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THERMALLY ACTIVATED LUMINESCENCE SPECTROSCOPY OF TRAPS IN DOSIMETRIC ULTRAFINE Al_2O_3-BeO CERAMICS

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At present, high-dose (more than 100 Gy) ionizing radiation is widely used in radiation technologies and scientific research. It is promising to use thermoluminescence (TL) dosimetry methods for registering high-dose radiation. One of the promising materials to detect high absorbed doses is ultrafine ceramics based on Al_2O_3-BeO [1]. This material was obtained by high-temperature vacuum annealing of nanostructured Al_2O_3 compacts in BeO crucibles in the presence of carbon [2]. We found that the TL of the dosimetric peak at 525 K of the studied Al_2O_3-BeO ceramics is not described by the simplest two-level model, but is due to the energy depth distribution of traps [1]. So far, evidence for the presence of the energy distribution of traps in the material under study has been obtained only under TL stimulation in the linear heating mode. Thereby it is of interest to study the TL kinetics with other methods of thermally activated spectroscopy (TAS); in particular, by using the analysis of isothermal decay curves [3] and fractional glow (FG) [4].

The aim of this work is to study TL of Al_2O_3-BeO ceramics by various TAS methods and to construct a kinetic model that takes into account the energy distribution of the traps and most fully describes the whole complex of TL properties of the material under study.

The samples used in this work were tablets 1 mm in thick and 5 mm in diameter. The technique of synthesizing ceramics had been described earlier [2]. To excite TL, the samples were irradiated at room temperature with a pulsed electron beam (60 A/cm^2, 2 ns) from the RADAN EXPERT accelerator with electron energy of 130 keV. The radiation dose was 15 kGy. TL was measured in three modes of TAS (linear heating at a rate of 2 K/s, isothermal heating and FG, the parameters of which were identical to those used in [4]).

An anomalous behavior of the TL isothermal decay curves of the dosimetric peak at 525 K in the temperature ranges of 423–463 K and 523–623 K was revealed, which consists in a decreasing decay rate with an increasing isothermal holding temperature. In the temperature range of 463–523 K, no anomalous behavior of the curves was observed. Analytical approximation of the TL decay curves, as well as the results of the Tm-Tstop and initial rise methods [5], make it possible to unambiguously reveal the presence of the energy distribution of traps responsible for the dosimetric peak. This conclusion is also confirmed by the presence of a temperature dependence of the trap activation energy in the indicated peak obtained by the FG method.

Based on the results of computer simulation of the charge transfer processes by solving systems of differential kinetic equations, it is shown that the observed features of the TL of the studied material, in particular, the anomalous behavior of the isothermal decay curves, are caused by the simultaneous emptying of several traps, whose distribution of activation energies has a form similar to the exponential one. The paper also discusses possible physical reasons for the appearance of the complex energy spectrum of the TL peak traps at 525 K.

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