

Microstructural analysis for europium in CdTe films

M. González-Alcudia^{a,*}, M. Zapata-Torres^a, M. Meléndez-Lira^b,
O. Calzadilla Amaya^c

^a CICATA-IPN Unidad Altamira, Km. 14.5 Carretera. Tampico-Puerto Industrial 89600, Altamira, Tamps, Mexico

^b Departamento de Física, CINVESTAV-IPN Unidad México. Apdo. Postal 14-740, 07000, México D.F., Mexico

^c IMRE-Facultad de Física, Universidad de la Habana, San Lázaro y I. Vedado 10400, Habana, Cuba

Abstract

CdTe:Eu films were grown by the pulsed laser deposition method on glass substrates. The targets were prepared with three different concentrations of Cd, Te and Eu employing CdTe and EuTe powders, homogenized by ball milling. X-ray diffraction measurements showed that the samples grown with a mixture of phases related with the structure of CdTe and EuTe, with a little increase of the lattice parameter. Scanning electron micrographs revealed that CdTe:Eu films presented a texture similar to solidified drops. Optical transmission spectroscopy was used for determinate the band gap of samples. Raman spectroscopy results shown broadening of Raman features associated with the structure of CdTe and EuTe with nominal Eu content.

© 2008 Published by Elsevier Ltd

Keywords: Rare earth (RE); CdTe; Pulsed laser deposition modified technique (PLD-M)

1. Introduction

Rare earth (RE) doped semiconductors have been attracting a great deal of interest due to their effect on optoelectronic properties and potential effects on optoelectronic devices. II–VI semiconductor compounds doped with rare earth elements exhibit high luminescence efficiency. Recently, the effect of rare earth doping on CdTe have been studied. Savchuk et al. [1] have previously reported results of optical and magneto-optical investigations of the CdTe crystals

* Corresponding address: CICATA-IPN, Unidad Altamira, Km. 14.5 Carretera Tampico-Puerto Industrial Altamira, C.P. 89600, Altamira Tamaulipas, Mexico. Tel.: +(01 833) 264 93 02x87509; fax: +260 01 24 87505.

E-mail address: mgonzalez@ipn.mx (M. González-Alcudia).

doped with Eu, Gd and Dy. Daudin et al. [2] shown that epitaxial Eu can be successfully grown onto a (001) CdTe layer. Chen et al. [3] reported $\text{Cd}_{1-x}\text{Gd}_x\text{Te}$ and Wruck et al. [4] studying optical spectra and some structural properties, showed that RE ion can be introduced up to the 10% range into CdTe films during molecular beam epitaxial (MBE) growth. On the other hand, pulsed laser deposition (PLD) is a promising method to prepare thin films with a complex composition, including rare earth and Ag-doped chalcogenide films [5] because all components of the target can be congruently evaporated. In this work we present the results of structural and optical characterization of CdTe:Eu films grown employing the PLD technique.

2. Experimental details

The materials employed to prepare the targets were powders of CdTe (purity 99.99 at.%) and EuTe (purity 99.9 at.%). In order to obtain targets with three different concentrations, we mixed CdTe and EuTe powders in the right amount to obtain $x = 0.1, 0.2$ and 0.46 in $(\text{CdTe})_{1-x}(\text{EuTe})_x$. A 10% in weight of CdCl was added to each powder mixture then ball milled for 8 h adding some drops of ethylene glycol. After this process, the mixtures were sintered at 800°C for 5 h under nitrogen atmosphere.

Finally, the powders were pressed into disks 10 mm in diameter and 1–2 mm in thickness using a 200 MPa pressure then introduced into vacuum quartz ampoules sealed and sintered at 850°C , during 3 h. CdTe:Eu thin films were grown on glass substrates by the pulsed laser deposition modified method (PLD-M) previously reported [6]. The films were prepared using a Nd:YAG laser at 1064 nm with a pulse width and repetition rate of 10 ns and 10 Hz, respectively. During deposition, the substrate temperature and ambient pressure were kept at 250°C and 10^{-3} Pa, respectively. The distance between source material and substrate was about 30 mm. The texture, structural and electronic properties of CdTe:Eu films were determined by scanning electron microscopy (SEM), X-ray diffraction, transmission and Raman spectroscopies. SEM measurements were made using a JEOL 6500 F. X-ray diffraction was performed with a Siemens D5000 diffractometer fitted with a Cu anode. Room temperature transmission measurements were carried out in a Perkin Elmer Lambda 40 UV-VIS. Room temperature Raman spectroscopy measurements were carried out in a Labram Dilor micro Raman ($\mu\text{-R}$) system employing a HeNe laser as excitation source.

