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EXPERIENCES OF GLOW CURVE ANALYSIS OF LiF DETECTORS

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The glow curves of LiF detectors have at least of seven peaks, e.g. in the 100-400°C temperature range. Unfortunately these peaks are strongly overlapping, however, the readings are made with special care. The glow curve reminds us of a NaJ spectra of poor resolution. The common light integration leads to questionable results, if the ratios of different peaks are not constant. It is the situation for instance, if a LiF detector is exposed in mixed neutron-gamma radiation field, because the peak ratios are different for the two kinds of radiation. This effect can be observed alike in the case of TLD-100, TLD-600 and TLD-700 detectors. Many glow curves of TLD-100, TLD-600 and TLD-700 detectors were investigated at different proportion mixing of neutron and gamma radiations. The possible adaptation of programs used in gamma spectroscopy for glow-peak selection was studied. This report gives a scope of our experiences.

Introduction

In case of slow and linear heating the single glow peaks inform us about the trap structure of the material investigated. The formation and filling of the different energy traps is defined by the rules of the material-radiation interactions. Consequently, a suitable analysis of the glow curve structure may give qualitative and quantitative informations about the applied radiation, too. In this way a broader field of applicability of the thermoluminescent dosimetry can be expected.

Experimental

In the present study TLD-100, TLD-600 and TLD-700 detectors of 3.2x3.2x0.9 mm size (produced by the Harshaw Chemical Company) have been investigated. The annealing of the detectors was carried out always in the same way, the heating of 1h at 400°C was followed by a long cooling period and by a 24h heating at 100°C. The readout process was ever 1-2 weeks after the irradiation. A heating cycle with a high heating rate up till 100°C, while in the readout zone between 100-400°C a slow linear heating rate ($3^{\circ}Cs^{-1}$) was applied. The measurements were carried out by the help of a 200 channel Glow curve analyzer (Harshaw Mod. 2080).

Two computer programs (written originally for the evaluation of NaJ spectra) were adapted for the peak separation. The first one is the whole-body counter evaluation program, used in the KFA-Julich ASS-BS [1], while the other one is a modified version of the program SPEC[2], written first of all for multiplett selection. From both programs only the parts serving originally for the photopeak selection and evaluation were used. After an optimisation of the Gaussian fitting parameters the intensity change of the glow peaks was studied in the case of different types of radiation.

The irradiations of the detectors were carried out by ^{137}Cs, by $^{90}Sr/^{90}Y$ sources, and by neutrons in the experimental channel of the research reactor "Merlin" respectively. The dose range of every presented measurement was between 0.1 and 1 Gy.

Results

Hundreds of glow curves were analysed by both applied programs. We could arrange a fairly good fit by the help of both ones, as it is discernible in Fig.1 and Fig.2. The first program was used mainly for the optimisation of

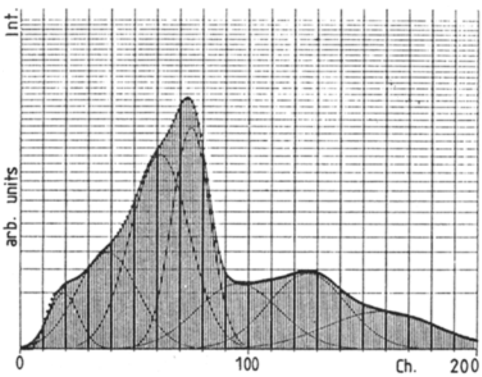

Fig.1. Glow curve analysis of a TLD-700 detector irradiated in mixed neutron-gamma field. Evaluation by a modified whole body counter program [1]

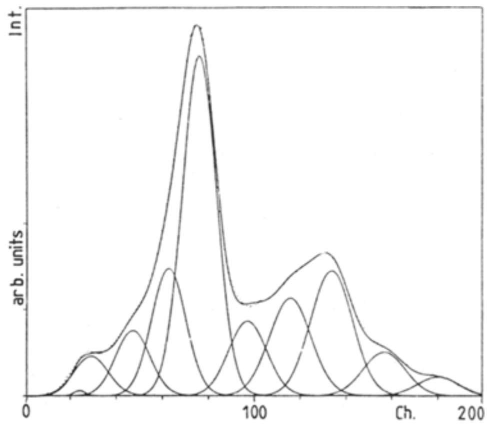

Fig.2. Glow curve analysis of a TLD-100 detector irradiated in mixed neutron-gamma field. Evaluation by the modified program SPEC [2]

the fitting parameters, being fairly elastic in variables, while the achievement of the program SPEC was generally more uniform, the quality of the fit was better in general. This fact can be explained probably by the small difference of the curve shape, namely it completes the pure Gaussian by an exponential tail at the low energy part of the curve. All evaluations show a growing of the FWHM value by the increasing temperatures.

