▣ PAPER ▣

ANALYSIS OF THE LiF:Mg,Cu,Si TL AND THE LiF:Mg,Cu,P TL GLOW CURVES BY USING GENERAL APPROXIMATION PLUS MODEL

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In this paper, we used computerized glow curve deconvolution (CGCD) software with several models for the simulation of a TL glow curve which was used for analysis. By using the general approximation plus model, parameters values of the glow curve were analyzed and compared with the other models parameters (general approximation, mixed order kinetics, general order kinetics). The LiF:Mg,Cu,Si and the LiF:Mg,Cu,P material were used for the glow curve analysis. And we based on figure of merits (FOM) which was the goodness of the fitting that was monitored through the value between analysis model and TLD materials. The ideal value of FOM is 0 which represents a perfect fit. The main glow peak makes the most effect of radiation dose assessment of TLD materials. The main peak of the LiF:Mg,Cu,Si materials has a intensity rate 80.76% of the whole TL glow intensity, and that of LiF:Mg,Cu,P materials has a intensity rate 68.07% of the whole TL glow intensity. The activation energy of LiF:Mg,Cu,Si was analyzed as 2.39 eV by result of the general approximation plus(GAP) model. In the case of mixed order kinetics (MOK), the activation energy was analyzed as 2.29 eV. The activation energy was analyzed as 2.38 eV by the general order kinetics (GOK) model. In the case of LiF:Mg,Cu,P TLD, the activation energy was analyzed as 2.39 eV by result of the GAP model. In the case of MOK, the activation energy was analyzed as 2.55 eV. The activation energy was analyzed as 2.51 eV by the GOK model. The R value means different ratio of retrapping-recombination. The R value of LiF:Mg,Cu,Si TLD main peak analyzed as 1.12×10^{-6} and α value analyzed as 1.0×10^{-3}. The R of LiF:Mg,Cu,P TLD analyzed as 7.91×10^{-4}, the α value means different ratio of initial thermally trapped electron density-initial trapped electron density (include thermally disconnected trap electrons density). The α value was analyzed as 9.17×10^{-1} which was the difference from LiF:Mg,Cu,Si TLD. The deep trap electron density of LiF:Mg,Cu,Si was higher than the deep trap electron density of LiF:Mg,Cu,P.

Keywords : General Approximation Plus, TL Curve, TL Glow Curve Analysis Program, Deep Trap, TL Analysis

1. INTRODUCTION

A thermoluminescence dosimeter (TLD) is one of the tools used for a radiation dose assessment with its characteristics, one of which is the amount of thermoluminescence from a TLD material is proportional to the absorbed radiation dose by the material. The TL glow curve is in compliance with several kinds of physical quantities of applies material. It is needed to analyze correctly in order to improve the accuracy of a radiation dose assessment. First order kinetics assume the probability of retrapping is negligible compared to the probability of recombination, Second order kinetics prefer not to assume that retrapping was negligible (which assumes the retrapping of the recombination are same. the general order kinetics (GOK) model assumed a numerical solution by first order kinetics and second order kinetics, and mixed order kinetics (MOK) model [1] assumed effect of thermally disconnect traps. These kinds of models are now in the wide use for glow curve analysis. But these models have several assumptions which were hard to apply real system. The general approximation (GA) model [2] applies in numerical analysis to a reduced effect of several assumptions and the general approximation plus model was based GA model which consider the effect of thermally disconnected traps which was recently developed. Among them, the general approximation plus (GAP) model [3] has the efficiency to analyze a full iteration (FI) glow curve. In this paper, we analyze the measured LiF:Mg,Cu,Si TL glow curve and measured LiF:Mg,Cu,P TL glow curve against the GAP Model

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compare it with a result of the others models.

2. THEORY

2.1 Thermoluminescence

Thermoluminescence is the emission of light from the insulator or semiconductor when it is heated which was light following the previous absorption of energy from radiation. In this statement could be found the three essential ingredients necessary for the production of thermoluminescence. Firstly, the material must be an insulator or a semiconductor. Secondly, the material must have at some time absorbed energy during exposure to radiation. Thirdly, the luminescence emissions triggered by heating the material.

Fig. 1 shows the energy level diagram. An electron (1) excited from the valence band to the conduction band can now become (2) trapped at trap where it will remain until it is given enough energy to return to conduction band from where it can undergo a normal (3) transition back to the valence band with the subsequent emission of light. The theory was not given full formal states until the work of Randall & Wilkins (1945) [4].

The TL Model outlined in Fig. 1 is the simplest that can be invoked to explain thermoluminescence when the process is accompanied by carrier transport through the lattice. Two energy levels are the minimum number needed in order to describe the thermoluminescence mechanism. The band model of an actual specimen may be much more complex than this but this simple picture can explain, at least qualitatively, all the fundamental features of thermoluminescence production.

