RMD Publications 2001

482) **Room-temperature semiconductor device and array configurations**

2001 Nucl Instrum Methods Phys Res Sect A Vol.458 Pages 288-296

Cirignano L, Grazioso R, Squillante MR

Abstract

The use of high atomic number, room-temperature semiconductors for radiation detectors always involves making compromises to optimize the performance for specific applications. In recent years, a number of sophisticated device configurations and a variety of new read-out methods have been developed to extract the desired information from the detector signal. These approaches have significantly mitigated the effects of the inherent deficiencies found in available materials and have opened the way for promising new applications. The benefits of such approaches and their limitations are reviewed for CdTe and Cd _{1-x}Zn_xTe (CZT) devices.

481) **X-ray imaging with PbI₂-based a-Si:H flat panel detectors**

2001 Nucl Instrum Methods Phys Res Sect A Vol.458 Pages 140-147

Bennett P, Cirignano L, Dmitriyev Y, Entine G, Klugerman M, Shah KS, Squillante MR, Street RA

Abstract

*In this paper, we discuss a new X-ray imaging detector which consists of lead iodide polycrystalline films as sensor and amorphous silicon flat panel arrays as read out. We present our investigation of such a detector in 5 cm*5 cm format with 100 mu m pixels. The signal amplitude, and sensitivity of the films have been measured along with spatial resolution properties such as line spread function (LSF) and modulation transfer function (MTF). Real-time imaging performance at 30 frames/s of lead iodide films has also been evaluated using vidicon tube approach. Important properties of lead iodide film are also discussed. Finally, the potential applications of this detector are analyzed.*

480) **A high-resolution, high-speed CT/radiography system for NDT of adhesive bonded composites**

2001 Proceedings of SPIE - The International Society for Optical Engineering Vol.4503 Pages 265-273

Nagarkar VV, Miller SR, Tipnis SV, Gaysinskiy V, Lempicki A, Brecher C

Abstract

Adhesive bonded composites used in naval, aerospace, and automotive technologies require routine nondestructive testing (NDT) to detect flaws and other integrity-reducing anomalies such as porosity, kissing disbonds, and delaminations. We have developed an x-ray radiography/CT system with fast scanning times based on high resolution, high efficiency scintillators coupled to a 1024 x 1024 pixel CCD via a fiberoptic taper. Typical CT systems for NDT use a fan beam x-ray source and a linear array of detectors, with scan times on the order of 10 hours depending on the desired resolution. The prototype CCD-based volumetric imaging system described here is capable of reducing this scan time to <1 hour while significantly improving resolution. Additionally, the system is capable of both CT and standard radiographic imaging. We have integrated two different scintillators in the prototype system. One is a structured CsI(Tl) screen, and the other is a new, pixelated, transparent optical ceramic (TOC) scintillator. This unique TOC has a density of 9.5 g/cm super(3) and a peak emission of 610 nm, particularly suitable for Si readouts. We present here the system design and preliminary results of radiographic imaging and volumetric CT reconstruction.

479) **High speed X-ray imaging camera for time resolved diffraction studies**

2001 IEEE Nuclear Science Symposium and Medical Imaging Conference Vol.1 Pages 164-167

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

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 (fps). The system is based on a modified architecture charge coupled device (CCD) optically coupled to a fiberoptic taper via an image intensifier. The front end of the taper is coupled to a specially designed microstructured CsI(TI) 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.

478) **Development of an ASIC for APD-based small animal PET**

2001 IEEE Nuclear Science Symposium and Medical Imaging Conference Vol.2 Pages 737-741

Woodring ML, Christian JF, Shah KS, Squillante MR, Kogan AI, Cherry S, Shao Y, Augustine FL

Abstract

Development of an advanced, application-specific integrated circuit (ASIC) for use with high-density, avalanche photodiode (APD) detector arrays has been undertaken. APD technology recently developed at Radiation Monitoring Devices (RMD) has demonstrated great promise in the form of compact arrays. While APD arrays are capable of providing the basis for a new generation of high-resolution, photon-imaging systems, it is extraordinarily difficult to use conventional pulse-processing circuitry to support the many signals generated by these arrays. Due to the high detector density, small size, and unique electronic features of APD arrays, conventional readout electronics quickly become problematic for the implementation to APD arrays in positron-emission tomography (PET) systems. As the focus of NIH Phase I Small Business Innovation Research (SBIR) research, we designed and developed an ASIC to enable the implementation of APD arrays in PET. The circuit incorporates preamplifier, timing, shaping, and sample-and-hold capabilities that are necessary for APD use in PET. The ASIC has been designed, fabricated, and has undergone preliminary evaluation. We report on the development process, operational requirements, and performance results.

