# Long Term Study Of Thermo Scientifc Harshaw TLD LiF Glow Curve Peaks and Sensitivities



#### Introduction

A series of work has been published in previous papers for the long term study of Thermo Scientific<sup>™</sup> Harshaw<sup>™</sup> TLD LiF materials over a 24-month period. Parts I and II were focused on the characteristic at the material fading, Lower Limit of Detection (LLD), and uncertainty. They were presented in SSD15 (2007)<sup>1</sup> and LumDetr (2009)<sup>2</sup>. This work is the continuation of this series – Part III: Glow Curve Peaks and Sensitivities. It presents the analysis and sensitivity change over 24 months for LiF:Mg,Ti and LiF:Mg,Cu,P materials stored at 0°C, 20°C, and 40°C.

Tables below list the parameters a, b, and c of fade function for each method, for LiF:Mg,Ti and LiF:Mg,Cu,P TLD cards, of their signal loss, sensitivity loss and the average, at storage temperatures of 0°C, 20°C and 40°C.

LiF:Mg,Cu,P – No Preheat

Peak3

0.006

-0.064

Peak4

-0.0069

0.0431

0.7882

Signal Loss

			1st-order		Weibull			
		Total	Peak5	Peak4	Peak5	Peak4		
		Signal Los	S					
40C	С		-0.0076	0.0086	0.0132	-0.0072	40C	Ċ
	а	-0.0569	0.0528	-0.0953	-0.1003	0.0261		6
	b	1.003	0.6161	0.2902	0.5632	0.2714		k
	a b	-0.0569 1.003	0.0528 0.6161	-0.0953 0.2902	-0.1003 0.5632	0.0261 0.2714		

LiF:Mg,Cu,P –	W/Preheat
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	Weibull					1st-order/Mo	od Gaussian	Weibull	
	Peak4	Peak3			Total	Peak4	Peak3	Peak4	Peak3
					Signal Los	S			
3	-0.0092	0.0063	40C	С		-0.0029	0.0016	-0.0026	0.0036
3	0.0668	-0.0657		а	-0.0165	0.0179	-0.0195	0.0166	-0.0332
4	0.7210	0.1699		b	1.0122	0.8595	0.0647	0.8358	0.0776

#### Summary

- Two fitting methods were used: 1st-order kinetics/modified Gaussian and Weibullarea fit.
- 1st-order kinetics functions fit LiF:Mg,Ti well in all temperature cases.
- For LiF:Mg,Cu,P, using modified Gaussian function for peak 4 to include the contribution from higher temperature peaks yields better fit.
- Weibullarea fit results in greater errors in allocating the relative weight of individual peaks, though the overall Fit-of-Merit is

### Study

loss were presented in Part I of this work<sup>1</sup>, and are listed in the tables, to the right, in blue. The stability or the fade rate of individual peaks at three representative temperatures are of interest in Part III. Therefore, glow curves at various temperatures are de-convoluted. Two different fitting methods are utilized. The first is the first-order kinetics fit, which is widely used for LiF:Mg,Ti based TLD materials. The previous work by Luo et al<sup>3</sup> showed a combination of first-order kinetics fit, with a modified Gaussian function to peak 4 for LiF:Mg,Cu,P material. Since increased interest is expressed on whether a commercial curve-fitting package is suitable for the glow curve de-convoluted purposes, the second method evaluated is a Weibull area fit using PeakFit<sup>®</sup>, a commercially available software package.

1. First Order Kinetics (Randall & Wilkins) combined with Modified Gaussian<sup>3</sup>:



where,  $I_i$  is the peak intensity of peak i  $I_{oi}$  is the height of peak i  $T_{mi}$  is the peak temperature of peak i  $E_i$  is the activation energy of peak i

