

RMD Publications 2004

539) **A new large area scintillator screen for X-ray imaging**

2004 Nuclear Instruments & Methods in Physics Research, Section B (Beam Interactions with Materials and Atoms) Vol.213 Pages 250-254

Nagarkar VV, Miller SR, Tipnis SV, Lempicki A, Brecher C, Lingertat H

Abstract

*We report on the development of a new, large area, powdered scintillator screen based on Lu₂O₃/Eu. As reported earlier, the transparent ceramic form of this material has a very high density of 9.4 g/cm³, a high light output comparable to that of CsI(Tl), and emits in a narrow spectral band centered at about 610 nm. Research into fabrication of this ceramic scintillator in a large area format is currently underway, however the process is not yet practical for large scale production. Here we have explored fabrication of large area screens using precursor powders from which the ceramics are fabricated. To date we have produced up to 16 * 16 cm² area screens with thickness in the range of 18 mg/cm². This paper outlines the screen fabrication technique and presents its imaging performance in comparison with a commercial Gd₂O₃:Tb (GOS) screen.*

538) **A high efficiency pixelated detector for small animal PET**

2004 IEEE Trans. Nucl. Sci. Vol.51 Pages 801-804

Nagarkar VV, Tipnis SV, Shah KS, Shestakova I, Cherry SR

Abstract

We report on the development of a new high efficiency detector for small animal PET. The detector is based on a monolithic block of LSO pixelated using laser ablation technique. The laser processing allows pixelation with very narrow, 70 μm wide, inter-pixel gaps resulting in a substantially enhanced sensitivity when the detectors are operated in coincidence mode. This paper presents the first results of a detector module fabricated using this approach. Preliminary imaging data at 511 keV obtained by coupling the pixelated LSO to a position sensitive photomultiplier tube (PSPMT) and a position sensitive avalanche photodiode (PSAPD) are presented.

537) **High-speed digital radiography using structured CsI screens**

2004 Nuclear Instruments & Methods in Physics Research, Section B (Beam Interactions with Materials and Atoms) Vol.213 Pages 476-480

Nagarkar VV, Tipnis SV, Gaysinskiy V, Miller SR, Shestakova I

Abstract

*We report on the development of a high-speed digital X-ray radiography system based on a microcolumnar CsI(Tl) scintillator optically coupled to a CCD. The new system is capable of acquiring 248 * 248 pixel images at the speed of 100,000 frames per second. The performance characteristics of CsI(Tl) screen in relation to the high-speed X-ray imaging requirements are described and compared to those of a commercial screen (Gd₂O₃:Pr). Additionally, representative X-ray imaging data acquired with the CsI(Tl) screen at 100,000 fps are presented.*

536) Characterization of very large silicon avalanche photodiodes

2004 IEEE Nucl. Sci. Symp. Conf. Rec. Vol.2 Pages 1270-1273

Entine G, Farrell R, McClish M, Olschner F, Shah KS, Squillante MR

Abstract

In this paper, we discuss recent advances in the high gain, very large area silicon avalanche photodiode technology. Very large area APDs (square and octagonal design, up to 45 cm²/area) have been built using the planar process. These APDs have been successfully operated as scintillation spectrometers. When cooled to -40°C, the energy resolution of 5.9 keV X-rays (⁵⁵Fe source) upon direct interaction with the 45 cm² APD was measured to be 2.4 keV (FWHM). The APD was coupled to a CsI(Tl) scintillator and irradiated with 662 keV gamma rays from ¹³⁷Cs source and the energy resolution was measured to be similar to 10% (FWHM) at the temperature of -40°C. A rise time of 2 ns was measured with the 40 cm² APD upon irradiation with 5.5 MeV alpha particles. A new packaging design has been developed to allow cooling of these large APDs to liquid nitrogen temperature. Evaluation of the 45 cm² APD has been conducted at LN₂ temperatures. Its gain was found to be as high as 10⁴, while the noise was measured to be similar to 0.8 electrons (rms). Detection of low intensity optical signal (LS@8 photons/pulse) with the 45 cm² APD has also been accomplished. COPYRIGHT 2004 IEEE.

