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Nuclear Instruments and Methods in Physics Research B 213 (2004) 325–328
NIM B Beam Interactions with Materials & Atoms
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Green stimulated luminescence of ZrO_2 + PTFE to UV radiation dosimetry

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Abstract

The use of optically stimulated luminescence (OSL) as a method for the determination of environmental radiation absorbed dose using solid state materials has become the main interest of the most great research centers. The aim of this work is to study some dosimetric characteristics of ZrO_2 to be used as a UVR dosemeter by using the OSL method. The most attractive characteristic of ZrO_2 is its very high intrinsic sensitivity to UV radiation. Optical characteristics of ZrO_2 were also studied. OSL typical decay was obtained. OSL response of ZrO_2 samples as a function of irradiation time was linear in the range of 30–1000 s. Experimental results showed that ZrO_2 exhibit attractive characteristics which make it suitable for UV dosimetry applications.

PACS: 29.40.−n; 78.45.+h; 78.40
Keywords: OSL; ZrO_2; UV radiation

1. Introduction

Scientists classify UV radiation coming from sun into three types or bands UVA, UVB and UVC. UVA and UVB, which reach the surface of the Earth, contribute to the serious health effects. The level of UV radiation reaching the Earth surface can vary, depending on a variety of factors. In response to the serious public health threat posed by exposure to increased UV levels, several research groups are interested in getting environmental and personal dosemeters to measure the level of environmental UV radiation.

UV dosimetry using thermoluminescence (TL) has been suggested in the past by several authors [1–4]. A similar dosimetric technique has been recently introduced and it is named optically stimulated luminescence (OSL) [5,6]. This technique has an advantage over conventional TL method due to the readout method: it is all optical, requiring no heating of the samples.

The use of OSL in radiation dosimetry has not been extensively reported, mainly due to the lack of good luminescent materials, which should have both high sensitivity to radiation and high optical stimulation efficiency. OSL was firstly suggested for dating application [7–10]. The aim of this work

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doi:10.1016/S0168-583X(03)01637-9

is to study the main dosimetric characteristics of ZrO_2 and its application in UV environmental radiation dosimetry, by means of OSL method.

2. Experimental procedures

Materials used in this study were ZrO_2 + PTFE pellets of 5 mm diameter and 0.8 mm thickness. These samples were prepared in our laboratory using the technique described elsewhere [11,12].

Before exposing to UV light, the samples were annealed at 300 °C during ten minutes in order to erase all possible previous information. Luminescence measurements were carried out using a spectrofluorimeter. In this equipment both emission and excitation spectra were determined.

Continued wavelength optically stimulated luminescence (CW-OSL) measurements were made at the Solid State Dosimetry Laboratories of the Oklahoma State University using the Riso automated TL/OSL reader DA-15. Samples were stimulated using a green LED (GSL) array with a wavelength of 523 nm and 30 mW/cm^2 of power density. All of the UV irradiations were made using a 300 W deuterium filtered lamp. OSL measurements were carried out in nitrogen atmosphere.

3. Results and discussion

The ZrO_2 samples were investigated using UV irradiations due that the most attractive feature of ZrO_2 is its very high sensitivity to UV radiation.

