Study of radioluminescence from $CaSO_4$:Eu films for real-time dosimetry

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Introduction

Active detectors based on semiconductors and diodes are largely applied for clinical dosimetry, however they present limitations mainly related to complex electronic structure, limited spatial resolution and high cost. Several materials which exhibit thermoluminescence (TL) and optically stimulated luminescence (OSL) also present radioluminescence (RL), as Al_2O_3:C,Mg. In principle, RL materials can be used in real-time dosimetry as active detectors if the intensity of the RL signal can be associated with the absorbed dose. The sensitive material can be coupled to optical fibers, CCD devices, or other device to collect its light emission. The phosphor $CaSO_4$:Eu has been studied as TL and OSL detector and literature reports good reproducibility, linear dose-response and negligible fading. Previously, $CaSO_4$:Eu OSL films were produced and applied for two-dimensional dose mapping in radiotherapy. Considering the potential application of $CaSO_4$:Eu films for medical applications, in this work we studied the radioluminescence emission of $CaSO_4$:Eu films.

Objective

The main objective of this work was to study the radioluminescence emission of $CaSO_4$:Eu films, to test the feasibility of applying these for real-time dosimetry as active detectors.

Materials and Methods

We used a Horiba Absorbance and Fluorescence Spectrometer, model Duetta, and obtained the emission spectra of the $CaSO_4$:Eu films (Figure 1), exciting with different wavelengths and observed two emission centre groups. The first group is at 385 nm, related to Eu^{2+} and the second group, related to Eu^{3+} is at 580 nm, 600 nm and 700 nm. Secondly, to study the radioluminescence emission from the CaSO4:Eu film, we used a custom made equipment named LUMI22, which has an X-ray tube (Moxtek 50kV) powered and controlled by a standard controller (FTC-200) to irradiate the samples, and a miniature fiber optic spectrometer (Ocean Optics, FLAME-S-XR1-ES) that is used to identify the wavelength of the emitted light (range 200-1050 nm).

Figure 1. $CaSO_4$:Eu film.

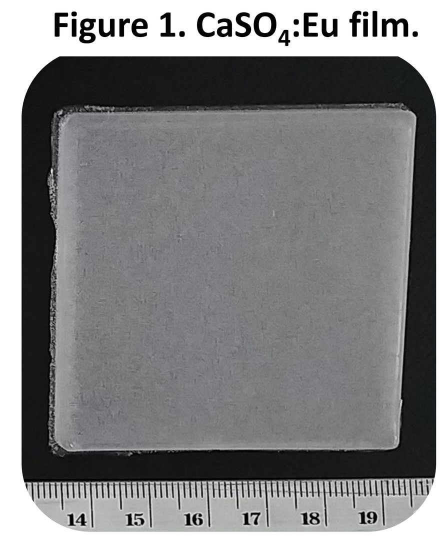
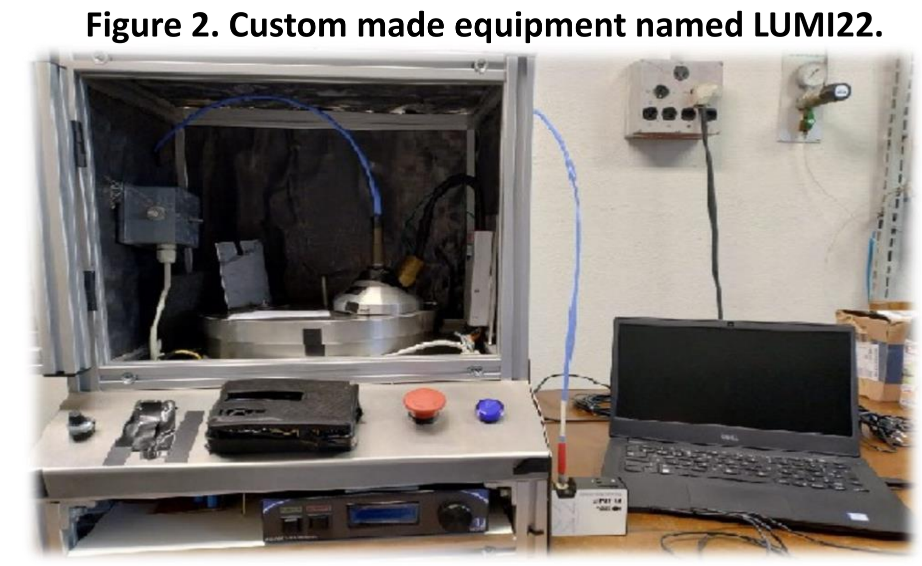


