552) **Single photon detection using geiger mode CMOS Avalanche Photodiodes**

2005 Proc SPIE Int Soc Opt Eng Vol.6013

Augustine FL, Christian JF, Lawrence WG, Stapels C

Abstract

Geiger mode Avalanche Photodiodes fabricated using complementary metal-oxide-semiconductor (CMOS) fabrication technology combine high sensitivity detectors with pixel-level auxiliary circuitry. Radiation Monitoring Devices has successfully implemented CMOS manufacturing techniques to develop prototype detectors with active diameters ranging from 5 to 60 microns and measured detection efficiencies of up to 60%. CMOS active quenching circuits are included in the pixel layout. The actively quenched pixels have a quenching time less than 30 ns and a maximum count rate greater than 10 MHz. The actively quenched Geiger mode avalanche photodiode (GPD) has linear response at room temperature over six orders of magnitude. When operating in Geiger mode, these GPDs act as single photon-counting detectors that produce a digital output pulse for each photon with no associated read noise. Thermoelectrically cooled detectors have less than 1 Hz dark counts. The detection efficiency, dark count rate, and after-pulsing of two different pixel designs are measured and demonstrate the differences in the device operation. Additional applications for these devices include nuclear imaging and replacement of photomultiplier tubes in dosimeters.

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

2005 IEEE Trans Nucl Sci Vol.52 Pages 3157-3159

Derenzo SE, Glodo J, Higgins W, 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 this material Ce/sup3+/ is an intrinsic constituent as well as a luminescence center for the scintillation process. Samples of CeBr/sub3/ showed high light output (similar to 68000 photons/MeV) and fast decay constant (similar to 17 ns). Furthermore, they exhibited excellent energy resolution for gamma-ray detection. For example, energy resolution of $LS 4% full width at half maximum (FWHM) has been achieved using this scintillator for 662 keV photons (/sup137/Cs source) at room temperature. High timing resolution ($LS 200 ps - FWHM) has been recorded with CeBr/sub3/-photomultiplier (PMT) and BaF/sub2/-PMT detectors operating in coincidence using 511 keV positron annihilation gamma-ray pairs. COPYRIGHT 2005 IEEE.

550) **APD-based X-ray imaging telescope using fresnel zone plates for extremely high spatial resolution**

2005 Proc SPIE Int Soc Opt Eng Vol.5923 Pages 1- 8

Christian J, Entine G, Farrell R, Kogan AI, Myers RA, Robertson F, Squillante MR, Tiernan TC, Woodring M

Abstract

A method for constructing an x-ray telescope with exceedingly high spatial resolution is to use a pair of coaxial, Fresnel zone plates aligned with an imaging x-ray detector. This combination allows the high sensitivity imaging of x-ray and gamma-ray sources ranging in energy from 1 keV to several hundred keV over a field of view of several degrees with spatial resolution of a fraction of an arc minute. We have implemented a version of such a telescope using several relatively new technologies. These include specialized techniques for constructing Fresnel zone plates from thin sheets of tungsten, a 64-element, avalanche photodiode (APD) array coupled to a matching, segmented, CsI(Tl) scintillator, a new ASIC which provides 16-channels of low noise amplification, and image processing software that provides the user not only with localized intensity information, but also with localized spectral information.

549) **Recent advances in columnar CsI(Tl) scintillator screens**

2005 Proc SPIE Int Soc Opt Eng Vol.5923 Pages 1 - 10

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

Abstract

Columnar CsI(Tl) screens are now routinely used in indirect digital x-ray imaging detectors. The CsI(Tl) scintillator provides high density, high atomic number, and high scintillation efficiency. These properties, coupled with the fact that CsI(Tl) can be grown in columnar form, provide excellent spatial resolution, high x-ray absorption, and low noise resulting in detectors with high overall detective quantum efficiency (DQE(f)). While such screens are now commercially available, developments leading to further improvements in scintillator performance are ongoing at RMD. Here we report on the recent progress in developing very thin (10 $mu@m) to very thick (similar to 3 mm) columnar screens and discuss their application potential in digital radiology and nuclear medicine.

