Evaluation of Luminescence Properties of Neutron Image Plates

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Abstract

Storage-phosphor imaging plates (IP) are widely used as position-sensitive detectors based on the effect of photostimulated luminescence (PSL). They consist of a film of finely dispersed storage phosphor (e.g. BaFBr:Eu^{2+}) in an organic binder on a thin plastic support. On irradiation, metastable color centers are created, which can then be excited by visible light to emit luminescence. Scanning the IP with a focused laser allows simultaneous excitation and detection of luminescence from the colour centers so that the stored information is read out spot-by-spot. These storage phosphors can be made sensitive to thermal neutrons by adding a neutron converter. Currently, there are two ILL Laue diffractometers, equipped with neutron IP's, VIVALDI, the first completed instrument of the Millennium Programme, located on a thermal beam, and LADI, located on a cold beam.

Neutron image-plates (Gd_2O_3 & BaFBr:Eu^{2+})

Advantages:
- no limitation in the count or dose rate
- high dynamic range - 8 orders of magnitude.
- high Detective Quantum Efficiency
- high spatial resolution (~200μm)
- flexible - (almost) any configuration
- cheap! - (if you already have a scanner)

Disadvantages:
- slow read-out (currently) several minutes
- sensitive to gamma-rays
- may be activated depending on material

Suited to Laue diffraction, powder diffraction, small-angle scattering in low-background environment at steady-state sources

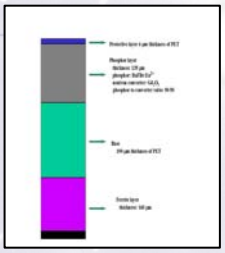


Fig.1. Commercial NIP (blue)

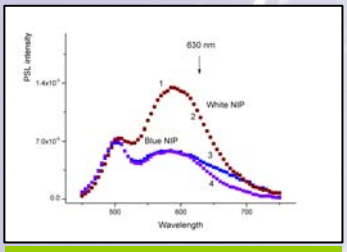


Fig.2. Stimulation spectra of commercial blue NIP and current VIVALDI NIP

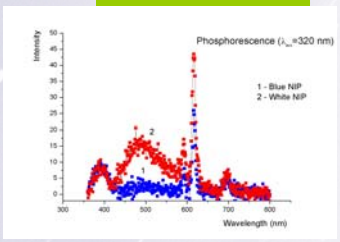


Fig3. Phosphorescence spectra

PSL study of new combinations of neutron converter/storage phosphors

-Eu-doped BaSrFBr, CsBr from Agfa, containing varying quantities - of Gd_2O_3 or $Li_2B_4O_7$ powder.
Jointly with Carel van Ejik group:
-$Sr_{2(1-x-y)}Ce_{2x}K_{2y}B_5O_9Br$ and $Ca_{2(1-x)}Ce_{2x}B_5O_9Br$
-99% enriched with ^{10}B $M_5B_5O_9X:Ce^{3+}$ (M= Ca,Sr; X=Cl, Br)

BaSrFBr:Eu^{2+} (from Agfa)

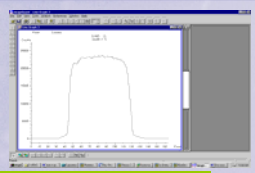


Fig.5. Direct beam at DB21 (irradiation 20 sec) BaSrFBr:Eu^{2+}/Gd_2O_3 (70/30)

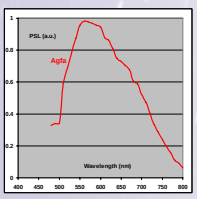


Fig.6. Photostimulation spectrum

Fig.4.. Plates withs samples

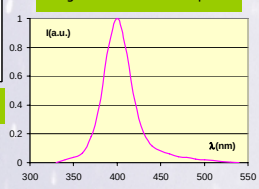
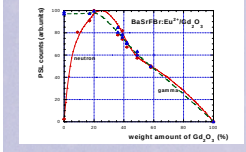


Fig.7. Emission spectrum



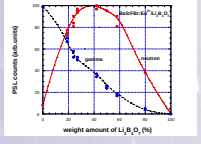


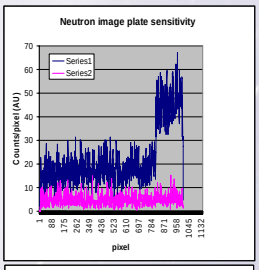
Fig.8 and 9. PSL vs% weight of Gd_2O_3 (or $Li_2B_4O_7$) for constant neutron irradiation (7.56 Å) and constant γ-irradiation (ambient background near VIVALDI)

Material	PSL counts/neutron	γ-sensitivity
White NIP (Fuji)	1	1
BaSrFBr:Eu^{2+}/$Li_2B_4O_7$ (80/20)	1.35	1.27
BaSrFBr:Eu^{2+}/Gd_2O_3 (80/20)	2.2	2.0

Should be even better with $^6Li_2{}^{10}B_4O_7$!!!

Background measurements

Image-plate and gamma measurements on D19 and LADI/T17



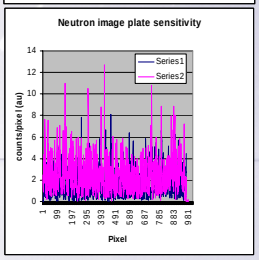


Fig.10. Gamma background measurements with NIP

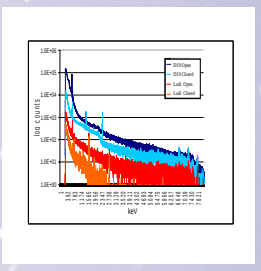


Fig.9. Gamma spectra at LADI and D19

Fig.11. Image-plate scanner

Image-Plate Development

(with Dean Myles)
BaSrFBr:Eu^{2+}/Gd_2O_3-paint(x/1-x); 320g of Gd_2O_3 per litre (Euro Collimators LTD
For several x, Gain=1.9-2.1

Fig.12. Test of small in-house NIP at LADI

Fig.13. Large in-house NIP and commercial Fuji NIP

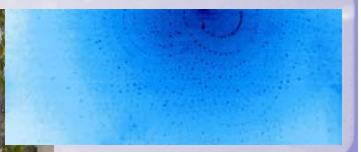


Fig.14. Test of small in-house-made NIP at LADI with glucose isomerase.

Phosphors for future: CsBr:Eu^{2+}, ???

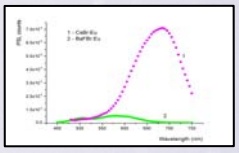


Fig.15. Stimulation spectra of BaFBr:Eu^{2+} and CsBr :Eu^{2+}

Conclusion

We have
- characterized present commercial NIP's
- characterized several new storage phosphors
- made first trials with in-house NIP's
- suggested that CsBr:Eu^{2+} and $^6Li_2{}^{10}B_4O_7$ are worth further development.

Other hardware improvements required are faster scanner and more intense laser sources

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