【Grant-in-Aid for Scientific Research(S)】

Integrated Science and Innovative Science (Comprehensive fields)

Title of Project : Development of an innovative PET technique using Geiger-mode APDs for future medical application

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Research Area : Imaging and Instrumentation for Nuclear Medicine

Keyword : medical imaging, PET, avalanche photodiode, MPPC

【Purpose and Background of the Research】

Positron emission tomography (PET) is an effective method of evaluating the distribution of radio-labeled tracers in vivo, and is rapidly gaining acceptance as an important tool for use in nuclear medicine. The use of dual modality PET/CT imaging, however, suffers from poor soft-tissue contrast, with patients also subjected to a significant radiation. Although Magnetic Resonance Imaging (MRI) is free from such problems, the Photo-Multiplier Tube (PMT) incorporated in a PET scanner is difficult to use within the MRI high magnetic field. Moreover, the spatial resolution attainable with a PMT-based PET (typically >5mm) is far from the theoretical limit of the PET resolution (≤ 1mm). An APD is a compact, high performance light-sensor that could also be used in the MRI. Moreover, given the advantage of pixel miniaturization, we have successfully developed a high-resolution PET technique with sub-millimeter spatial resolution. Our goal in this research is to further extend an innovative PET technique using Geiger-mode APDs for future application in (1) depth-of-interaction (DOI)-PET, (2) MRI-PET, and also used in a Time-Of-Flight (TOF) capable PET scanner.

【Research Methods】

This is a 5-year research project starting from FY2009. As a high performance light sensor, several types of Geiger-mode APD-arrays will be designed and developed in cooperation with Hamamatsu Photonics K. K. We will make a prototype gamma-ray camera consisting of a MPPC-array optically coupled to a DOI matrix consisting of either LYSO or LuAG scintillators. To read the MPPC signals with an amplification gain of $10^{5\text{-}6}$, a high speed, low-noise, analog ASIC will be developed that includes pulse height and timing discriminators for TOF measurements. A versatile MPPC-based PET module will be fabricated by combining all the detector components, which is expected to be less than 50x50x100 mm^2 in size. A pair of module and coincidence circuits will be assembled into an experimental prototype gantry to evaluate the spatial resolution. Capability as a TOF and MRI-PET scanner will be also tested in the final stage of the development.

【Expected Research Achievements and Scientific Significance】

Recent developments in photo detector have induced the family of multi pixel silicon detectors such as Si-PM and MPPC, operated in Geiger mode. Such sensors are extremely compact, robust and easy to operate, and immediately found broad application in the various fields of experimental physics and nuclear medicine. However, the sensor itself is still in research and development (R&D) phase, and our project will be the first case/trial of providing "on-demand" detectors that could be easily applicable to future PET scanner. Also development of all detector units in domestic may increase the PET market share in Japan.

【Publications Relevant to the Project】

・J.Kataoka *et al.,* "Development of an APD-based PET Module and Preliminary Resolution Performance of an Experimental Prototype Gantry", *IEEE, Trans. Nucl. Sci.*, in press, 2010

・J. Kataoka *et al.,* "Development of large-area, reverse-type APD –arrays for high-resolution medical imaging," *Nucl. Inst. and Meth. A*, vol.604, pp.323–326, Jun. 2009

・J. Kataoka *et al.,* "An active gain-control system for Avalanche photo-diodes under moderate temperature variations," *Nucl. Inst. and Meth. A*, vol.564, pp.300–307, Jun. 2006

・J. Kataoka *et al.,* "Recent progress of avalanche photodiodes in high-resolution X-rays and gamma-rays detection," *Nucl. Inst. and Meth. A*, vol.541, pp.398–404, Jun. 2005.

【Term of Project】 FY2010-2014

【Budget Allocation】 68,400 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.spxg-lab.phys.waseda.ac.jp/