3. Results and discussion

The films were dark gray in color, uniform and firmly adherent to the substrate. The samples M1, M2 and M3 were the films prepared with the target with $x = 0.1, 0.2$ and 0.46 in $(\text{CdTe})_{1-x}(\text{EuTe})_x$, respectively. The SEM micrographs indicate that samples have spherical particles with diameters between about 0.05–1 μm , as shown in Fig. 1. Even when spherical morphology could be associated with PLD process we ruled out this possibility because the experimental setup impeded direct incidence of ejected material on the substrate.

X-ray diffraction (XRD) patterns for the samples M1, M2, M3, and the simulated spectra of CdTe and EuTe are presented in Fig. 2. The patterns were indexed using the JCPDF 150 770 and 760 120 for CdTe and EuTe, respectively. The presence of a phase mixture with crystal structure related to CdTe and EuTe can be seen. For M1 the XRD pattern shows a crystal structure very similar to CdTe indicating a possible Eu incorporation in the CdTe lattice. M2 and M3 X-ray patterns had a mixture of the phases related with EuTe (F3m3) and CdTe (F-43m). EuTe related peaks have a greater intensity in sample M3. Considering that all samples have a zinblende

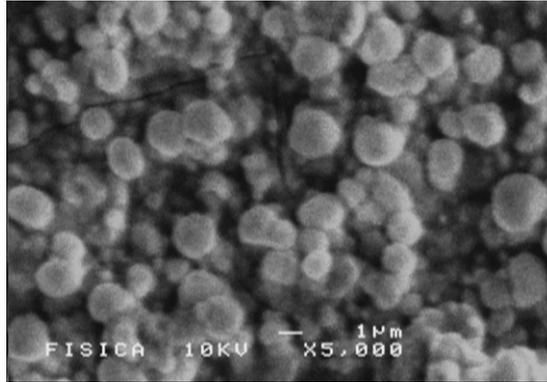


Fig. 1. SEM micrograph of sample M3.

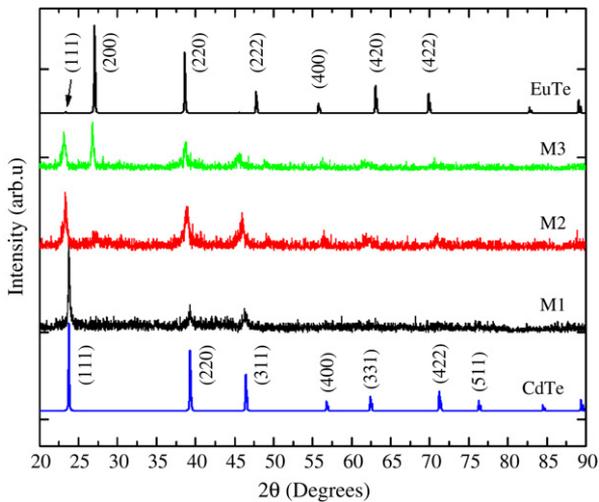


Fig. 2. X-ray diffraction spectra of samples M1, M2 and M3 and the simulated spectra of CdTe and EuTe.

structure a lattice parameters were calculated (M1:6.48, M2:6.49 and M3:6.51 Å), obtaining a small increase; these could be due to that a small amount of Eu is incorporated in the cell.

In Fig. 3 we presented transmission spectra of the studied samples. It is clear that except for sample CdTe there are changes in the absorption edge curvature that could be due to two phases, impurities or lattice imperfections. The optical band gap (E_g) of the pulsed laser deposited CdTe:Eu films, was estimated from the $(\alpha^*hv)^2$ vs $hv(E - E_g)$ curves, where α is the optical absorption coefficient in cm^{-1} , computed from the transmittance data, and hv is the photon energy in eV. The obtained values of E_g were 1.51, 1.81 and 1.97 eV for the samples M1, M2 and M3, respectively.

The μ -R spectra of the CdTe:Eu films are shown in Fig. 4. The observed μ -R spectra for samples M1 and M2 show two groups of peaks: (i) the LO phonon frequency of the bulk CdTe [LO: 163 cm^{-1}] and (ii) modes appear in M1 [at 120 and 135 cm^{-1}] and M2 [at 118 and 135 cm^{-1}].

