CURRIER RECOMBINATION AND OPTICAL EXCITATION IN THE GAAS DOPING SUPERLATTICES

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Processes connected with recombination and optical excitation of non-equilibrium current carriers in the GaAs doping superlattice crystals are analyzed in detail. Results of self-consistent calculations of the potential relief and transformation of the electron spectrum under excitation and in dependence on the superlattice design parameters are presented. Influence of high doping on the electron-hole recombination in *n-i-p-i* crystals is determined taking into account the Gaussian fluctuations of impurity concentrations [1, 2]. The developed approach allows describing adequately the behavior of the spontaneous radiative emission at changing the quasi-Fermi levels. As a rule, the fluctuations of dopant concentrations, correlation in the impurity distribution, and screening of the electrostatic potential have an effect independently in *n*- and *p*-regions.

It is shown, that the lifetime of current carriers τ in the luminescence process in doping superlattice structures covers a wide range versus the optical power excitation P. Therewith, more general cases than in [3, 4] are examined. The relation between the rate of optical excitation $kP/h\nu_{exc}$, where $k(\nu_{exc})$ is the absorption coefficient and ν_{exc} is the frequency of excitation quanta, and the difference of the quasi-Fermi levels ΔF was established. Two effects are important, i. e., (a) low-dimensional character of the carrier distribution and (b) change in the overlap of electron and hole wave functions. At low excitation, non-radiative recombination can play principal cause in the stabilization of the effective lifetime of current carriers. At high excitation, the carrier lifetime τ approaches the value in bulk crystals.

The major attention has been given to the compensated GaAs superlattices with *i*-layers (*n-i-p-i* crystals) and with no *i*-layers (*n-p-n-p* structures). The layer thickness of *n*-, *p*-, and *i*-type were 20, 40, or 60 nm and the concentrations of the doping impurities Te and Zn were made up to 10^{18} cm^{-3}. Photoluminescence spectra and the time constants of luminescence intensity decay were measured at $h\nu_{exc} = 2.4$ eV in the temperature interval from 11 to 300 K. In addition, the influence of α-particle irradiation and isochronal thermal annealing on the luminescence spectra and the carrier lifetime was also investigated [5]. As an example,

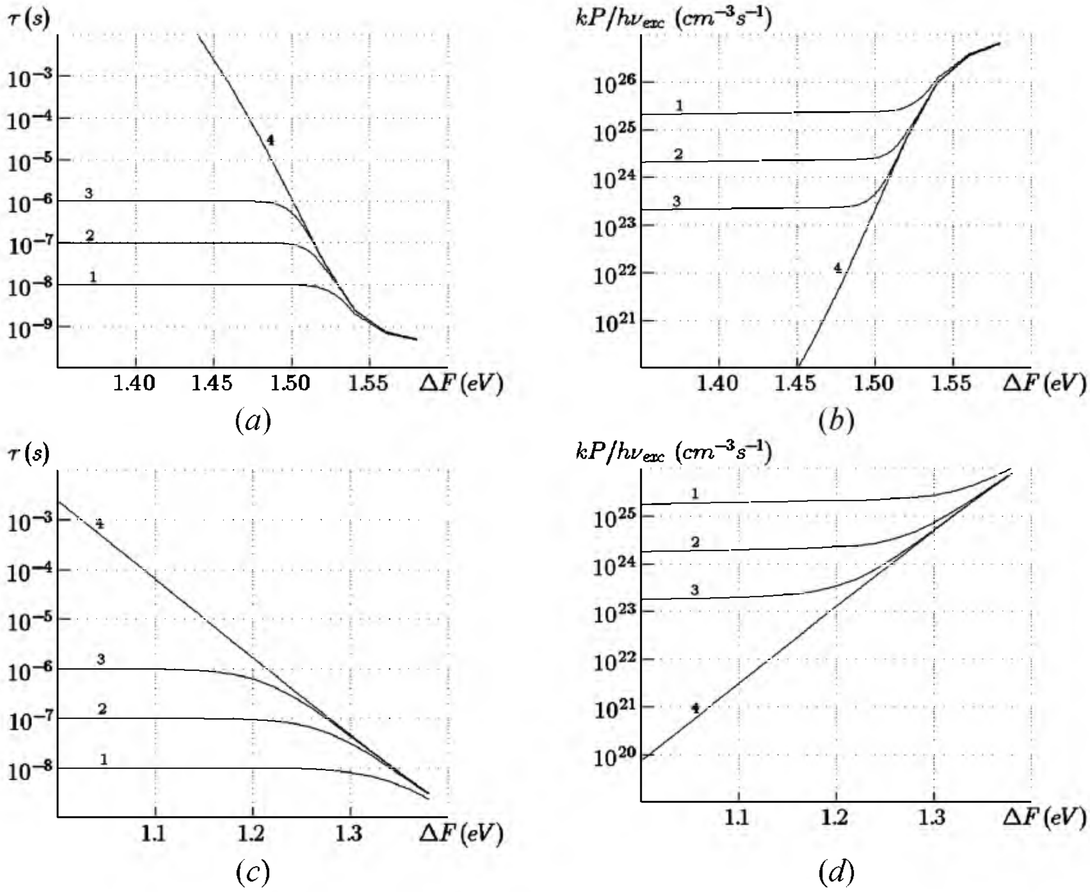

Fig. 1. Dependencies (*a*, *c*) of the lifetime τ and (*b*, *d*) rate of excitation $kP/h\nu_{\text{exc}}$ on the quasi-Fermi level difference ΔF in *n–i–p–i* crystal for the differen temperatures T=20 (*a*, *b*), 300 K (*c*, *d*) and non-radiative lifetime constants τ_{nr}. (1) $\tau_{\text{nr}} = 10$ ns, (2) $\tau_{\text{nr}} = 100$ ns, (3) $\tau_{\text{nr}} = 1$ μs, (4) $\tau_{\text{nr}} = \infty$. $d_n=d_p=d_i= 40$ nm, $N_a=N_d= 10^{18}$ cm^{-3}.

results of the calculations are presented in Fig. 1. Comparison has been provided with the data for the GaAs δ-doped superlattices [6].

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