UNIVERSIDADE DE SÃO PAULO

INSTITUTO DE FÍSICA
CAIXA POSTAL 20516
01498-970 SÃO PAULO - SP
BRASIL

PUBLICAÇÕES

IFUSP/P-1021

DEPENDENCE OF GLOW PEAKS TEMPERATURE OF LiF ON Mg,Cu DOPANTS CONCENTRATION UNDER GAMMA AND UV IRRADIATION

A.M. Fausto, A.W. Mol and **E. Okuno**
Instituto de Física, Universidade de São Paulo

Novembro/1992

DEPENDENCE OF GLOW PEAKS TEMPERATURE OF LiF ON Mg, Cu DOPANTS CONCENTRATION UNDER GAMMA AND UV IRRADIATION

A. M. Fausto, A.W. Mol and E. Okuno
Laboratório de Dosimetria
Instituto de Física
Universidade de São Paulo
Caixa Postal 20516
01498-970 São Paulo, SP, BRASIL

Abstract — Thermoluminescence (TL) of LiF doped with different concentrations of Mg and/or Cu has been investigated. The glow peaks temperature for all available samples, submitted to a thermal treatment and exposed to 0.26 mC/kg of gamma rays or 0.4 J/cm^2 of UV or to both radiations consecutively, were also analyzed. The experimental results suggest that UV radiation fill the traps of samples doped with Mg directly, and that each radiation, gamma or UV, preferentially fills different depth traps.

INTRODUCTION

Newly developed lithium fluoride, doped with Mg, Cu and Mg, Cu, P, has been found [1-8] 3 — 50 times more sensitive, than that of TLD-100 from Harshaw Chemical Co.. Consequently, these highly-potential TLD materials are stimulating the radiation dosimetry community to dedicate an extensive research effort to characterize and to understand their TL properties for use in personnel dosimetry as well in several other dosimetric fields.

In this paper we present a comparative dosimetric study of LiF doped with several different concentrations of Mg and Cu. We characterize their TL responses undery, UV and γ+UV irradiations, and establish the temperature dependence of the glow peaks with their dopants' concentration.

EXPERIMENTAL METHOD

We used in this work LiF samples doped with several different concentrations of Mg and Cu. They were all in powder form (74-149 μm) and were manufactured by Nemoto and Co. Ltd., Japan. Dr. T. Nakajima, from Physics Division of National Institute of Radiological Sciences, Japan, kindly supplied to us the LiF samples. The table 1 shows the concentrations of Mg and Cu (in mol%) of the 14 samples used in this work. LiF (TLD-100) (Harshaw, USA) ribbons (3x3x1 mm^3) were also used as reference standard for all the processes along this work.

Table 1. LiF samples with Mg and Cu concentrations.

Mg (mol%) ↓ \ Cu (mol%) →	0.00	0.03	0.06	0.12
0.0	S_{00}	S_{01}	S_{02}	S_{03}
0.1	S_{10}	S_{11}	S_{12}	———
0.2	S_{20}	S_{21}	S_{22}	S_{23}
0.4	S_{30}	———	S_{32}	S_{33}

Before irradiation all samples were heat treated at 400°C for one hour, than they were quickly cooled until room temperature and followed for two hours at 100°C. All the thermal treatments were done in air and the temperature of the oven was controlled within ±5°C. Careful procedures were under taken, avoiding light exposure of samples after thermal treatment. During the experiment all the samples were used only once at each cycle of thermal treatment, exposure to radiation and TL reading.

The measurements were done in a conventional TL reader. Between the sample and the EMI 9789 photo multiplier tube, with the band pass from 300 to 900 nm, placed a KG -1 optical filter. In each measurement (31.0±0.1) mg of power were linearly heated at the rate of 3.7°C/s. During readouts, the N_2 gas flowed though the sample chamber at a rate of 0.5 l/min.

