thermoscientific

DOSE REANALYSIS FEASIBILITY STUDY USING HARSHAW TLD™ LiF:Mg,Cu,P

Introduction

LiF-based thermoluminescent dosimeters (TLDs), such as TLD-100, have been widely studied for more than forty years. They are used in many research and commercial applications. One of the many advantages of this TLD material is that its traps are emptied during readout and then it can be reused. The loss of sensitivity for hundreds of reuses is insignificant. In the 1990s, high sensitivity material LiF:Mg,Cu,P (MCP) was introduced by Thermo Fisher Scientific (Harshaw TLD). In MCP's early development, despite all the desirable properties it offered, it drew criticism for its residual signal level because it was higher than that of TLD-100. However, after more than a decade of production and refinement, Harshaw TLD has improved its MCP material to achieve <0.5% residue. At the same time, higher residual MCP was made as well. Interest has been shown regarding the feasibility of reanalysis of LiF-based materials and this high residual MCP material is well-suited to a reanalysis study.

Experiment

Commercially available Thermo Scientific™ Harshaw™ TLD M5500 reader and MCP materials are used. Various heating rates and heating temperatures are explored to find the proper heating profile that offers good reanalysis ability as well as good dosimetric properties.

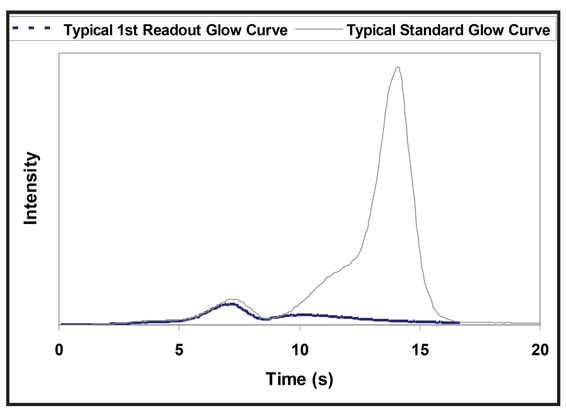
Setup, Study and Results

Material:
Thermo Scientific HarshawTLD high residue LiF:Mg,Cu,P
4.5mm dia. x 0.38mm

Reader:
Thermo Scientific HarshawTLD Model 5500 TLD Reader

Irradiator:
Thermo Scientific HarshawTLD Model 2210

It is known that an MCP glow curve consists of four peaks (<240°C) and that the low temperature peaks are well separated from its main dosimetric peaks. Preparation of the material consists of clearing the material using the standard time temperature profile (TTP) for MCP material followed by irradiation and then another reading of the material using the standard TTP but limited to 180°C. This preparation eliminates the low temperature fading peaks 1 and 2 as shown:



With the optimal heating profile determined, testing of the dosimetric properties testing then followed.

Uniformity:
35 samples were prepared after being cleared and irradiated to 2.4 mSv. The standard deviation is 10%.

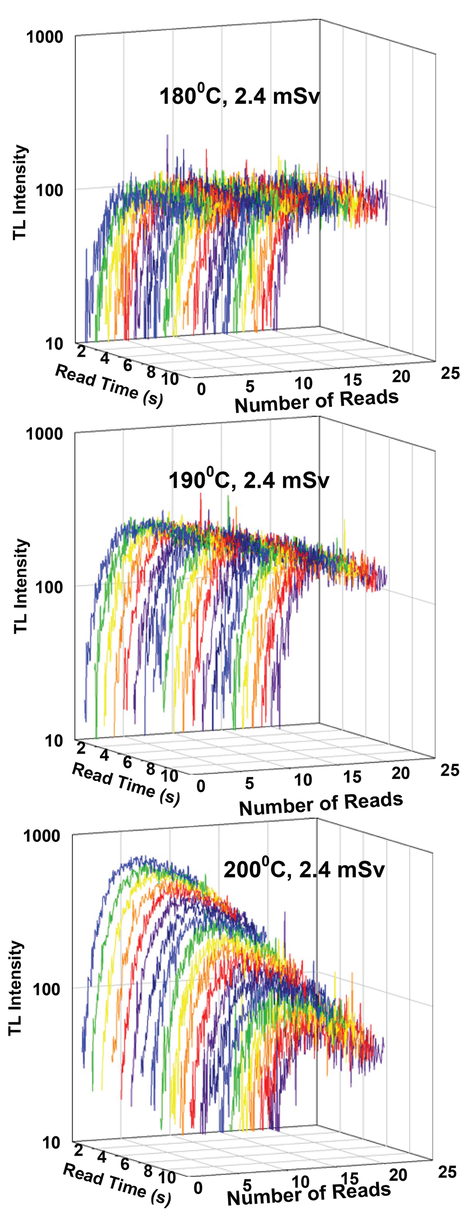
Lower Limit Detection:
10 samples were tested. The irradiation level was 2.4 mSv. Using the following equation, LLD is reported as 1.17 mSv, which yields Detection Threshold be 0.56 mSv.

