Deposition time effect on the optical properties of $Zn_{1-x}Mn_xTe$ films obtained by close-spaced vacuum sublimation

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Summary
In this paper we have been researching the influence of the deposition time and substrate temperature of diluted magnetic films $Zn_{1-x}Mn_xTe$, obtained by sublimation in a closed volume, on their optical properties. As a result, in the range of 400-800 nm wavelength spectral dependence of the transmittance T(λ), reflectance R(λ) and absorption α(λ) was obtained, and the band gap E_g of the material layers was calculated.

Introduction
One of the main characteristics of the window layers film solar converters is their optical transparency over a wide wavelength range. The most potentially attractive materials for this application are wide-gap semiconductors group A_2B_6 and solid solutions based on them, including– $Zn_{1-x}Mn_xTe$ [1]. This material has p-type conductivity, large band gap, the controlled change in the concentration of manganese allows to change the lattice period of the solution. It enables the creation of heterojunctions for microelectronics and solar energy devices with the distribution limit close to the ideal. In the present paper the dependence of the optical properties of the films of solid solutions $Zn_{1-x}Mn_xTe$ from their deposition time and substrate temperature was investigated.

Experimental
The films of solid solutions $Zn_{1-x}Mn_xTe$ were taken on the not orienting substrates from glass by sublimation method in a quasi-closed volume [2]. The pressure of the residual gases in the chamber was no more than $5 \cdot 10^{-3}$ Pa. Temperature of the evaporator was T_e = 800 ^{0}C, substrate temperature was changed in the range T_s = (350-650) ^{0}C. Evaporation of semiconductor purity powder containing approximately 5% manganese was carried. Two series of samples was made: with time of deposition – 4 minutes (series 1) and 10 minutes (series 2). Investigation of the optical characteristics of the layers was carried out at room temperature using a spectrophotometer UV-2000. The spectral range for measuring transmittance was 300-1100 nm, to measure the reflection coefficient at the same wavelength range used console SFO-2000.

Results
The investigated films $Zn_{1-x}Mn_xTe$ have a grain size D = 0.5-0.9 μm at the thickness d ~ 0,85-1,69 μm (series 1) and d = 1.72-2.84 μm (series 2), whereas with increasing substrate temperature its value is rising. The

analysis revealed that the calculated values of d were slightly lower than in films ZnTe deposited under similar conditions [3].

Typical transmission spectra and reflection of the films of solid solutions $Zn_{1-x}Mn_xTe$, obtained at different temperatures and with different time of deposition, are shown in the Fig. 1. Oscillatory nature of the curves is due to the phenomenon of interference, which occurs when the film thickness commensurate with the wavelength of the incident radiation.

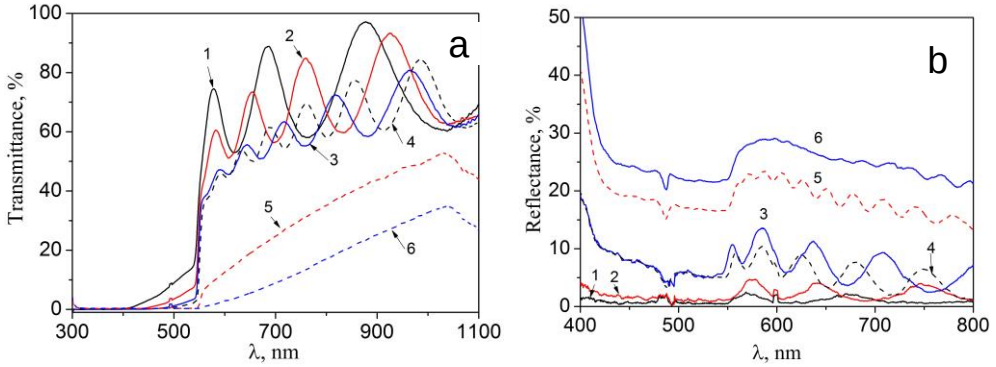

Fig. 1. Transmission (a) and reflection spectra (b) of the films $Zn_{1-x}Mn_xTe$, deposited under T_e = 800 ^{0}C and the substrate temperature T_s= 350(1,4), 500(2,5) and 650(3,6) ^{0}C. Lines 1-3 are series 1, Lines 4-6 are series 2

As shown in the figure, with wavelength more than λ ~ 540-550 nm (lower photon energy E_g of the material) there has been a significant increase in transmittance layers. Established that investigated condensates have transmittance which when λ > 800 nm was (55-95)% for the series 1 and (40-70)%. for the series 2, respectively. The difference between the transmission coefficients films obtained at different temperatures condensation caused by different crystalline and phase structure of these samples, the presence of grain boundaries and different roughness of the surface.

The coefficient of diffuse light reflection for films $Zn_{1-x}Mn_xTe$ was < 10% for the series 1 and about (15-30)% for the series 2. A similar dependence for the coefficient of specular reflection of light was observed. by increasing the substrate temperature revealed reduction in the *R*, that apparently was due to the occurrence of pronounced relief as the pyramid on the layers surface.

According to calculations, coefficient of light absorption of the obtained material layers in the range of energy radiation larger than band gap, is α = (2-3,5) 10^6 cm^{-1} (series 1) and α = (4.0-7.1) 10^6 cm^{-1} (series 2). $(\alpha h\nu)^2 - h\nu$ *dependencies* for samples of different series of films $Zn_{1-x}Mn_xTe$, that allowed us to determine the energy gap of the material, are shown in the Fig. 2.

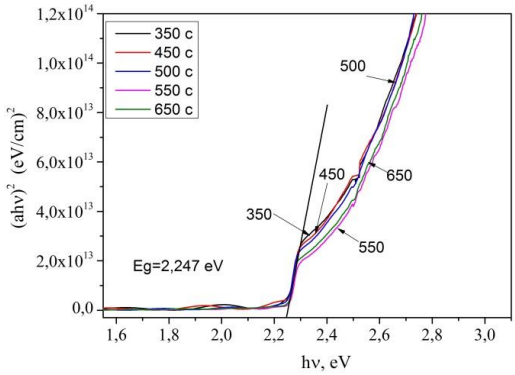

Fig. 2. $(\alpha h\nu)^2 - h\nu$ *dependencies of* $Zn_{1-x}Mn_xTe$ *films obtained under various substrate temperatures.*

As shown in the figure, in the films obtained at different substrate temperatures and deposition time, bandgap material differs slightly and is about E_g=2.25 eV. This value is slightly different from the values obtained by us earlier [4] – E_g=2.15-2.23 eV, which may be due to change of the concentration of manganese in the films depending on the deposition process conditions.

Conclusion

In this work was obtained the influence of substrate temperature and deposition time on the spectral dependence of the transmittance T (λ), reflectance R(λ) and absorption α(λ) of the films of solid solutions $Zn_{1-x}Mn_xTe$, and the band gap E_g of the material was calculated. As a result, studies have found that transmittance values of the films of solid solutions $Zn_{1-x}Mn_xTe$ is reduced from (55-95)% to (40-55)% with increasing deposition time (thickness) films from 4 to 10 min. The bandgap of the material was about 2.25 eV and weakly dependent on the time of deposition.

References

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