535) Effects of Ce concentration on scintillation properties of LaBr₃:Ce

2004 IEEE Nucl. Sci. Symp. Conf. Rec. Vol.2 Pages 998-1001

Derenzo SE, Glodo J, Higgins WM, Moses WW, Shah KS, Van Loef EVD, Weber MJ, Wong P

Abstract

In this communication we report on our investigation of scintillation properties of LaBr₃:Ce as a function of Ce concentration. We have studied crystals nominally doped with 0.5, 5, 10, 20, and 30%Ce (by mole). Reports published so far suggested that as the Ce content increases, there is a decrease in light output and little or no change in decay time constants. Our results show that the light output does not change with Ce concentration up to 30% and depends mostly on the crystal and measurement quality. On the other hand we have found timing properties to be a strong function of concentration. As the Ce content increases the principal decay time constant of scintillation decreases from similar to 26 ns for 0.5%Ce to similar to 17 ns for crystals with >5%Ce. Moreover, there is also a significant change in rise time constants. The rise time measured for a sample doped with 0.5%Ce is up to 9 ns, whereas for samples doped with >10%Ce it reduces to less than 0.5 ns. The change of rise time has a major effect on the timing properties of this scintillator, with timing resolution improving from 390 ps to less than 200 ps (FWHM). COPYRIGHT 2004 IEEE.

534) Optical and scintillation properties of Cs₂LiYCl₆:Ce³⁺ and Cs₂LiYCl₆:Pr³⁺ crystals

2004 IEEE Nucl. Sci. Symp. Conf. Rec. Vol.1 Pages 265-268

Glodo J, Higgins WM, Shah KS, Van Loef EVD

Abstract

In this paper we report on the optical and scintillation properties of Cs₂LiYCl₆:Ce³⁺ and Cs₂LiYCl₆:Pr³⁺ crystals. Crystals of Cs₂LiYCl₆ doped with different Ce³⁺ and Pr³⁺ concentrations were grown and studied under optical, X-ray, gamma ray, and thermal neutron excitation. These scintillators exhibit core-valence and self-trapped exciton luminescence in addition to fast emission from Ce³⁺ and Pr³⁺. Efficient thermal neutron detection was observed for both scintillators. The position of the neutron peak in its pulse height spectrum was found at about 5 times the channel number of the position of the gamma peak. COPYRIGHT 2004 IEEE.

533) **A new sensor for thermal neutron imaging**

2004 IEEE Nucl. Sci. Symp. Conf. Rec. Vol.1 Pages 254-258

Antal JJ, Bobek L, Gaysinskiy V, Nagarkar VV, Shestakova I, Tipnis SV

Abstract

Thermal neutrons serve as a useful tool in probing macromolecular structures in protein crystallography and in investigations of new materials. However, neutron techniques are underutilized due to the lack of high performance digital, position sensitive detectors. The primary limiting factor in current detectors is the converter screen which converts the neutron signal into visible light. Here we report on a new type of neutron sensitive screen for use in digital imaging systems. The screen consists of a pixelated, microstructured CsI(Tl) scintillator film sandwiched between two neutron converting layers of GdF/sub3/. To increase the effective surface area of the GdF/sub3/ conversion layer and to enhance the contrast resolution of the images, the CsI(Tl) layer is pixelated using micromachining techniques. For testing their imaging performance, the sensors were optically coupled to a CCD system to form an imaging detector. The system was subjected to imaging tests at a thermal neutron port of the University of Massachusetts Lowell Research Reactor. The results of these preliminary imaging experiments are presented here. COPYRIGHT 2004 IEEE.