A comparison of the gamma and beta irradiations shows small, but not a clearly characteristic change in the glow curve structure. The altering of the glow curve shape is not enough for an unambiguous distinction of these radiations.

The peaks of high temperatures have relatively small intensity after an irradiation of gammas (and betas). It means, that the fit, based on a poor statistics, is quite uncertain. The results of some gamma measurements are summarized in Table I. The first column gives a series of the literature peak temperatures after Horowitz [3], while the second one shows the borders of the temperatures, among which peaks were determined by the computer. The next three columns contain the relative peak intensities normalized for the main peak at a temperature of 186 °C. The structure of the glow curve and the intensity of the single peaks are on the whole similar for the detectors TLD-100, 600 and 700, however, there are small, but characteristic differences, too.

Table I

Measured relative peak intensities and temperature ranges after irradiations by ^{137}Cs source. In the first column there are temperature values taken from the reference [3].

Peak temperature [°C]	Evaluated temperature [°C]	Relative intensities		
		TLD-100	TLD-600	TLD-700
130	128.4±0.3	13.7±1.9	9.5±1.0	11.3±1.3
165	159.6±0.5	52.4±2.3	46.9±0.4	45.5±1.2
190	186.0	100	100	100
225	233 ± 3	2.27±0.14	1.49±0.12	2.33±0.47
255	260 ± 7	2.51±0.30	1.07±0.07	2.41±0.31
280	290 ±16	0.94±0.74	0.86±0.12	0.71
310	329 ± 6	0.86	0.37±0.36	0.94±0.37

The shape of the glow curves of detectors irradiated by neutrons strongly differs from those irradiated by gammas [4]. There is a matter of fact that together with the neutrons gamma radiation also appears. The effects of the neutrons were investigated therefore at different neutron spectra and at different gamma-neutron ratios. A summary of the results is shown in Table II. The high temperature peaks of the TLD-100 and TLD-600 detectors have about one order of magnitude growing uniformly in comparison to the peak of 186°C again. Because of the higher intensities their positions are more exactly defined, as they were in the case of pure gamma radiation. The higher variation of the peak intensities is a consequence only of the calculation of the average for different gamma-neutron ratios. Above 200°C the character of the peaks is identical, their relative intensities change after the quality of the radiation uniformly. A consequence of this fact is that their separation is not necessary for a glow curve shape analysis carried out for the differentiation of the neutron and gamma components of the measured radiation. Another typical change of the glow curve shape is a definite decrease of the peak of 160°C. It shows unambiguously that the peaks investigated are formed by (at least) three different mechanisms.

Table II

Measured relative intensity ranges and temperatures after irradiations in different mixed neutron-gamma fields at the research reactor "Merlin". The temperature values in the first column are taken from the reference [3]

Peak temperature [°C]	Evaluated temperatures [°C]			Relative intensities		
	TLD-100	TLD-600	TLD-700	TLD-100	TLD-600	TLD-700
130	128.0	132.3	128.8	12.6 ±0.8	12.5 ±2.1	10.3 ±0.6
165	159.6	160.7	159.4	41.1 ±7.2	31.6 ±4.4	45.5 ±1.2
190	186.0	186.0	186.0	100	100	100
225	225.0	222.4	231.2	13.5 ±7.1	19.0 ±3.6	2.49±0.33
255	250.0	249.0	258.0	13.7 ±8.5	21.5 ±4.6	2.48±0.21
280	271.6	273.1	288.3	14.5 ±8.4	20.3 ±5.6	1.11±0.47
310	304.0	304.1	325.9	5.58±3.16	6.87±1.82	1.41±0.18
390	335.4	336.6		2.96±1.28	3.10±0.66	

The solid state physics effects seem to be identical at the three detector types while the intensity differences among them show only the unlike content of the ^{6}Li isotope. The glow curve shape analysis may lead therefore to the neutron-gamma selection by using LiF detectors.

References

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