thermoscientific

UV-INDUCED BLEACHING OF DEEP TRAPS IN HARSHAW TLD LiF:Mg,Cu,P and LiF:Mg,Ti

L. Benevides[1], S. Voss[1], I. Nita[2], J. Rotunda[2], K.Velbeck[2], L.Z. Luo[2], and M. Moscovitch[3]

[1] The US Naval Dosimetry Center, Bethesda, MD 20889, USA, [2] Thermo Fisher Scientific, Oakwood Village, OH 44146, USA, [3] Georgetown University Medical Center, 3970 Reservoir Road NW, Washington DC, 20057, USA

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Abstract

The effects of UV-induced bleaching of deep traps on Thermo Scientific™ Harshaw™ thermoluminescent LiF:Mg,Cu,P and LiF:Mg,Ti materials were investigated. During a normal heating cycle, LiF:Mg,Cu,P is limited to a maximum temperature of 240°C. LiF:Mg,Ti can be read to higher temperatures, however encapsulation in PTFE limits the maximum readout temperature to 300°C. Generally, for both materials, these respective temperatures are sufficient for emptying traps corresponding to the main dosimetric peaks. However, when the dosimeters are subjected to high doses, such as 1 Gy (much higher than individual monitoring dose levels), higher temperature traps are filled that cannot be emptied without exceeding the above mentioned maximum temperatures. These high temperature traps tend to be unstable during normal readout and can significantly increase the residual TL signal. The purpose of this study is to investigate the applicability of a UV-induced bleaching technique for emptying higher temperature traps following high dose applications. In addition, in the case of LiF:Mg,Cu,P, where the maximum temperature is significantly lower, we investigated the possibility of reducing the residual signal using the application of repeated readout cycles. The optical bleaching approach was found to be effective in the case of LiF:Mg,Ti; however, for LiF:Mg,Cu,P, no reduction in the residual signal was observed. For this latter material, the application of repeatable readout cycles is very effective and residual signals equivalent to dose levels as low as 0.01 mGy were observed following an initial dose of 5 Gy. To the best of our knowledge, this is the first attempt to apply an "optical annealing" technique to the HarshawTLD materials.

Introduction

LiF:Mg,Cu,P and LiF:Mg,Ti are widely used in both environmental and personal dosimetry applications. In both applications the dose levels are typically low (in the order of mGy or less). However, occasionally these dosimeters are exposed to significantly higher dose levels such as in the case of the accident categories of the NVLAP or the DOELAP US proficiency testing. Exposure of these materials to higher dose levels results in partial population of deeper, higher temperature traps (> 300°C). These traps survive the normal typical readout cycles of both materials; i.e., maximum temperatures of 240°C and 300°C for LiF:Mg,Cu,P and LiF:Mg,Ti, respectively. Unfortunately, these filled deep traps are partly emptied during subsequent use of these materials and can generate high levels of residual signal. This signal may interfere and limit the applicability of TL elements with high dose history to low dose levels. The purpose of this study is to investigate the feasibility of using UV light to bleach the deep traps in both materials for the purpose of reducing the residual TL signal.

Setup

Harshaw TLD-700H (7LiF:Mg,Cu,P) 3.6mm diameter x 0.38mm thickness pellets were tested using a Model 3500 Planchet type TLD Reader. (Fig. 1)

Dosimeters were irradiated using a 4.4x108 kBq 137Cs Source. A neutral density filter was used in the TLD Reader, on the first read only, to diminish the high light signal by a factor of 100. The Time Temperature Profile used during reads was as follows: Preheat = 50°C, Rate = 10°C/second, Maximum Temperature = 240°C, Acquisition Time = 30 seconds, Anneal Temperature = 240°C @ 10 seconds.

A Logical Devices Inc. Model QUV-T8 EPROM eraser was used during the UV treatment. The bulb in this unit has a peak wavelength of 254 nm and has a UVC output of 1.7 W.

Harshaw TLD-100 (LiF:Mg,Ti) 3.2 mm x 3.2 mm x 0.38 mm thickness chips were also used to compare results. TLD-100 is already known to respond to UV Bleaching. The Time Temperature Profile used during reads was as follows: Preheat = 50°C, Rate = 10°C/second, Maximum Temperature = 300°C, Acquisition Time = 33.33 seconds.

Study

The testing included the following steps:

- Nine TLD-700H pellets were cleared by reading once in the reader.
- The pellets were then irradiated to 5 Gy.
- Three TLD-700H pellets were put under the UV light for 1/2 hour.
- Three TLD-700H pellets were put under the UV light for 1 hour.
- Three TLD-700H pellets were not subjected to the UV treatment and were used as controls.
- All pellets were then read in the TLD reader.