548) **Optical and scintillation properties of Cs/sub2/LiYCl/sub6/ : Ce/sup3+/ and Cs/sub2/LiYCl/sub6/ : Pr/sup3+/ crystals**

2005 IEEE Trans Nucl Sci Vol.52 Pages 1819-1822

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

Abstract

In this paper we report on the optical and scintillation properties of Cs/sub2/LiYCl/sub6/ : Ce/sup3+/ and Cs/sub2/LiYCl /sub6/ : Pr/sup3+/ crystals. Crystals of Cs/sub2/LiYCl /sub6/ doped with different Ce/sup3+ / and Pr/sup3+/ 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 Ce /sup3+/ and Pr/sup3+/. Efficient thermal neutron detection was observed for both scintillators. The position of the neutron peak in the pulse height spectra was found at about 5 times the channel number of the position of the /sup137/Cs 662 keV gamma peak. $CPY 2005 IEEE.

547) **Effects of Ce concentration on scintillation properties of LaBr /sub3 /:Ce**

2005 IEEE Trans Nucl Sci Vol.52 Pages 1805-1808

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

Abstract

In this communication, we investigate the scintillation properties of LaBr/sub3/:Ce as a function of Ce concentration. We have studied crystals nominally doped with 0.5%, 5%, 10%, 20%, and 30% Ce (by mole). Previous reports suggest that as the Ce content increases, there is a decrease in light output and little or no change in decay time constants. These results show that the light output does not change with Ce concentration up to 30% and depends mostly on the crystal quality. On the other hand we have found the timing properties to be a strong function of Ce 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 $GRT 5% Ce. Moreover, there is 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 $GRT 10% Ce it is 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 361 ps to less than 100 ps (full width at half maximum). $CPY 2005 IEEE.

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

2005 IEEE Trans Nucl Sci Vol.52 Pages 1109-1113

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 2005 IEEE.

545) **Development and characterization of CMOS avalanche photodiode arrays**

2005 Proc SPIE Int Soc Opt Eng Vol.5726 Pages 122-131

Augustine FL, Christian JF, Entine G, Lawrence WG, Squillante MR

Abstract

Avalanche photodiode (APD) arrays fabricated by using complementary metal-oxide-semiconductor (CMOS) fabrication technology offer the possibility of combining these high sensitivity detectors with cost effective, on-board, complementary circuitry. Using CMOS techniques, Radiation Monitoring Devices has developed prototype pixels with active diameters ranging from 5 to 60 microns and with measured quantum efficiencies of up to 65%. The prototype CMOS APD pixel designs support both proportional and Geiger modes of photo-detection. When operating in Geiger mode, these APDis act as single-optical-photon- counting detectors that can be used for time-resolved measurements under signal-starved conditions. We have also designed and fabricated CMOS chips that contain not only the APD pixels, but also associated circuitry for both actively and passively quenching the self-propagating Geiger avalanche. This report presents the noise and timing performance for the prototype CMOS APD pixels in both the proportional and Geiger modes of operation. It compares the quantum efficiency and dark-count rate of different pixel designs as a function of the applied bias and presents a discussion of the maximum count rates that is obtained with each of the two types of quenching circuits for operating the pixel in Geiger mode. Preliminary data on the application of the APD pixels to laser ranging and fluorescent lifetime measurement is also presented.

544) **Solid-state photomultiplier in CMOS technology for gamma-ray detection and imaging applications**

2005 IEEE Nuc Sci Symp and Medical Imaging Conference Vol.Oct. 23-29 Page 2775

Stapels CJ, Lawrence WG, Christian JF, Squillante MR, Entine G, Augustine FL, Dokhale P, McClish M

543) **An application-specific integrated circuit for positron emission tomography**

2005 IEEE Nuc Sci Symp and Medical Imaging Conference Vol.Oct. 23-29 Page 2936

Christian JF, Dokhale PA, Lawrence WG, Stapels CJ, Augustine FL, Shah KS, Squillante MR

542) **The solid-state photomultiplier for an improved gamma-ray detector**

2005 IEEE Conf on Technologies for Homeland Security (1105) Vol.April 26-28

Stapels CJ, Christian JF, Squillante MR, Entine G, Augustine FL, Lawrence WG

541) **Development and characterization of CMOS avalanche photodiode arrays**

2005 Photonics West, Semiconductor Photodetectors II (5726) Vol.January 22-27

Lawrence WG, Christian JF, Augustine FL, Squillante MR, Engine G

540) **A new solid state tritium surface monitor**

2005 Fusion Sci and Technology Vol.48 Page 409

Williams RS, Myers R, Dogrue D, Farrell R