-0.0015 -0.0015 20C ( -0.0030 0.0040 0.0054 0.001 0.0000 0.0749 -0.0729 0.0256 -0.0605 0.0116 -0.0339 0.0398 -0.0394 0.0252 -0.0097 0.0208 -0.0028 -0.0524 -0.0187 -0.0065 0.8081 0.0683 1.0018 0.4238 0.3275 0.3626 0.4092 b 1.0032 0.7683 0.1769 0.6799 0.1916 b 1.0243 0.8108 0.0700 b -0.0043 -0.0021 0.0019 -0.0037 0.0035 0.0074 -0.0043 0.0060 0.0036 0C 0.0022 0.0063-0.0425 -0.0036 0.0537 -0.0415 0.0158 a -0.0153 -0.0462 0.0376 -0.0077 0.0107 a 0.0056 -0.0037 0.0120 0.0005 0.0216 1.0531 0.3813 0.3079 1.0256 0.6818 0.1609 0.9992 0.0407 0.8210 0.0523 0.4768 0.1807 0.8495 0.0853 0.8507 b b Sensitivity Loss Sensitivity Loss Sensitivity Loss 40C c 0.0045 -0.0053 0.0039 40C c 40C c 0.0021 -0.0033 0.0013 -0.0078 0.0107 -0.0028 0.0006 -0.0036 -0.0036 0.0142 -0.0335 a -0.0315 0.0050 -0.0148 a -0.0726 0.0400 -0.1179 0.0095 -0.0533 0.0238 -0.0441 a -0.0292 0.0080 -0.0205 1.0075 0.6348 0.3282 0.4014 0.3351 b 1.0240 0.8208 0.1731 0.7617 0.1566 b 1.0343 0.8654 0.0655 0.8577 0.0632 -0.0043 -0.0016 20C c 0.0011 -0.0014 -0.0067 0.0000 -0.0086 -0.0046 20C c -0.0025 -0.0011 0.0025 20C c -0.0044 0.0795 -0.0019 a -0.0249 0.0153 0.0573 -0.0386 a -0.0139 0.0311 0.0314 0.0072 a -0.0736 -0.0539 0.0140 -0.0101 -0.0064 0.7994 0.0502 b 1.0832 0.3074 0.3641 0.3388 0.7659 0.6472 0.1981 b 1.0513 0.4397 b 1.0339 0.1489 0.8145 0.0651 0C c -0.0077 0.0012 0.0004 -0.0016 0.0010 -0.0015 0.0024 0C c 0.0062 -0.0042 0.0022 0C c 0.0018 -0.0019 a -0.0333 0.0123 -0.0028 -0.0003 -0.0490 0.0255 -0.0034 -0.0011 -0.0051 0.0068 0.0377 a -0.0060 a 0.0043 0.0129 0.0081 1.0568 0.1926 0.3502 0.2825 b 1.0111 0.8478 0.7024 0.1424 1.0033 0.8557 0.8076 0.0675 0.4532 0.0990 0.0388 b Average Average Average 40C c 40C c 40C c -0.0077 0.0096 0.0052 -0.0033 -0.0052 0.0054 -0.0072 0.0051 -0.0033 0.0019 -0.0029 0.0024 0.0464 -0.0430 -0.0037 a -0.0270 0.0263 0.0453 -0.0549 -0.0228 0.0129 0.0108 -0.0240 a -0.0647 -0.1066 -0.0591 -0.0200 а 0.8045 0.7414 0.1633 1.0233 1.0053 0.6255 0.3092 0.4823 0.3032 b 1.0156 0.1688 0.8625 0.0651 0.8467 0.0704 b 20C c 0.0076 0.0025 -0.0031 0.0004 20C c -0.0014 0.0000 -0.0048 0.0021 20C c -0.0031 0.0000 -0.0029 -0.0015 0.0772 -0.0312 a -0.0218 0.0134 0.0485 -0.0390 a -0.0102 0.0022 -0.0630 -0.0634 0.0198 -0.0220 0.0281 -0.0080 0.0261 0.0676 0.8038 0.0593 1.0425 0.4317 0.3175 0.3633 0.3740 b 1.0186 0.7671 0.1629 0.6636 0.1948 b 1.0378 0.8126 b 0C 0.0043 0.0014 -0.0026 0.0030 -0.0020 0.0061 -0.0052 0.0029 -0.0029 0C 0.0020 -0.0020 С -0.0089 С 0.0048 0.0043 0.0142 0.0043 0.0457 -0.0222 0.0078 a -0.0107 -0.0476 0.0316 -0.0056 0.0049 -0.0044 0.0124 -0.0379 а b 1.0550 0.4650 0.1867 0.3657 0.2952 b 1.0183 0.8487 0.0922 0.6921 0.1517 b 1.0012 0.8532 0.0398 0.8143 0.0599 1.0 1.0 -0.8 0.8 0.6 Ř 0.6 0.4 -0.4 0.2 0.2 0.0 0.0 1.2 1.0 1.0 

better. The main peak has less percentage compared to that of 1st-order kinetic fit.

• Both fitting methods show that the dosimetric peaks 4+5 (or 3+4 for LiF:Mg,Cu,P) are relatively stable in all temperatures cases. No fade in 24 months for LiF:Mg,Cu,P with preheat.

 Two fitting methods agreed with each other for LiF:Mg,Cu,P TLD card in storage temperature of 20°C, with specified preheated readout setup.

• Complete set of parameters (a, b, and c) of fade function are provided for all various cases.







where,  $a_0 = area$   $a_1 = center$   $a_2 = width (>0)$  $a_3 = shape (>1.01)$ 

#### **Materials and Readout Setups**

Readout	LiF:Mg,Ti TLD1776	LiF:Mg,Cu,P TLD1776H			
Setup	No-Preheat	No-Preheat	W/Preheat		
Preheat	50°C for 0s	50°C for 0s	165°C for 10s		
Heating Rate	25°C/s	15°C/s	15°C/s		
Acquire	13s to Max 300°C	23s to Max 260°C	13s to Max 260°C		





0.8

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0.8

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