THE CHARACTERISATION OF THE TEMPORAL RESPONSE OF SCINTILLATORS FOR USE IN RADIATION DETECTION

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Introduction

Scintillators are used in the detection and identification of radioactive materials and for various medical and nondestructive testing techniques. There are two principal properties of interest:

Afterglow is not a well defined property[1][2][3]. It is accepted to be a persistent low light level that is present after irradiation. This can lead to blurring in dynamic imaging and difficulty in identification of radioactive materials.

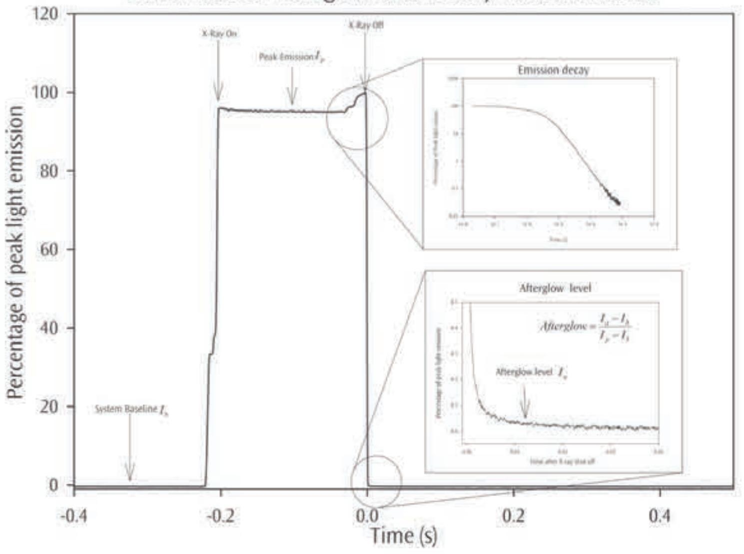
Hysteresis is a change in the intensity of the emitted light due to previous exposures to ionising radiation[3]. This leads to the creation of latent images and will invalidate an energy calibration when trying to indentify radioactive materials.

Characterisation of these two phenomena will allow for the determination of the suitability of new scintillators for demanding applications and aid in the development of existing scintillators.

Afterglow

The luminescence mechanisms in scintillators can vary due to the host matrix and the dopant. Each of these mechanisms has an associated emission decay time[2].

The point at which a scintillator exhibits afterglow and not a long decay is not well defined. This weak definition leads to confusion and difficulty in assessing a scintillator for specific applicactions.



A typical afterglow measurement. An X-Ray shutter is used to give a known exposure and a rapid shutoff

The afterglow of some scintillators such as CsI(Tl) is dependent on the excitation conditions. This dose dependence is not well understood. The excitation conditions can be separated into the following:

- Excitation energy
- Radiation intensity
- Duration of the excitation

The presence of impurities and crystal defects are also known to influence the afterglow[2][3]. These factors are also under investigation.