477) **INTEGRATED FLUORESCENCE DETECTION SYSTEM IN POLYDIMETHYLSILOXANE FOR MICROFLUIDIC APPLICATIONS**

2001 Analytical Chemistry Vol.73 Pages 4491-4498

Chabinyc ML, Chiu DT, McDonald JC, Stroock AD, Christian JF, Karger AM, Whitesides GM

Abstract

A prototype of an integrated fluorescence detection system that uses a microavalanche photodiode as the photodetector for microfluidic devices fabricated in PDMS is described. The detection limit of the prototype was determined by finding the minimum detectable concentration of a solution of fluorescein. The device was used to detect the separation of a mixture of proteins and small molecules by capillary electrophoresis.

476) **A comparative study of CsI(Tl) screens for macromolecular crystallography**

2001 Proc SPIE Int Soc Opt Eng Vol.4508   Pages 15-19

Gaysinskiy V, Miller SR, Nagarkar VV, Tipnis SV

Abstract

At RMD we have fabricated structured CsI(Tl) screens tailored for macromolecular x-ray crystallography applications. Diffraction patterns typically consist of several closely spaced Bragg peaks of varying sizes and intensities, and the detection of such features requires screens with high light output, high resolution, and excellent x-ray absorption. Properties of these screens, for example, light output or spatial resolution, were tailored by post deposition treatments to suit the specific needs of the application. Specifically, we have produced up to 45 um thick CsI(Tl) screens with excellent resolution over the spatial frequency range of 0 to 20 lp/mm and very low noise. Imaging characteristics of these screens along with the commercial Gd₂O₂S (GOS) have been measured using a CCD detector with a fiberoptic taper. Performance of these screens in terms of point spread function (PSF(f)), light output, noise power spectrum (NPS(f)), and the modulation transfer function (MTF(f)) was measured. It is observed that the intrinsic properties of the structured CsI(Tl) screens are heavily influenced by the substrate on which the films are deposited and on the post deposition coatings, thus providing at latitude for modifying the screen properties to match the needs of the application.

475) **A high-resolution, high-speed CT/radiography system for NDT of adhesive bonded composites**

2001 Proc SPIE Int Soc Opt Eng Vol.4503   Pages 265-273

Brecher C, Gaysinskiy V, Lempicki A, Miller SR, Nagarkar VV, Tipnis SV

Abstract

Adhesive bonded composites used in naval, aerospace, and automotive technologies require routine nondestructive testing (NDT) to detect flaws and other integrity-reducing anomalies such as porosity, kissing disbonds, and delaminations. We have developed an x-ray radiography/CT system with fast scanning times based on high resolution, high efficiency scintillators coupled to a 1024 × 1024 pixel CCD via a fiberoptic taper. Typical CT systems for NDT use a fan beam x-ray source and a linear array of detectors, with scan times on the order of 10 hours depending on the desired resolution. The prototype CCD-based volumetric imaging system described here is capable of reducing this scan time to 〈1 hour while significantly improving resolution. Additionally, the system is capable of both CT and standard radiographic imaging. We have integrated two different scintillators in the prototype system. One is a structured CsI(Tl) screen, and the other is a new, pixelated, transparent optical ceramic (TOC) scintillator. This unique TOC has a density of 9.5 g/cm ³ and a peak emission of 610 nm, particularly suitable for Si readouts. We present here the system design and preliminary results of radiographic imaging and volumetric CT reconstruction.