532) **Investigation of CZT devices with capacitive frisch grids**

2004 IEEE Nucl. Sci. Symp. Conf. Rec. Vol.7 Pages 4402-4406

Cirignano L, Kim H, Klugerman M, Li L, Shah KS, Wong P

Abstract

Recent experimental results and simulations of planar CZT detectors with capacitive Frisch grids are presented. A computer program which incorporates material properties, device design, and operating conditions was developed to simulate device performance. Simulated spectra were compared with measured spectra. Energy resolution of 1.7% at 662 keV was obtained at room temperature for a device with dimensions of 5mm 5mm and 10mm. Spectra also were compared with spectra from a scintillator/photodetector. COPYRIGHT 2004 IEEE.

531) **CeBr/sub3/ scintillators for gamma-ray spectroscopy**

2004 IEEE Nucl. Sci. Symp. Conf. Rec. Vol.7 Pages 4278-4281

Derenzo SE, Glodo J, Higgins WM, Moses WW, Shah KS, Van Loef EVD, Weber MJ

Abstract

In this paper, we report on a new scintillator, cerium bromide (CeBr /sub3/), for gamma-ray spectroscopy. Crystals of this scintillator have been grown using Bridgman process. In CeBr/sub3/, Ce/sup3+/ is an intrinsic constituent as well as a luminescence center for the scintillation process, has high light output (similar to 68,000 photons/MeV) and fast decay constant (similar to 17 ns). Furthermore, it shows excellent energy resolution for gamma-ray detection. For example, energy resolution of \$LS@4% (FWHM) has been achieved using this scintillator for 662 keV photons (/sup137/Cs source) at room temperature. High timing resolution (\$LS@200 ps - FWHM) has been recorded with CeBr/sub3/-PMT (photomultiplier tubes) and BaF/sub2/-PMT detectors operating in coincidence using 511 keV positron annihilation gamma-ray pairs. Potential applications of this material are addressed. COPYRIGHT 2004 IEEE.

530) **A CCD-based detector for SPECT**

2004 IEEE Nucl. Sci. Symp. Conf. Rec. Vol.4 Pages 2449-2452

Barber W, Entine G, Gaysinskiy V, Hasegawa B, Nagarkar VV, Shestakova I, Singh B, Tipnis SV

Abstract

We are investigating the use of a CCD for high-resolution radionuclide imaging. The use of a CCD has the potential to provide very high spatial resolution on the order of 200 to 400 μm , while significantly simplifying the readout electronics. The detector is based on a special CCD with on-chip multiplication gain that allows high-speed operation while maintaining the read noise at a very low level of 1e^- electron. To achieve high detection efficiency and excellent spatial resolution for incident gamma flux, a specially fabricated thick microcolumnar CsI(Tl) scintillator was optically coupled to the CCD. A prototype SPECT imaging system was assembled by incorporating pinhole/parallel hole collimators in the design. The use of this system for radionuclide imaging has been demonstrated through tomographic imaging of a test phantom filled with $^{99\text{m}}\text{Tc}$. COPYRIGHT 2004 IEEE.

529) **Microcolumnar CsI (TI) films for small animal SPECT**

2004 IEEE Nucl. Sci. Symp. Conf. Rec. Vol.5 Pages 3334-3337

Gaysinskiy V, Nagarkar VV, Shestakova I, Taylor S

Abstract

Microcolumnar CsI(Tl) films in the range of 50 to 500 μm thickness are routinely used in digital x-ray imaging as they simultaneously provide a high spatial resolution and excellent x-ray absorption. The use of such films for radionuclide imaging has not yet been possible due to the unavailability of thick films required to provide adequate stopping power for gamma ray energies typically used in such applications. We report here the development of up to 2.6 mm thick microcolumnar CsI(Tl) films well suited for small animal SPECT imaging using such radioisotopes as ^{125}I (similar to 30 keV) and $^{99\text{m}}\text{Tc}$ (140 keV). This paper discusses scintillator fabrication, characterization, and demonstrates its use for high resolution SPECT imaging. The data show that a resolution of 400 μm in reconstructed images can be achieved using this approach. COPYRIGHT 2004 IEEE.

