ULTRAFINE OXIDE CERAMICS FOR LUMINESCENT DOSIMETRY OF HIGH-INTENSITY IONIZING RADIATION

S. V. Nikiforov, D. V. Ananchenko, T. V. Shtang, N. Yu. Karavannova

Ural Federal University named after the first President of Russia B. N. Yeltsin, Ekaterinburg, Russia

High-intensity ionizing radiation is currently widely used in radiation technologies and scientific research for sterilization of food products and medical instruments, wastewater treatment, brachytherapy, and modification of the properties of composite materials, metals, and alloys. Luminescent detectors based on nanostructured materials are promising for monitoring the parameters of such radiation due to their increased radiation resistance [1]. Most commercial luminescent detectors have an upper limit of the dose detection range of 1–100 Gy. Therefore, the search for and study of new luminescent materials suitable for dosimetry of high-intensity radiation fields providing absorbed doses of 1 kGy or more is an urgent task [2].

The aim of this work is to synthesize and study the luminescent and dosimetric properties of ultrafine ceramics based on wide-bandgap oxide dielectrics irradiated with high doses. We investigated ceramics based on both simple oxides (Al_2O_3, ZrO_2) and composite (Al_2O_3–BeO) obtained by solid-phase synthesis. To synthesize ceramics with different crystallite sizes (40–500 nm), we used sintering compacts made of nanopowders in different atmospheres in an electric furnace at T = 700–1700°C, as well as their irradiation with high-energy electrons (1.4 MeV) with a high power density (20–30 kW/cm^2) [3]. It was found that annealing of ceramics at T > 1000°C leads to a significant increase in the intensity of thermoluminescent (TL) peaks, which correlates with the increase in the size of nanoparticles. Ceramics obtained by the electron beam method have the maximum TL response, which is associated with the formation of radiation-induced traps and luminescence centers during synthesis. It was found that in Al_2O_3–BeO ceramics the TL response is caused not by monoenergetic traps, but by their distribution over the energy depth. The analysis of the dose dependences of the TL of ceramics irradiated with high doses of gamma radiation (Co–60) and electron beam (130 keV, 1–100 kGy) revealed their predominantly sublinear character, which proves the prospects of the materials synthesized in this work for measuring high doses. The parameters and mechanisms of the formation of the TL fading of ceramics associated with the presence of localized transitions of charge carriers are also discussed in the work.

References

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