Applied Radiation and Isotopes 136 (2018) 111–117

Contents lists available at ScienceDirect

Applied Radiation and Isotopes

journal homepage: www.elsevier.com/locate/apradiso

Synthesis and dosimetry features of novel sensitive thermoluminescent phosphor of LiF doped with Mg and Dy impurities

E. Sadeghi[a,b,*], M. Zahedifar[a,b], M. Khalifeh Shoushtari[a]

[a] Physics Department, University of Kashan, Kashan, I.R.Iran
[b] Institute of Nanoscience and Nanotechnology, University of Kashan, Kashan, I.R.Iran

HIGHLIGHTS

- Lithium fluoride doped with Mg and Dy was fabricated for the first time using melting method.
- This dosimeter exhibits proper thermoluminescence properties.
- TL sensitivity of the fabricated phosphor is close to that of TLD-100 powder.
- TL properties such as fading, linearity of dose response and reusability are investigated.

ARTICLE INFO

Keywords:
Thermoluminescence
LiF:Mg
Dy
Dosimetry
Melting method

ABSTRACT

Lithium fluoride doped with Mg and Dy was fabricated for the first time using melting method. The optimum concentrations of impurities and thermal treatment were studied to achieve high thermoluminescence (TL) sensitivity. TL sensitivity of the fabricated phosphor is close to that of TLD-100 powder. T_m-T_{stop} technique was used to identify the number of overlapped TL glow peaks. Initial rise, isothermal decay and computerized glow curve deconvolution (CGCD) methods were applied to obtain kinetic parameters of the prepared TL material. Three component glow peaks were distinguished at temperatures 395, 448 and 510 K. Other TL properties such as fading, linearity of dose response and reusability are also presented and discussed.

1. Introduction

TL phenomenon in insulator materials can occur when the solids are exposed to ionizing radiation and then thermally stimulated (Bos, 2007). The peak intensity and the area underneath the TL glow peak are related to the absorbed dose. LiF-based TL materials are extensively used in personal monitoring because of chemical stability, low energy dependence and near tissue equivalence. These phosphors have effective atomic number of 8.14 which is close to that of biological tissue, 7.4 (Chen and Mckeever, 1997). It was found that TL intensity, sensitivity and emission of LiF crystal are intensely modified by type and amount of dopant and also the preparation method (Kim et al., 2004). Magnesium is reported to be one of the most effective dopants in increasing the TL response. Mg-related defects act as electron traps by forming impurity- vacancy dipoles in LiF (McKeever et al., 1995). Other dopants like copper, phosphorus and titanium are immensely studied. LiF:Mg,Ti, processed in the form of TLD-100, has proven to be a useful phosphor for TL dosimetry and LiF:Mg, Cu,P as GR-200, has become a popular TL dosimeter for clinical applications (Horowitz, 1993; Azorin et al., 2015). Today, materials doped with rare earth ions are widely used because of their special characteristics due to their atomic structures (the incomplete 4f shell) (Zahedifar et al., 2013; Jiang et al., 2008).

In this study a new phosphor, LiF:Mg, Dy, is introduced and compared to TLD-100 powder. The optimized concentrations of Mg and Dy dopants and the best annealing regime which provides the highest TL response were obtained. Other dosimetry features such as dose response, fading and reusability are studied and discussed. Number of peaks and kinetic parameters such as the activation energy and kinetics order were investigated by isothermal decay, initial rise and computerized glow curve deconvolution (CGCD) methods. The number of glow peak components in the complex glow curve of the produced phosphor were identified by T_m-T_{stop} analysis and the results were used as input parameters in CGCD procedure. Good agreement was found between CGCD and other mentioned methods.

This paper deals with successful development of LiF:Mg,Dy TL material using melting method. In previous works on characteristics of LiF:Mg,Dy, this phosphor has been prepared by edge defined film fed

* Corresponding author at: Physics Department, University of Kashan, Kashan, I.R.Iran.
E-mail address: sdgh@kashanu.ac.ir (E. Sadeghi).

https://doi.org/10.1016/j.apradiso.2018.02.021
Received 18 August 2017; Received in revised form 15 February 2018; Accepted 19 February 2018
Available online 22 February 2018
0969-8043/

