DOSIMETRIC CHARACTERIZATION OF LiF THIN FILMS FOR SOFT X-RAYS USING THE TSEE TECHNIQUE

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ABSTRACT

The dosimetry of weakly penetrating radiations, such as alpha and beta particles and low energy X-rays has led to a development of new materials and techniques that present superficial interactions, as happens with exoelectron emission. This technique is being used to measure short range particles. The Thermally Stimulated Exoelectron Emission (TSEE) consists of low energy electrons that are emitted from the surface of many insulating solids at temperatures below those at which termionic emission occurs, following mechanical deformation, physical phase changes, chemical reactions, or exposure of the surface to ionizing radiation. In this work, the properties of LiF thin films on aluminum and stainless steel substrates were investigated using the TSEE technique, to verify their usefulness for X radiation detection. Results on glow curves, calibration curves, energy dependence and response reproducibility of the samples are presented.

I. INTRODUCTION

For the measurement of short range radiations, such as alpha and beta particles and low energy X-rays, the detectors shall have preferentially a thin sensitive layer to be capable to detect these radiations, without loss of sensitivity.

Thermally stimulated exoelectron emission (TSEE) has received considerable attention in recent years because it is a technique that can be used in these cases, due to the shallow surface region within exoelectrons originate. The escape depht of exoelectrons is less than 100 nm[1,2].

The physical properties of TSEE are related to those of thermoluminescence[3,4]. Due to an exposure to ionizing radiation, the electrons near the insulator's surfaces or the crystals can be elevated to higher energy states into impurities traps. Upon thermal stimulation, these electrons are released from the traps. If their energy exceeds the electron affinity, they will be able to leave the surface of the insulator or crystal. The emitted electrons are called exoelectrons and the curve of this emission as a function of temperature is called TSEE glow curve[5].

For the detection of low energy electrons, there are a number of counting systems; among them, windowless Geiger Müller detectors, proportional counters, ionization chambers and electron multipliers can be cited[5,6]. The electron multipliers are used preferentially for experimental research than for practical dosimetric purposes. In all devices, the sample is directly placed at the counter and then it is linearly heated up to a certain temperature.

In this work, the properties of LiF thin films on aluminum and stainless steel substrates were investigated using the TSEE technique, to verify their usefulness for X radiation dosimetry. Results on glow curves, response reproducibility, calibration curves and energy dependence are presented.

II. MATERIALS AND METHODS

LiF thin films with 2 μm thickness were produced by the assisted physical deposition method of electron beam evaporation[7] on aluminum and stainless steel substrates. The LiF thin films were tested in X radiation beams of a Rigaku-Denki generator, Model Geigerflex, with a Philips tube Model PW/2184/00 (Tungsten target and Beryllium window - 60 kV). Prior to each irradiation, the samples were thermally treated at 400 °C for 15 min. The readout of the samples was made in a 2π windowless proportional counter, with hemispherical volume and with P-10 gas flow (10% Methane + 90% Argon), developed at IPEN[8]. The samples are inserted into the counter and they are fixed on a heater plate; the heating is linear at a rate of 5.0 °C/s. The temperature control for this linear heating is carried out by a temperature programmer TP-2000 (Theall Engineering Company), that provides rates between 0.1 and 5.0 °C/s, from room temperature up to 400 °C. The glow curves were recorded in a multichannel scaler (EG&G - Ortec ACE-MCS SN 363 plug in card).

III. RESULTS

Glow Curve. Figure 1 shows the TSEE glow curve for a LiF thin film on aluminum substrate irradiated with 1.0 Gy of X radiation (17.7 keV). The main glow peak appears at 155 °C. In Fig. 2 the TSEE glow curve for a LiF thin film on stainless steel substrate is shown. In this case the dosimetric peak occurs at about 143 °C. The materials show different glow curves shapes.

