$$I(\phi) = S^2 \frac{\theta}{\delta\Phi} r^2 \left[\frac{\sin(\phi^r/2)}{\phi r/2}\right]^2, \tag{1}$$

where S^2 is the intensity of the spontaneous radiation, $\theta = (2\ell/c)|1 - R \exp(k\ell')|$, $\delta\Phi \simeq |1 - R \exp(k\ell')|$, and $\phi = 4\pi\ell\nu/c$ is the phase shift per pass. According to [1], the half-width of the mode decreases in proportion to the time (to the number of passes), and the peak power increases like the square of the time. Accordingly, the decrease of the generation time in picosecond pumping should become manifest in a broadening of the generated modes and in the occurrence of a diffuse generation band. Comparing the generation spectra obtained for different durations of the picosecond pulse, it can be concluded that at a constant resonator length the diffuseness of the spectrum increases with decreasing pulse duration. Analogously, the diffuseness of the generation spectrum increases also with increasing resonator base. These results lead to a preliminary conclusion that the duration of the picosecond pulse can be estimated from the form of the generation spectrum of an organic dye in the resonator with a specified base.

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PULSED NARROWING OF p-n JUNCTION IN TWO-PHOTON EXCITATION

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Two-photon absorption in homogeneous crystals has been investigated in sufficient detail. There are practically no published data, however, on two-photon excitation of p-n junctions and heterojunctions. The reason for this can be understood if it is recognized that such crystals contain impurities that lead to the single-photon excitation mechanism. One should expect, however, the impurity centers to become depleted at sufficiently high excitation levels and generation of electron-hole pairs in the volume to begin. If this process is active enough, then considerable changes in the properties of the p-n junction should occur. To reveal such changes, the following experiment was organized.

A p-ZnTe - n-CdSe heterojunction was excited with a neodymium laser (pulse energy 0.4 J, pulse duration at half-width 35 nsec, $\hbar\omega = 1.17$ eV), as a result of which one could expect two-photon generation of electron-hole pairs both in the zinc telluride ($E_g = 2.26$ eV) and in the cadmium selenide ($E_g = 1.7$ eV). We measured the no-load voltage V_{nl}, the short-circuit current I_{sc}, and the lux-ampere characteristic of the heterojunction in the photodiode regime. A standard registration procedure with a long-persistence oscilloscope was used. The time resolution of the circuit was 10^{-8} sec.

The results of the measurement of no-load voltage V_{nl} (measured at the peak value) are shown in Fig. 1. Figure 1b shows, in a logarithmic scale, a section of the curve a corresponding to two-photon absorption. Figure 2 shows the kinetics of the relaxation of V_{nl} at different excitation intensities.

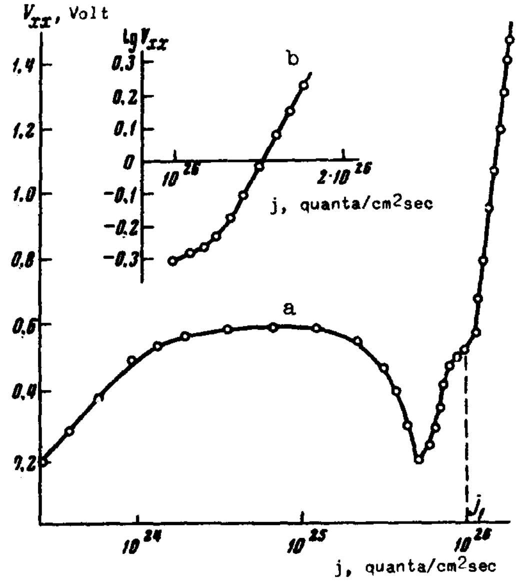

Fig. 1. Dependence of V_{nl} on excitation intensity.

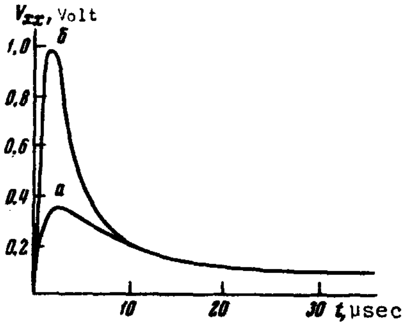

Fig. 2. Kinetics of relaxation of V_{nl}: a - low excitation level ($J < J_1$), b - high excitation level ($J > J_1$).

