Studies of optically stimulated luminescence of YAlO₃:Mn²⁺ crystals grown by the floating zone and Czochralski methods

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Abstract

Mn²⁺-doped YAlO₃ (YAP) crystal is a good candidate for thermally stimulated (TSL) or optically stimulated luminescent (OSL) dosimetry of ionising radiation [1]. This material has a high effective atomic number ($Z_{eff} \sim 31.4$), making it particularly useful for estimating the energy range of unknown photon radiation fields [2, 3]. However, the optically stimulated luminescence and the effect of optical bleaching in this material have not yet been thoroughly investigated. It is necessary to establish the optimal conditions for measuring the OSL response of this material for use in dosimetry. To achieve this, the Mn^{2+} -doped crystals, in particular YAlO₃, (Y-Gd)AlO₃ and (Y-Lu)AlO₃, were grown by the floating zone (FZ) and the Czochralski (CZ) methods and studied in detail.

In our experiments, it was investigated the influence of the intensity and wavelength of optical stimulation on the kinetics of the OSL response. Besides the influence of the time parameters of pulse stimulation on the form of the OSL kinetics has been studied. The effect of host material composition on the TSL and OSL properties, including the activation energy of shallow traps and the main dosimetric TSL peak at about 200 °C, was determined.

Motivation and aim of the work

The aim of the study was to investigate the regularities and peculiarities of the OSL phenomenon in YAP: Mn-based crystals using different spectral and temporal modes of optical stimulation of delocalisation of charge carriers captured during irradiation with ionising radiation, aimed at establishing the role of various factors in the OSL phenomenon, forming the kinetics of its attenuation, and establishing the relationship between the measured characteristics of OSL and the absorbed dose of ionising radiation.









Signal attenuation kinetics of CW-OSL crystal YAP:Mn,Si(#15)



Conclusions • The signal decay kinetics of OSL detectors based on YAP:Mn²⁺ crystals under sufficiently intense continuous stimulation contains at least three components. The first of them corresponds to the optical emptying of mainly shallow traps, the second component - to the main dosimetric traps. The longest component with a time constant of hundreds of seconds is due to the presence of deep traps.

—— CZ#40 —— CZ#39

----- CZ#34

- CZ#31

- The magnitude of the observed OSL signal and the shape of its 'slow' decay kinetics significantly depend on the duration of the stimulation pulse and the duration of registration (time between stimulation pulses).
- The obtained results indicate the need for complete emptying of deep traps, for example, by heating to about 400 °C, before reusing the studied YAP:Mn²⁺ detectors

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[1] Ya. Zhydachevskii et al., *Radiat. Meas.* 94 (2016) 18-22 [2] V. Chumak et al., *Radiat. Meas.* 106 (2017) 638-643 [3] S. B. Ubizskii et al., *ICTEE* 3 (2023)153-162 [4] H. Przybylińska et.al., J. Phys. Chem. C 126 (2022) 743–753 *Contact information:* mgr. Vasyl Stasiv, stasiv@ifpan.edu.pl