494) **Multiplexed avalanche photodiode arrays for radiation imaging**

2002 X-Ray and Gamma-Ray Detectors and Applications IV, Seattle, WA, July 7-9, 2002, Bellingham, WA, Society of Photo-Optical Instrumentation Engineers.July 7-9

Woodring ML, Farrell R, Christian JF, Kogan AI, Squillante MR, Entine G, Wehe DK

Abstract

The development of monolithic arrays of multiplexed, high-gain avalanche photodiodes suitable for use in a spectroscopic radiation-imaging device is underway at RMD. To dramatically reduce the electronics required to support a large array of discrete pixels, we have utilized a unique property of avalanche photodiodes and the method in which they are produced to develop a relatively simple readout scheme using row-column addressing. By adding a step to the avalanche photodiode creation, it is possible to place two separate diode contacts onto the back of each photodiode in the array. These isolation diodes allow the readout of an entire row or column of photodiodes through a common readout line. A data-decoding matrix uniquely determines the position in the array while simultaneously supporting the goal of reducing the number of signal readout lines and support electronics. This approach reduces the number of pre-amplifiers, pulse-shaping circuits, and sample-and-hold stages from n exp 2 to 2n (n pixels on a side) per array. Recent research has been carried out with a 14 x 14 pixel, planar-processed avalanche photodiode array having pixels 2.00 mm on a side with 2.25-mm pitch. These arrays will be paneled to form the photodetector of a radiation imager of approximately 100-sq cm photosensitive area. To reduce the contribution of noise from each pixel to the common readout lines, research is being carried out to develop a discriminator with an adjustable threshold for each avalanche photodiode readout connection. Initial performance results from multiplexed arrays, a discussion of the active discrimination contacts, and the current status of the imager research project are given.

493) **Multiplexed avalanche photodiode arrays for radiation imaging**

2002 Proceedings of SPIE Vol.4784 Pages 199-207

Woodring ML, Farrell R, Christian JF, Kogan AI, Squillante MR, Entine G, Wehe DK

Abstract

The development of monolithic arrays of multiplexed, high-gain avalanche photodiodes suitable for use in a spectroscopic radiation-imaging device is underway at RMD. To dramatically reduce the electronics required to support a large array of discrete pixels, we have utilized a unique property of avalanche photodiodes and the method in which they are produced to develop a relatively simple readout scheme using row-column addressing. By adding a step to the avalanche photodiode creation, it is possible to place two separate diode contacts onto the back of each photodiode in the array. These isolation diodes allow the readout of an entire row or column of photodiodes through a common readout line. A data-decoding matrix uniquely determines the position in the array while simultaneously supporting the goal of reducing the number of signal readout lines and support electronics. This approach reduces the number of pre-amplifiers, pulse-shaping circuits, and sample-and-hold stages from n exp 2 to 2n (n pixels on a side) per array. Recent research has been carried out with a 14 x 14 pixel, planar-processed avalanche photodiode array having pixels 2.00 mm on a side with 2.25-mm pitch. These arrays will be paneled to form the photodetector of a radiation imager of approximately 100-sq cm photosensitive area. To reduce the contribution of noise from each pixel to the common readout lines, research is being carried out to develop a discriminator with an adjustable threshold for each avalanche photodiode readout connection. Initial performance results from multiplexed arrays, a discussion of the active discrimination contacts, and the current status of the imager research project are given.

492) **Photon-counting spectrometer for elemental analysis using LIBS**

2002 Proc SPIE Int Soc Opt Eng Vol.4878 Pages 49-53

Karger A, Myers R, Taylor D

Abstract

Avalanche Photodiode (APD) arrays are being applied to Laser-Induced Breakdown Spectroscopy (LIBS) for elemental analysis with standoff detection capability. This instrument, which represents a valuable addition to planetary rover missions as well as Earth-based applications, benefits from the advantages common to both Geiger-mode and proportional-mode APDs, which are solid-state detectors with virtually single-photon sensitivity, higher quantum efficiency than photomultiplier tubes or intensified CCDs, and rapid sub-nanosecond response speed. We have demonstrated LIBS detectability better than 770 parts-per-billion of sodium utilizing the photon-counting Geiger-mode APD. In a LIBS system, an APD array offers the unparalleled prospect of selecting in each channel the most appropriate temporal window for detecting the target species. In real-time detection systems, such as microfluidics-based fluorescence detection of bacterial spores, these compact, robust APD arrays promise portable hand-held instruments that utilize tight optical coupling.