In gamma irradiation, we used a ^{137}Cs source. We fixed the exposure on 0.26 mC/kg (1R) at 190 cm from the source for all samples. For UV illumination a high pressure Hg lamp with 400 W (PHILIPS HPL-N), without the external glass bulb, was used. Here, we carefully spread the powders over a glass plate and continuously monitored its temperature along the entire period of irradiation, which remained at around ~30°C. We fixed the UV radiant exposure on 0.4 J/cm² (~10 cm from the lamp source for 20 minutes) considering that for this value the glow peaks are almost saturated. To study the

phototransference, the samples were first submitted to gamma rays and followed by UV illumination in the conditions above quoted.

RESULTS AND DISCUSSION

The 14 samples of LiF doped with Mg and/or Cu exposed to gamma rays (γ), UV light and γ rays followed by UV light (γ + UV) can be gathered in three main groups, depending on the characteristics of their glow curves: *(i)* Undoped sample; *(ii)* Samples doped with Cu only and *(iii)* Samples doped with Mg only and Mg + Cu.

Typical glow curves of some of these samples (S_{00} ,S_{02} ,S_{10} and S_{11}) exposed to γ, UV and γ+UV irradiations are showed in figures 1, 2, 3 and 4. The table 2, 3 and 4 list all the average peak temperatures from at least 15 measurements.

As a general result we observe that: (1) the glow peaks due to UV light always appear in the lower temperature region than that due to γ rays; (2) TL peaks present in the glow curves, when the samples are irradiated with γ rays followed by UV light are the same that are present for the sample submitted to each radiation separately; (3) samples without Mg show small glow peaks from both radiations γ and UV. On the other hand, samples with Mg and Mg + Cu show small glow peaks due to UV light, but they showed a higher glow peak induced by γ rays.

Now each group is analyzed separately:

(i) Undoped sample (S_{00}) — When submitted to γ rays, its glow curve shows two peaks very near at 182°C and 200°C. Under UV illumination, a very broad band appears whose maximum is at 118°C. Figure 1 shows these glow curves and table 2 lists its temperatures.

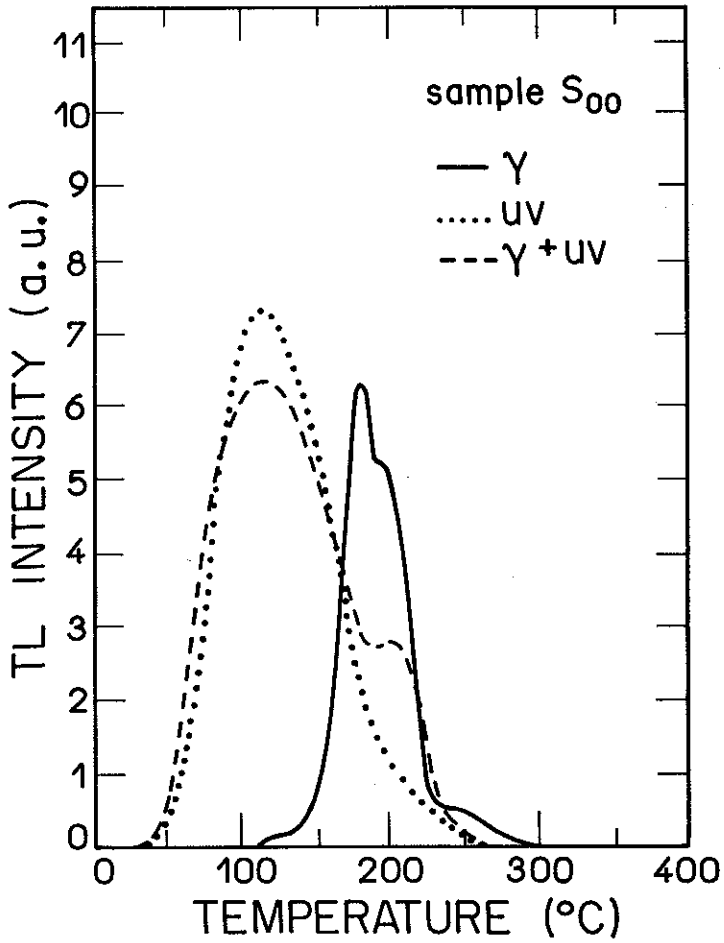

Figure 1. Glow curves of S_{00} sample. Annealed at 400°C—1h followed by 100°C—2h and exposed to: gamma rays (0.26 mC/kg), UV(0.4 J/cm^2) and gamma rays + UV. The heating rate was 3.7°C/s.

