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OPTICAL CHARACTERISTICS QUARTZ CRYSTALS

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Abstract
Absorption spectra (SP), gamma, photo-, thermoluminescence (GL, FL, TL) and other optical properties of quartz crystals, nature of crystal structure defects, shape and features of occurrence, concentration of various impurity elements were investigated.

Keywords: absorption, crystal, structure, quartz, radiation, radiation-optical properties, amorphization, recombination, fluence, neutron, embryo, recombination.

Introduction

Currently, when studying the amorphization of the structure of quartz crystals during irradiation, the change in the intensity of the photoluminescence band (FL) with a maximum at 660 nm, due to the glow of non-bridge oxygen atoms (NAC), which stably exist only in amorphous regions, is used as a probe. It should be noted that in the luminescence spectrum of quartz crystals containing individual nuclei of the amorphous phase (AF) and the quasi-amorphous layer, one luminescence band of 660 nm is observed. According to [1], the thermal stability of individual AF nuclei and the quasi-amorphous layer, therefore, and the thermal stability of the NAs contained in their volume, are different. Therefore, in this work, a change in the thermal stability of defective centers responsible for the 660 nm band in quartz crystals exposed to sequential exposure to proton fluence 4.10^{14} cm-2 and a dose of γ quanta 10^{10} P (type I sample), as well as crystals exposed to sequential exposure to proton fluence 10^{15} cm-2, dose of γ quanta 1010 P and neutron fluence 10^{16} cm-2 (type II sample), after annealing in the range of 200 ÷ 600°C was used as a probe. Studies have shown that in the spectrum of FL samples

irradiated with proton fluences 4.10^{14}, 10^{15} cm-2, as in neutron-irradiated crystals [2], there are bands with maxima at 550 and 660 nm. Additional exposure to γ quanta up to a dose of 10^{10} P leads to an increase in their intensities. After annealing in the range of 200 ÷ 600°C in I-type samples, as the annealing temperature increases, the intensities of the 550 and 660 nm bands decrease and, when 500°S, the bands disappear. In type II samples, after annealing at 200 and 300°S, the intensities of the 550 and 660 nm bands increase, and then decrease and also disappear during 500°S (Figure).

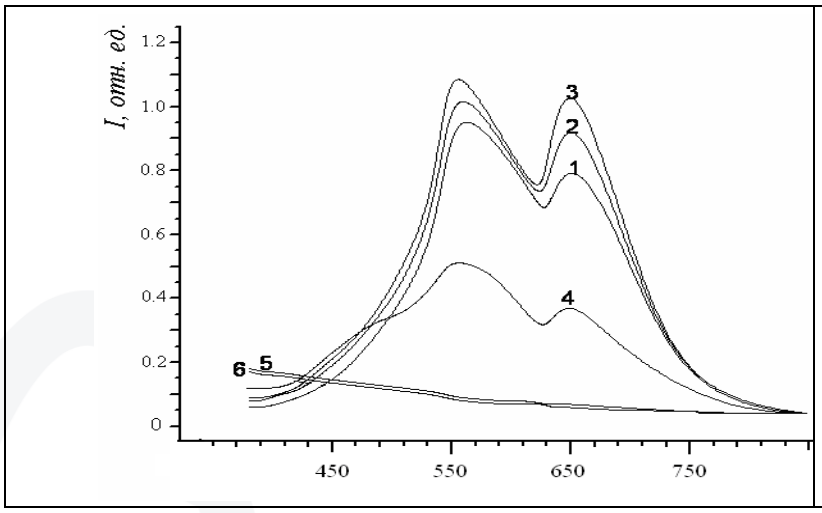

Figure. FL spectra of samples of type II before (1) and after annealing at 200 (2), 300 (3), 400 (4), 500 (5), 600°S (6)

Currently, the nature of the defective center responsible for the appearance of the 550 nm band has not been established. This is beyond the scope of this work and is the subject of further research. Therefore, in the future, to discuss the results obtained, we use only the dependence of the parameters of the 660 nm band on the irradiation fluence and annealing temperature.

[2] shows that the change in the intensity of the 3640 cm-1 band attributed to the SiO_2 phase after heating in the range of 200 ÷ 900° S is stepwise. After heat treatment at 200 and 300°S, the intensity of the 550, 660 nm bands increases and then decreases. The observed processes are assumed to occur as follows. The stability of the nuclei of other phases arising from neutron irradiation has different sizes. An increase in neutron fluence leads to an increase in the concentration and size of the nuclei. The release of stress due to the interaction of the nuclei with each other or thermally leads to their decay. Therefore, there are temperature ranges within which the increase in size and thermal decay of the nuclei occur.