528) **A high speed functional MicroCT detector for small animal studies**

2004 IEEE Nucl. Sci. Symp. Conf. Rec. Vol.5 Pages 3229-3233

Entine G, Gaysinskiy V, Nagarkar VV, Paulus MJ, Shestakova I, Singh B, Tipnis SV

Abstract

Dedicated MicroCT systems for noninvasive screening of small animals are now in routine use. However, speed of operation limits their use for functional studies. At RMD we are addressing this need by developing a digital x-ray detector that can simultaneously provide high speed, high sensitivity, and a large active imaging area. The system consists of a special high speed CCD detector optically coupled to a scintillator. In its current configuration, the system provides 5 cm² active area, spatial resolution of similar to 100 μm , and can operate at speeds of up to 225 frames per second. The system has been used to acquire volumetric CT data with 360 projections in similar to 12 seconds compared to several minutes needed for most commercial systems. This paper presents design of various system components and performance characterization along with the CT reconstruction data on a mouse phantom. COPYRIGHT 2004 IEEE.

527) **High-performance scintillator screen for medical imaging applications**

2004 Proc SPIE Int Soc Opt Eng Vol.5541 Pages 133-140

Miller SR, Nagarkar VV, Shestakova I, Tipnis SV

Abstract

*We report on recent advances in the development of powdered Lu₂O₃:Eu scintillator screens. The Lu₂O₃:Eu scintillator has excellent intrinsic material properties including high density (9.5 g/cm³), high average atomic number (63), and a peak emission of 610 nm. We have characterized the performance of screens fabricated from this material in comparison with commercial Gd₂O₂S:Tb screens. This paper presents resolution in terms of MTF(*f*), noise properties in terms of NPS(*f*), and overall NEQ(*f*), obtained by coupling the screens to a CCD detector. We have included sample radiographic images that demonstrate the ability to produce high quality images. These screens are currently under development, and further improvements in performance are expected with optimization of the scintillator and fabrication methods.*

526) **High energy resolution scintillation spectrometers**

2004 IEEE Trans Nucl Sci Vol.5 (1) Pages 2395-2399

Glodo J, Gupta T, Higgins W, Klugerman M, Shah KS, Wong P

Abstract

In this paper, we report on cerium doped scintillator-LaBr₃:Ce for gamma ray spectroscopy. Crystals of this scintillator have been grown using the Bridgman process. This material when doped with cerium has high light output (~60000 photons/MeV) and fast principal decay constant (~30 ns). The peak of LaBr₃:Ce emission is at 360 nm. LaBr₃:Ce shows excellent energy resolution for gamma ray detection. For 662 keV gamma rays (137Cs source), energy resolution of 2.6% (full-width at half-maximum) has been recorded at room temperature for LaBr₃:Ce crystals coupled to a photomultiplier. This energy resolution is over two times better than that of NaI(Tl) scintillators. Analysis of the energy resolution of LaBr₃:Ce scintillators is presented. Energy resolution of LaBr₃:Ce crystals coupled to silicon avalanche photodiodes is also discussed.

525) **Lu₁3:Ce - A new scintillator for gamma ray spectroscopy**

2004 IEEE Trans Nucl Sci Vol.51 Pages 2302-2305

Derenzo SE, Dorenbos P, Glodo J, Gupta T, Higgins W, Klugerman M, Moses WW, Shah KS, Weber MJ, Wong P

Abstract

In this paper, we report on a new cerium doped, high atomic number scintillator, Lu₁3:Ce, for gamma ray spectroscopy. Crystals of this material have been grown using Bridgman process. Lu₁3 crystals doped with 0.5 and 5% Ce³⁺ show high light output (similar to 50000 photons/MeV) and fast principal decay constant (23 to 31 ns). The Ce³⁺ emission peaks at 474 nm. Energy resolution of Lu₁3:Ce coupled to photomultiplier tube (PMT) and measured at 662 keV was similar to 11% full-width at half-maximum (FWHM). Timing resolution of Lu₁3-PMT and BaF₂-PMT detectors operating in coincidence mode was measured to be 210 ps (FWHM). Potential applications of this scintillator are discussed.

