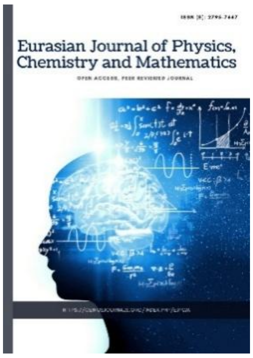

Photoluminescent properties in quantum-sized structures $Cd_{0,83}Zn_{0.17}Te/ZnTe/GaAs$ of GaAs and $Al_XGa_{1-X}As$

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ABSTRACT

The change in optical characteristics was determined with the influence of electron and X-ray irradiation in the buffer layers of quantum-sized structures $Cd_{0,83}Zn_{0.17}Te/ZnTe/GaAs$. Changes in the maxima, bands corresponding to 500 nm and 560-580 nm, associated with transitions on DA pairs, as well as bands I_1=2.48 eV (500 nm) and I_2=2.21 eV (550 nm) were determined. The I_2 band is attributed to a transition associated with intrinsic defects in the ES.

Keywords: Quantum-sized structures, extended defects, photoluminescence, temperature dependencies.

Introduction. Interest in the radiation of quantum-sized structures based on A_2B_6 materials is due to the possibility of manufacturing injection sources of coherent [1] and incoherent radiation, as well as electron-pumped emitters [2-3] covering virtually the entire visible range. The spectrum of NT FL quantum-sized structures $Cd_{0,83}Zn_{0.17}Te/ZnTe/GaAs$ was considered in three energy regions:

1. Region of bound excitons and transitions to small levels from the conduction band (519-550 nm).
2. Region of radiation from donor-acceptor pairs (550-590 nm).
3. Region corresponding to radiative recombination at deep defects (590-775 nm).

Quantum-sized structures were grown by molecular beam epitaxy on the Katun installation. The quality of the ZnTe epitaxial layer and the ZnTe/GaAs interface was investigated by low-temperature photoreflection and photoluminescence (LT PL T=4.2 and 77 K). Measurements of photoluminescence (PL) and reflection (R(λ)) spectra were performed at 4.2 and 77 K on a spectral instrument with a resolution of ≤0.5 meV. The PL spectra were excited by radiation from an Ar laser model LGN-503 with λ_1=0.5145 and λ_2=0.4880 μm. Irradiation with electrons with an energy of 1.8 MeV and an integral fluence of cm^{-2} was carried out on an ILU-6 pulse accelerator in the following mode: pulse duration 700 μs, frequency 25 Hz, electron current density in the pulse $3,5x10^{14}$ $cm^{-2}\cdot s^{-1}$. As can be seen in Fig. 1, the reflection curve, R(λ), shows features associated with heavy and light exciton resonances (I_{FX}^{lh} and I_{FX}^{hh} , marked with arrows) holes. The magnitude of residual elastic deformations was calculated based on the position and splitting of resonances of light and heavy holes in the reflection spectra. The residual elastic deformations $\varepsilon(\varepsilon_{xx} = \varepsilon_{yy})$ were calculated using the formula [3]: $\Delta E = 2b\cdot\varepsilon\cdot(S_{11}-S_{12})/(S_{11}+S_{12})$, where $\Delta E = FX^{lh} - FX^{hh}$, (meV); deformation potential b = +1.30 eV; elasticity coefficients $S_{11} = 2{,}4\cdot10^{-11}$ and $S_{12} = -0{,}87\cdot10^{-11}$ $м^2\cdot H^{-1}$. The value of tensile deformations was $\varepsilon=6.5\cdot10^{-4}$, 77 К. After irradiation, there was a slight shift of the exciton resonance features towards shorter wavelengths and a decrease in the value of ΔE relative to the initial sample. The deformation value for the irradiated sample was $\varepsilon= 6.24\cdot10^{-4}$, 77 К, i.e., elastic deformation relaxation occurred by an amount of $(\varepsilon_0 - \varepsilon_\phi)/\varepsilon_0\cdot100\%=4\%$, where $\varepsilon_{0,\phi}$-are the deformations in the initial (irradiated) sample, respectively. [4-5]/