Table 2. The average temperatures of the thermoluminescent (TL) glow peaks from the irradiated sample S_{00}, annealed at 400°C—1h followed by 100°C—2h and exposed to: gamma rays (0.26 mC/kg), UV(0.4 J/cm^2) and gamma rays + UV. The heating rate was 3.7°C/s.

Sample	Radiation	Band – I	Peak – II	Peak – III	Peak – IV
LiF (Mg = 0, Cu = 0)	γ	insensible	(182±10)°C	(199±10)°C	unresolved
	UV	(118±9)°C	unresolved	unresolved	insensible
	γ + UV	(117±10)°C	unresolved	(202±10)°C	unresolved
Average Temperature		(118±7)°C		(200±7)°C	

(*ii*) Samples doped with Cu only (S_{01} ,S_{02} ,S_{03}) — The same both peaks (at 182°C and 200°C)of the sample S_{00} are present in these samples when submitted to γ rays. Under UV illumination two broad bands appear at 102°C and 153°C. Figure 2 shows these characteristics for sample S_{02}. The glow peak temperatures are seen in table 3.

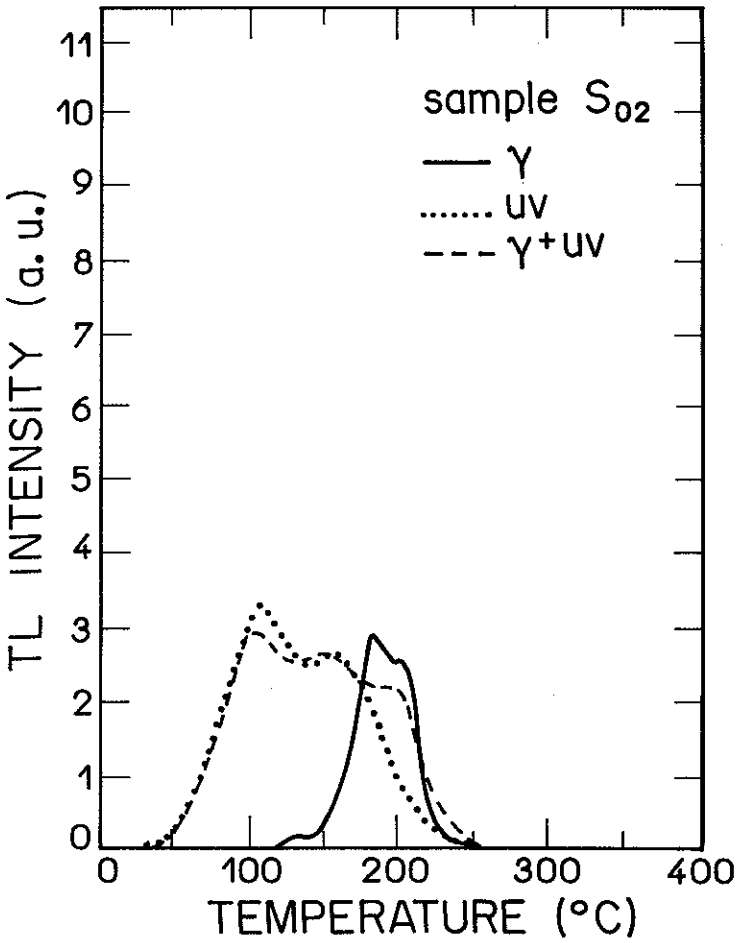

Figure 2. Glow curves of S_{02} sample. Annealed at 400°C—1h followed by 100°C—2h and exposed to: gamma rays (0.26 mC/kg), UV(0.4 J/cm^2) and gamma rays + UV. The heating rate was 3.7°C/s.

