GRADED BAND-GAP FORMATION IN CdZnTe BY YAG:Nd LASER RADIATION

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Abstract

A mechanism for formation of graded band-gap in $Cd_{1-x}Zn_xTe$ sample using the second harmonic of a Q-switched YAG:Nd laser radiation (LR) is proposed which involves Thermogradient Effect (TGE). Results of investigation of the photoluminescence (PL) spectra at 5 K show that the concentration of atom Zn is increased owing to aggregation of the VCd with Zn after laser irradiation in the bulk of the sample. The possibility to form the graded band-gap in $Cd_{1-x}Zn_xTe$ crystal by the second harmonic of YAG:Nd laser radiation have shown.

Keywords: $Cd_{1-x}Zn_xTe$*;laser;Thermogrdadient effect; Graded band-gap*

Introduction

Band-gap structures on the basis of **CdZnTe** are perspective materials for creation of various semiconductor devices, in particular for highly effective converters of a sunlight, selective and broadband photo detectors, spectrally scanning lasers with a low threshold current [1, 2].

The development of new methods for creation of structures with use of pulse laser radiation has great value for microelectronics and optoelectronics, in particular with wide use band-gap structures. Pulse laser radiation is one of perspective methods of the directed updating electric and recombination properties of ternary alloy. The given method of processing has localness and short duration of influence on the semiconductor. A number of papers are devoted to influence of a pulse laser irradiation on the semiconductor [3-10]. The big attention is given for studying of modification of surface layers as a result of laser influence nanosecond range [3, 4, 10 - 12].

The high gradient of temperature, arising at action of pulse laser radiation nanosecond range, causes redistribution of point defects (vacancies and interstitial atoms) toward of a temperature gradient. According to TGE [13] Cd interstitial atoms (Cdi) move toward of increase in temperature, and Cd vacancies (VCd) move to an opposite direction, where minimum temperature.

The purpose of this work is experimental investigation of the possibility grated band-gap creation in ternary alloy **CdZnTe**

Experimental details

The following method has been used in the work: photoluminescence (PL). The PL method allows one to investigate the energy spectrum and concentration of luminescence centers. Single crystals of $Cd_{1-x}Zn_xTe$ (x=0,06), were used in our experiments. Irradiation was carried out at room temperature and atmospheric pressure. The samples have been irradiated by the second harmonic ($\lambda = 532$ nm, τ=15ns) of the YAG:Nd laser in Q-modulation with the intensity from 0,2 MW/cm^2 to 2 MW/cm^2. It is necessary to use the second harmonic of YAG:Nd laser with higher absorption coefficient for creation high grad T. The irradiated surface of crystal was covered with a thin layer of SiO_2 in order to avoid material evaporation by laser heating. The thickness of SiO_2 layer was 0,3 μm and it was transparent for laser radiation. The samples were sides to $10x10x2\ mm^3$.

Results and discussion

The initial PL spectrum contains an intensive line (A^0, X) at 1.6139 eV ascribed to excitons bound to shallow acceptors (Cd vacancies - VCd) and a weaker line (D°, X) of excitons bound to shallow donors at 1.6186 eV. The PL band around 1.55 eV is caused by recombination of donor-acceptor pairs (DAP) and consists of the zero-phonon line (ZPL) at 1.592 eV and its LO-phonon replicas.

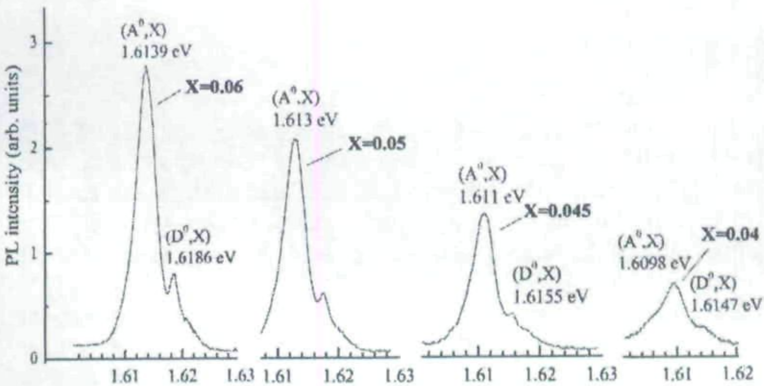

Fig.1. Photoluminescence spectra of $Cd_{1-x}Zn_xTe$ crystals before and after laser processing

After laser irradiation of $Cd_{1-x}Zn_xTe$ crystal with intensity 0.2 MW/cm^2 all the lines of PL spectra start to shift to lower energy of spectra (red shift). In turn, spectral shift of the A°X line at maximal laser intensity $I=2MW/cm^2$ was 41meV (Fig.1). In a recent study [14] have shown that the incorporation of Zn into the CdTe lattice results in a significant reduction of cadmium vacancies in the structure of the mixed crystal. The movement of A^0X can be explaining by redistribution of Zn atoms and VCd. Calculation of the distribution of the Zn atoms and the CdI in the presence of temperature gradient (grad T) in direction of laser beam propagation has shown that concentration of Zn atoms increased in the bulk of the semiconductor [6].

Its follows that the concentration of the VCd is increased in the same place as concentration of the Zn atoms. As a result the situation in the bulk of semiconductor becomes favorable for recombination VCd by Zn atoms.

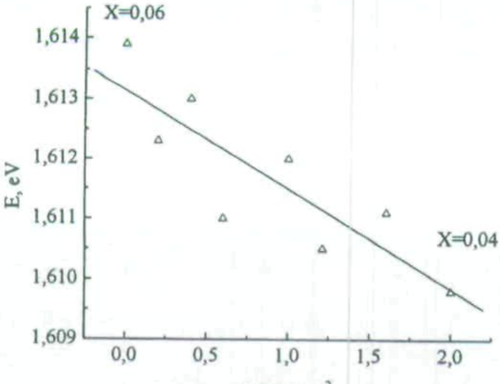

Fig.2. Evolution of the 1.6139eV exciton bound energetic position depending on laser intensity

In the ternary the decrease of Zn concentration leads to decreasing of the $Cd_{1-x}Zn_xTe$ [15] band gap near the irradiated surface, correspondingly. As it follows from fig.2 the Zn concentration near irradiated surface decreases by 2%. The change of Zn concentration from X=0,06 to X=0,04 (Fig. 2) in direction of the bulk of the sample assume to change of band-gap into the $Cd_{1-x}Zn_xTe$.

The intensities of the exciton luminescence peaks is decreasing appreciably due to increasing of absorption of PL and its excitation light as deepening of the exciting layer. The peaks shift to the lower energy due to decrease of the energy band gap that is well visible from fig 2. The change of energetic position of A^0X exciton recombination (experimental) can be explained by decrease of width of semiconductor band-gap.

Conclusions

1. The possibility to form the graded band-gap in $Cd_{1-x}Zn_xTe$ crystal by the second harmonic of YAG:Nd laser radiation have shown.
2. The Thermogradient effect has the main role in the redistribution of Zn atoms at the irradiated surface of $Cd_{1-x}Zn_xTe$ using YAG:Nd laser second harmonic with intensity from 0.2 MW/cm2 till 2 MW/cm2.

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