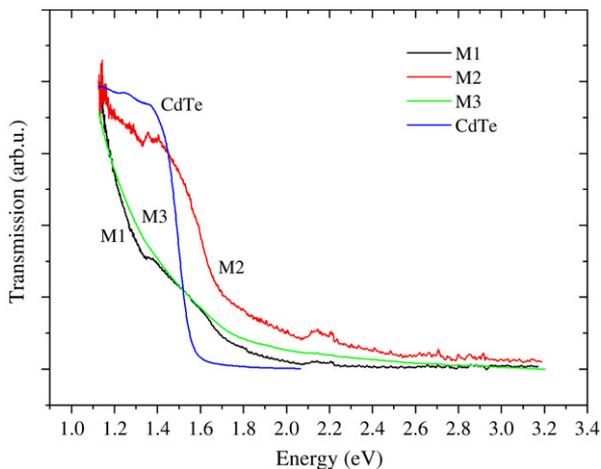


Fig. 3. Optical transmittance spectra of samples M1, M2, M3 and CdTe.

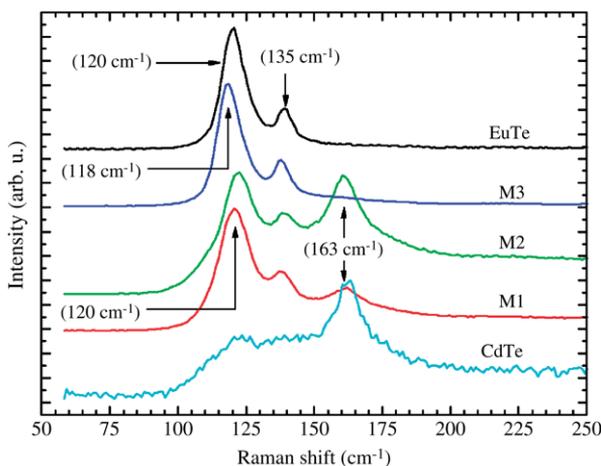


Fig. 4. Raman scattering spectrum of samples CdTe, M1, M2, M3 and EuTe.

However, the μ -R spectra are dominated by the longitudinal optical vibration at $\sim 120 \text{ cm}^{-1}$. This band is attributed to phonon mode of related to EuTe [7,8].

4. Conclusions

In summary, the films obtained by processing the target by ball milling are grown with a mixture of phases related to the structure of CdTe and EuTe, showing a little increase of the lattice parameter. For the studied samples the band gap increases with Eu content. The vibrational modes obtained were related to the CdTe and EuTe compounds.

Acknowledgments

This work was supported by CONACYT and SIP-IPN. The authors express their gratitude to Javier A. Zapata T., Alejandra Garcia S., Marcela Guerrero and Ana Soto for their technical help.

References

- [1] A.I. Savchuk, S.Yu. Paranchych, V.M. Frasnuyak, V.I. Fediv, Yu.V. Tanasyuk, Ye.O. Kandyba, P.I. Nikitin, *Mater. Sci. Eng. B* 105 (2003) 161.
- [2] B. Daudin, P. Gros, E. Ligeon, A.C. Chami, *Appl. Surf. Sci.* 65–66 (1993) 827.
- [3] C. Chen, X. Wang, A. Liu, H. Wu, *J. Appl. Phys.* 87 (2000) 6463.
- [4] D. Wruck, R. Boyn, L. Parthier, F. Henneberger, *J. Cryst. Growth* 184–185 (1998) 119.
- [5] D.B. Chrisey, G.K. Hübner, *Pulsed Laser Deposition of Thin Films*, John Wiley & Sons, Inc., New York, 1994.
- [6] M. Gonzalez-Alcudia, A. Márquez-Herrera, M. Zapata-Torres, M. Meléndez-Lira, O. Calzadilla-Amaya, *Adv. Tech. Mat. Mat. Proc. J.* 9 (2007) 81.
- [7] P.M. Amirtharaj, F.H. Pollak, *Appl. Phys. Lett.* 45 (1984) 789.
- [8] L.E. Schmutz, G. Dresselhaus, M.S. Dresselhaus, *J. Magn. Magn. Mater.* 11 (1979) 412.