Table 3. The average temperatures of the thermoluminescent (TL) glow peaks from irradiated LiF (Cu) samples, annealed at 400°C—1h followed by 100°C—2h and exposed to: gamma rays (0.26 mC/kg), UV(0.4 J/cm^2) and gamma rays + UV. The heating rate was 3.7°C/s.

Sample	Radiation	Peak – I_A	Peak – I_B	Peak – II	Peak – III	Peak – IV
LiF (Cu)	γ	insensible	unresolved	(182±10)°C	(203±6)°C	insensible
	UV	(102±3)°C	(153±5)°C	unresolved	unresolved	insensible
	γ + UV	(102±6)°C	(149±7)°C	unresolved	(202±6)°C	insensible
Average Temperature		(102±4)°C	(152±4)°C		(203±5)°C	

(*iii*) Samples doped with Mg only and Mg + Cu — In all samples exposed to gamma rays only one peak at 242°C is present. When illuminated with UV light two peaks at 120°C and 168°C are present. As an example, figures 3 and 4 show the glow curves of samples S_{10} and S_{21}. The glow peak temperatures are seen in table 4.

Table 4. The average temperatures of the thermoluminescent (TL) glow peaks from irradiated LiF (Mg,Cu), annealed at 400°C—1h followed by 100°C—2h and exposed to: gamma rays (0.26 mC/kg), UV (0.4 J/cm^2) and gamma rays + UV. The heating rate was 3.7°C/s.

Sample	Radiation	Peak – I_A	Peak – I_C	Peak – II	Peak – III	Peak – IV
LiF (Mg)	γ	insensible	insensible	insensible	unresolved	(242±4)°C
&	UV	(102±3)°C	(168±4)°C	unresolved	unresolved	unresolved
LiF(Mg,Cu)	γ+UV	(99±4)°C	(163±4)°C	unresolved	unresolved	(244±4)°C
Average Temperature		(100±3)°C	(165±3)°C		(200±7)°C	(242±4)°C