491) **Position Sensitive APDs for Small Animal Pet Imaging**

2002 IEEE Nucl Sci Symp Med Imaging Conf Vol.3 Pages 1411-1415

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

Abstract

In this paper, an 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 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 〈 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.

490) **A Novel, Distortion-Free Position Sensitive APD for Nuclear Imaging**

2002 IEEE Nucl Sci Symp Med Imaging Conf Vol.1 Pages 464-467

Farrell R, Glodo J, Grazioso R, Olschner F, Shah KS

Abstract

We have investigated a new position sensitive avalanche photodiode (PSAPD) for indirect and direct radiation imaging. This PSAPD exhibits minimal image distortion and still has all the attractive characteristics of our normal high gain APDs. The arc-PSAPD incorporates a resistive arc between the corner contacts which eliminates the 'pincushion' or 'barrel' effect commonly seen with four corner contact devices. Simulations have been performed to model the position distortion of such a device. Position and energy resolution have also been measured with these devices. Gamma ray imaging with various scintillator arrays and direct charged particle and low energy x-ray images have been acquired.

489) **LaBr₃:Ce Scintillators for Gamma Ray Spectroscopy**

2002 IEEE Nucl Sci Symp Med Imaging Conf Vol.1 Pages 92-95

Derenzo SE, Glodo J, Klugerman M, Moses WW, Shah KS, Weber MJ

Abstract

In this paper, we report on a relatively new scintillator - LaBr 3 for gamma ray spectroscopy. Crystals of this scintillator have been grown using Bridgman process. This material when doped with cerium has high light output (similar to 60,000 photons/MeV) and fast principal decay constant (?25 ns). Furthermore, it shows excellent energy resolution for ?-ray detection. Energy resolution of 3.2% (FWHM) has been achieved for 662 keV photons (137Cs source) at room temperature. High timing resolution (260 ps - FWHM) has been recorded with LaBr3-PMT and BaF 2-PMT detectors operating in coincidence mode using 511 keV positron annihilation ?-ray pairs. Details of its scintillation properties, and variation of these properties with changing cerium concentration are reported. Potential applications of this material are also addressed.

488) **Feasibility of a Beta-Gamma Digital Imaging Probe for Radioguided Surgery**

2002 IEEE Nucl Sci Symp Med Imaging Conf Vol.1 Pages 43-47

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 ¹³¹I and ¹⁸F. 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 microcolumnar CsI(TI) 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(TI) 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.

487) **High-speed x-ray imaging camera for time-resolved diffraction studies**

2002 IEEE Trans Nucl Sci Vol.49 (II) Pages 2415-2419

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

Abstract

We report here on a high-speed X-ray imaging camera, specifically developed for time resolved diffraction studies using synchrotron and laboratory X-ray sources. This camera is capable of acquiring six X-ray images at speeds of up to 2300 frames per second (f/s). The system is based on a modified architecture charge coupled device (CCD) optically coupled to a fiber-optic taper via an image intensifier. The front end of the taper is coupled to a specially designed microstructured CsI(Tl) scintillator screen capable of providing high light output, very high-detection efficiency, and excellent spatial resolution. In addition to the time resolved diffraction studies, this detector will be extremely valuable in applications such as dynamic imaging of small animals, X-ray microtomography, and materials science applications. This paper discusses the design and performance characterization of the imaging system. Additionally, we present some preliminary high-speed X-ray imaging data obtained using laboratory X-ray sources.

