Phosphor materials that can store the energy of ionizing radiation or even daylight by accumulating charge carriers in deep traps have a great applied importance. The stored energy can be released gradually as delayed luminescence, the rate of the process being controlled by thermal or optical stimulation. Those materials have attracted much attention in sustainable energetics, personal dosimetry, optical information storage and fluorescent biolabels for in-vivo medical research [1].

In this regard, ZrO$_2$ nanopowder is a promising but insufficiently studied material that exhibits remarkable thermoluminescence (TL) and afterglow at 490 nm upon illumination with UV light (~280 nm) [2].

The aim of this investigation was to clarify the nature of photoluminescence (PL) center and the charge traps responsible for the afterglow, TL and optically stimulated luminescence (OSL) by applying heat treatment in reducing and oxidizing environment, red-NIR photostimulation and more careful TL analysis. We also studied the temperature dependence of the PL intensity for different ZrO$_2$ powders.

Annealing in slightly reducing environment produced distinctive changes in TL peak intensities, implying that most of the traps have a relation with either anion vacancies or interstitials (V$_{O}$, I$_{O}$). Additional TL peaks were resolved by using a variant of T$_{m}$-T$_{stop}$ analysis and by charging the material at different temperatures.

We also demonstrated an efficient optically stimulated luminescence of the emission band centering at 490 nm by several red or NIR laser sources after charging the ZrO$_2$ powders with UV light (Fig. 1). Therefore the ZrO$_2$ nanopowders can serve simultaneously as thermoluminescent, persistent luminescent and photostimulated luminescent material with a possibility to tune the trap densities by heat treatment conditions.

![Figure 1. OSL from sol-gel prepared ZrO$_2$ nanopowder (annealed in H$_2$ (5%)/Ar at 1000°C) after charging at 266 nm for 3 minutes. OSL was conducted either at (a) −100 °C (1064 nm) or (b) 25 °C (808 and 660 nm).](image-url)

References
