Docket #: S04-235A

Semiconductor Crystal High Resolution Imager

Stanford researchers have patented a novel concept for a position sensitive high-energy photon sensor device for high resolution radiation imaging that can enhance capabilities of Positron Emission Tomography (PET). This radiation imaging idea uses direct semiconductor detectors (e.g. Cadmium-Zinc-Telluride, CZT) instead of scintillation crystals. A great advantage of this direct semiconductor detector is that the intrinsic resolution is set by the collection electrode pattern deposited on the semiconductor crystal rather than by cutting and processing miniscule crystals, as is the case with high resolution scintillation crystal designs. Finally, because there is no photodetector, the effective crystal packing fraction is >99%. This design has the capability of recording the 3-D coordinates of individual high energy photon interactions in the detectors. This latter feature enables methods to accurately estimate the incoming photon incident angle as well as the sequence of multiple interactions, which offer new signal processing paradigms for PET.

Stage of Research

- Incorporated methods for robust and reliable electrode deposition, developing scalable readout electronics, and tested detectors.
- Achieved 1 mm3 spatial resolution determined by the electrode pattern and energy resolution 3% FWHM at 511 keV.
- Currently in the process of scaling up to a 8x8x4 cm “box-shaped” FoV system.
- Developed new signal processing paradigms using the 3-D interaction positioning capability

Applications

- Cancer imaging
- Nuclear Medicine -PET, SPECT
- Molecular imaging

- High energy photon imaging
- Spectroscopy
- Astrophysics
- Security screening
- Radiation detection/imaging
- Homeland defense
- Mineral exploration

Advantages

- Robust and efficient
- Design facilitates uniform, ultra-high (?1 mm) spatial resolution comparable to MRI and x-ray CT.
- Design uses 4 cm thick crystals with 99% packing fraction for high 511 keV photon detection efficiency.
- Design has 3% FWHM energy resolution at 511 keV enabling excellent background rejection for high image contrast and quantitative accuracy of image data.
- Compatible with other imaging modalities for multi-modality platforms.

Publications

- C.S. Levin, F. Habte, A.M.K. Foudray, J. Chang, G. Chinn. Impact of High Energy Resolution Detectors on the Performance of a PET System Dedicated to Breast Cancer Imaging. *Physica Medica*. Vol. XXI • Supplement 1 • 2006, pp. 28-34
- F. Habte, A.M.K. Foudray, P.D. Olcott, C.S. Levin. Effects of System Geometry and Other Physical Factors on Photon Sensitivity of High Resolution Positron Emission Tomography . *Physics in Medicine and Biology*. 52 (2007) 3753-3772.
- Gu Y, Matteson J, Skelton RT, Deal AA, Stephan EA, Duttweiler F, Gasaway TM, Levin CS. Study of a High Resolution, 3-D Positioning Cross-Strip Cadmium Zinc Telluride Detector for PET. Conference Record of the 2008 IEEE Nuclear Science Symposium and Medical Imaging Conference.
- G Chinn, CS Levin, "A method to reject random coincidences and extract true from multiple coincidences in PET using 3-D detectors", IEEE nuclear science symposium and medical imaging conference, 2008.

- Pratx, G; Levin, CS. Bayesian reconstruction of photon interaction sequences for high-resolution PET detectors. Physics in Medicine and Biology, Vol. 54, Issue 17, pp. 5073-5094, 2009. Selected as Feature Article of the Month, American Institute of Physics, August 2009.
- H Peng, CS Levin, "Design study of a high-resolution breast-dedicated PET system built from cadmium zinc telluride detectors", Physics in Medicine and Biology, Vol. 35, Iss. 9, pp. 2761-2788, 2010.

Patents

- Published Application: WO2006039494
- Published Application: 20080042070
- Issued: 8,063,380 (USA)

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