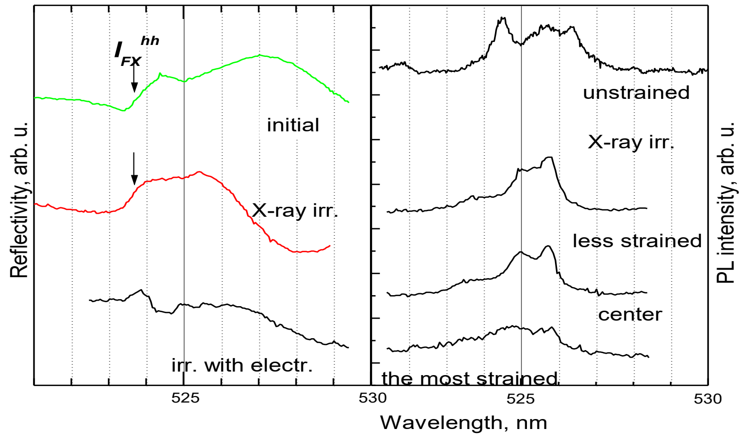

Fig. 1 shows the reflection spectra, $R(\lambda)$,of the initial ZnTe buffer layer without quantum-sized layers before (curve 1) and after electron irradiation (curve 2).

The change in elastic deformation, calculated from the low-temperature PL spectra of the same sample, both initial and irradiated with electrons, based on the shift in the position of the band associated with the heavy hole (I_{FX}^{hh}) exciton ($h\nu_0$=2.3800 eV, 4.2 К amounted to $\Delta\varepsilon=1.6\cdot10^{-5}$,, which is in good agreement with the data obtained from the reflection spectra at 4.2 K. The nature of the defects in the epilayer and at the interface was identified from the exciton line spectra. A significantly inhomogeneous distribution of Ga in the near-surface region was established. It turned out that at the very surface of the ZnTe ES, the concentration of gallium increases significantly, i.e., gallium accumulates near the growth surface. At the same time, there is an increase in concentration V near the surface. After irradiation, the position of exciton resonance features shifts toward shorter wavelengths. This is associated with noticeable relaxation (reduction) of stresses after irradiation. The mechanism of radiation-stimulated stress relaxation in quantum-sized structures may be associated with the generation of extended and point defects or with a change in the composition of the well due to interdiffusion of its components. In addition to the features associated with excitons in the buffer layer, the reflection spectra $R(\lambda)$ at energies coinciding with the maximum radiation from the quantum well (I_{QW}) show features superimposed on the interference pattern that “follow” the shift of the FL maximum during irradiation. These features shift toward lower energies under X-ray irradiation and toward higher energies under fast electron irradiation.

Indeed, after irradiation, a shift toward shorter wavelengths is observed in the exciton lines, which indicates a decrease in tensile stresses in this layer. Since there was practically no relaxation in a single ZnTe buffer ES, it can be concluded that in a complex heterostructure, radiation-stimulated relaxation of stresses (associated with the mismatch of the lattice parameters of wells and barriers) mainly occurs between the epitaxial layer and the substrate. At the same time, a significant decrease in the intensity of exciton luminescence associated with defects and/or impurities is observed in the epitaxial layers of the ES, which may be due to the appearance of non-radiative recombination centers as a result of defect reactions occurring during irradiation. It is assumed that Ga donors diffuse from their GaAs substrates into the ZnTe film during growth. In the heterointerface region, an 810-860 nm FL band is clearly visible. A band at ƛ=833.4 nm, corresponding to the e-Zn transition, is also visible. Traces of residual Zn acceptors against the background of much more intense transitions associated with residual impurities indicate that Zn diffusion into the GaAs substrate occurs. The film-substrate transition layer is formed during growth, and not as a result of classical heterodiffusion of components in the film and substrate. After electron irradiation, a shift in the short-wave direction of the exciton lines from the buffer ES, under KYA, is observed in the epitaxial films, which indicates a decrease in tensile stresses in this layer. Since there is practically no relaxation in a single buffer ES (ZnTe), it can be assumed that in a complex heterostructure, radiation-stimulated stress relaxation mainly occurs between wells and barriers (associated with the mismatch of well and barrier parameters).

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