In the simple thermoluminescence model (same as Fig. 2), TL equations are described by the following three equations [5]

$$-\frac{dm}{dt} = A_m m n_c$$

$$-\frac{dn}{dt} = sne^{-\frac{E}{kT}} - A_n(N-n)n_c$$

$$\frac{dn_c}{dt} = \frac{dm}{dt} - \frac{dn}{dt} = sne^{-\frac{E}{kT}} - n_c[mA_m + (N-n)A_n]$$

The terms are: n is the concentration of the electrons in the traps, n_c is the concentration of the electrons in the conduction band, q is the concentration of the deep trap, m is the concentration of the holes in the recombination centers, N is the concentration of the available electron trap, A_m is the recombination transition coefficient for the electrons in the conduction band with holes in the recombination centers, A_n is the transition coefficient for the electrons in the conduction band becoming trapped, s is the frequency factor, k is the Boltzmann constant, and E is the thermal activation energy. With the following assumptions,

$$n_c << n+q, \qquad \left|\frac{dn_c}{dt}\right| << \left|\frac{dn}{dt}\right|, \qquad I = -\frac{dm}{dt} \approx -\frac{dn}{dt},$$

$$R \equiv \frac{A_n}{A_m}, \quad m = n + n_c + q, \quad \alpha \equiv \frac{n_0}{n_0+q}, \quad n_{c(initail)} \approx 0$$

The TL intensity and parameters can be expressed as Table 1. The Fig. 3 shown that relation of glow curve analysis models.

2.2 Figure of Merits (FOM)

The goodness of the fitting was monitored through the value of the figure of merits (FOM) [6], where FOM is given by:

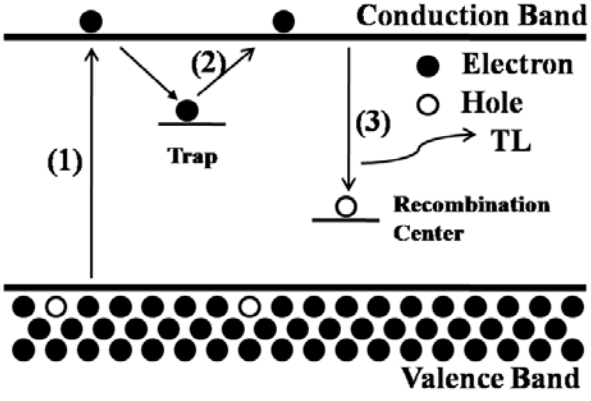

Fig. 1. A simple model of thermoluminescence.

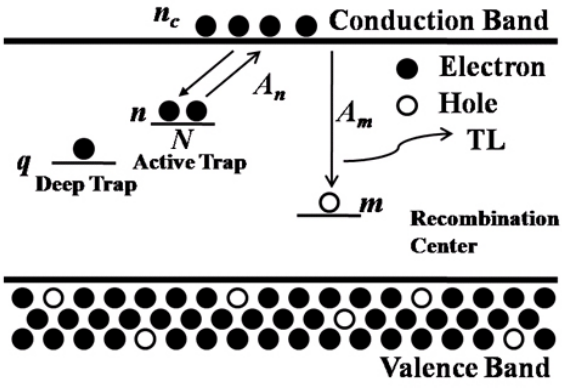

Fig. 2. Phenomenological model of the thermally stimulated release of trapped electrons from localized trapping model and recombination process.

Table 1. TL Intensity and Kinetics Parameters of Several Models.

Model	TL Intensity	Parameters
General-Order Kinetics (GOK)	$-\frac{dn}{dt} = s'n^b e^{-\frac{E}{kT}} \; (s' = sA_m / NA_n)$	n_0, E, s, b
Mixed-Order Kinetics (MOK)	$-\frac{dn}{dt} = s'n(n+q)e-\frac{E}{kT}$ $A_n = A_m \rightarrow (s' = s/(N+q))$ $NA_n >> (n+q)A_m \;\&\; n << N \rightarrow (s' = sA_m / NA_n)$	n_0, E, s, α
General Approximation (GA)	$-\frac{dn}{dt} = \frac{sn^2 e^{-\frac{E}{kT}}}{n + R(N-n)}$	n_0, E, s, R, N
General Approximation Plus (GAP)	$-\frac{dn}{dt} = \frac{sn(n+q)e^{-\frac{E}{kT}}}{(n+q) + R(N-n)}$	n_0, E, s, R, N, α

