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Connection between TSL and afterglow in mixed oxide garnet ceramics

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Oxide garnet materials are widely used as scintillators and phosphors and are being actively investigated. Composition versatility for this class of materials enables optimizing garnets' physical properties to specific application requirements in terms of density, light output or afterglow. Many medical and industrial scintillator applications have strict requirements to time performance of scintillators. E.g. medical computed tomography (CT) requires low (0.1%) afterglow levels in the ms-time range [1].
Relatively high light yields (> 50-60 ph/KeV) have been reported for the Ce-doped (Y,Gd)- and Gd₃(Ga,Al)-mixed garnets [2]. However, many of the oxide garnets are characterized by a multi-exponential decay and severe afterglow [3]. The afterglow is due to trapping of electrons and holes. Trap centers are investigated using thermally stimulated luminescence (TSL) and isothermal decay (afterglow) measurements. Generally, TSL and afterglow curves of scintillators are studied separately, even though traps responsible for both processes can be the same.
This talk describes our research on the Ce-doped (Y,Gd)- and Gd₃(Ga,Al)-garnet ceramics with the aim to correlate their TSL and afterglow measurements. The samples were either co-doped with 2–50 mole ppm of Cr, Yb or Eu, or left nominally pure. For all the samples TSL curves at 1-40 K/min heating rates and afterglow curves in the 10⁻³-10⁴ sec time range and at several temperatures in the 300-430 K range have been measured.
We have developed procedures to determine trap parameters such as thermal trap depth and frequency factor in an unambiguous manner by connecting TSL and afterglow measurements. In order to accomplish that, we have devised a special method of extracting the lifetime of trapped carriers from afterglow measurements, independent of kinetic order.

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