TRITIUM DETECTION WITH $BeO:TiO_2$ -CERAMIC TL DETECTORS

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INTRODUCTION

The problems associated with registration of alpha and very soft beta radiation are well known and they spur a search for new ways of their solution (1). We used new thermoluminescent (TL) detectors on the basis of $BeO:TiO_2$ ceramics for ^3H ($E_{\beta\ max}$ =18 keV) detection. A characteristic feature of the detectors is their complete optical opacity and existence of a thin (20 μm) sensitive)layer on the $BeO:TiO_2$ surface (2). Thanks to these properties the detector sensitivity to irradiation with short-range charged particles was much higher than to irradiation with accompanying quanta (3).

EXPERIMENTAL

Thermoluminescence was measured using a DTU-01 instrument (Lithuania) The TL peak of the glow curve in the temperature range from 420 to 440 K is used only for the read-out procedure.

Two methods of tritium detection were used in the study. According to one method the detector was irradiated by a standard source of tritium arranged at a distance of 0.5-1 mm from its surface. The TL signal amplitude increased linearly with an increasein the exposure time. The measurement results showed that the lower detection limit is 10 of β-particles found on the detector surface.

According to the other method the detector was brought into a momentary mechanical contact with the surface of the source. It was found that the detector based on the $BeO:TiO_2$ ceramic possesses the ability to accumulate and retain for a long time tritium diffusing into the sensitive layer of the material. The TL signal of such a detector is induced by its self-irradiation. The measurements showed that the TL output is proportional to the time of the detector self-irradiation, i.e. the effect of "dose accumulation" takes place. This property persisted for several weeks, even when a few tens of cycles of TL read-outs were performed during that period. Shown in the Figure is the measured TL response vs. the "self-irradiation" time of two detectors (curves 1 and 2).

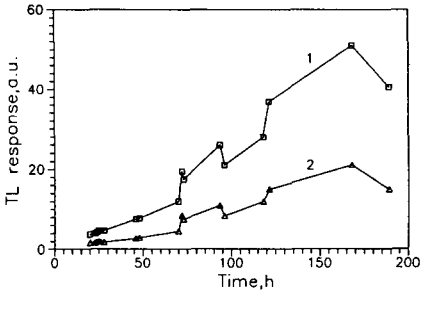

Figure. TL response vs. self-irradiation time of two $BeO:TiO_2$ ceramic detectors

These experiments were carried out using purposefully chosen detectors, which had different TL sensitivities determined by the former method as described above. It follows from the Figure that an increase in the self-irradiation time is indeed accompanied by an almost linear rise of the TL response. A comparison of the two methods under discussion shows that an increase in the TL output due to the "dose accumulation" effect provides an additional 10- to 100-fold rise of the tritium detection sensitivity. Besides, as is seen from the Figure, the curves 1 and 2 have sharply nonlinear portions. Most surprisingly, the said portions are fully coincident. It is unlikely that this synchronous change in the TL sensitivity is caused by migration of tritium in the detector surface. Then diffusion constants of tritium in thin surface layers of two different detectors should be ideally coincident, which is, in our opinion, highly improbable. We believe the most plausible explanation of the presence of synchronous "steps" in "TL response - accumulation time" curves 1 and 2 obtained for two detectors with different sensitivity is instability of the TL read-out device. Specifically, we attribute the observed effect to instability of the detector heating unit. During the measurement procedure sensitivity of the recording circuit before and after heating of the detectors was constant as determined using a radioisotope reference light source. It may be assumed with a certain degree of confidence that the said two detectors helped us reveal a time fluctuation of the stability of the read-out device; the time fluctuation could not be detected with the reference light source.

The self-irradiation effect was examined additionally by the method of thermally stimulated exoemission (TSEE). The measurements were made in vacuum. The effect was fully reproducible for several hours but its sensitivity dropped with every heating-measurement cycle. The effect ceased if the samples were kept in vacuum for a few days. When TL was measured in air, sensitivity of the detectors lowered only 1.6-1.8 times in 2 months. This fact can be accounted for by a more intensive withdrawal of tritium from the surface layer of the detectors subject to heating and storage in vacuum. This inference does not contradict the mechanism of tritium diffusion in the lattice of the BeO ceramic (4).

CONCLUSION

Our preliminary studies of TL in BeO:TiO_2 -based detectors show that they may be useful for determination of tritium contamination and serve as TL standards for testing of read-out devices.

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