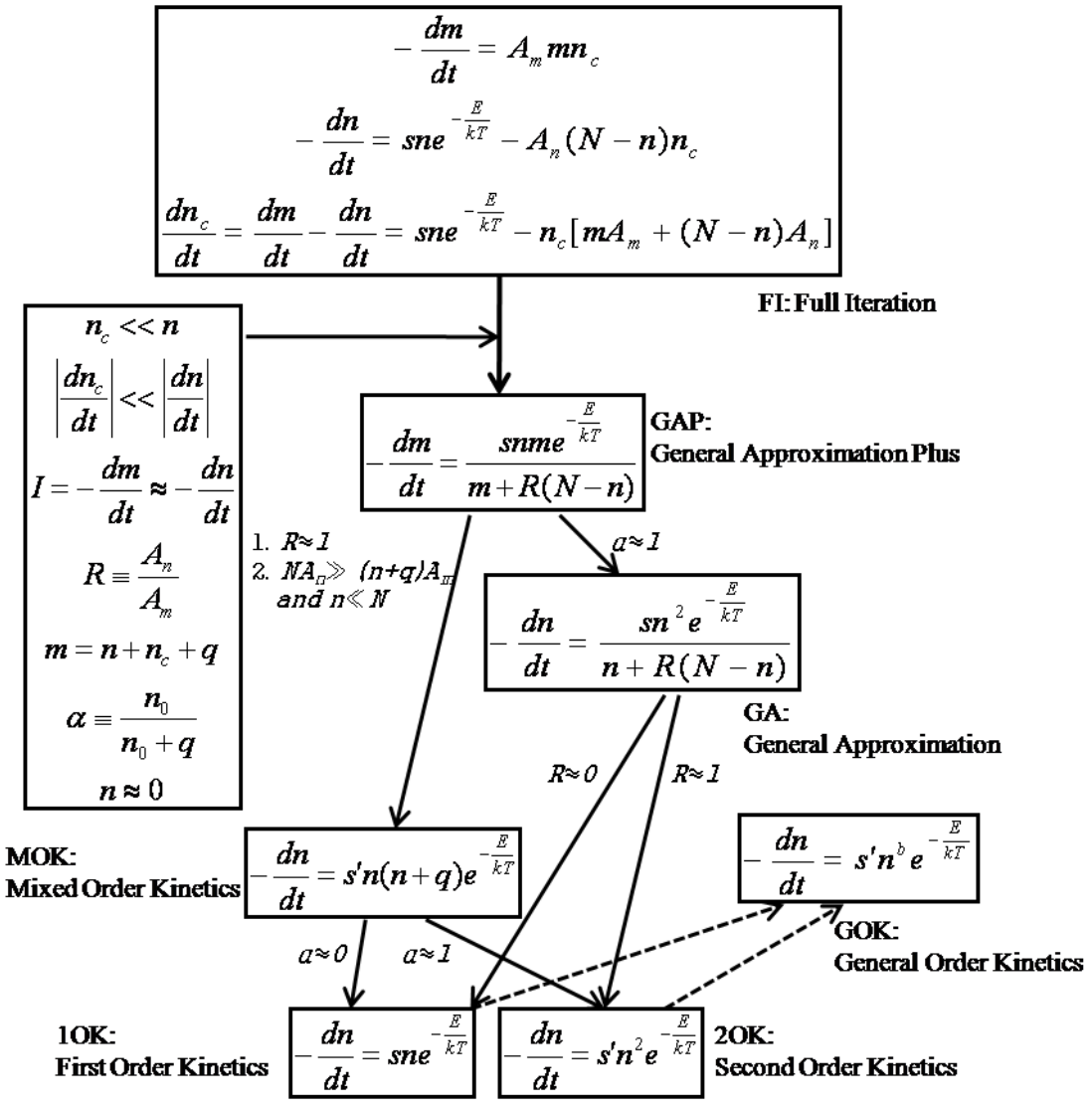

Fig. 3. The relation of glow curve analysis models.

$$FOM(\%) = \frac{\sum |I_i - Y_i|}{\sum I_i} \times 100\%$$

Where I_i is measured TL intensity and Y_i is the best fit value of the TL intensity. The ideal value of FOM is 0, which represents a perfect fit.

2.3 Analysis Ability of the Glow Curve Analysis Models

A Luminescence and Electron Spin Resonance Dating (LED) 2008 in Beijing came out with an account of Fig. 4 ~ Fig. 7 (2008. Chung KS) [3]. Fig. 4 ~ Fig. 7 were the analyzed result of a generated glow curve which has one activation trap, one thermally disconnected trap and one recombination center by GOK, MOK, GA, and GAP models. Here, the residual value was the gap of the analyzed curve and generated curve.

The generated FI glow curve consists of the several parameters which are n_0, s, N, A_m, E, R, and α. The parameter values are shows Fig. 4 which generated glow curve with n_o = 1.0 x 10^9 m^{-3}, s = 1.0 x10^{14} s^{-1}, N = 1.0x$10^{-7}$$m^{-3}$, E = 1.3 eV, R = 0.01, and α = 0.1.

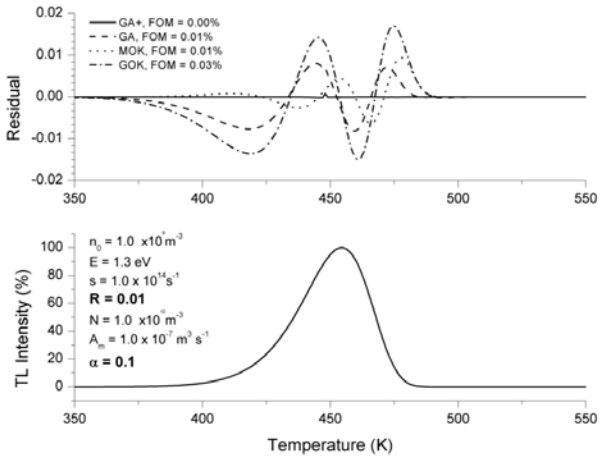

Fig. 4. The result of the analyzed FI glow curve of E=1.3, R=0.01, and α =0.1 [Chung KS, 2008].

Fig. 4 shows the case of E=1.3, R=0.01, and α=0.1. The GAP model was analyzed as FOM of 0%, the other models having the FOM value of 0.01%~0.03% with analysis.

Fig. 5 shows the case of E=1.3, R=0.1, and α=0.1. The GAP model was analyzed as FOM of 0%, the GA model analyzed FOM as 0.12%, the MOK model analyzed FOM as 0.01%, and the GOK mod el analyzed FOM as 0.14%.

Fig. 6 shows the case of E=1.3, R=0.1, and α=0.5. The GAP model was analyzed as FOM of 0.01%, the GA model analyzed FOM as 2.52%, the MOK model analyzed FOM as 0.47%, and the GOK model analyzed FOM as1.12%.