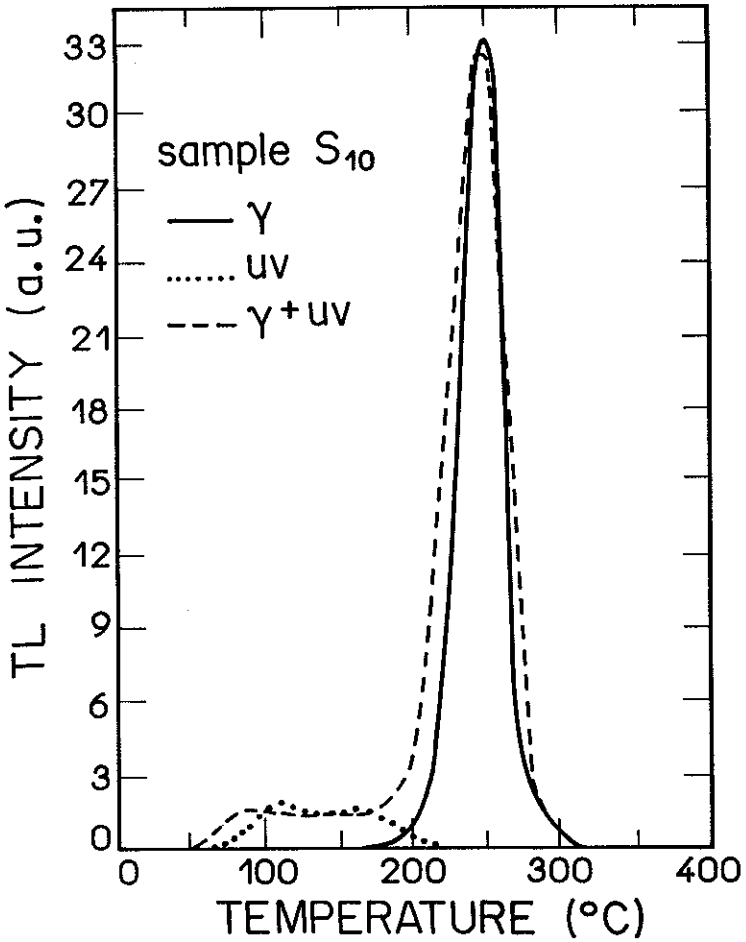

Figure 3. Glow curves of S_{10} sample. Annealed at 400°C—1h followed by 100°C—2h and exposed to: gamma rays (0.26 mC/kg), UV(0.4 J/cm^2) and gamma rays + UV. The heating rate was 3.7°C/s.

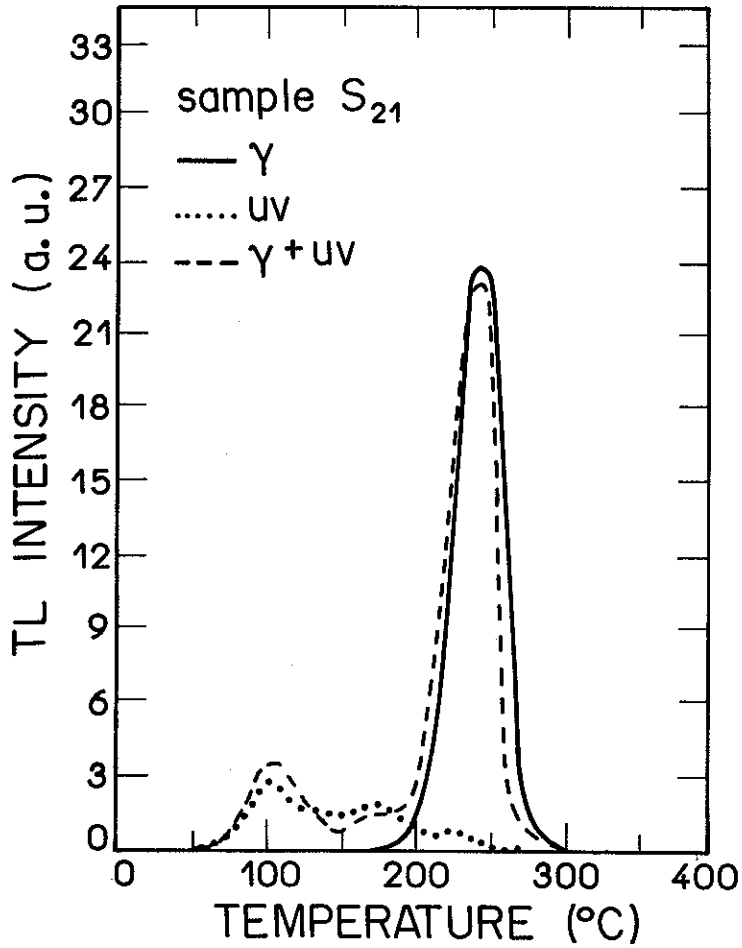

Figure 4. Glow curves of S_{21}.sample. Annealed at 400°C—1h followed by 100°C—2h and exposed to: gamma rays (0.26 mC/kg), UV(0.4 J/cm^2) and gamma rays + UV. The heating rate was 3.7°C/s.

The effect of UV light on the peak at 242°C (TL peak-IV) previously induced by gamma rays can be analysed though the curve of figures 5 and 6. The heights were displayed as a function of Mg concentration, using Cu concentration as a parameter for each sample exposed to γ rays and γ + UV radiation respectively. Comparing both figures, we notice that the average TL peak heights coincide within the error under both irradiations for all samples, except in sample S_{23}.