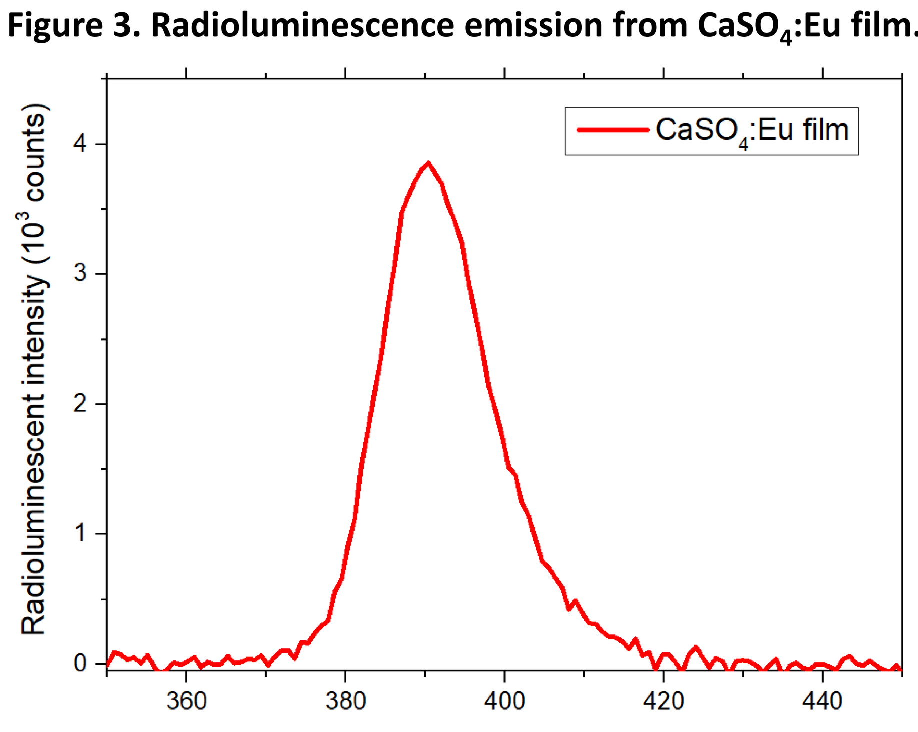
Figure 2. Custom made equipment named LUMI22.