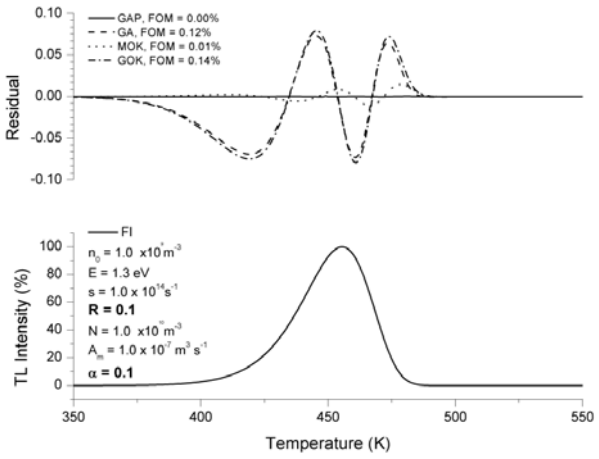

Fig. 5. The result of the analyzed FI glow curve of E=1.3, R=0.1, and α =0.1 [Chung KS, 2008].

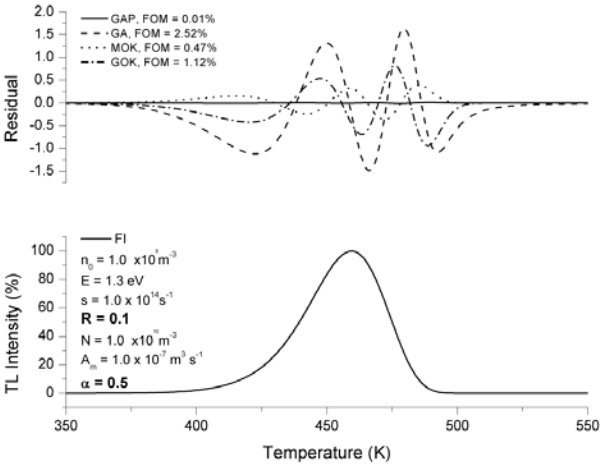

Fig. 6. The result of the analyzed FI glow curve of E=1.3, R=0.1, and α =0.5 [Chung KS, 2008].

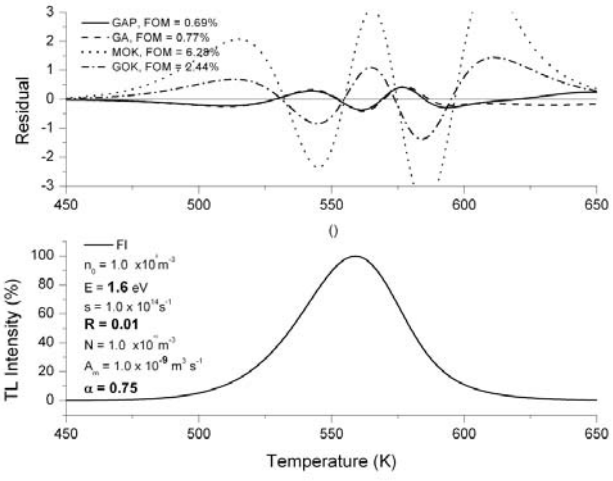

Fig. 7. The result of the analyzed FI glow curve of E=1.6, R=0.01, and α =0.75 [Chung KS, 2008].

Fig. 7 shows the case of E=1.3, R=0.1, and α=0.5. The GAP model was analyzed as FOM of 0.69%, the GA model analyzed FOM as 0.77%, the MOK model analyzed

FOM as 6.28%, and the GOK model analyzed FOM as 2.44%.

Fig. 4 ~ Fig. 7 FOMs were summarized in Table 2. The GAP model FOMs were analyzed as 0.00%~0.69%, the GA models were analyzed as 0.01% ~ 2.52%, the MOK model analyzed as 0.01% ~ 6.29%, and GOK model analyzed as 0.03% ~ 2.44%.

Fig. 8 [7] announced in "A Study on a New Analysis Method for Thermoluminescence Glow-curve by the General Approximation Model". Fig. 8 makes with n_o = 1.0×10^{9} m^{-3}, $E = 1.0$ eV, $s = 1.0 \times 10^{12}$ s^{-1}, $N = 1.0 \times 10^{-10}$ m^{-3}, $A_m = 1.0 \times 10^{-7}$ $m^3 s^{-1}$, $R = 0.001 \sim 1$, and $\alpha = 0.1 \sim 1$ of the FI glow curve. The activation energy value (E) of by using GOK, MOK, GA, and GAP models were shown in a graph. Table 3 shows the activation energy (E) value of Fig. 8. The difference of the generated activation energy and analyzed the activation energy as -0.10% ~ 0.24% in GAP model, the case of GA model has difference as -15.09% ~ 0.24%, the MOK model has difference as 0.25% ~ 12.99% and GOK model has difference as -8.73% ~ 6.99%.

Table 2. Summarized FOM of Fig. 4~ Fig. 7.

Model		GAP			GA			MOK			GOK		
Parameters	E(eV)	1.3		1.6	1.3		1.6	1.3		1.6	1.3		1.6
	α	0.1	0.5	0.75	0.1	0.5	0.75	0.1	0.5	0.75	0.1	0.5	0.75
Figure of merits (FOM)	R=0.1	0.00%	0.01%		0.12%	2.52%		0.16%	0.47%		0.14%	1.12%	
	R=0.01	0.00%		0.69%	0.01%		0.77%	0.01%		6.29%	0.03%		2.44%

