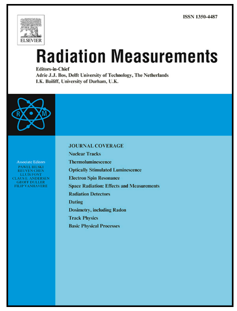
Accepted Manuscript



ID-MDE-O-09: Radiophotoluminescence and optically stimulated luminescence from Al_2O_3:C,Mg films using a 1D modular reader

L.F. Nascimento, M. Kamparieri, J.P. Oliveira, F. Vanhavere

PII: S1350-4487(17)30098-7

DOI: 10.1016/j.radmeas.2017.02.006

Reference: RM 5709

To appear in: *Radiation Measurements*

Received Date: 12 September 2016

Revised Date: 1 February 2017

Accepted Date: 3 February 2017

Please cite this article as: Nascimento, L.F., Kamparieri, M., Oliveira, J.P., Vanhavere, F., ID-MDE-O-09: Radiophotoluminescence and optically stimulated luminescence from Al_2O_3:C,Mg films using a 1D modular reader, *Radiation Measurements* (2017), doi: 10.1016/j.radmeas.2017.02.006.

ID-MDE-O-09: Radiophotoluminescence and Optically Stimulated Luminescence from Al_2O_3:C,Mg films using a 1D modular reader

Nascimento, L.F.*; Kamparieri, M.; Oliveira, J.P.; Vanhavere, F.
Radiation Protection Dosimetry and Calibration,
Belgian Nuclear Research Centre (SCK-CEN) – Belgium *ldfnasci@sckcen.be

ABSTRACT
The radiophotoluminescence (RPL) and optically stimulated luminescence (OSL) combined signals from Al_2O_3:C,Mg films were investigated in the dose range of interest in radiotherapy medical dosimetry (0.1 to 40 Gy). The results showed that the RPL signal is linear over the dose range investigated. The systems based on red excitation have a better dose detection range (starting from 0.2Gy), compared to the system based on UV excitation (1 Gy). The RPL dose measurements are performed using a modular system by illumination of the Al_2O_3:C,Mg detectors with 335 nm or 650 nm light and measuring the intensity of the 750 nm fluorescence, while OSL is measured using the modular system with blue 470 nm light. We demonstrated the feasibility of combining RPL and OSL readouts by proposing a protocol where one can acquire cummulative dose response (RPL) and dose reproducibilty (OSL). The main challenge was to account for sensitization caused by accumulated dose when using the OSL technique, without affecting the RPL readouts.

1. INTRODUCTION

The radiophotoluminescence (RPL) and optically stimulated luminescence (OSL) dose response and reproducibility characteristics of Al_2O_3:C,Mg detectors were investigated after irradiation with electron doses ranging from 0.1 to 40 Gy. The two main motivations of this work were: 1) fundamental research for understanding the luminescence process in Al_2O_3:C,Mg and 2) the practical use of two different signals (OSL and RPL) for radiation dosimetry.

The main difference between RPL and OSL is that in RPL the stimulation with light does not result in the ionisation of the defect, but only in its excitation. Illuminating an irradiated sample results in the excitation of electrons from the defect ground state to the defect excited state. Relaxation from the excited state back to the ground state yields luminescence (RPL). One of the advantages of using this approach is that the dose can be read multiple times without destroying the signal.

RPL effects in minerals and synthetic inorganic solids were observed by Przibram, and were studied extensively by him and his students at the Vienna Institut fur Radiumforschung (McKeever, 2002; Przibram, 1959). Examples of RPL materials are given for F_2-centres (or M-centres) in alkali halides (Etzel and Schulman, 1954; Regulla, 1972) and from glasses (Miyamoto et al., 2010; Piesch and Regulla, 1980).

Optical and dosimetric properties of a new radiophotoluminescent material based on aluminium oxide doped with carbon and magnesium (Al_2O_3:C,Mg) with aggregate oxygen vacancy defects was first presented by M. Akselrod and A. Akselrod in 2006 (Akselrod and Akselrod, 2006; Akselrod et al., 2003). Previously, this material has been investigated for non-destructive imaging of tracks to detect and assess doses from heavy charged particles and neutrons (Akselrod and Sykora, 2011), and recently also as a RPL detector for application in high dose dosimetry (~Gy) (Ahmed et al., 2013).

Aluminium oxide doped with carbon and magnesium (Al_2O_3:C,Mg) has advantages as a dosimetric detector (Akselrod and Akselrod, 2006; Akselrod et al., 2006). Basic research into fundamental mechanisms, modelling, and the development of new experimental techniques is important to yield applications in radiation dosimetry, including environmental, retrospective, personal, medical, and space dosimetry.

Here, we investigated two RPL readout approaches for Al_2O_3:C,Mg crystals for dosimetry applications and combined the use of both RPL and OSL in doses commonly used in radiotherapy. One disadvantage of Al_2O_3:C,Mg RPL is that the signal cannot be easily reset to zero (Akselrod and Akselrod, 2006), and the sensitivity of the technique is relatively low when compared to the well stablished Al_2O_3:C-OSL technique (Ahmed et al., 2013). Because of that, combining the advantages of both technique (RPL and OSL) is of interest for broadening its dosimetric applications, such as in scenarios where dose can be measured repeatedly (in RPL mode) together with the assessment of a destructive dose measurement with better sensitivity (OSL). It is important also to point out that the RPL signal from Al_2O_3:C,Mg is not affected by ambient light, compared to the known strong OSL light-induced fading (Gronchi et al., 2007). Because of that, it is possible to check the dose using RPL in cases where the samples could not be completely shielded and/or manipulated in dark rooms, or in cases where, by mistake, an irradiated sample is exposed to ambient light.