neutron imaging techniques for industrial imaging

Advances in custom screen design & production offer significant enhancement of performance in thermal neutron imaging. Such improvements are vital to precise operation in very demanding applications.

Background

Thermal neutrons, unlike X-rays, interact with various materials with very specific cross sections, largely independent of Z. Examples of high cross section elements include hydrogen and carbon while iron has a low cross section. The possibility therefore exists to utilise neutrons to image the flow of hydrocarbons within a metal structure or evaluate hydrogen trapping in titanium which could cause a fatal flaw within an aircraft turbine blade.

Conventionally neutron imaging techniques have been the preserve of fundamental research laboratories. However, as such large, centralised facilities have been forced towards commercial operation and the high cost of neutron sources has been declining, industrial corporations have been evaluating the benefits of neutron imaging.

Demands for high performance materials, improved international security, industrial inspection, new medical imaging techniques – all these examples are areas in which neutron imaging is being developed to improve analysis techniques.

Key to development of this technology is high performance detection and imaging technology. With the cost and handling difficulties of ^{3}He and similar point detectors increasing - scintillator design linked to photo-multiplier or CCD imaging systems will be of particular focus.

Further, scintillator systems offer the possibility of large area imaging as well as specially constructed geometries to create very large area, high cross section and cost effective arrays.

Applied Scintillation Technologies Solution

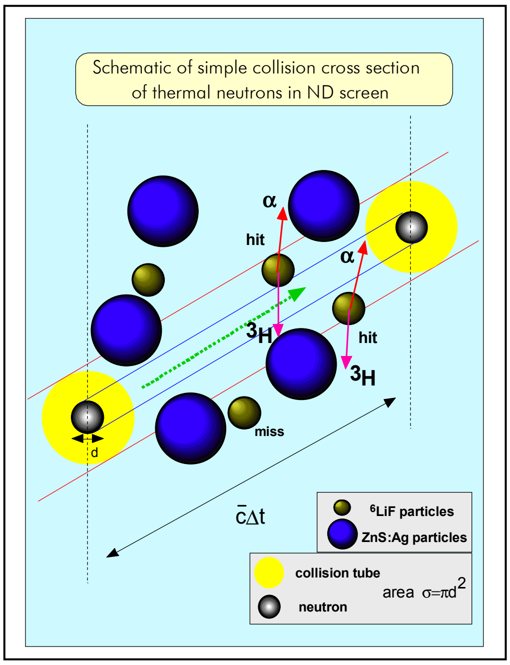
AST manufactures ^{6}Li – cerium activated glass which provides extremely robust thermal neutron scintillators which are commonly used to detect back-scattered neutrons from hydrocarbon baring shales in oil exploration.

While such scintillators may be utilised in a range of applications – particularly in harsh environments – it is AST's development of large area imaging screens which is providing the features and benefits demanded by the developing markets described.

The screens, formed from a blend of ^{6}LiF and a phosphor, rely on the ^{6}Li:thermal neutron interaction shown:

$$^{6}Li + n^{0} \rightarrow He + triton + 4.8MeV$$

The ejected triton interacts with the phosphor to create a scintillation event which can be detected by a PMT or CCD imaging system.



AST, by carefully assessing the compromises required between absorption, sensitivity and resolution in real applications have developed 2 screen formats with features which significantly enhance imaging performance.

AST's blue emitting ND screen has unique, low sensitivity to background gamma to improve discrimination, while AST's NDg emits in the green, ideal for CCD coupling.

Both ND and NDg screen types have been shown to have higher resolution than competitive products while both can be custom manufactured in the largest commercially available size.

AST product advantages

Key to success in developing such high performance neutron imaging screens is AST's comprehensive materials knowledge.

^{6}Li has a large neutron cross section (approx 40mb) but low Z giving good sensitivity with high X-ray discrimination (unlike gadolinium based scintillators for example).

However, it is also essential to ensure maximum capture of tritons (which have a short mean free path) ejected from the ^{6}Li/n^{0} interaction. The volume relationship between phosphor & ^{6}Li is therefore critical with mass ratio, relative particle sizes and material distribution variables needing to be optimised.

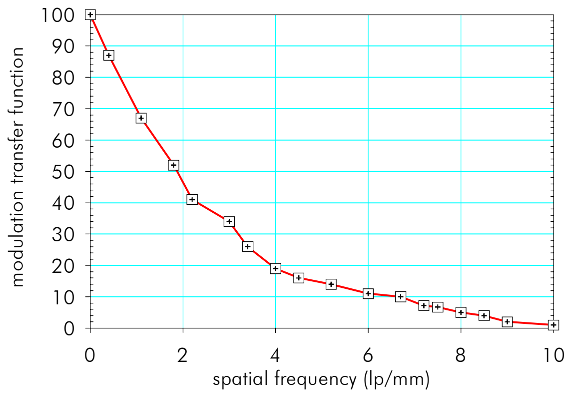
Containing this mix in a stable screen structure, adds further variables - maximising ^{6}Li cross section while minimising self absorption of emitted light.

AST's extensive experience in neutron & X-ray screen development and manufacture have ensured a product optimised for thermal neutron imaging applications.

Typical specification

phosphor	ND (data sheet 39) NDg (data sheet 40)
screen characteristics	
♦ maximum size	1000mm x 800mm
♦ coating weight (standard)	102 mg/cm^2
♦ coating weight variation	+/-8 mg/cm^2
♦ screen thickness (standard)	0.42mm +/-10%
♦ density (standard)	2.4g/cm^3
screen performance	
♦ emission colour	blue (ND type)
♦ green	(NDg type)
♦ peak emission	460nm (ND type)
♦ 560nm	(NDg type)
♦ minimum pulse separation	2.5us
♦ MTF @ 10%	6 lp/mm

MTF curve of AST's ND screen with CCD imaging system



data courtesy of IQI & University of Virginia

Applied Scintillation Technologies has the knowledge and expertise based on years of experience to partner you in the development of custom products for neutron imaging and detection.
Resolution, sensitivity, speed & colour of response are a few of the parameters that can be influenced in the production of a customised product that more closely relates to your customer need.

- A customised product is often a more cost effective solution
- Formulations can be developed to meet your specific requirements
- Exceed your initial expectations through partnership development
- An ISO9002 company – quality assurance is guaranteed through every delivery
- Product differentiation can provide unique product positioning versus competitors
- Enjoy continued product development and technical support through partnership

APPLIED SCINTILLATION TECHNOLOGIES LTD
8 ROYDONBURY INDUSTRIAL ESTATE
HORSECROFT ROAD
HARLOW CM19 5BZ UNITED KINGDOM
TEL +44 [0] 1279 641234 FAX +44 [0] 1279 413679
e-mail sales@appscintech.com

APPLIED SCINTILLATION TECHNOLOGIES

www.appscintech.com