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The study on the characteristics of LiF:Mg,Cu,Si TL material for mass manufacture

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1. Introduction

The utilizing techniques of nuclear and ionizing radiation spread out overall industry containing nuclear power, institute, college and hospital. The number of worker associated radiation increases also continually and the cases of radiation exposure increases equally. Therefore, all possible measures must be taken against radiation accident, and it must be assessed radiation dose of workers associated radiation using personal dosimeter or another radiation detector. The personal radiation dosimeters are currently film dosimeter and thermoluminescent dosimeter. It is possible to measure radiation dose more diversely by introducing glass dosimeter and optically stimulated luminescence dosimeter(OSL). In Europe and America, it has been commercially developed personal radiation dosimetry technique, but in Korea, its all were dependent on abroad. In 1980s and 1990s, the laboratory of college had performed basic study for $Li_2B_4O_7$ TL material[1-2]. After 2000s Korea Atomic Energy Research Institute(KAERI) had completed and developed LiF:Mg,Cu,Na,Si and LiF:Mg,Cu,Si as the TL material for using personal and environmental dosimeter performed fundamental radiological research[3-5], and those applied for and obtained a patent.

We took over the manufacturing process and technique of LiF:Mg,Cu,Si from KAERI. For production on a large scale, the dosimetric characteristics of TL material has been investigated in this study being sponsored the research and development funds of The Small & Medium Business Administration(SMBA).

2. Method and Result

2.1 Preparation of production system of TL material

A pellet-type LiF:Mg,Cu,Si TL material was prepared with the dopants of $MgSO_4 \cdot 7H_4O$, $CuSO_4 \cdot 5H_2O$ and SiO_2. The production procedure was as follows. With the LiF powder, three dopants were mixed in distilled water by a magnetic stirrer. The mixture of LiF and dopants were dried on a hot plate. For the activation of this mixture, it was heated at temperature 1273 K for 30 minutes in a platinum crucible. The activated mixture pulverized in an agate mortar. The pulverized mixture was selected on the grain size of 150 micrometers below by reference sieve. The selected grain were rinsed with HCl acid to remove impurities contained and were washed with distilled water and then dried. The grains selected were fabricated to a pellet, with the size of 4.5 mm in diameter and 0.8 mm in thickness by palletizing with a press. The solidified pellet was sintered at a temperature close to melting point for 10 minutes under the state of nitrogen atmosphere. Finally, the sintered pellet was annealed at 573 K for 10 minutes and annealed again 533 K for 10 minutes. To produce a large scale to TL pellet in this study, we designed and made a sintering furnace and an automatic press.

2.2 Dosimetric characteristics of TL material

2.2.1. Glow curve structure and sensitivity

The relative sensitivity of this TL material was measured about 10-20 times higher than that of LiF:Mg,Ti(TLD-100) by reading with Rados TLD system(RE-1) at 573 K after irradiation with the dose of 5 mGy by Sr-90 sources. The structure of glow curve was that the peak of high temperature reduced significantly. This means the reduction of residual signals.

2.2.2. Dose response

The linearity of the TL response of the phosphor to radiation dose is one of the important properties for a TL detector. To investigate the linearity of TL detector, the TL dosimeter attached to phantom was irradiated the range of dose 0.3 to 100 mSv with gamma ray of Cs-137 and beta ray of Sr-90 in this study, respectively.

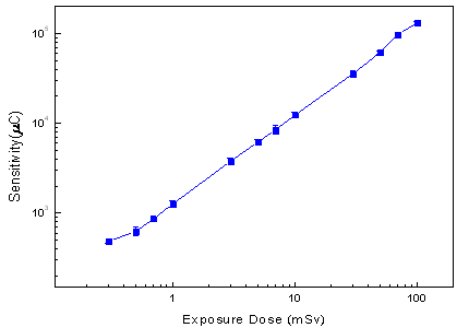

Figure 1. The dose response of LiF:Mg,Cu,Si TL detector (gamma ray of Cs-137)

2.2.3. Reusability

To evaluate reusability of LiF:Mg,Cu,Si TL detector, we prepared with 40 TL detectors and iterated 100 times the process of irradiation, reading and thermal annealing for each detector in the same condition. The result of reusability was agreed the value of 100-th measurement with that of first measurement within 10%.

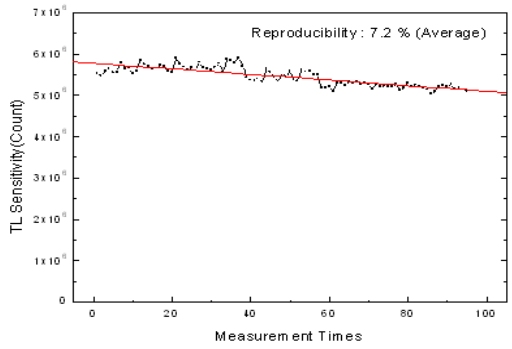

Figure 2. Reusability of LiF:Mg,Cu,Si TL detector (measured 100 times)

3. Conclusions

A pellet-type LiF:Mg,Cu,Si TL material has been developed for mass manufacture and commercial detector through this study. It is worth mentioning that dual-step annealing is an effective method for this TL material in order to reduce residual dose as well as to get a good glow curve structure and high sensitivity. And this developed TL detector is excellent in linearity of radiation dose and reusability.

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