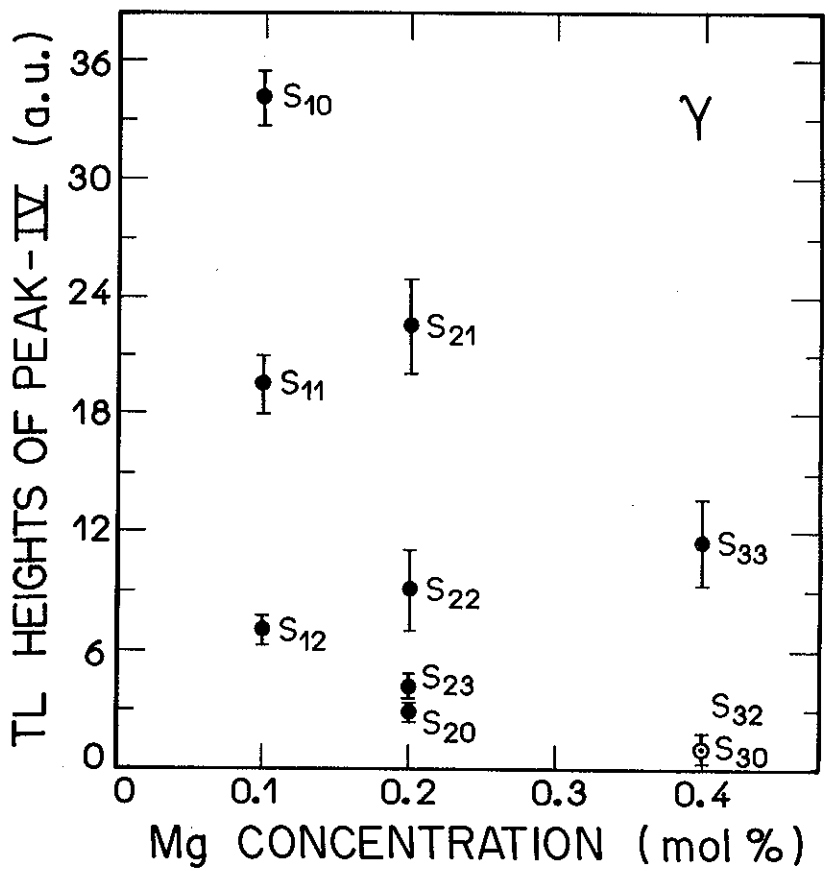

Figure 5. TL peak heights at (242±4)°C as a function of Mg concentration of LiF (Mg,Cu) samples exposed to gamma rays (0.26 mC/kg).