474) **Radiation hardness of high gain avalanche photodiodes**

2001 IEEE Nucl Sci Symp Med Imaging Conf Vol.1 Pages 240-244

Farrell R, Grazioso R, Reucroft S, Shah KS, Swain J

Abstract

*In this paper, we report on evaluation of radiation hardness of deep diffused, high gain avalanche photodiodes (APDs). We have performed experiments on 2 mm * 2 mm APDs to quantify the degradation in performance over a range of particle fluences. Eight APDs were irradiated at the Paul Scherrer Institut (Switzerland) with 72 MeV protons ranging from a fluence of 1 * 10⁸ protons/cm² to 2 * 10¹² protons/cm² with an equivalent 1 MeV neutron fluence of similar to 2 * 10⁸ n/cm² to 5 * 10¹² n/cm². The performance parameters measured include quantum efficiency (QE), gain, noise, and leakage current. Cooling and annealing measurements were also performed to explore options for reversing the effects of the damage sites within the APD. Our measurements show that our APDs have a minimal loss of performance in noise and QE up to about 1 * 10¹² n/cm². Beyond this neutron fluence, we see a decrease in QE and increase in noise. We were able to reverse the performance degradation of the higher irradiated APDs with moderate cooling and with annealing at 100 degree(s) C.*

473) **High speed X-ray imaging camera for time resolved diffraction studies**

2001 IEEE Nucl Sci Symp Med Imaging Conf Vol.1 Pages 164-167

Gaysinskiy V, Miller SR, 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 (fps). The system is based on a modified architecture charge coupled device (CCD) optically coupled to a fiberoptic taper via an image intensifier. The front end of the taper is coupled to a specially designed microstructured CsI(TI) 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.

472) **A new X-ray scintillator for digital radiography**

2001 IEEE Nucl Sci Symp Med Imaging Conf Vol.1 Pages 134-137

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

Abstract

We report a new scintillator based on a transparent ceramic of Lu2 O3:Eu. The material has an extremely high density of 9.4 g/cm 3 and a light output comparable to CsI:Tl. Its narrow band emission at 610 nm perfectly matches the spectral response of CCDs. To enhance the spatial and contrast resolution, we have developed a special process to pixelate the scintillator and prevent the spread of light within the scintillator volume. The performance of this pixelated device was thoroughly evaluated and found to equal or surpass all other currently known scintillators. The new scintillator is expected to play a major role in digital radiographic systems, when readout technologies capable of taking advantage of the transparency are developed further.

471) **Development of an ASIC for APD-based small animal PET**

2001 IEEE Nucl Sci Symp Med Imaging Conf Vol.2 Pages 737-741

Augustine FL, Cherry S, Christian JF, Kogan AI, Shah KS, Shao Y, Squillante MR, Woodring ML

Abstract

Development of an advanced, application-specific integrated circuit (ASIC) for use with high-density, avalanche photodiode (APD) detector arrays has been undertaken. APD technology recently developed at Radiation Monitoring Devices (RMD) has demonstrated great promise in the form of compact arrays. While APD arrays are capable of providing the basis for a new generation of high-resolution, photon-imaging systems, it is extraordinarily difficult to use conventional pulse-processing circuitry to support the many signals generated by these arrays. Due to the high detector density, small size, and unique electronic features of APD arrays, conventional readout electronics quickly become problematic for the implementation to APD arrays in positron-emission tomography (PET) systems. As the focus of NIH Phase I Small Business Innovation Research (SBIR) research, we designed and developed an ASIC to enable the implementation of APD arrays in PET. The circuit incorporates preamplifier, timing, shaping, and sample-and-hold capabilities that are necessary for APD use in PET. The ASIC has been designed, fabricated, and has undergone preliminary evaluation. We report on the development process, operational requirements, and performance results.

470) **Large-area APDs and monolithic APD arrays**

2001 IEEE Trans Nucl Sci Vol.48 Pages 2352-2356

Cirignano L, Farrell R, Grazioso R, Myers R, Shah KS

Abstract

*In this paper, development of large-area planar avalanche photodiodes (APDs) and monolithic APD arrays for X-ray and scintillation detection is discussed. Single APDs with areas as large as 10 cm² have been fabricated and tested with a CsI(TI) scintillator (3.8 cm diameter, 2.5 cm height). The resolution of the 662-keV photopeak has been measured to be 9% (FWHM). The X-ray detection performance, gain, and noise of these large APDs have been characterized. Multielement APD arrays have also been fabricated in various formats, such as 4 * 4 to 14 * 14 elements (2 mm pixels), and the uniformity of gain, noise, and sensitivity has been evaluated for 4 * 4 arrays using an ⁵⁵Fe source. Timing properties have been measured. Packaging issues related to the APD arrays are discussed.*

