# Gamma Ray-Induced Radiation Damage in Ultrafast $Lu_2O_3$:Yb Ceramic Scintillators

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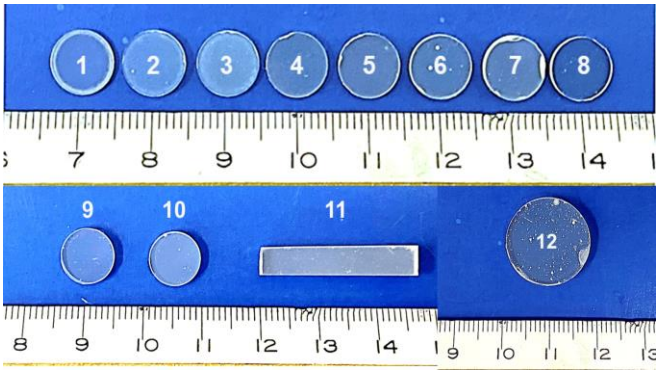
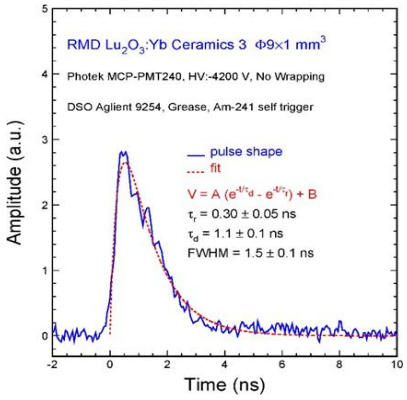
Abstract

Activated by charge transfer luminescence ytterbium doped lutetium oxide ($Lu_2O_3$:Yb) is an ultrafast scintillator. Combined with its high density (9.4 g/cm$^3$), it is a promising ultrafast inorganic scintillator for breaking the picosecond (ps) timing barrier for future high energy physics (HEP) time of flight (TOF) and ultrafast calorimetry applications. We report gamma ray-induced radiation damage in $Lu_2O_3$:Yb and $Lu_{2x}Y_{2(1-x)}O_3$:Yb ceramic samples fabricated in Radiation Monitoring Devices Inc. All samples show X-ray excited luminescence peaked at 370 nm with an ultrafast decay time of one ns observed by using a microchannel plate-photomultiplier tube-based test bench. Pulse height spectra and light output as a function of integration time were measured before and after irradiation up to 20 Mrad. This is a part of an on-going investigation for developing ultrafast inorganic scintillators for future HEP experiments.

The high energy physics (HEP) and GHz hard X-ray imaging communities are pursuing fast and ultrafast inorganic scintillators. Ultrafast heavy inorganic scintillators are important for breaking the picosecond (ps) timing barrier for future time of flight (TOF) and ultrafast calorimetry applications in HEP. With high density (9.4 g/cm3) and large dE/dx (11.6 MeV/cm), ytterbium doped lutetium oxide ($Lu_2O_3$:Yb) ceramics are a promising ultrafast scintillation. Fig. (a) shows twelve $Lu_2O_3$:Yb and $Lu_{2x}Y_{2(1-x)}O_3$:Yb ceramic samples fabricated in Radiation Monitoring Devices Inc. (RMD). Fig. (b) shows a typical ultrafast decay time of 1.1 ns measured by using a microchannel plate-photomultiplier tube-based test bench. Scattering centers are visible in these samples.

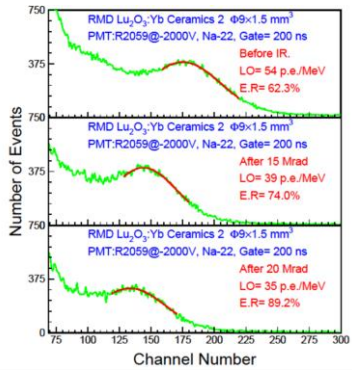



(a)

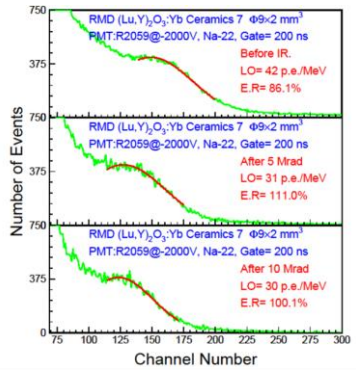



(b)

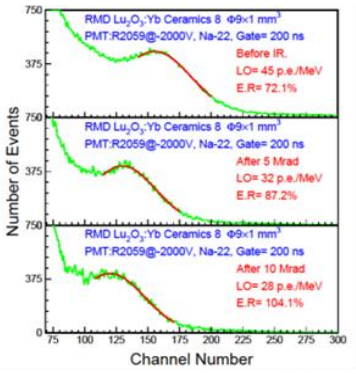
Excellent radiation resistance against ionization dose, protons and neutrons, however, is required for future HEP experiments at the energy and intensity frontiers. Gamma ray irradiation was conducted at Caltech by using a two curie Cs-137 source. Pulse height spectrum (PHS) and light output (LO) as a function of integration time were measured before and after irradiation in steps of 5 Mrad up to 20 Mrad. Figs. (c), (d) and (e) and (f), (g) and (h) show pulse height spectra and LO as a function of integration time, respectively, for $Lu_2O_3$:Yb sample 2, $Lu_{2x}Y_{2(1-x)}O_3$:Yb sample 7 and $Lu_2O_3$:Yb sample 8.



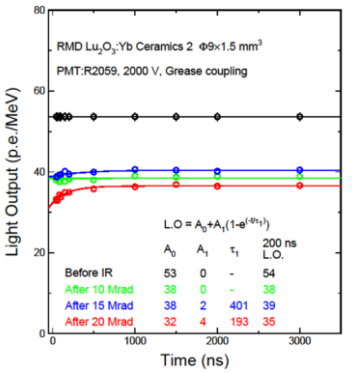

(c)



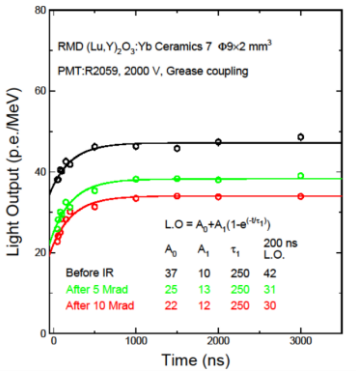

(d)



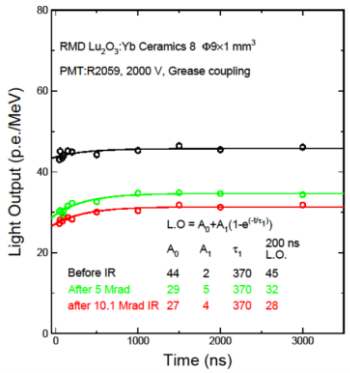

(e)




(f)




(g)




(h)

All samples show light output loss after the 1st five Mrad. $Lu_{2x}Y_{2(1-x)}O_3$:Yb appears having slower scintillation than $Lu_2O_3$:Yb. Supported by DOE SBIR program, RMD has recently fabricated $Lu_2O_3$:Yb and $Lu_{2x}Y_{2(1-x)}O_3$:Yb ceramic samples with much improved optical and scintillation properties. The result of RMD sample batches with improved transparency will be reported in this conference.