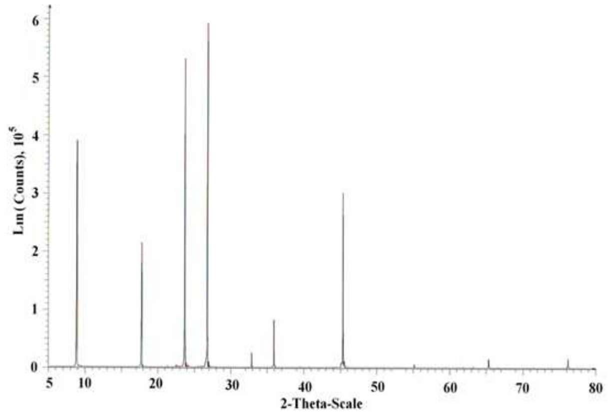
Thus, we obtained $Cd_{1-x}Mn_xTe$ (x=0.05) thin film of high perfection with smooth and glossy surface and having homogeneous composition of Cd, Te, Mn.

The crystal structure of obtained samples was investigated by x-ray diffraction method on x-ray difractometer Broker, Germany D8 ADVANGE before and after γ-irradiation

(Fig.5).



a)



b)

Fig. 5. *X-ray diffraction patterns of $Cd_{1-x}Mn_xTe$ (x=0.05) thin films on mica substrate: a) before γ-irradiation b) after γ-irradiation by E_γ=31krad, t_γ=23min*

The results of x-ray diffraction measurements showed that the crystals had a periodical structure, as designed artificially. It has been found that the synthesized samples and films obtained on mica substrates have a polycrystalline structure and indicated on the base of cubic lattice with appropriate parameters.

In order to verify the change of crystallinity upon γ-irradiation, x-ray diffraction of $Cd_{1-x}Mn_xTe$ (x=0.05) thin films was examined for non-irradiated and irradiated thin films.

After γ-irradiation by doses D_γ=31krad the intensity in x-ray diffraction patterns is changed. The x-ray patterns of non-irradiated samples showed all the characteristic scattering peaks. While, the x-ray patterns of irradiated sample appeared different. The irradiated samples showed less degree of crystallinity as evidenced by fewer peaks of lower intensity.

It has been studied electrophysical properties of $Cd_{1-x}Mn_xTe$ thin films at T=300 K. We have investigated Volt Ampere Characteristics (VAC) of $Cd_{1-x}Mn_xTe$ thin films at T=300 K (Fig.6). The curve of VAC consists of 2 parts: ohmic part and part of violation of ohm's low (n=1.5). Ohm's law is right till the voltage

$$V_x=en_0L^2/\varepsilon$$

In the case of traps absence the Ohm's law has the following formula:

$$I=en_0\mu V/L$$

Here L- is the length of sample, e- is the electron charge, ε- is the dielectric permittivity, μ- is the mobility, n_0- is the concentration of the free charge carriers [10].

We have investigated the influence of γ-radiation on electrophysical properties of $Cd_{1-x}Mn_xTe$ thin films at T=300 K (Fig.6). Samples were irradiated 3 times: 1) 7 min by doses 10 krad, 2) 16 min by doses 21krad, 3) 15 min 20krad. As a result the VAC has changed after irradiation in dependence of γ-irradiation dose. The resistance is changed too.

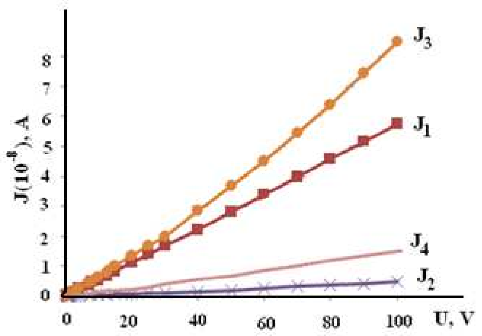


Fig. 6. *VAC of $Cd_{1-x}Mn_xTe$ (x = 0.05) thin films obtained on mica substrates: J_1-before irradiation, J_2-after irradiation D_γ=10krad, J_3- after irradiation D_γ=31krad, J_4-after irradiation D_γ=51krad*

The results of investigations of spectral dependence of photoconductivity of $Cd_{1-x}Mn_xTe$ thin films at T=300 K is given in Fig.7.