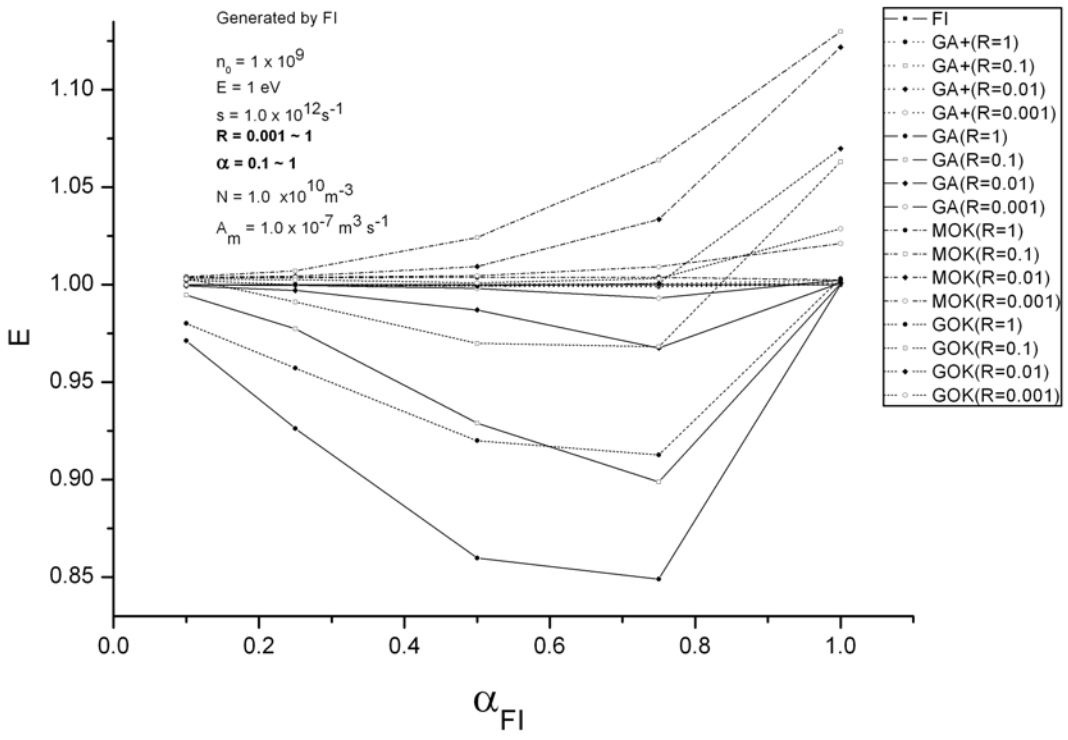

Fig. 8. Analyzed E value with the analysis model [Oh MA, 2009].

Table 3. Summarized FOM of Analyzed E Value in Fig. 8.

E(eV: by FI)	Parameter		E(eV)			
	α	R	GAP	GA	MOK	GOK
E=1.0	1	0.001	1.00244	1.00244	1.02113	1.02871
		0.01	1.00096	1.00099	1.12182	1.06988
		0.1	1.00029	1.00060	1.12987	1.06298
		1	0.99998	1.00039	1.00245	1.00321
	0.75	0.001	1.00055	0.99319	1.00923	1.00321
		0.01	1.00009	0.96752	1.03357	1.00067
		0.1	0.99929	0.89888	1.06393	0.96822
		1	0.99898	0.84907	1.00374	0.91269
	0.5	0.001	1.00026	0.99810	1.00459	1.00101
		0.01	1.00013	0.98706	1.00938	0.99930
		0.1	0.99973	0.92904	1.02423	0.96999
		1	0.99936	0.85983	1.00376	0.92005
	0.25	0.001	1.00006	0.99966	1.00386	1.00258
		0.01	1.00007	0.99712	1.00436	1.00003
		0.1	0.99997	0.97739	1.00710	0.99120
		1	0.99974	0.92632	1.00370	0.95725
	0.1	0.001	1.00002	0.99995	1.00380	1.00288
		0.01	1.00003	0.99943	1.00384	1.00235
		0.1	1.00001	0.99471	1.00412	1.00325
		1	0.99995	0.97126	1.00370	0.98013

3. MATERIALS AND METHODS

3.1 TLD Materials

TLD materials were used in the LiF:Mg,Cu,Si [8,9] and the LiF:Mg,Cu,P [10,11]. The LiF:Mg,Cu,Si TLD was invented by the Korea Atomic Energy Research Institute (KAERI) which showed that a TLD has high sensitivity, low energy responsibility, and very high reusability. The LiF:Mg,Cu,P is well known for the use of a personal radiation dose assessment which has 30~50 times the high sensitivity of LiF:Mg,Ti. But LiF:Mg,Cu,P TLD has low thermal stability and high residual intensity.

3.2 Measurement of Glow Curve

Beta-ray was irradiated in this experiment. A Beta-ray irradiation was performed using a $^{90}Sr/^{90}Y$ source. (Reference dose irradiator 6527; Studvik) The data analyzed in this study represent measurements collected using a Harshaw TLD 4500 manual reader [12] and 1 Ks^{-1} heating rates. A reliable TL kinetics analysis requires a low heating rate to minimize the temperature lag between the heating plate and the emitting surface.

4. RESULTS AND DISCUSSION

4.1 Analyzed Glow Curve

Fig. 9 shows the measured glow curve and the analyzed glow curve of LiF:Mg,Cu,Si. It was the result of analyzing the analysis model and a measured glow curve. And the measured glow peaks were analyzed by five deconvolution peaks. The residual value means the gap of analyzed with the measured glow curve difference with the fitting value of the glow curve. Table 4 shows the FOM value which has a direct link (by definition) to the residual.

According to the analysis results of analyzing the glow curve of LiF:Mg,Cu,Si it was found that the MOK model had FOM of 0.75%, GOK model had FOM of 0.82%, and the GA model had the FOM of 0.98%.