Note: because of the high light signal expected, a neutral density filter with an optical density of 2.0 was used during this reading.

- The neutral density filter was removed from the reader.
- All pellets were then read repeatedly.

Likewise, a similar test was performed using TLD-100 (LiF:Mg,Ti) for comparison purposes.

Results and Discussion

Figure 2 shows a typical glow curve for LiF:Mg,Cu,P. Figure 3 shows a glow curve of 7LiF:Mg,Cu,P obtained during the second readout of a dosimeter of high dose history. Note the significant contribution of the high-temperature peak. This peak is the source of the residual signal in 7LiF:Mg,Cu,P. Figure 4 is the same as Figure 3 with one difference – the sample was exposed to UV light before the second readout. This glow curve clearly shows the PTTL peak (low temperature) and again the high temperature peak – the same peak shown in Figure 3 as the dominant peak. The residual signals for UV-treated 7LiF:Mg,Cu,P are shown in Figure 5. As shown, there is no significant difference between the UV-treated samples and the controls, suggesting that any UV bleaching effects are insufficient to significantly affect the residual TL.

In contrast, as shown in Figure 6, the effect of UV light on the residual signal of 7LiF:Mg,Ti is significant. For 7LiF:Mg,Cu,P, repeated reads of the same dosimeter appears to be very effective in reducing the residual signal as shown in Figure 7. Approximately 25 repeatable readouts at standard maximum temperature (240°C) are sufficient to reduce the residual signal to the equivalent of dose levels as low as 0.01 mGy following an initial dose of 5 Gy. No change in sensitivity, within +5%, of the treated dosimeters, was observed.