Results

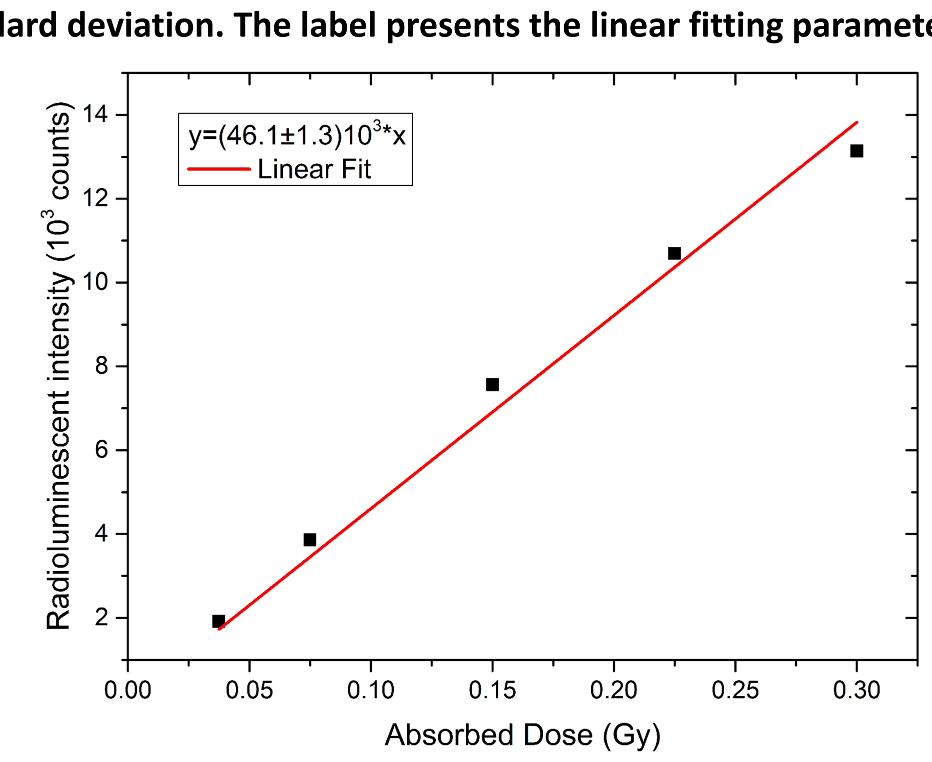
Radioluminescence signal

Figure 3. Radioluminescence emission from $CaSO_4$:Eu film.



Dose Response

Figure 4. $CaSO_4$:Eu film radioluminescence response as a function of dose. Each data point corresponds to the average RL intensity of three samples and the error bars are the average standard deviation. The label presents the linear fitting parameters



Emission spectra from $CaSO_4$:Eu film

Figure 5. Emission spectrum of $CaSO_4$:Eu film excited with 245 nm shows luminescence peaks at 580 nm, 600 nm and 700 nm, related to Eu^{3+}.