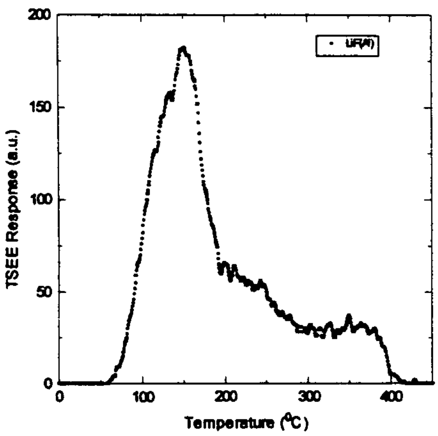

Figure 1- TSEE Glow Curve of a LiF Thin Film on Aluminum Substrate Irradiated with 1.0 Gy (X-rays, 17.7 keV).

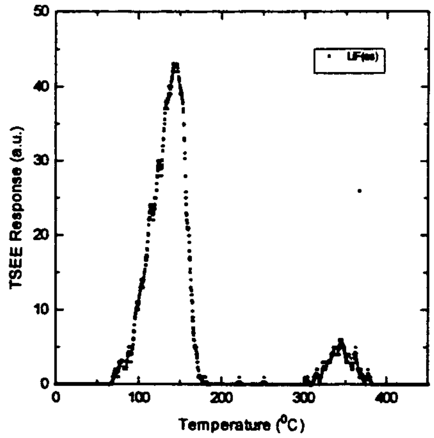

Figure 2 - TSEE Glow Curve of a LiF Thin Film on Stainless Steel Substrate Irradiated with 1.0 Gy (X-rays, 17.7 keV).

Reproducibility. The reproducibility of the TSEE response of LiF thin films was obtained measuring them ten times after repeated standard annealing and irradiation (21.2 keV, 1.0 Gy) procedures . The standard deviation after ten readout cycles was lower than 8.0 and 6.0% for LiF on stainless steel and aluminum substrates respectively.

Calibration Curve. The TSEE response of both kinds of materials as a function of the absorbed dose of X radiation (17.7 keV) was measured in the range of 0.05 up to 5 Gy, and the results are shown in Fig. 3.The standard deviation of these measurements was always less than 10%. As can be seen, the LiF thin films present in both cases supralinearity behavior.

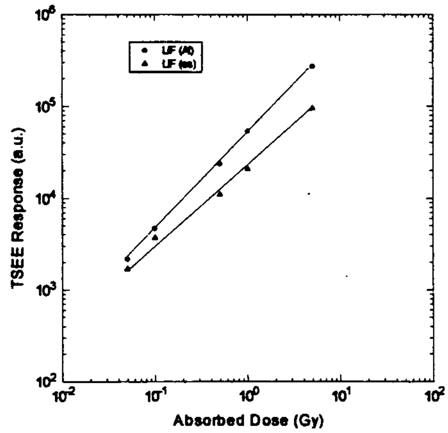

Figure 3 - The TSEE Response for LiF Thin Films (X-rays, 17.7 keV).

Energy Dependence. The performance of LiF thin films was studied in relation to its energy dependence for X-rays. The TSEE response was measured from samples exposed to 1.0 Gy in soft X radiation beams from 14.3 to 21.2 keV in air. The results are shown in Fig. 4.This energy dependence may be improved using different substrates and cover materials.

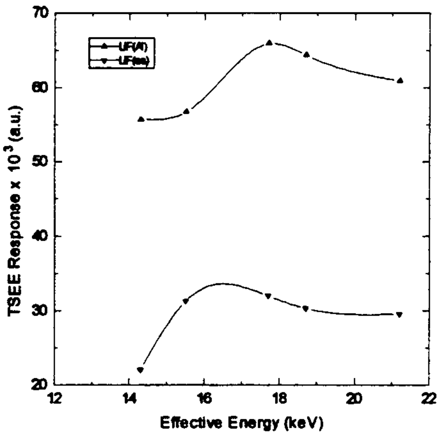

Figure 4 - Energy Dependence of LiF Thin Films Irradiated with 1.0 Gy.

IV.CONCLUSION

The preliminary results on some dosimetric characteristics as reproducibility, glow curves, calibration curves and energy dependence of LiF thin films studied in this work indicate that these materials may be useful for soft X radiation detection.

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