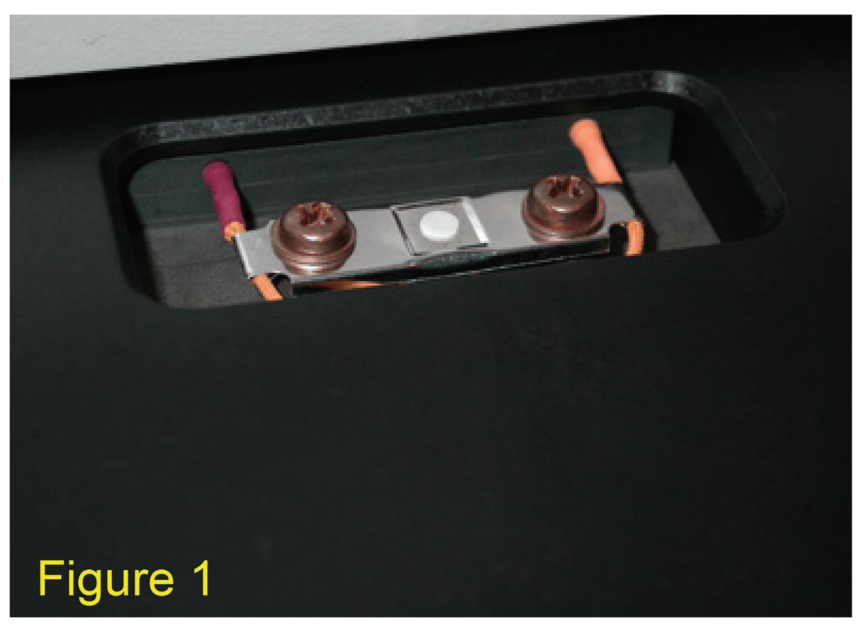
Figure 1

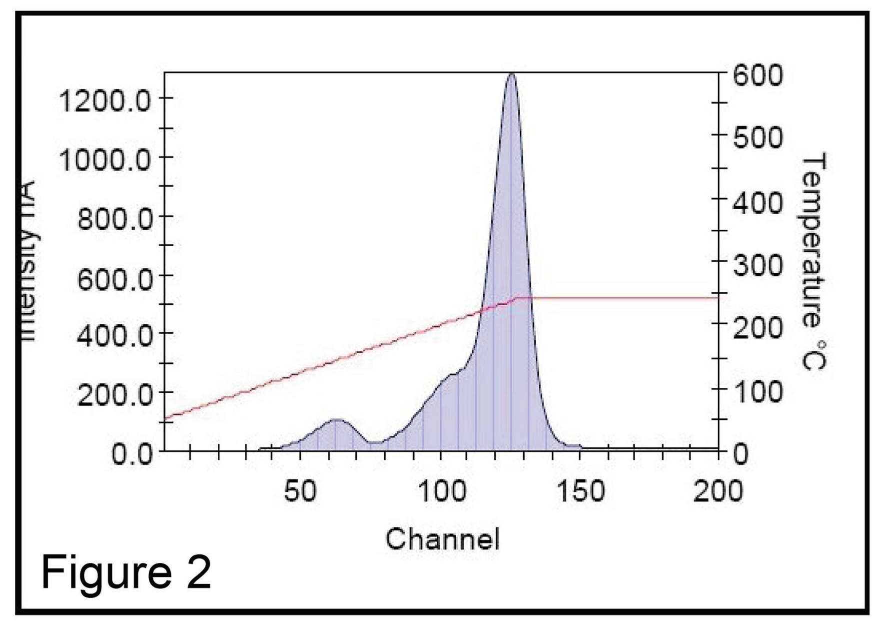

Figure 2

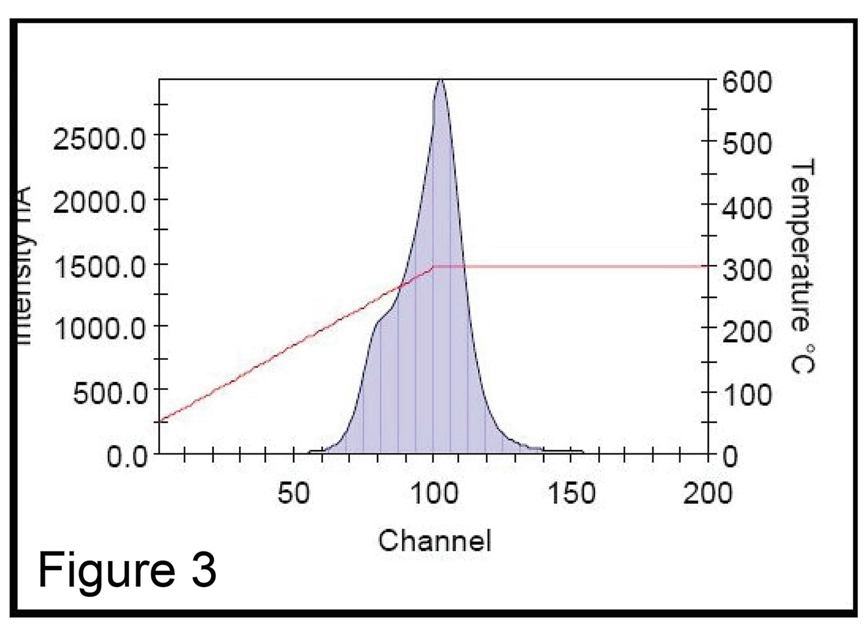

Figure 3

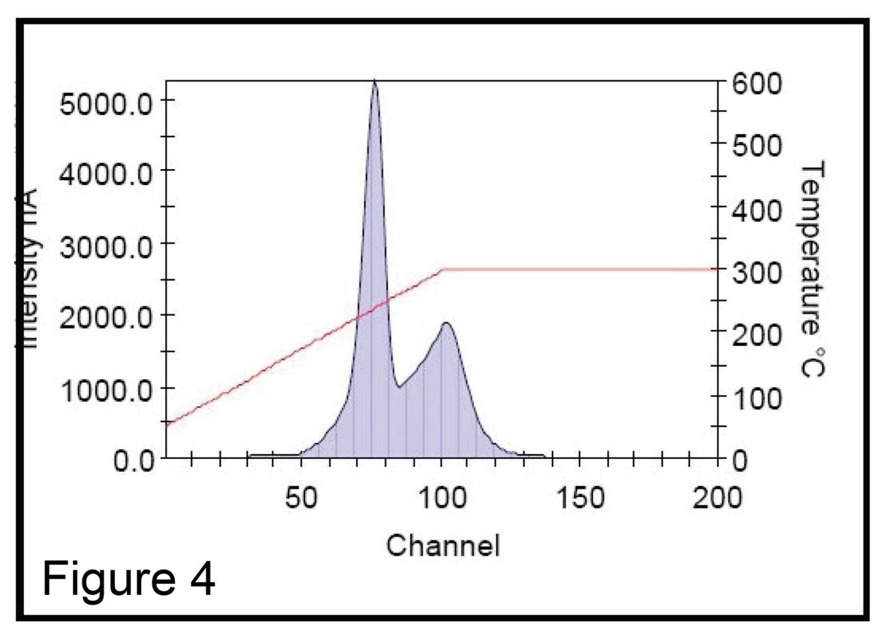

Figure 4

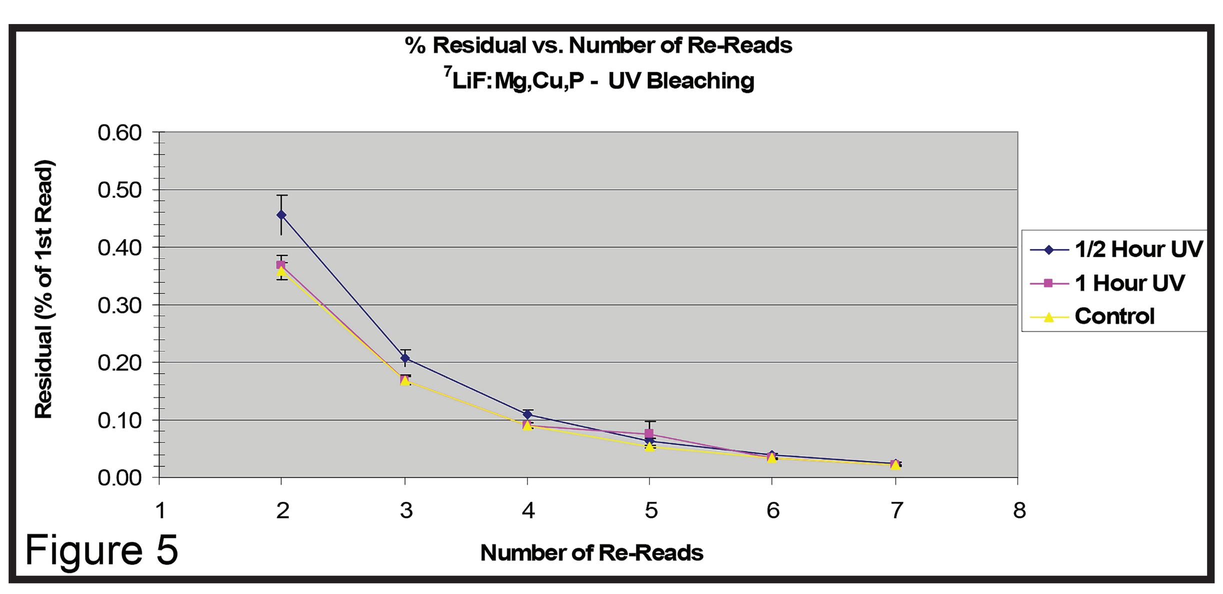

Figure 5

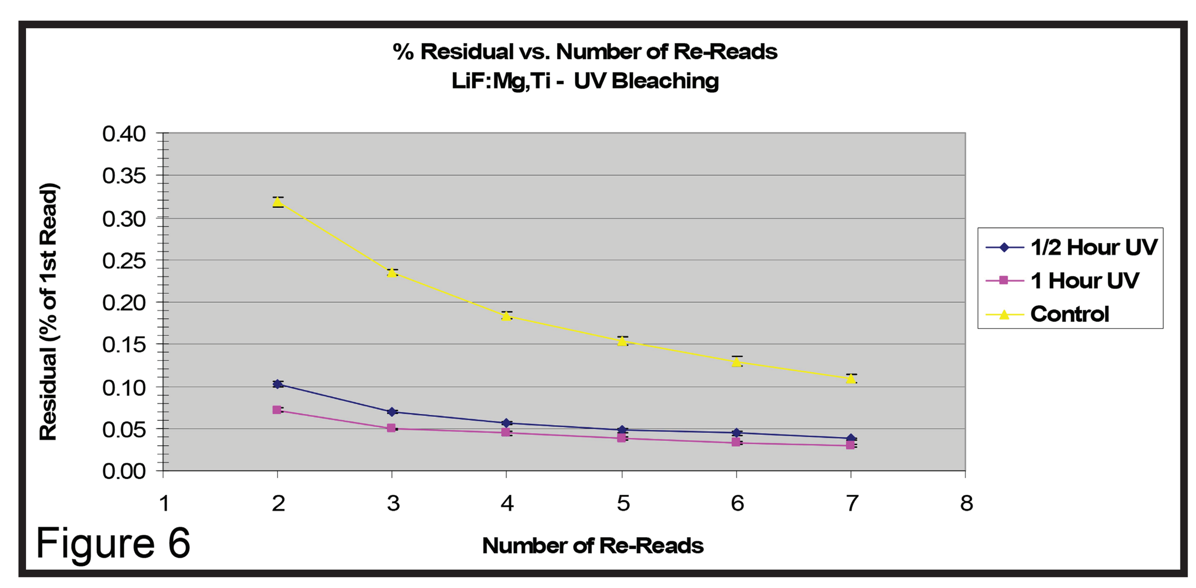

Figure 6

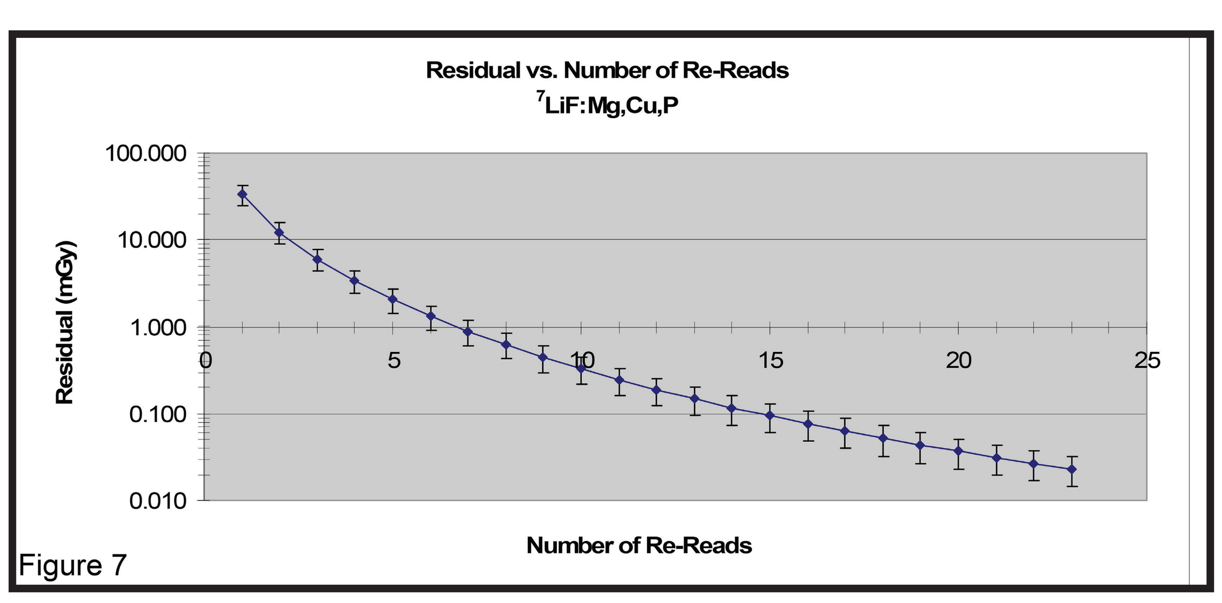

Figure 7

Conclusions

1. UV-bleaching is effective in the reduction of residual signal of LiF:Mg,Ti.
2. For 7LiF:Mg,Cu,P, no significant reduction of the residual signal was observed following UV-bleaching at 254 nm. Further