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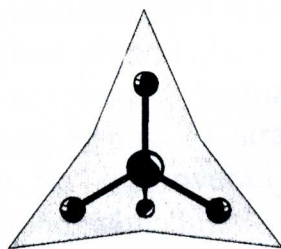
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ACTUAL PROBLEMS OF SEMICONDUCTOR PHYSICS

ABSTRACT BOOK
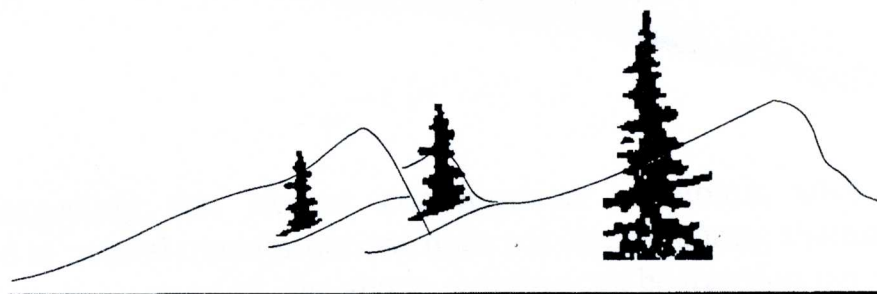
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SPECIFICITY OF PHOTOINDUCED KINETICS IN AMORPHOUS CHALCOGENIDES

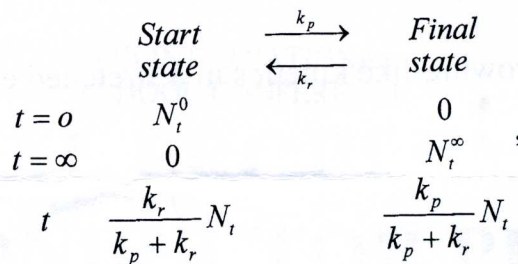## V. Balitska[1,2], O. Shpotyuk[2], M. Shpotyuk[2,3]

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The kinetics peculiarities of photodarkening in thin chalcogenide films were satisfactorily described in terms of photon-assisted site switching (PASS) facilitating percolative growth of atomic clusters at ground state [1].

Within this formalism, the final photodarkened sites (independently on their origin), having higher energy, are supposed to be formed from original (start) sites, giving a dynamic intersite balance owing to straightforward (production) and backward (relaxation) reactions. So the overall set of photoinduced defect production-relaxation processes along with initial conditions can be conveniently presented via a scheme:

$$
\begin{array}{ccc}
 & \text{Start} & \xrightarrow{k_p} & \text{Final} \\
 & \text{state} & \xleftarrow{k_r} & \text{state} \\
t = o & N_t^0 & & 0 \\
t = \infty & 0 & & N_t^\infty \\
t & \dfrac{k_r}{k_p + k_r} N_t & & \dfrac{k_p}{k_p + k_r} N_t
\end{array}
$$

where N_t^o is initial concentration of atomic sites available for relaxation; k_p and k_r are probabilities of precursor trapping and detrapping in final state, respectively.

The general differential equation, which governs population of structural defects responsible for photodarkening N in an arbitrary time moment t can be presented as:

$$\frac{dN}{dt} = k_p(N_t - N) - k_r N .\qquad(1)$$

By suggesting that overall concentration of atomic sites evolved in photoinduced structural transformations does not change during illumination, being nearly constant $N_t = const = N_t^0$, the above equation can be transformed to:

$$\frac{dN}{dt} = k_p N_t^0 - k_p N - k_r N = k_p N_t^0 - N(k_p + k_r).\qquad(2)$$

This eq. (2) has simple solution, which can be presented in a single exponential form:

$$N = a\left(1 - e^{\left(-t/\tau\right)}\right),$$
(3)

where $a = \dfrac{k_p}{k_p + k_r} N_t^0$ is normalized magnitude of photoexcited sites.

However, in case of dispersive nature of underlying photostructural transformations, the following change of variables should be undertaken in eq. (3):

$$(kt) \rightarrow (kt)^\beta = \xi$$
(3)

with non-despersivity index $0 \le \beta \le 1$ and $k = k_p + k_r$.

This allows to introduce a new rate equation relative to this variable ξ:

$$\frac{dN}{d\xi} = \frac{k_p}{k} N_t^0 - \frac{k_p + k_r}{k} N = \frac{k_p}{k} N_t^0 - N = \frac{k_p N_t^0 - kN}{k}$$
(4)

with solution giving growing-like kinetics in a stretched exponential form:

$$N = a\left(1 - e^{\left(-t/\tau\right)^\beta}\right).$$
(5)

With a purpose of adequate mathematical description of observed *in-situ* photodarkening kinetics, the numerical values of fitting parameters in eq. (3), (5) were calculated in such a way to minimize mean-square deviations of experimentally measured points from stretched exponential low.

It was established the dispersive photodarkening kinetics obeying stretched exponential function is observed in relatively thicker films, while in thinner films this kinetics corresponds to single exponential function, justifying that photostrucrural transformation itself is nondispersive in nature. This process is limited by film thickness (thickness-limited), since during illumination the film material undergo significant modification because of photostructural transformations, which change the penetration depth d^* of pumping light (the photodarkening or photoinduced decrease in optical transmission is always associated with decrease in d^*).

[1] A. Ganjoo, H. Jain Millisecond kinetics of photoinduced changes in the optical parameters of As_2S_3 films. – Phys. Rev., 2006, v. B74, p. 024201-1-6.