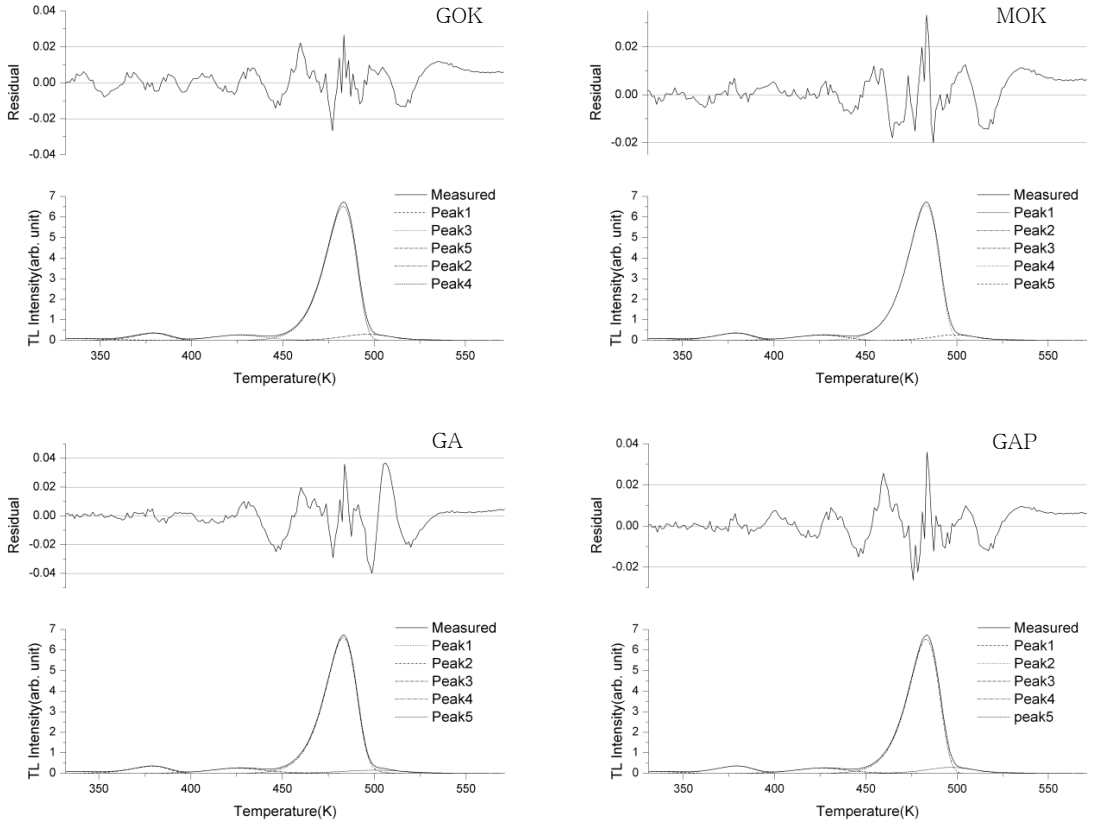

Fig. 9. The analysis results of LiF:Mg,Cu,Si glow curve.

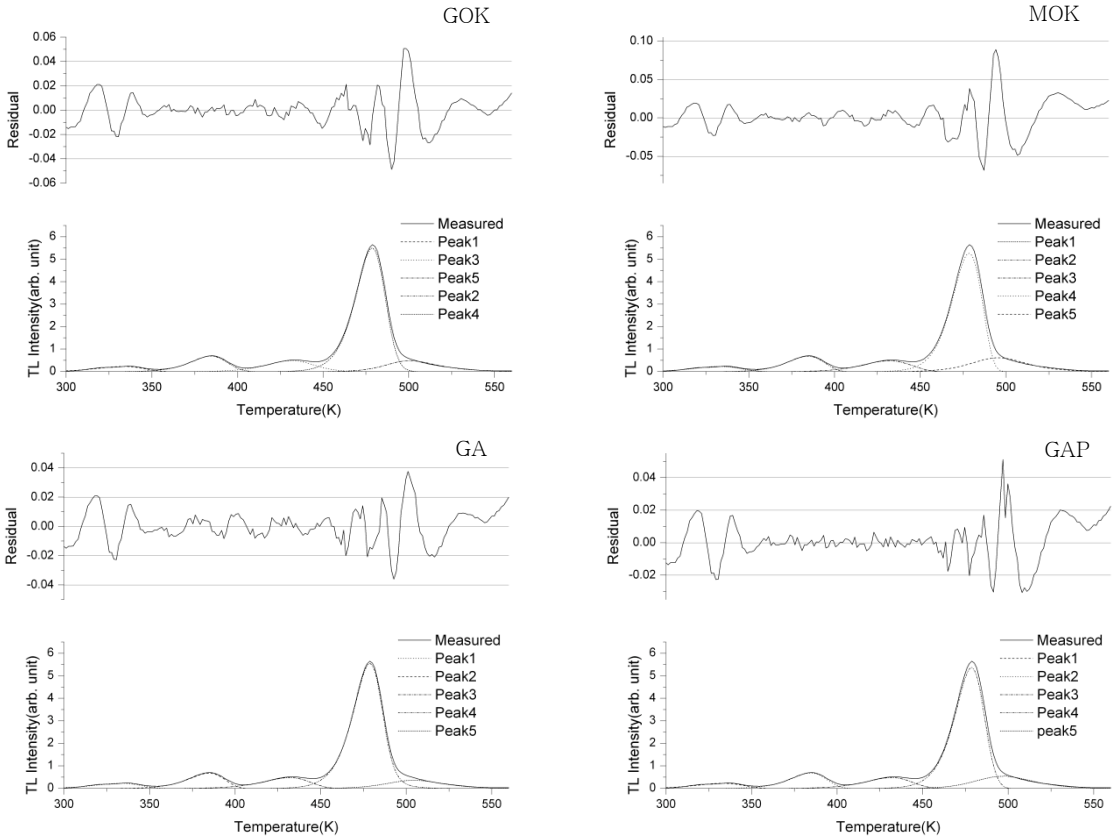

Fig. 10. The analysis results of LiF:Mg,Cu,P glow curve.

