KAUNO TECHNOLOGIJOS UNIVERSITETAS

ISSN 1822-508X

International Conference

RADIATION INTERACTION WITH MATERIAL AND ITS USE IN TECHNOLOGIES 2008

Kaunas, Lithuania

24-27 September, 2008

ISSN 1822-508X

KAUNAS UNIVERSITY OF TECHNOLOGY
VYTAUTAS MAGNUS UNIVERSITY
LITHUANIAN ENERGY INSTITUTE
RIGA TECHNICAL UNIVERSITY

International Conference

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Kaunas, Lithuania
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Program and materials

TECHNOLOGIJA
KAUNAS, 2008

PROPERTIES OF NANOSTRUCTURE ON A SURFACE OF $Cd_{0.9}Zn_{0.1}Te$ COMPOUND BY LASER RADIATION

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Abstract

Self-organizing structures of nanometer size are observed on the surface of CdZnTe crystal irradiated by strongly absorbed Nd:YAG laser radiation (LR) at intensities within 4 - 12 MW/cm^2. The effect of exciton quantum confinement manifested by a shift to higher energies of the A^0,X exciton line of the photo-luminescent spectrum is present in structures of 10 – 15 nm in diameter at the top of nano-hills. A graded band gap structure with optical window is formedat the top of nano-hills.

Keywords: Self-organizing structure, Nd:YAG laser, exciton quantum confinement effect, CdZnTe crystal

One of the most method of semiconductor processing providing high locality and cleaner "technology", speed of processing by updated electric and recombination properties is laser processing. The most important electronics problem at semiconductor laser processing is the change of the material structure [1] and occurrence barrier structures [2]. The perspective of this direction has to further experimental and theoretical research of process occurring near-surface layer of crystal.

The change of optical properties and surface morphology of near-surface layer of $Cd_{1-x}Zn_xTe$ (x=0,1) crystal by laser radiation with aim to create graded band-gap was investigated.

Samples of $Cd_{1-x}Zn_xTe$ with x=0.1 were used in our experiments. Irradiation was carried out at room temperature and atmospheric pressure. The samples have been irradiated by the second harmonic λ = 532 nm of the Nd: YAG laser with intensity of 4 -12 MW/cm^2. The irradiated surface of crystal was covered with a thin layer of SiO_2 in order to avoid material evaporation by laser heating. PL spectra were measured at 14 K using an Ar+ laser for excitation.

The methods of photoluminescence (PL) and atomic force microscope (AFM) were used in the experiments. On the surface of the semiconductor crystal the nanostructure was formed after laser irradiation with intensity of I ≈ 4 MW/cm$^{2.}$ As the result the A^0X line of PL spectrum starts to shift in the direction of high energy "blue shift" (Fig.1.).

The shift of A^0X line is ΔE=7.7meV at laser intensity of I =12 MW/cм$^{2.}$ The moving of exciton line A^0X is explained by exciton quantum confinement effect into nanostructure formed on semiconductor surface. The roughness of micro-relief of the original surface of the crystal was found to be about 10 nm

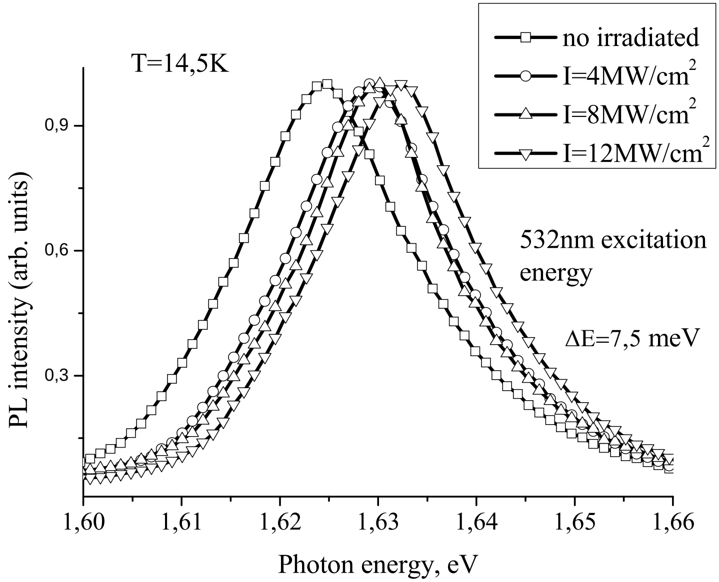

Fig. 1. Photo-luminescence line of the A^0,X exciton in $Cd_{1-x}Zn_xTe$ (x=0,1) before and after irradiation measured at 14,5 K: a) before irradiation, b) after irradiation at the intensity of 4 MW/cm^2, c) after irradiation at the intensity of 8 MW/cm^2, d) after irradiation at the intensity of 12 MW/cm^2.