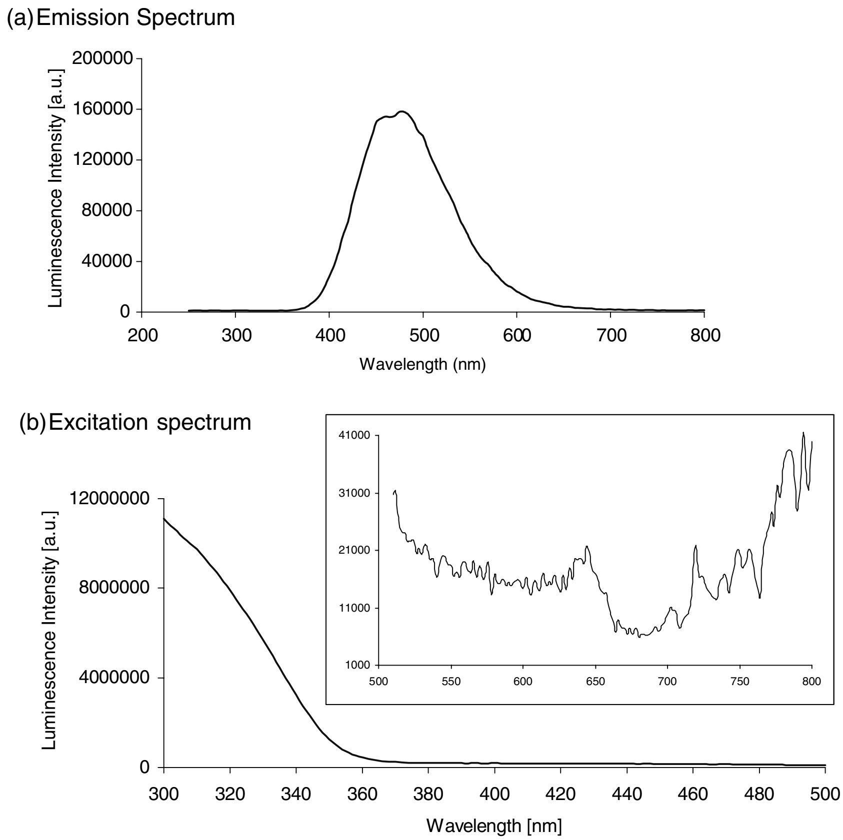

Fig. 1. OSL emission and excitation spectra of ZrO_2 obtained at room temperature: (a) emission spectrum, (b) excitation spectrum.

Before performing the OSL measurements, the samples were placed in a spectrofluorimeter to obtain optical characteristics as emission and excitation spectra. The spectral characteristics of ZrO_2 are shown in Fig. 1. This figure shows the ZrO_2 emission spectrum having a band peaking at 480 nm.

Typical OSL decay curve of ZrO_2 after UV irradiation is shown in Fig. 2. It can be observed at least two components in this OSL decay curve: a very fast component and a slow component.

Fig. 3 shows the GSL signal versus UV irradiation time for samples of ZrO_2 stimulated as described before. The light output is the total integrated output integrated over 523 nm beam for a stimulation period of 300 s. The background OSL values were subtracted for all additive time measurement taken. For the arrangement described the minimum measurable time was 30 s of irradiation time. The signal response is seen to be linear up to 1000s. After this irradiation time, the OSL response exhibited saturation.

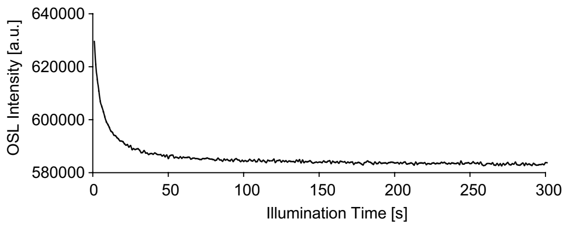

Fig. 2. OSL decay curve as a function of illumination time obtained for ZrO_2 after UV irradiation.

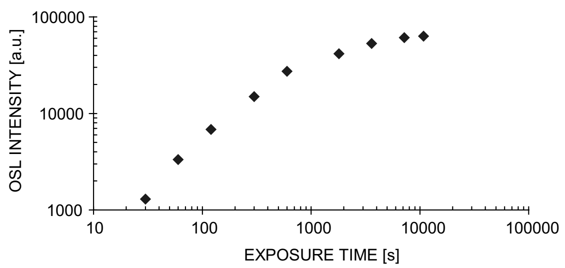

Fig. 3. OSL response of ZrO_2 samples as a function of 260 nm UV irradiation time.

4. Conclusions

In summary, the photoluminescent emission (PTLE) observed in $ZrO_2 + PTFE$ samples, irradiated with green photons, yields a transient, time dependent UV luminescence signal. Re-irradiation after annealing caused a reappearance of the luminescence. This effect confirms that the stimulated luminescence from irradiated samples is a result of the interaction of UV radiation with matter. Additional utility lies in the sensitivity of the technique which is very high. It is only necessary to deplete a fraction of the trapped charge in any one measurement.

Since the green stimulated luminescence signal is proportional to UV radiation dose, the feasibility of using $ZrO_2 + PTFE$ in UV radiation dosimetry by means of OSL method is well demonstrated.

The experimental results obtained for ZrO_2 showed that this material could be useful for detection of UV using OSL method. Taking into account special care of exposure to light, this material can be used in to personal UV dosimetry.

Acknowledgements

Work supported by a grant of CONACYT. Research Project 400200-5-32564-E. The authors would like to thank to Prof. Steave McKeever and colleagues for facilitating their laboratory and equipment to carried out OSL experiments.

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