Fig. 10 shows the GAP model, GOK model, and GA model as 1.49%, and the MOK model showed 2.17% of analyzing the glow curve of LiF:Mg,Cu,P. FOMs of Fig. 9 and Fig. 10 were summarized in Table 4.

Table 4. The Analysis Models of Figure of Merits.

	GOK	MOK	GA	GAP
LiF:Mg,Cu,Si	0.82%	0.75%	0.98%	0.79%
LiF:Mg,Cu,P	1.49%	2.17%	1.49%	1.49%

4.2 Analyzed Parameters

Table 5 and Table 6 show parameters of LiF:Mg,Cu,Si TL glow curve and LiF:Mg,Cu,P TL glow curve. The parameter means the physical information of each trap.

The R of the LiF:Mg,Cu,Si TL glow curve main peak was analyzed as 1.12×10^{-6}, α was analyzed as 1.00×10^{-3}, N was analyzed as 9.35×10^{11}, and n_0 was analyzed as 1.45×10^{8} when using the GAP model.

The activation energy of the LiF:Mg,Cu,Si TL glow curve was analyzed as 2.39 eV when using the GAP model. When using the GOK model, it was analyzed as 2.38 eV and it had the result of the GAP model and an error margin of 0.6%, the GA model has an error margin of 0.1% with 2.40 eV and the MOK model was analyzed to have an error margin of 4.3% as 2.29 eV.

The R of the main peak of the LiF:Mg,Cu,P TL glow curve was analyzed as 7.91×10^{-4}, α was analyzed as 9.17×10^{-1}, N was analyzed as 8.72×10^{9}, and n_0 was analyzed as 1.21×10^{8} when using GAP model.

The activation energy of the LiF:Mg,Cu,P TL glow curve was analyzed as 2.39 eV when using the GAP model. When using the GOK model, it was correlated to 2.51 eV, and it had the result of the GAP model and an error margin of 4.9%, The GA model has on error margin of 0.9% with 2.37 eV, and the MOK model was analyzed to have an error margin of 6.6% as 2.55 eV.

The glow curves of LiF:Mg,Cu,Si and LiF:Mg,Cu,P TLD were analyzed by using the GAP model. The main peak was analyzed as the 2.39eV. The case of 2,3,5 peaks of LiF:Mg,Cu,Si TL glow curve and LiF:Mg,Cu,P TL glow curve has the same activation energy.

n_o was the initial trapped electron density which means the total intensity of each peaks. The LiF:Mg,Cu,Si TLD radiation ratio was analyzed as 1.25%, 5.34%, 6.69%, 80.76%, and 5.96%. And the LiF:Mg,Cu,P TLD radiation ratio of each peak was analyzed as 4.25%, 10.46%, 9.40%, 68.07%, and 7.82%.

Table 5. Parameters of LiF:Mg,Cu,Si Glow Peaks.

	Parameters	Peak 1	Peak 2	Peak 3	Peak 4	Peak 5
General order kinetics	Energy(eV)	1.54	1.45	1.53	2.38	2.16
	s"(s^{-1})	1.21×10^{22}	2.13×10^{18}	1.10×10^{17}	7.54×10^{23}	9.76×10^{20}
	b(order of kinetics)	3.94	1.22	1.81	9.92×10^{-1}	1.81
	$n_0(cm^{-3})$	3.51×10^{6}	8.66×10^{6}	9.72×10^{6}	1.44×10^{8}	1.07×10^{7}
Mixed order kinetics	Energy(eV)	1.48	1.21	1.36	2.29	2.54
	s' (s^{-1})	3.21×10^{19}	9.93×10^{14}	5.74×10^{14}	9.64×10^{22}	1.74×10^{22}
	A	9.81×10^{-1}	1.98×10^{-3}	5.45×10^{-1}	1.36×10^{-1}	9.97×10^{-1}
	$n_0(cm^{-3})$	2.29×10^{6}	9.46×10^{6}	9.26×10^{6}	1.47×10^{8}	8.92×10^{6}
General approximation	Energy(eV)	1.20	1.22	1.31	2.40	1.36
	s (s^{-1})	2.07×10^{17}	1.68×10^{15}	5.29×10^{14}	1.20×10^{24}	3.73×10^{12}
	$R(A_n/A_m)$	1.11×10^{-4}	3.11×10^{-5}	2.66×10^{-5}	2.03×10^{-6}	1.66×10^{-3}
	$N(cm^{-3})$	2.49×10^{10}	1.05×10^{8}	4.87×10^{11}	9.29×10^{11}	1.26×10^{9}
	$n_0(cm^{-3})$	2.38×10^{6}	9.32×10^{6}	1.05×10^{7}	1.48×10^{8}	7.53×10^{6}
General approximation plus	Energy(eV)	1.37	1.24	1.41	2.39	2.01
	$s(s^{-1})$	8.09×10^{21}	6.05×10^{17}	1.17×10^{16}	1.13×10^{24}	4.14×10^{19}
	$R(A_n/A_m)$	2.66×10^{-3}	1.20×10^{-1}	1.45×10^{-3}	1.12×10^{-6}	1.56×10^{-4}
	$N(cm^{-3})$	2.15×10^{11}	8.91×10^{10}	1.14×10^{10}	9.35×10^{11}	7.03×10^{10}
	α	8.46×10^{-1}	1.47×10^{-1}	9.97×10^{-1}	1.00×10^{-3}	9.91×10^{-1}
	$n_0(cm^{-3})$	2.25×10^{6}	9.58×10^{6}	1.02×10^{7}	1.45×10^{8}	1.07×10^{7}

Table 6. Parameters of LiF:Mg,Cu,P Glow Peaks.

