Development of a setup for measuring the afterglow of scintillating materials

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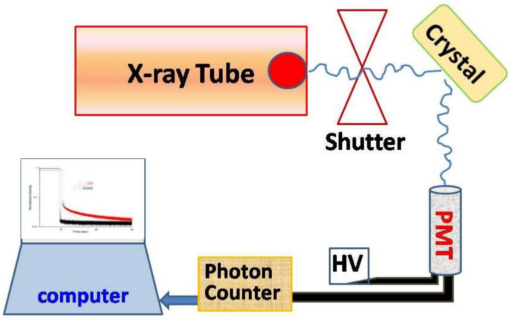
Introduction

The scintillating materials are essential for the technology developments as they find various applications including high energy physics, security, medical and industries. The main ideal scintillator characteristics include high light yield, fast decay time, high density, high radiation and mechanical hardness and low afterglow [1]. The afterglow is basically defined with the emitted light left after switching off the higher energy radiation. High afterglow not only decease the light output of the scintillator, It has also deterministic effect like ghost effect in radiography and limits the application of scintillating materials in various devices. The afterglow mainly depends on the scintillation kinetics and defect structure of the materials. The quantification of afterglow is necessary to minimize it by materials engineering and optimizing the dopants and co-dopants.

The stimulated emission decay very fast and very feeble light remains over the background after switching off the incident radiation. It therefore makes the measurement of afterglow very challenging which requires a pulsed radiation sources or a fast mechanical shutter to block the incoming radiation in couple of milliseconds and sensitive readout system having very low background.

Setup details

Schematic diagram of an afterglow measurement setup is shown in figure 1a. A white X-ray tube having tungsten target and operating at 40kV and 30 mA was used as an excitation source. The X ray shutter consists of a 5mm SS disc with a suitable slot for allowing the X rays to pass through. The disc is mounted on the shaft of a stepper motor. The stepper motor rotates the disc to bring it in the HOME position and while it does this, it also stretches the silicone rubber sleeve used to generate the spring effect. The stepper motor is energized in this condition such that the stepper motor can align the disc in HOME position by overcoming the stretching force exerted by the silicone rubber sleeve attached to solid base of stand.



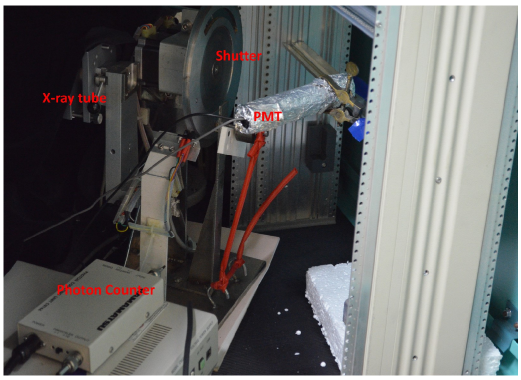


Fig. 1 The schematics and a photograph of the afterglow setup.

As soon as the motor is de-energized, the spring effect of the rubber sleeve along with the weights mounted on the disc rotate the disc rapidly and align the solid part of the disc to block the X rays. The shutter stops the incident radiation in 2-3 ms depending on the spot size of X-ray. The setup was properly shielded for the radiation and light. The Hamamatsu photomultiplier tube was selected for its low dark current to get the week afterglow signal over background. The X-ray was collimated to 1 mm circular spot for faster shutter speed. Hamamatsu photon counter was used to record the emitting light. The emitted light was integrated for 500 microseconds. The image of actual setup is shown in figure 1b.

Results and Discussion

The afterglow measurements were carried out on some of the single crystal scintillators grown in Crystal Technology Section, Technical Physics Division, BARC. Some of the results are presented in figure 2. The integrated intensity suddenly drops when shutter cut down the incident light. The measured light after that decreases exponentially. The fraction of light remaining after 5 ms of switch off the incident radiation was measured to be around 5-6 % in case of CsI:Tl scintillators. The result is in good agreement with the reported values for this crystal and therefore validates our measurement setup. The afterglow for oxide crystals was found to be around one order lesser in comparison with the halide crystals. The promising scintillator crystal GGAG (Ce) was found to have the afterglow comparable with the other oxide crystals like $CdWO_4$ etc. However it decays very slowly in comparison with other scintillators. The fraction of this persistent light is only 1% of the maximum emitted light and therefore should not have much adverse effects in various applications. Due to the reflection geometry of the measurements, the emission from polycrystalline samples could be also investigated for the afterglow properties. The setup can be also used to study the effect of co-dopants on the afterglow properties. These results will help for designing the scintillating materials with dopant and co-dpants having required properties.

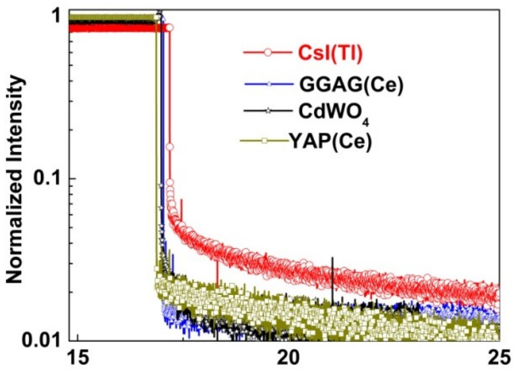


Fig. 2 Alpha and gamma decay curves of GGAG:Ce,B and phoswich.

Conclusion

A setup was fabricated and tested for measuring the afterglow which is an important characteristic of scintillating materials. The measurements on standard samples validate the system functioning. More experiments on various scintillating materials are in progress. The results are being used to understand the defect structure of various co-doped scintillators which would help in designing the materials having required properties.

References

[1] Martin Nikl, *Meas. Sci. Technol.* **17** (2006) R37–R54.
[2] Bartle C. M. et al., *Nuclr. Inst. Meth. Phys. Res. A,* **651** (2011) 105-109.