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high extending to 150 – 200 nm (Fig. 2a). After irradiation at intensity of 12 MW/cm^2 the surface morphology had changed: nano-size structures of about 10 nm high had grown on the microstructures as seen in Fig. 2b. Irradiation of $Cd_{1-x}Zn_xTe$ (x=0,1) crystals by Nd:YAG laser at intensities below the threshold intensity of 4 MW/cm^2 had not changed the surface morphology. The generation of nanostructures began at intensities I ≥ 4 MW/cm^2.

The shift of the exciton line is explained by the effect of quantum confinement in the nano-structures emerging on the semiconductor surface.

The effect of the A^0,X exciton line shift is theoretically described on the basis of the exciton quantum confinement [4].

At nano-size of structures the effect of exciton quantum confinement is observed as the increase of the exciton energy and decrease of the exciton radius. The effect, on its turn, is related to the increase of the energy gap of the semiconductor.

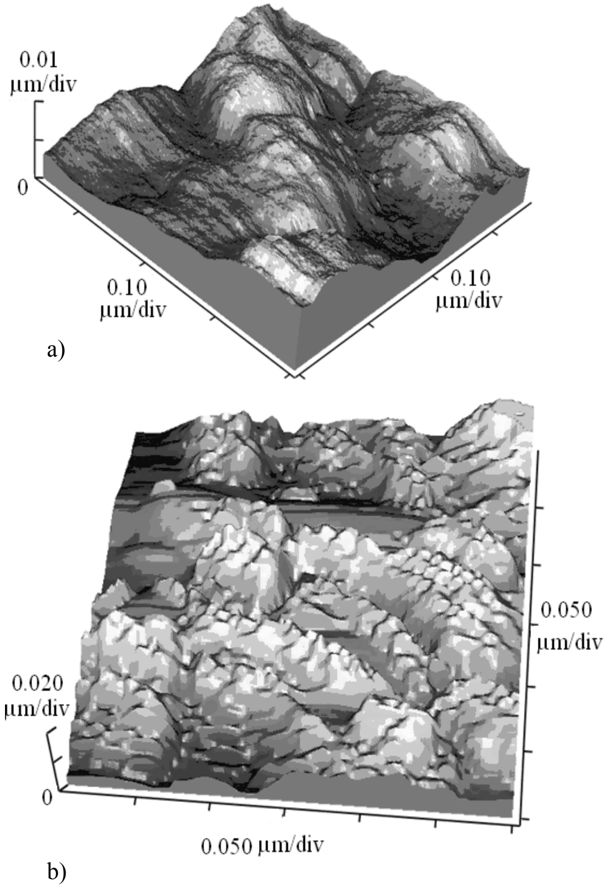

Fig. 2. Atomic force microscope images of the $Cd_{1-x}Zn_xTe$ (x=0,1) surface: a) before irradiation, b) after irradiation at the intensity of 12 MW/cm^2.

The increase of the exciton energy is proportional to the decrease of cross section area toward the top of the nano-hill.. The energy band gap of the $Cd_{1-x}Zn_xTe$ crystal increases along the axis of the nano-hill perpendicular to the sample surface. Thus, a graded band gap structure with optical window is formed in the nano-hill.

The graded band-gap structure with insulating burred layer was formed as a result of influence of temperature gradient on redistribution of Cd and Zn atoms.

Studies of the effect of highly absorbed laser radiation on the optical properties of the $Cd_{1-x}Zn_xTe$ (x=0,1) compound have revealed the formation of nano-structures on the surface of the semiconductor under irradiation by the Nd:YAG laser within the intensity range of 4 – 12 MW/cm^2. The effect of exciton quantum confinement is present in structures diameter of which at the top of nano-hills is 10 – 15 nm and less. A graded band gap structure with optical window is formed on top of the nano-hills.

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