524) A high efficiency pixelated detector for small animal PET

2004 IEEE Trans Nucl Sci Vol.51 Pages 801-804

Cherry SR, Nagarkar VV, Shah K, Shestakova I, Tipnis SV, Sameer V

Abstract

We report on the development of a new high efficiency detector for small animal PET. The detector is based on a monolithic block of LSO pixelated using laser ablation technique. The laser processing allows pixelation with very narrow, 70 μ m wide, inter-pixel gaps resulting in a substantially enhanced sensitivity when the detectors are operated in coincidence mode. This paper presents the first results of a detector module fabricated using this approach. Preliminary imaging data at 511 keV obtained by coupling the pixelated LSO to a position sensitive photomultiplier tube (PSPMT) and a position sensitive avalanche photodiode (PSAPD) are presented.

523) Investigation of the energy resolution and charge collection efficiency of Cd(Zn)Te detectors with three electrodes

2004 IEEE Trans Nucl Sci Vol.51 Pages 1229-1234

Cirignano L, Kim H, Shah K, Squillante M, Wong P

Abstract

Radiation Monitoring Devices, Inc., has recently investigated Cd(Zn)Te detector with three electrodes. Planar devices were refabricated as three-electrode devices after recording pulse height spectra. From the spectroscopy measurements at room temperature, photon energy resolutions of 8.3% and 3.5% FWHM were obtained, without noticeable loss of the detector efficiency, with the "three-electrode detector" for gamma ray energies of 122 and 662 keV, respectively, while no discernable full energy peaks were apparent with the planar detectors. The full contact cathode was grounded while two different bias voltages were applied to each anode electrode, even though the induced signal was collected only from the center anode. By investigation of the real and weighting electric field of the detector, the possible reasons for the improved spectra with the three-electrode detector were determined. The strong real electric field around the two anodes very likely enhances the created charge velocity and results in increasing the possibility to induce full charge collection. From additional measurements with increased differences between two bias voltages applied to the anodes, the effects of the strong real electric field on the improved energy spectrum have been confirmed.

522) Feasibility of a beta-gamma digital imaging probe for radioguided surgery

2004 IEEE Trans Nucl Sci Vol.51 Pages 110-116

Entine G, Gaysinskiy V, Nagarkar VV, Shestakova I, Stack BC, Tipnis SV, Tornai MP

Abstract

We report here on a novel design of a digital, intraoperative imaging probe intended for use in radio-guided surgical procedures in conjunction with radiolabels such as ^{131}I and ^{18}F . The probe allows the user to rapidly localize tumors by detecting the highly penetrating gamma rays, and then image the tumor with the short-range beta rays. The system provides a rapid, high-resolution, image of the interrogated area, fulfilling the need for clear delineation of tumors during radio-guided surgical procedures. The beta imaging sensor consists of a micro-columnar CsI(Tl) scintillator screen capable of providing very high detection efficiency, high light output and excellent spatial resolution coupled to a CCD via a flexible, coherent fiberoptic bundle. The gamma sensor is a shielded piece of crystalline CsI(Tl) coupled to a photodiode located behind the image sensitive front end. The feasibility of this design was studied by separately testing the beta imaging and gamma detection components. The operation of the components was characterized with intrinsic performance measurements of count rates, signal-to-noise ratios, spatial resolution, as well as time for acquiring useful images using radionuclide and anthropomorphic phantoms.