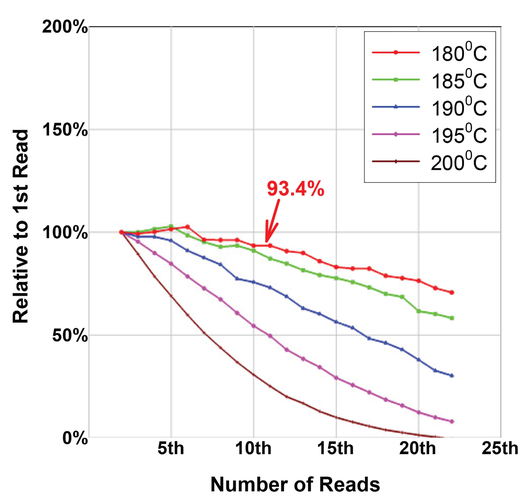
$$LLD = \frac{2\left(t_n s_0 + t_m^2 s_\mu^2 H_B\right)}{1 - t_m^2 s_\mu^2}$$

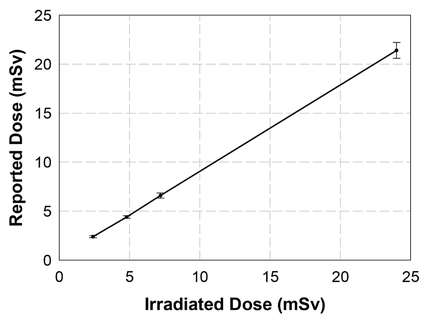
tn or ***tm*** = student's t value corresponding to 95% confidence and ***(n-1)*** or ***(m-1)*** degrees of freedom
S_0 = standard deviation of ***n*** background dosimeters
S_μ = relative standard deviation of ***m*** irradiated dosimeters
H_B = average measurement of background (induced and non-induced radiation)