As follows from Fig. 1a, single-photon excitation processes occur at $J < J_1$, and a quadratic dependence of V_{nl} on the intensity of the exciting light is observed at $J > J_1$. The growth of V_{nl} was limited by the destruction of the materials, and the maximum value did not exceed the forbidden band of CdSe.

For a qualitative estimate of the dependence of V_{nl} on the radiation intensity it is necessary to use the condition that the total current j of the heterophotocell vanish. Taking into account the two-photon excitation mechanism the light-induced current j_c of the diode was determined by the formula

$$j_c = A(1 - \beta_1)J + B(1 - \beta_2)J^2,$$

where A and B are constants that depend on the oscillator strengths of the single-photon excitation of the impurity and the two-photon excitation of the electron-hole pairs, respectively; β_1 and β_2 are the dimensionless carrier-recombination coefficients for the single- and two-photon excitation mechanisms. The "leakage" current j_v through the barrier layer (in the approximation wherein the potential has an exponential distribution) can be written in the form

$$j_v = j_s(e^{eV/rkT} - 1),$$

where j_s is the saturation current and r is a phenomenological parameter that takes into account the mechanism of the passage of the current through the heterojunction (usually r ∿ 10 and more [1, 2]). In the case of strong pulsed light fluxes, r starts to depend on the radiation intensity, something that must be taken into account when the theory is compared with experiment. We obtain:

$$V_{nl} = \frac{rkT}{e} \ln\left\{1 + \frac{1 - \beta_1}{j_s} AJ + \frac{1 - \beta_2}{j_s} BJ^2\right\}.$$

As follows from the kinetics of the process (Fig. 2), V_{nl} has a sharp decrease at intensities corresponding to the region of the quadratic growth, as a result of which the recombination coefficients β_1 and β_2 are close to unity. In this case

$$V_{nl} \cong \frac{rkT}{ei_s}\{(1 - \beta_1)AJ + (1 - \beta_2)BJ^2\}.$$

With increasing intensity J, the contribution of the linear term "becomes saturated" (the impurity is depleted), and starting with $J > J_1$ (Fig. 1) the function $V_{nl} = f(j)$ becomes quadratic. The dip on the volt-lux characteristic is possibly connected with the change of the recombination mechanism.

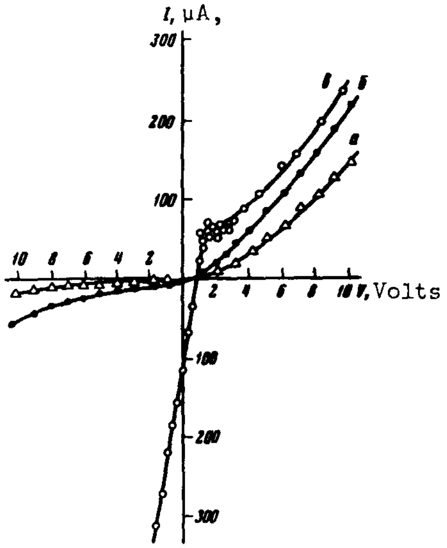

Fig. 3. Current-voltage characteristic: a - in darkness, b - under illumination at $J < J_1$, c - under illumination at $J > J_1$.

We note that the considerable increase of V_{nl} is evidence of divergence of the Fermi quasilevels and corresponds to a sharp narrowing of the junction for a time at least of the order of the time of action of the laser pulse. We plotted also the dark current-voltage characteristics (curve a), the current-voltage characteristics in the regime of laser illumination at low intensities $J < J_1$ (curve b), and the current-voltage characteristics at high levels of optical excitation $J > J_1$ (curve c). When plotting curves b and c, the current was determined from the peak value. It is important to note that curve b does not differ in form from the current-voltage characteristic taken in the static regime when the heterojunction is eliminated [3].

As follows from the figure, when $J < J_1$ the characteristic of the diode has the usual character (the inverse current is smaller than the forward current at equal voltages). With increasing laser-light intensity ($J > J_1$), when the two-photon mechanism of generation of electron-hole pairs begins to play the decisive role, the diode character becomes inverted (the forward resistance of the diode exceeds the inverse resistance). This fact is evidence that the pulsed narrowing of the p-n junction causes tunnel transitions to assume a role, and the current-voltage characteristic of the p-n junction has a form similar to the characteristic of a tunnel diode.

The foregoing results point to the possibility of pulsed control of the electric parameter of the p-n junction with the aid of a laser.

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