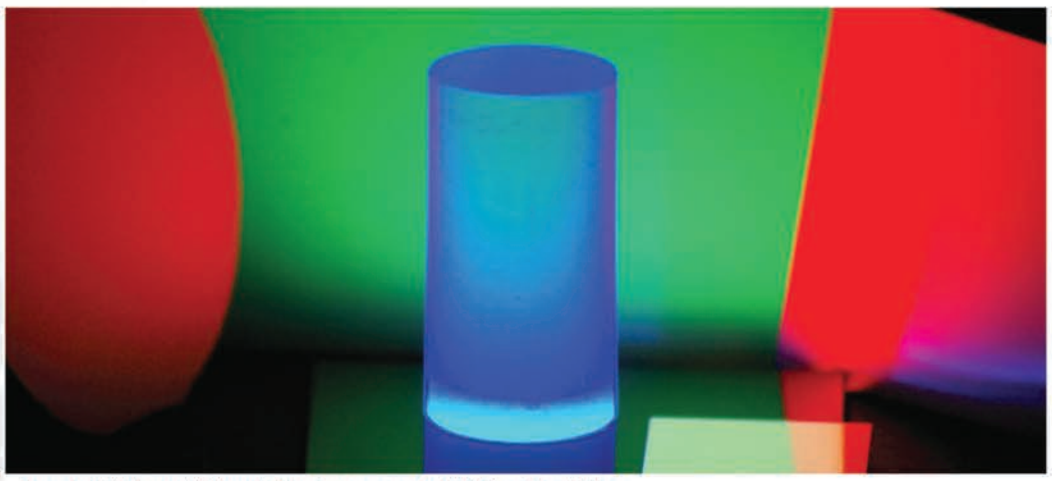
Measuring the afterglow

An X-Ray shutter was developed that has attenuates ~100% of X-Rays at 40 keV, it has a minimum exposure of 50 ms and an open/shut time of ~600 μs. This system is complemented by a pulsed X-Ray unit which has a 60 ns FWHM pulse width. These allow for the characterisation of the light output from ~0.1 μs and beyond.

What is a scintillator?

A scintillator is a transparent dielectric medium that exhibits luminescence induced by ionisng radiation[1][2]. Coupling to a light sensitive devices such as a CMOS sensor allows for radiation detection or the formation of a radiograph.

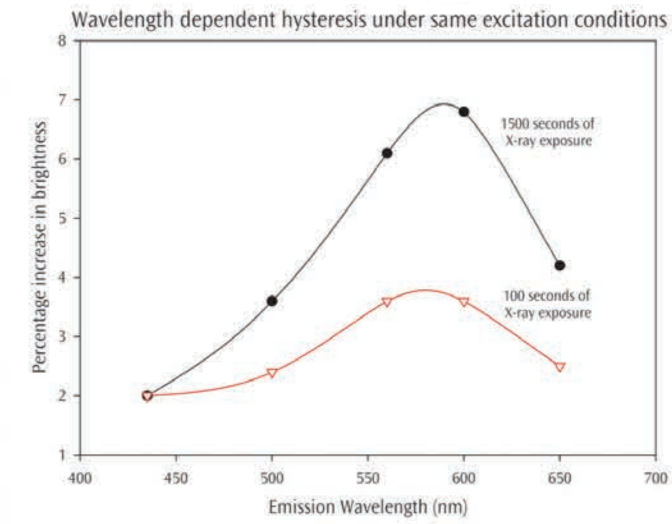
Typically a dopant is added to a host matrix which increases the luminescence efficiency of the scintillator[1][2]. Desirable properties in scintillators include a high effective atomic number, a high density, high brightness, rapid scintillation decay and mechanical robustness[1][2].



Several scintillators exhibiting photoluminescence under UV (318 nm) irradiation.

Hysteresis

The change in the light intensity of a scintillator due to previous exposure to ionising radiation is temporary[3]. The initial change and the subsequent recovery need to be measured. This is dependent on the nature of the exposure to ionising radiation and the material. The recovery from this exposure can take days. Therefore a stable system is required to characterise this phenomena.



The hysteresis effect in this scintillator shows a wavelength dependence. The brightness at the point where the X-Rays are turned on is taken to be 100%

Measuring the hysteresis effect

There are several characteristics of the hysteresis effect of interest:

- Dose dependence (X-ray energy, intensity and duration)
- Change in emission spectrum of scintillator
- Relationship with decay and afterglow

This can be studied by coupling the scintillator to a light sensitive device and measuring the output over time under controlled excitation conditions. The use of bandpass filters allow for wavelength dependence to be measured.

Conclusion

The outlined techniques allow for characterisation of important properties of scintillators that have consequence in detection and identification of radioactive materials and for medical and nondestructive imaging techniques.

Further work

Investigating the relationship between the hysteresis and afterglow. Use the developed techniques to characterise and develop new and existing scintillation materials. Investigate the role of crystal quality and purity in these properties.

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