486) **Position-sensitive avalanche photodiodes for gamma-ray imaging**

2002 IEEE Trans Nucl Sci Vol.49 (I) Pages 1687-1692

Farrell R, Grazioso R, Harmon ES, Karplus E, Shah KS

Abstract

In this paper, we report on the investigation of silicon avalanche photodiodes (APDs) for high-energy photon imaging applications. This includes a new APD design that provides X-ray and X-ray imaging with significant reduction in electronic readout requirements. This new APD design, referred to as position-sensitive avalanche photodiode (PSAPD), involves charge sharing amongst the electrodes that enable determination of position of interaction. PSAPDs with 14 215; 14 mm² area have been fabricated using planar processing. The performance of these devices has been evaluated for energy resolution, timing resolution (4 ns full-width at half-maximum), and spatial resolution (similar to 300 um intrinsic spatial resolution). The potential of these APDs in high-energy physics and medical imaging is addressed.

485) **RbGd2/Br7/: Ce scintillators for gamma-ray and thermal neutron detection**

2002 IEEE Trans Nucl Sci Vol.49 (I) Pages 1655-1660

Bennett PR, Cirignano L, Derenzo SE, Grazioso R, Gupta TK, Klugerman M, Moses WW, Shah KS, Weber MJ

Abstract

In this paper, we report on gamma-ray and thermal neutron detection with RbGd₂Br₇ : Ce scintillators. RbGd₂Br₇ : Ce (RGB) is a new scintillator material that shows high light output (56 000 photons/MeV) and has a fast principal decay constant (45 ns) when doped with 10% Ce. These properties make RGB an attractive scintillator for γ-ray detection. Also, due to the presence of Gd as a constituent, RGB has a high cross-section for thermal neutron absorption and can achieve close to 100 % stopping efficiency with 0.5-mm-thick RGB crystals. Crystals of RGB with three different Ce concentrations (0.1, 5, and 10%) have been grown. Their basic scintillation properties such as light output, decay time, and emission spectrum have been measured. In addition, high-efficiency thermal neutron detection has been confirmed in our studies.

484) **Complex formation of cytochrome P450cam with putidaredoxin: Evidence for protein-specific interactions involving the proximal thiolate ligand**

2002 J Biol Chem Vol.277 Page 2547

Unno M, Christian JF, Sjodin T, Benson DE, MacDonald IDG, Sligar SG, Champion PM

Abstract

We have performed resonance Raman studies on ferrous NO- and CO-adducts of cytochrome P450(cam) and investigated the effects of diprotein complex formation with reduced putidaredoxin. We have found that the Fe-NO stretching mode of NO-P450(cam) can be resolved into two peaks at 551 and 561 cm(-1), and the binding of putidaredoxin increases the intensity of the high frequency component. Because the Fe-NO mode has been shown to be more sensitive to the nature of the heme proximal ligand than to the distal pocket environment, such a perturbation upon putidaredoxin binding is suggestive of changes in conformation or electronic structure that affect the proximal iron-cysteine bond. In accordance with this idea, the isotope shifts for the Fe-XO stretching and Fe-X-O bending modes (X = N or C) are insensitive to the presence or absence of putidaredoxin, indicating that the geometry of the Fe-X-O unit is not significantly altered by the complex formation. On the other hand, complex formation does induce a perturbation of the low frequency heme vibrational modes, suggesting that alterations of the heme electronic structure and/or geometry take place when putidaredoxin binds. We also find that cytochrome b(5) minimally affects the heme active site of the enzyme, although both putidaredoxin and cytochrome b(5) bind to the same or similar site on P450(cam). These observations suggest that there is a key specific interaction between P450(cam) and putidaredoxin, and that this interaction increases the population of a protein conformation that exhibits structural and/or electronic distortions of the heme group associated with the proximal side of the heme pocket and the S --> Fe electron donation. These electronic and structural changes are potentially correlated with H-bonding to the proximal cysteine.

483) **Plasma etching of cesium iodide**

2002 J Vasc Sci Technology A Vol.20 Pages 132-137

Yang X, Hopwood J, Tipnis S, Nagarkar V, Gaysinskiy V