521) Position sensitive APDs for small animal PET imaging

2004 IEEE Trans Nucl Sci Vol.51 Pages 91-95

Cherry SR, Dokhale PA, Entine G, Farrell R, Glodo J, Grazioso R, McClish MA, Shah KS

Abstract

In this paper, investigation of position sensitive avalanche photodiodes (PSAPDs) as optical detectors for reading out segmented scintillation arrays of LSO in high resolution PET modules is reported. PSAPDs with 8 × 8 mm² and 14 × 14 mm² area have been characterized with single LSO crystals and arrays. Energy resolution of 19% (FWHM) for 511 keV γ -rays and coincidence timing resolution of similar to 3 ns (FWHM) have been recorded with PSAPD coupled to 1 × 1 × 20 mm³ LSO detectors. Flood histogram studies have been successfully conducted by coupling multi-element element LSO arrays (1 mm pixels, 20 mm tall) to the PSAPDs. Finally, depth of interaction (DOI) resolution of \pm 4.5 mm (FWHM) has been measured by coupling two PSAPDs on opposite ends of a 20 mm long LSO crystal with a 1 × 1 mm² cross section. Based on these results, PSAPDs appear to be promising for high resolution PET. An important advantage of these PSAPDs is significant reduction in electronic readout requirements.

520) Evaluation of CZT detectors with capacitive Frisch grid structure

2004 Proc SPIE Int Soc Opt Eng Vol.5198 Pages 1 - 8

Cirignano L, Kim H, Klugerman M, Li L, Shah KS, Squillante MR, Wong P

Abstract

Recent results have shown that capacitive Frisch grid structures significantly improve spectroscopic performance of planar CZT detectors especially at higher energies. This paper presents results obtained with larger detectors than those previously reported on. Devices with various aspect ratios and grid length-to-device thickness ratios were fabricated and evaluated. A FWHM energy resolution of approximately 2% at 662 keV was obtained for a device with dimensions of 5 mm × 5 mm × 9.2 mm.

519) High-speed digital radiography using structured CsI screens

2004 Nucl Instrum Methods Phys Res Sect B Vol.213 Pages 476-480

Gaysinskiy V, Miller SR, Nagarkar VV, Shestakova I, Tipnis SV

Abstract

We report on the development of a high-speed digital X-ray radiography system based on a microcolumnar CsI(Tl) scintillator optically coupled to a CCD. The new system is capable of acquiring 248 × 248 pixel images at the speed of 100,000 frames per second. The performance characteristics of CsI(Tl) screen in relation to the high-speed X-ray imaging requirements are described and compared to those of a commercial screen (Gd₂O₂S(Pr)). Additionally, representative X-ray imaging data acquired with the CsI(Tl) screen at 100,000 fps are presented. © 2003 Elsevier B.V. All rights reserved.

518) A new large area scintillator screen for X-ray imaging

2004 Nucl Instrum Methods Phys Res Sect B Vol.213 Pages 250-254

Brecher C, Lempicki A, Lingertat H, Miller SR, Nagarkar VV, Tipnis SV

Abstract

We report on the development of a new, large area, powdered scintillator screen based on Lu₂O₃(Eu). As reported earlier, the transparent ceramic form of this material has a very high density of 9.4 g/cm³, a high light output comparable to that of CsI(Tl), and emits in a narrow spectral band centered at about 610 nm. Research into fabrication of this ceramic scintillator in a large area format is currently underway, however the process is not yet practical for large scale production. Here we have explored fabrication of large area screens using precursor powders from which the ceramics are fabricated. To date we have produced up to 16 × 16 cm² area screens with thickness in the range of 18 mg/cm². This paper outlines the screen fabrication technique and presents its imaging performance in comparison with a commercial Gd₂O₂S:Tb (GOS) screen. ©CPY 2003 Elsevier B.V. All rights reserved.