469) **Structured LiI scintillator for thermal neutron imaging**

2001 IEEE Trans Nucl Sci Vol.48 Pages 2330-2334

Entine G, Gaysinskiy V, Klugerman Y, Nagarkar VV, Squillante MR, Tipnis SV

Abstract

We are currently developing high-resolution high-efficiency microcolumnar LiI films for thermal neutron imaging. The films are produced by the vapor deposition of LiI on a fiber-optic substrate and hermetically sealed in a specially designed aluminum package. Our work has produced up to 1.2-mm-thick films with column diameters of approximately 30 mu m. We have also performed imaging studies by optically coupling some of these films to a fiber-optic taper-based charge-coupled device. The imaging performance of the system was experimentally evaluated at Radiation Monitoring Devices, Inc., as well as at the thermal neutron port of the University of Massachusetts Lowell Research Reactor. The LiI films exhibited excellent scintillation characteristics with a spatial resolution as high as 4.5 lp/mm (line pairs per millimeter). This paper outlines the film characterization and performance evaluation conducted during the course of the study. The new sensor described here is expected to usher in the development of large-area high-resolution digital thermal neutron detectors with improved detection efficiency and dynamic range and faster readout times than the current sensors.

468) **On the rate distribution analysis of kinetic data using the maximum entropy method: Applications to myoglobin relaxation on the nanosecond and femtosecond timescales**

2001 J Phys Chem Vol.B105   Page 7847

Kumar ATN, Zhu L, Christian JF, Demidov AA, Champion PM

467) **Resonance Raman and EPR investigations of D251N oxycytochrome P450cam/putidaredoxin complex**

2001 Biochemistry Vol.40   Page 6852

Sjodin T, Christian JF, MacDonald IDG, Davydov R, Unno M, Sligar SG, Hoffman BM, Champion PM

Abstract

Flash photolysis investigations of horse heart metmyoglobin bound with NO (Mb(3+)NO) reveal the kinetics of water entry and binding to the heme iron. Photodissociation of NO leaves the sample in the dehydrated Mb(3+) (5-coordinate) state. After NO photolysis and escape, a water molecule enters the heme pocket and binds to the heme iron, forming the 6-coordinate aquometMb state (Mb(3+)H2O). At longer times, NO displaces the H2O ligand to reestablish equilibrium. At 293 K, we determine a value k(w) approximately 5.7 x 10(6) s(-1) for the rate of H2O binding and estimate the H2O dissociation constant as 60 mM. The Arrhenius barrier height H(w) = 42 +/- 3 kJ/mol determined for H2O binding is identical to the barrier for CO escape after photolysis of Mb(2+)CO, within experimental uncertainty, consistent with a common mechanism for entry and exit of small molecules from the heme pocket. We propose that both processes are gated by displacement of His-64 from the heme pocket. We also observe that the bimolecular NO rebinding rate is enhanced by 3 orders of magnitude both for the H64L mutant, which does not bind water, and for the H64G mutant, where the bound water is no longer stabilized by hydrogen bonding with His-64. These results emphasize the importance of the hydrogen bond in stabilizing H2O binding and thus preventing NO scavenging by ferric heme proteins at physiological NO concentrations.

466) **Penetration and binding to ferric myoglobin**

2001 Biochemistry Vol.40   Page 5728

Cao W, Christian JF, Champion PM, Rosca F, Sage JT

465) **An integrated fluorescence detection system in poly(dimethylsiloxane) for microfluidic applications**

2001 Analytical Chemistry Vol.73   Page 4491

Chabinyc ML, Chiu DT, McDonald JC, Stroock AD, Christian JF, Karger AM, Whitesides GM

464) **Near-unity below-band-gap absorption by microstructured silicon**

2001 Appl Phys Lett Vol.78   Page 1850

Wu C, Crouch CH, Zhao L, Carey JE, Younkin R, Levinson JA, Mazur E, Farrell RM, Gothoskar P, Karger A

463) **Performance of a small field digital detector for soft X-ray imaging**

2001 Proc SPIE: Physics of Medical Imaging Vol.4320   Pages 172-177

Siefert A, Flynn M, Shah M, Nagarkar VV

462) **Investigation of microcolumnar scintillators on an optical fiber coupled compact imaging system**

2001 IEEE Trans Nucl Sci Vol.48   Pages 637-644

Tomai MP, Archer CN, Weisenberger AG, Wojcik R, Popov V, Majewski S, Keppel CE, Levin CS, Tipnis SV, Nagarkar VV