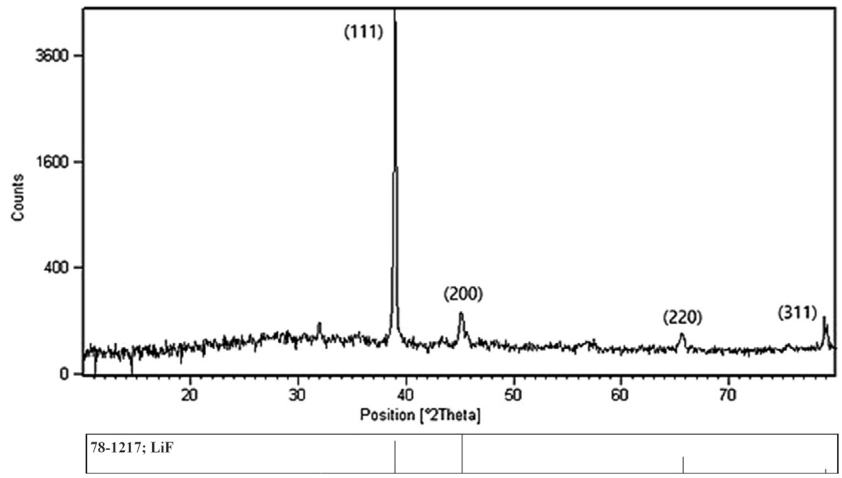

Fig. 1. XRD pattern of the fabricated LiF:Mg,Dy powder. Reference pattern of lithium fluoride is also shown.

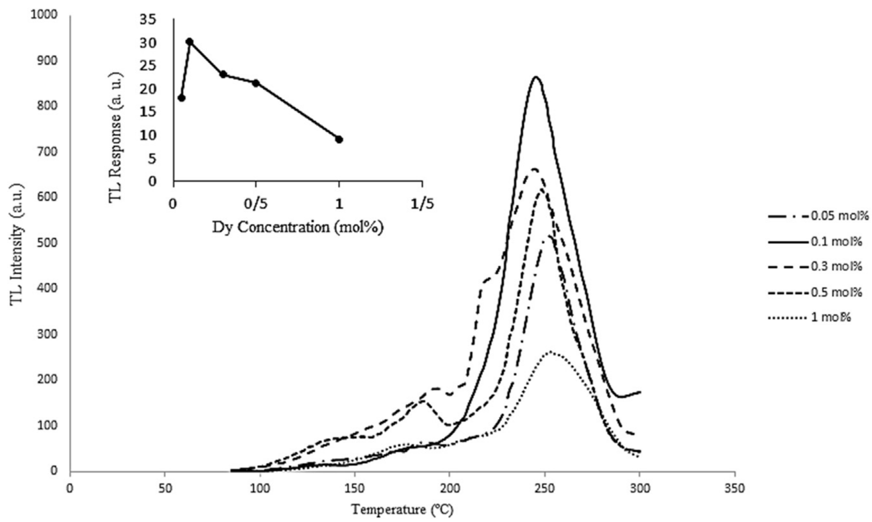

Fig. 2. TL Glow curves of LiF:Mg,Dy with different Dy concentrations and a fixed Mg concentration of 0.2 mol% at 500 mGy gamma dose from ^{60}Co. TL responses of different Dy concentrations are shown as insert.

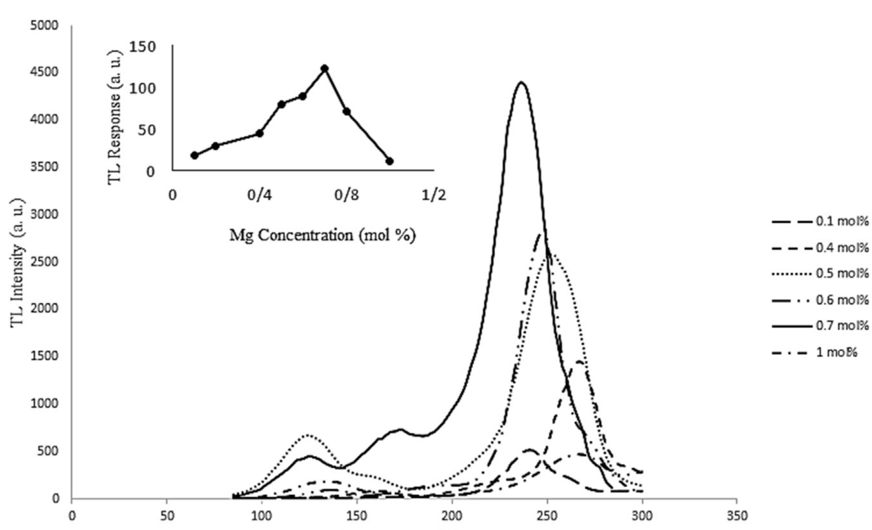

Fig. 3. Some TL glow curves with different Mg concentrations and optimized Dy concentration of 0.1 mol% and an administrated gamma dose of 500 mGy from ^{60}Co. TL responses of different Mg concentrations are shown as insert.