517) High spatial resolution x-ray telescope using fresnel zone plates and pixilated APDs

2004 IEEE Nucl Sci Symp .Rome, Italy

Entine G, Myers R, Tiernan TC

516) Investigations of photolysis and rebinding kinetics in myoglobin using proximal ligand replacements

2004 Biochemistry Vol.43 Page 11109

Cao W, Ye X, Sjodin T, Christian JF, Demidov AA, Berezhna S, Wang W, Barrick D, Sage JT, Champion PM

Abstract

We use laser flash photolysis and time-resolved Raman spectroscopy of CO-bound H93G myoglobin (Mb) mutants to study the influence of the proximal ligand on the CO rebinding kinetics. In H93G mutants, where the proximal linkage with the protein is eliminated and the heme can bind exogenous ligands (e.g., imidazole, 4-bromoimidazole, pyridine, or dibromopyridine), we observe significant effects on the CO rebinding kinetics in the 10 ns to 10 ms time window. Resonance Raman spectra of the various H93G Mb complexes are also presented to aid in the interpretation of the kinetic results. For CO-bound H93G(dibromopyridine), we observe a rapid large-amplitude geminate phase with a fundamental CO rebinding rate that is approximately 45 times faster than for wild-type MbCO at 293 K. The absence of an iron proximal ligand vibrational mode in the 10 ns photoproduct Raman spectrum of CO-bound H93G(dibromopyridine) supports the hypothesis that proximal ligation has a significant influence on the kinetics of diatomic ligand binding to the heme.

515) Characterization and modeling of APD pixels made with CMOS technology

2004 Nano-Materials for Defense Applications Symp, Maui, HI Vol.Feb. 19-26

Christian JF, Svolos G, Kogan AI, Augustine FL, Squillante MR, Entine G

514) Portable video/gamma camera for surveillance, safeguards, treaty verification and area monitoring

2004 Proc. 45th INMM Annual Meeting, Orlando, FL Vol.July 18-22

Christian JF, Squillante MR, Woodring M, Entine G

513) LIBS using avalanche photodiode array

2004 3rd Intl Conf on Laser Induced Plasma Spectroscopy and Applications (LIBS), Malaga, Spain .Sept. 28-Oct. 1

Gurjar R, Karger A, Hahn D

512) Performance measurements of a depth-encoding PET detector module based on position-sensitive avalanche photodiode read-out

2004 Phys Med Biol Vol.49 Pages 4293-4304

Dokhale PA, Silverman RW, Shah KS, Grazioso R, Farrell R, Glodo J, McClish MA, Entine G, Tran VH, Cherry SR

Abstract

We are developing a high-resolution, high-efficiency positron emission tomography (PET) detector module with depth of interaction (DOI) capability based on a lutetium oxyorthosilicate (LSO) scintillator array coupled at both ends to position-sensitive avalanche photodiodes (PSAPDs). In this paper, we present the DOI resolution, energy resolution and timing resolution results for complete detector modules. The detector module consists of a 7 x 7 matrix of LSO scintillator crystals (1 x 1 x 20 mm³ in dimension) coupled to 8 x 8 mm² PSAPDs at both ends. Flood histograms were acquired and used to generate crystal look-up tables. The DOI resolution was measured for individual crystals within the array by using the ratio of the signal amplitudes from the two PSAPDs on an event-by-event basis. A measure of the total scintillation light produced was obtained by summing the signal amplitudes from the two PSAPDs. This summed signal was used to measure the energy resolution. The DOI resolution was measured to be 3-4 mm FWHM irrespective of the position of the crystal within the array, or the interaction location along the length of the crystal. The total light signal and energy resolution was almost independent of the depth of interaction. The measured energy resolution averaged 14% FWHM. The coincidence timing resolution measured using a pair of identical detector modules was 4.5 ns FWHM. These results are consistent with the design goals and the performance required of a compact, high-resolution and high-efficiency PET detector module for small animal and breast imaging applications.