	Parameters	Peak 1	Peak 2	Peak 3	Peak 4	Peak 5
General order kinetics	Energy(eV)	0.71	1.28	1.39	2.51	2.39
	s"(s^{-1})	$4.16X10^{9}$	$5.59X10^{15}$	$1.43X10^{15}$	$3.49X10^{25}$	$1.16X10^{23}$
	b(order of kinetics)	1.01	1.12	1.41	1.18	2.56
	$n_0(cm^{-3})$	$7.59X10^{6}$	$1.89X10^{7}$	$1.75X10^{7}$	$1.24X10^{8}$	$1.98X10^{7}$
Mixed order kinetics	Energy(eV)	0.78	1.33	1.36	2.55	1.89
	s' (s^{-1})	$3.29X10^{10}$	$1.94X10^{16}$	$3.57X10^{14}$	$7.11X10^{25}$	$2.03X10^{15}$
	α	$3.05X10^{-1}$	$3.02X10^{-1}$	$4.67X10^{-1}$	$3.02X10^{-1}$	$9.99X10^{-1}$
	$n_0(cm^{-3})$	$7.63X10^{6}$	$1.86X10^{7}$	$1.71X10^{7}$	$1.18X10^{8}$	$2.63X10^{7}$
General approximation	Energy(eV)	0.71	1.21	1.18	2.37	1.97
	$s(s^{-1})$	$4.41X10^{9}$	$6.68X10^{14}$	$4.60X10^{12}$	$1.23X10^{24}$	$4.60X10^{21}$
	$R(A_n/A_m)$	$4.10X10^{-7}$	$5.40X10^{-6}$	$4.53X10^{-7}$	$8.68X10^{-5}$	$1.02X10^{2}$
	$N(cm^{-3})$	$4.28X10^{7}$	$1.15X10^{8}$	$4.06X10^{8}$	$1.15X10^{11}$	$1.75X10^{8}$
	$n_0(cm^{-3})$	$7.47X10^{6}$	$1.85X10^{7}$	$1.68X10^{7}$	$1.29X10^{8}$	$1.57X10^{7}$
General approximation plus	Energy(eV)	0.75	1.26	1.22	2.39	2.03
	$s(s^{-1})$	$4.95X10^{11}$	$3.23X10^{15}$	$1.55X10^{13}$	$2.15X10^{24}$	$1.41X10^{21}$
	R (A_n/A_m)	$4.91X10^{-3}$	$6.11X10^{-4}$	$6.00X10^{-3}$	$7.91X10^{-4}$	2.39X10
	$N(cm^{-3})$	$1.81X10^{11}$	$2.76X10^{9}$	$1.04X10^{8}$	$8.72X10^{9}$	$5.86X10^{7}$
	α	$2.11X10^{-1}$	$8.00X10^{-1}$	$8.84X10^{-1}$	$9.17X10^{-1}$	$9.95X10^{-1}$
	$n_0(cm^{-3})$	$7.55X10^{6}$	$1.86X10^{7}$	$1.67X10^{7}$	$1.21X10^{8}$	$2.39X10^{7}$

The α value of LiF:Mg,Cu,Si TL glow peak main peak was analyzed at close to zero. It means that many electrons were in the deep trap. On the other hand, in the case of LiF:Mg,Cu,P had the α value as 0.91. The electron density of deep trap of the LiF:Mg,Cu,Si TLD and the LiF Mg,Cu,P TLD has contrasted α value.

5. CONCLUSION

In this paper, the LiF:Mg,Cu,Si TLD and the LiF:Mg,Cu,P TLD were analyzed by using the GAP model, which was the effective glow curve analysis model and we compared the result of analyzing TL glow curves.

By using the GAP model, the peak activation energy of the LiF:Mg,Cu,Si TLD material was analyzed as 1.37 eV, 1.24 eV, 1.41 eV, 2.39 eV, and 2.01 eV. In the LiF:Mg,Cu,P TLD, it had analyzed activation energy of 0.75 eV, 1.26 eV, 1.22 eV, 2.39 eV, and 2.03 eV. Particularly, the main peak activation energy as 2.39 eV of both TLD values was analyzed.

And we could know through an analysis of n_0 that it was the difference of the intensity ratio of the main peak intensity and the total output intensity. The main peak intensity of LiF:Mg,Cu,Si TL glow curve has an 80.76% of total LiF:Mg,Cu,Si TL glow curve intensity, but the main peak intensity of LiF:Mg,Cu,P TL glow curve has 68.07% of total LiF:Mg,Cu,P TL intensity. The high rate of main peak intensity was an advantage for radiation dose assessment.

The α value analyzed the LiF:Mg,Cu,Si TL glow curve which was close to 0. On the other hand, the LiF:Mg,Cu,P TL glow curve became an α value as 0.91. The two TLD materials were analyzed that the electron concentration of the deep trap had a large-scale difference. Still, we could not understand the deep trap affect for the TLD glow curve. We needed to inquire through additional experiments how the deep trap affects the TLD material.

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