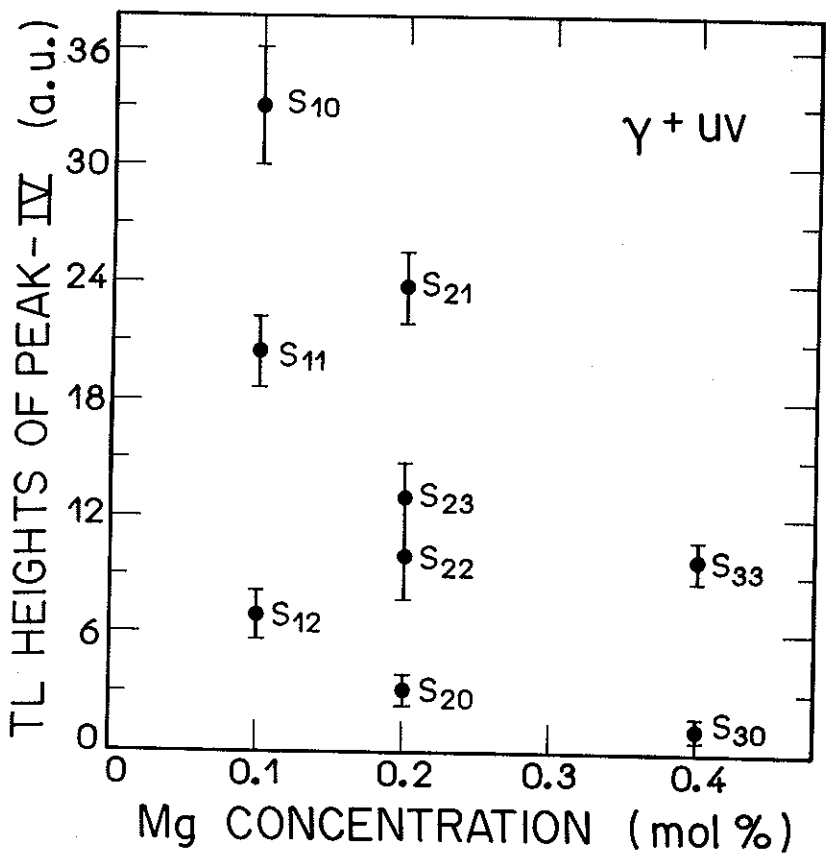

Figure 6. TL peak heights at (244±4)°C as a function of Mg concentration of LiF (Mg,Cu) samples, exposed to gamma rays (0.26 mC/kg) + UV (0.4 J/cm^2).

This is a peculiar result. To other phosphors the UV radiation, usually, transfers charge carriers from deep traps to shallow ones. Consequently, the TL peak intensities in the high temperature range, from traps filled by ionizing radiation, decrease under subsequent UV illumination and TL peaks in the low temperature range rise.

CONCLUSIONS

The glow peak at 242°C can be used as a dosimetric peak for gamma radiation and the samples doped with Mg show only this peak.

As the temperature of glow peaks is different for samples exposed to γ rays from that to UV light, it means that these radiations fill preferentially different depth traps. At least no phototransference was observed from the peak 242°C to the lower temperature peaks. These characteristics show the potential usefulness of LiF(Mg,Cu) in simultaneous gamma and UV radiation dosimetry.

ACKNOWLEDGEMENTS

We are grateful to Dr. T. Nakajima for encouragement and discussions. We thank him and Nemoto and Co. Ltd., Japan, for LiF samples supplied to us.

REFERENCES

1. Nakajima, T., Murayama, Y., Matsuzawa, T. and Koyano, A. *Development of a New Highly Sensitive LiF Thermoluminescent and its Applications.* Nucl. Instrum. Methods **157,** 155-162 (1978).

2. Nakajima, T., Murayama, Y., and Matsuzawa, T. *Preparation and Dosimetric Properties of a Highly Sensitive LiF Thermoluminescence Dosimeter.* Health Phys. **36,** 79-82 (1979).

3. DeWerd, L. A., Cameron, J. R., Wu Da-Ke., Papni, T. and Das, I. J. *Characteristics of a New Dosemeter Material; LiF (Mg,Cu,P).* Radiat. Prot. Dosim. **6**, 350-352 (1984).

4. Shoushan, W., Guolong, C., Fang, W., Yuanfang. Li., Ziying, Z. and Jianhuan, Z. *Newly Developed Highly Sensitive LiF (Mg,Cu,P) TL Chips with High Signal-to-Noise Ratio.* Radiat. Prot. Dosim. **14**, 223-27 (1986).

5. Bhuwan Chandra, Lakshmanan, A. R., Bhatt, R. C. and Vohra, K. G. *Annealing and Re-usability Characteristics of LiF (Mg,Cu,P) TLD Phosphor.* Radiat. Prot. Dosim. **3**, 161 (1982).

6. Bhuwan Chandra, Pradhan, A. S., Lakshmanan, A. R., and Bhatt, R. C. *Dosimetric Characteristics of Thermoluminescent LiF (Mg,Cu,P) Phosphor.* Bull. Radiat. Prot. IARP (India) **6.**(3/4),89 (1983). Also in Radiat. Prot. Dosim. **8**, 217 (1984).

7. Driscoll, C. M. H., McWhan, A. F., O'Hagan, J. B., Dodson, J., Mundy, S. J. and Todd. C. D. *The Characteristics of New LiF Preparations and Sensitised LiF.* Radiat. Prot. Dosim. **17**, 367-371 (1986).

8. Shoushan, W. *The Dependence of Thermoluminescence response and Glow Curve Structure of LiF(Mg,Cu,P) TL Materials on Mg,Cu,P Dopants Concentration.* Radiat. Prot. Dosim. **25**, 133-136 (1988).