Thermochromic Effect in Doped $Bi_{12}SiO_{20}$ Crystals

A. Dyachenko, T. Panchenko

Oles Honchar Dnipropetrovsk National University, 49010 Dnipro, Ukraine

By now, thermochromic effect (TCE) attracts attention of researches because of the urge to learn its physical nature in inorganic crystals and interrelation between TCE and photochromic effect (PCE) as well as owing to the usage of availability in heat-indicating devices and thermochromic display units.

Results of TCE experimental studying in photorefractive crystals of complex oxides $Bi_{12}SiO_{20}$ (BSO), doped by Al and Ga ions (BSO:Al and BSO:Ga correspondingly) are presented.

Crystals BSO:Al, BSO:Ga were grown by Czochralski method along the crystallographic direction [001]. The Al and Ga content in crystals according to data of spectral-emission analysis was 0.5 mass.%. The samples were prepared as a set of polished plates with thickness d = 4.8 ÷ 5.5 mm with large planes (001).

The procedure was as follows. Thermal influence on stationary absorption spectra $\alpha(h\nu, T)$ in the range $h\nu$ = 0.5 ÷ 3.4 eV were carried out in cycles "heating - cooling" in the temperature range T = 300 – 600 K. Moreover, stationary $\alpha(T)$ and photoinduced absorption $\alpha^{ph}(T)$ temperature dependences for the different spectral range (IR-, visible and nearby UF) and the so-called curves of PCE thermal erasing $\Delta\alpha^{ph}(T) = \alpha^{ph}(T) - \alpha(T)$ were carried out.

The results obtained are reduced to the follows. Difference spectra $\Delta\alpha(h\nu, T = 300\ K) = \alpha^{T}(h\nu, T = 300\ K) - \alpha_0(h\nu, T = 300\ K)$, which were taken after the cycle "heating – cooling" passing, have a close similarity for BSO:Al and BSO:Ga crystals. Corresponding curves with a complex structure indicate TCE occurrence and several types of thermo induced defects. Temperature dependences $\alpha(h\nu, T)$ in the nearby UF- range ($h\nu$ = 3.1 – 3.4 eV) close to exponential, obey to Uhrbach rule and indicate a significant temperature shift of the fundamental absorption edge of the researched crystals. Stationary absorption is small in visible and IR-ranges and any temperature peculiarities are observed, curves of the photoinduced absorption have a complicated structure with maxima in the nearby IR- range ($h\nu$ = 0.5 – 1.25 eV). Thermal fading curves have a stepped form, which denote a thermal destruction of photoinduced centers. Temperature, which correspond to the absorption sharp decrease in the "step" on curves $\Delta\alpha^{ph}(T)$ assign a thermal activation energy of the PCE erasing process. All received curves are characterized by a hysteresis.

Obtained results analyzed within the framework of the model for redistribution of electrons over donor and acceptor levels of the band gap involving spectral and thermal data of the photoconductivity for BSO:Al and BSO:Ga crystals [1, 2].

[1] A.A. Dyachenko, T.V. Panchenko, Excitation and erasure of photochromic effect in the $Bi_{12}SiO_{20}$ crystals doped with Al, Ga and Sn, *Ukrainian Journal of Physical Optics* **16**(3) (2015) 127 – 133.

[2] A.A. Dyachenko, T.V. Panchenko, Optical and thermal erasing photochromic effect in Al doped $Bi_{12}SiO_{20}$ crystals, *Functional materials* **23**(2) (2016) 197 – 201.