studies will be required to determine if different UV energies can be more effective.
3. Repeated readings of 7LiF:Mg,Cu,P can significantly reduce the residual TL with no noticeable change in sensitivity.

References

1. Moscovitch M and Horowitz Y S, Thermoluminescent materials for medical applications: LiF:Mg,Ti and LiF:Mg,Cu,P, Radiation Measurements, 2007, 41: S71-S77, 2007
2. Ramlo M, Moscovitch M, and Rotunda J E, Further studies in the reduction of residual in Harshaw TLD-100H (LiF:Mg,Cu,P), Radiat Prot Dosimetry, 125: 217-219, 2007.
3. Moscovitch M, St. John T J, Cassata J R, Blake P K, Rotunda J E, Ramlo M, Velbeck K J, and Luo L Z, The application of LiF:Mg,Cu,P to large scale personnel dosimetry: current status and future directions, Radiat Prot Dosimetry, 119: 248 – 254, 2006
4. Moscovitch M., "Personal dosimetry using LiF:Mg,Cu,P," Radiat. Prot. Dosim., 85, 49-56, 1999.

Thermo Fisher SCIENTIFIC

Kenneth J. Velbeck
Thermo Fisher Scientific
One Thermo Fisher Way
Oakwood Village, Ohio 44146, USA
Kenneth.Velbeck@thermofisher.com

www.thermofisher.com/dosimetry

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