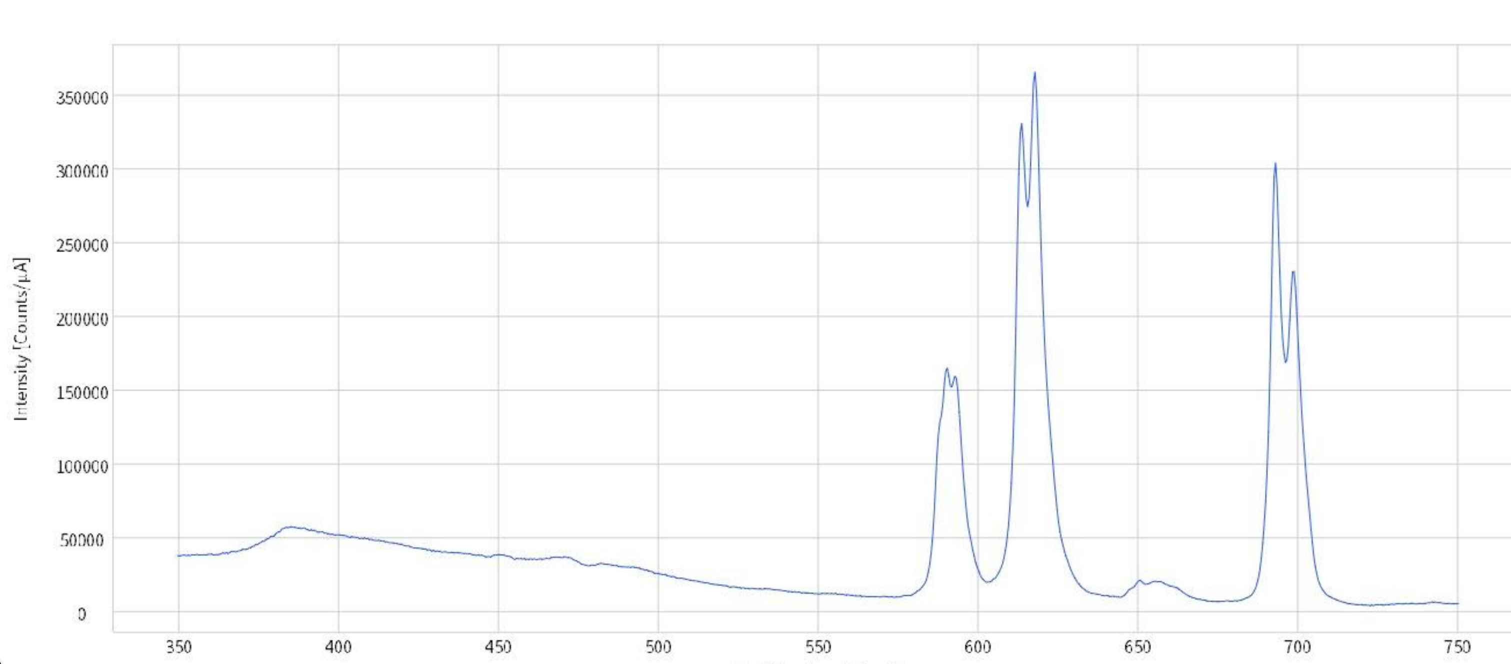
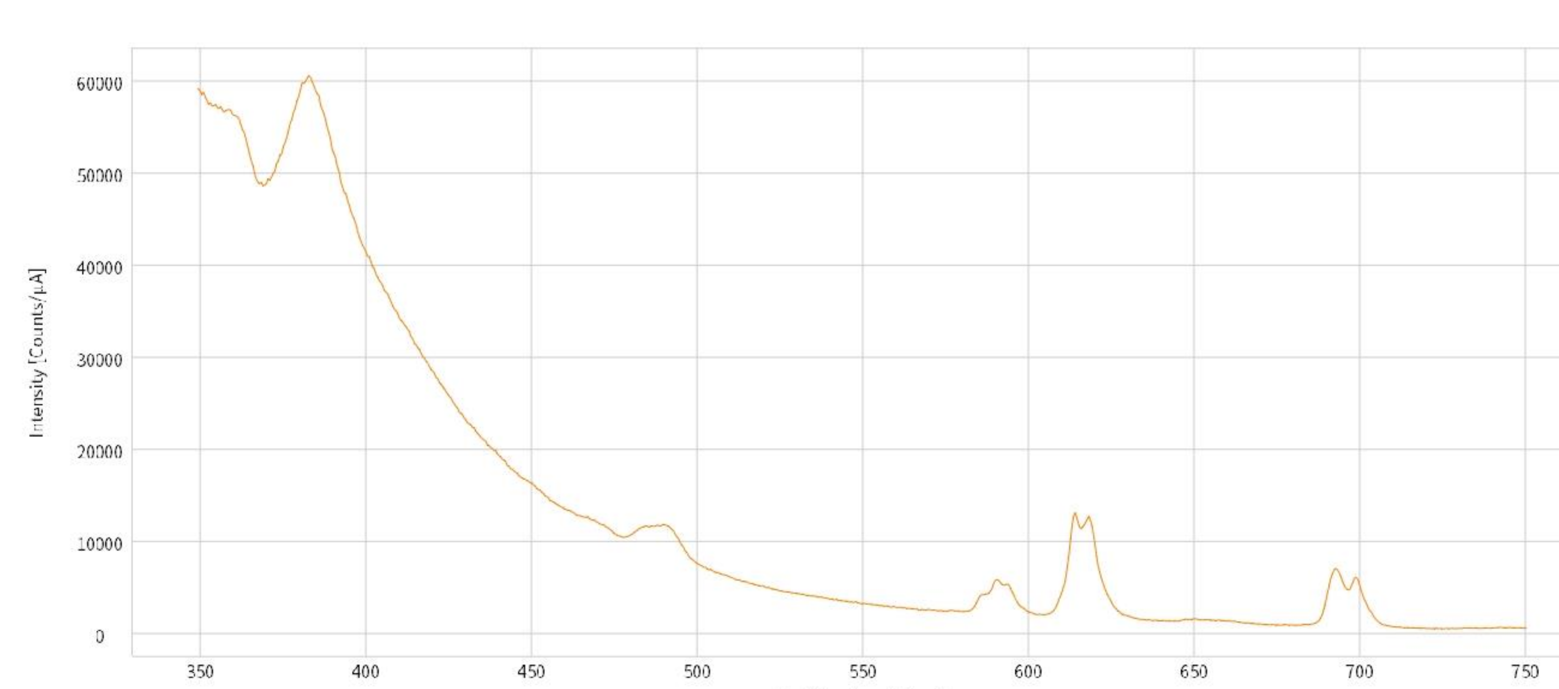


Figure 6. Emission spectrum of $CaSO_4$:Eu film excited with 290 nm shows luminescence peaks related to Eu^{2+}, at 385 nm.



Conclusions

Results showed a radioluminescent peak at 390 nm, which should be related to Eu^{2+}. The RL sensitivity is (46.1 ± 1.3) 10^3 counts/Gy. The film does not need thermal or optical treatment and the radioluminescent peak is reproducible. Comparing the RL intensity after 10 consecutive irradiations with the same conditions, the maximum coefficient of variation is 2.5%. The dose response of the RL is linear (R-square 0.9959) from 0.04 to 0.3 Gy. Results show that the $CaSO_4$:Eu film is promising for use with the RL technique in real-time clinical dosimetry. It should be possible to evaluate dose distributions in real time using the film and a reader with several fiber optics, for example.

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