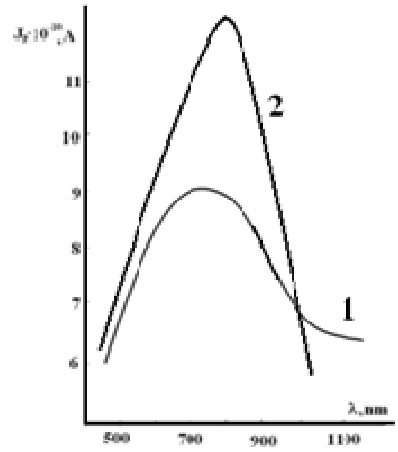


Fig. 7. *Photoconductivity of $Cd_{1-x}Mn_xTe$ (x = 0.05) thin films obtained on mica substrate: 1-before irradiation, 2-after irradiation D_γ=10krad*

The spectral range spans the wavelength region λ=400nm–1200nm. There is a broad band in the spectrum of photoconductivity. The band gap calculated from maxima (λ=720nm) of photoconductivity is equal to Eg=1.72eV at the temperature T=300 K. This result is in a good agreement with our previous theoretical results and with literature data [11].

In Fig.7 it is given the spectral dependence of photoconductivity before and after irradiation. After γ-irradiation till D_γ=30krad doses the photosensitivity is increased but the further increasing of doses leads to disappearing of sensitivity.

We have defined lifetime of carries in $Cd_{1-x}Mn_xTe$ (x = 0.05) thin films by the method of relaxation of photoconductivity at lighting of the monocrystal with monochromatic light of wavelength λ=530nm at T=300 K (Fig.8). The value of lifetime is τ=4.1 μsec. The γ-irradiation till D_γ=51krad doses don't influence to the lifetime of carries.

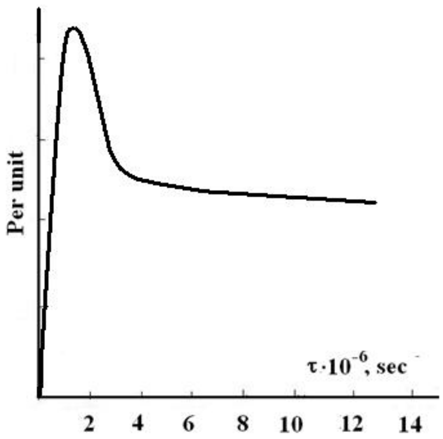


Fig. 8. *Kinetics of photosignal changing at impulse lighting*

3. Conclusion

It was obtained of $Cd_{1-x}Mn_xTe$ (x = 0.05) thin film on mica substrate of high perfection with smooth and glossy surface and having homogeneous composition of Cd, Te and Mn content.

The crystal structure of obtained samples was investigated by x-ray diffraction method. It has been found that thin films have a polycrystalline structure and indicated on the base of cubic lattice.

It has been studied the influence of γ-irradition on srtucture and electrophysical properties of $Cd_{1-x}Mn_xTe$ (x=0.05) thin films. After irradiation the intensity in x-ray diffraction patterns is changed. VAC and resistance has changed after irradiation in dependence of γ-irradiation dose. After γ-irradiation doses till D_γ=30krad the photosensitivity is increased but the further increasing of doses leads to disappearing of sensitivity

We defined lifetime of carries in $Cd_{1-x}Mn_xTe$ thin films τ=4.1 μsec. The γ-irradiation till D_γ=51krad doses don't influence to the lifetime of carries.

Acknowledgment

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