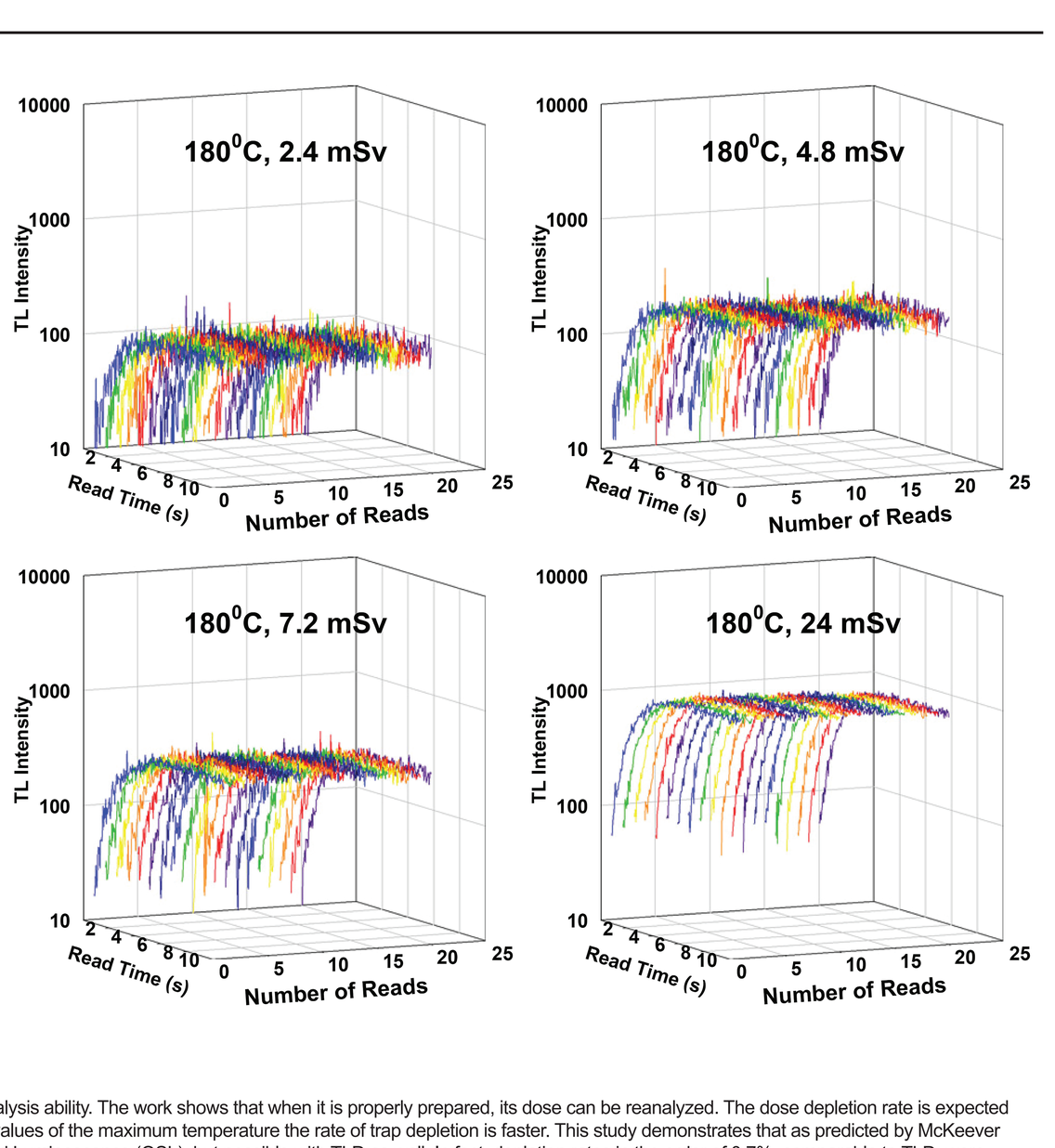
Linearity:
10 samples were prepared and irradiated to dose levels: 2.4, 4.8, 7.2 and 24 mSv and then read. The dose response is shown on the right.

Finding the best heating profile that results in the least signal depletion rate is the first step in the evaluation process. Various profiles with different temperatures and/or readout times have been tested. Graphs below show samples of glow curves in the test with various read times and temperatures. It is concluded that a temperature profile of 10s at 1800C gives the most desirable results as seen in the middle right graph. With this heating profile, the signal depletes 6.6% after ten readouts and is independent of the irradiated dose. Graphs at lower portion show the glow curves of each re-read at dose levels of 2.4–24 mSv.









Conclusions

Specially-formulated 7LiF:Mg,Cu,P material was investigated for its dose reanalysis ability. The work shows that when it is properly prepared, its dose can be reanalyzed. The dose depletion rate is expected at 0.7 ± 0.1% per read when the maximum temperature is 1800C. For higher values of the maximum temperature the rate of trap depletion is faster. This study demonstrates that as predicted by McKeever and Moscovitch, dose re-analysis is not a unique feature of Optically Stimulated Luminescence (OSL), but possible with TLD as well. In fact, depletion rates in the order of 0.7%, comparable to TLD, were obtained using a commercially available OSL system.

References

1. Velbeck, K.J., Luo, L.Z., Ramlo, M.J. and Rotunda, J.E., The Dose Response of Harshaw TLD-700H, Radiat. Prot. Dosim, 119, 255-258, 2006
2. Ramlo, M.J., Moscovitch, M. and Rotunda, J.E., Further Studies in the Reduction of Residual in Harshaw TLD-100H (LiF:Mg,Cu,P), Radiat. Prot. Dosim, 125, 217-219, 2007
3. Luo, L.Z., Velbeck, K.J., Moscovitch, M. and Rotunda, J.E., LiF:Mg,Cu,P Glow Curve Shape Dependence On Heating Rate, Radiat. Prot. Dosim, 119, 184-190, 2006
4. Mckeever S.W.S and Moscovitch M., Topics under Debate - On the advantages and disadvantages of optically stimulated uminescence dosimetry and thermoluminescence dosimetry, Radiat. Prot. Dosim., 104, 263-270, 2003
5. Benevides L, Romanyukha A, Hull F., Duffy M., Voss S. and M. Moscovitch, Light induced fading in the OSL response of Al2O3:C. Radiation Measurements, Accepted Manuscript, 2009

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