Based on the above data, we believe that in the damaged layer of the crystal subjected to the sequential effect of the fluence of protons 4.10^{14} cm-2 and the dose

of γ quanta 10^{10} P, along with point defects, separate AF embryos with different sizes appear. During annealing in the range of 200-600°C, the nuclei gradually decay, which leads to a decrease in the intensities of the 550 and 660 nm bands with increasing temperature. According to the data [3], a quasi-amorphous layer also appears in type II samples. Since the thermal stability of the quasi-amorphous layer is greater than the thermal stability of individual AF nuclei [1], at 200 and 300°S there is an increase, and at high temperatures there is a decrease in the size of individual AF nuclei and the quasi-amorphous layer, which, respectively, increases and decreases the intensities of the 550 and 660 nm bands.

Absorption spectra (SP), gamma, photo-, thermoluminescence (GL, FL, TL) and other properties of dyeing (type I) and non-dyeing (type II) quartz crystals with an admixture of Ge (10-4-0.006%) under the action of ionizing radiation were studied to clarify the dependence of the nature and nature of structure defects on the form and features occurrences, concentrations of impurities. In the spectra of HL, FL, TL crystals in the region of 77-230 K, one glow band is observed with a maximum at 530 nm. The intensity of the FL band decreases with increasing excitation temperature (Fig. 1). In the region of 77-300 K, the positions of the peaks of thermal illumination of type I crystals and < c > SiO_2 crystal growth pyramids with Ge [4] coincide. The spectral composition of TV peaks is represented by one band 530 nm, the intensity of which reaches a maximum at 190 K. under identical conditions, its intensity is greater in type I crystals and increases with increasing concentration of Ge.

A band of 530 nm was observed in SiO_2 crystals with Ge and earlier [5-8]; regarding its nature, there are different opinions. It is assumed that it occurs during annihilation of exciton-like excitations localized on defective GeO_4 tetrahedra [5] due to recombination of holes with electrons of centers of unknown nature [6,7]. According to [8], this band is due to the radiative decay of excitons formed by the recombination approach of mobile holes to E "(Ge) (or [Ge (I, II, III, IV) e-]) centers having different areas of thermal stability and spectroscopic parameters [4,9,10]. The results of the present study and the data [4, 6] suggest that the 530 nm band is due to the radiative decay of excitons formed at the [Ge (I) e-] centers.

In the spectra of FL, TL and GL type II crystals at 230 K, a new glow band was first detected with a maximum at 680 nm, the intensity of which increases with increasing excitation temperature and Ge concentration. Comparison of our results with the data [9] suggests that the 680 nm band arises in a recombination process involving electrons released from [Ge (c) e-/Na] centers and holes trapped

at a [AlO_4] or metastable center of unknown nature. It is known that [Ge (c) e-/Na] centers are unstable at room temperature and cause an absorption band with a maximum of 290 nm. Thermal discoloration of this strip and the metastable hole center occurs simultaneously in the region of 280-300 K [9]. In the region of 330-400 K, the discoloration rate of the 290 nm band increases [11].

The 290 nm band is also observed in type II DP crystals. Its intensity increases with increasing concentration of Ge, and in case of holding the crystals at room temperature, it decreases over time and disappears within a few days. A correlated decrease in the intensity of the 680 nm band is observed. Illumination in the FL excitation band (λ_V = 330 nm) leads to an increase in the rates of incidence of intensities of both bands. In the 300-400 K region, the 290 nm band is decolorized within a few minutes, accompanied by thermal luminescence with a maximum of 680 nm. Recombination of electrons with a hole captured at the [AlO_4] center is considered to give a glow in the region of 470-490 nm (see [4]). It is assumed [11] that in the temperature range of 300-700 K, recombination of electrons released from [Ge (c) e-/Na] centers with holes trapped at [AlO_4] centers leads to the appearance of TL with a maximum of 485 nm. It has recently been found that in high purity Ge SiO_2 irradiated with X-rays at liquid helium temperatures, hole centers are formed. The hole is trapped by the oxygen atom of the impurity germanium tetrahedron and is stable up to 70 K (see [10]). Recombination of electrons with such a hole in the range of 4-70 K leads to the appearance of TL in the region of 400-650 nm [10].

These data suggest that the 680 nm band is due to the recombination of electrons freed from [Ge (c) e-/Na] centers with a metastable hole trapped by an oxygen atom of an impurity germanium tetrahedron.

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