Optical Tomographic Device for Combination with MR/CT/PET/SPECT in Preclinical Imaging (P-706)

Key facts

- micro-lens array with a plurality of micro-lenses
- detector: CMOS sensor with high sensitivity
- compatibility with MR/CT/PET/SPECT
- multimodal imaging generating images simultaneously in DICOM standard

Background

Optical techniques, such as bioluminescence and fluorescence, are emerging as powerful new modalities for molecular imaging in disease and therapy. Combining innovative molecular biology and chemistry, researchers have developed optical methods for imaging a variety of cellular and molecular processes *in vivo*, including protein interactions, protein degradation, and protease activity. Whereas optical imaging has been used primarily for research in small-animal models, there are several areas in which optical molecular imaging will translate to clinical medicine.

Planar optical imaging and optical tomography (OT) are emerging as alternative molecular imaging modalities that detect light propagated through tissue at single or multiple projections. A number of optical-based imaging techniques are available, from macroscopic fluorescence reflectance imaging to fluorescence imaging/tomography that has recently been demonstrated to localize and quantify fluorescent probes in deep tissues at high sensitivities at millimeter resolutions.

Technology

DKFZ has developed an optical imaging detector for fluorescence and bioluminescence in small animal imaging that is compatible with magnetic resonance imaging (MRI), computed tomography (CT), positron electron tomography (PET) and Single-photon emission computed tomography (SPECT).

Compatibility of light detection with PET has been accomplished by the development of an optical detector that consists of a 25 mm x 100 mm photon sensor (liquid cooled) for light detection, a microlens array for field-of-view definition, a septum mask for cross-talk suppression, and a transferable filter for wavelength selection. A single detector possesses an effective thickness of less than 8 mm and is operated at close proximity to the imaged object. Multiple detectors are arranged so as to form a hexagonal detector geometry allowing circumferential data acquisition through 360°. Adjacent to each detector, optical components for single spot and total object light illumination are integrated to facilitate fluorescence imaging and tomography. The outer diameter of the overall light-tight cylinder housing is 118 mm. All materials of the instrument have been selected for low attenuation and scattering of high-energy (isotopic) photons. Hence, this system is fully insertable into any PET system with a minimum bore diameter of 120 mm. Acquired optical sensor data are back-projected onto the animal's surface via an inverse mapping algorithm to form projection surface images. FMT data reconstruction is guided by priors from the reconstructed PET data.

The instrument has been evaluated regarding its optical performance, including radiation durability, using various phantoms and measurement setups, and was successfully used in a number of preclinical studies, such as simultaneous positron (18F-FDG, 68Ga-RGD) - bioluminescence (PC-3-hVEGF-Luc) imaging of reporter gene expression and receptor targeting in mice or simultaneous imaging of fluorescent XenoLight-RediJect-2-DG-750 and radio-labeled FDG probes.

Advantages

- no necessity for contact between detector and object

- thin CMOS detector (option for small device)
- high resolution/sensitivity
- combination MR/CT/PET/SPECT possible

Development Stage
An OT prototype has been developed, established and tested successfully in animal studies in combination with MR/CT/PET.

Inventors
The invention was jointly conceived by Jörg Peter, Ralf Schulz and Daniel Unholtz, department of Medical Physics in Radiology, E020 of DKFZ.

Intellectual Property
Patent applications for "Optical Tomographic Detector" are pending based on the international PCT (WO2006111486) as US 11/918,857, JP2008-537131, EP1875210, CA2615580.

Reference
"Iterative reconstruction of projection images from a microlens-based optical detector." By Cao L, Peter J. published in Opt Express. 2011 Jun 20;19(13):11932-43. doi: 10.1364/OE.19.011932. PMID: 21716427

"Geometrical co-calibration of a tomographic optical system with CT for intrinsically co-registered imaging." By Cao L, Breithaupt M, Peter J. published in Phys Med Biol. 2010 Mar 21;55(6):1591-606. Epub 2010 Feb 17. PMID: 20164534

"Image formation with a microlens-based optical detector: a three-dimensional mapping approach." By Unholtz D, Semmler W, Dössel O, Peter J. published in Appl Opt. 2009 Apr 1;48(10):D273-9. PMID: 19340119

"A novel optical tomographic instrument for multimodal imaging application in mice" in J. Nucl. Med. 2011; 52 (Supplement 1):1958; by Joerg Peter and Liji Cao; Medical Physics in Radiology, German Cancer Research Center, Heidelberg, Germany; Abstract No. 1958

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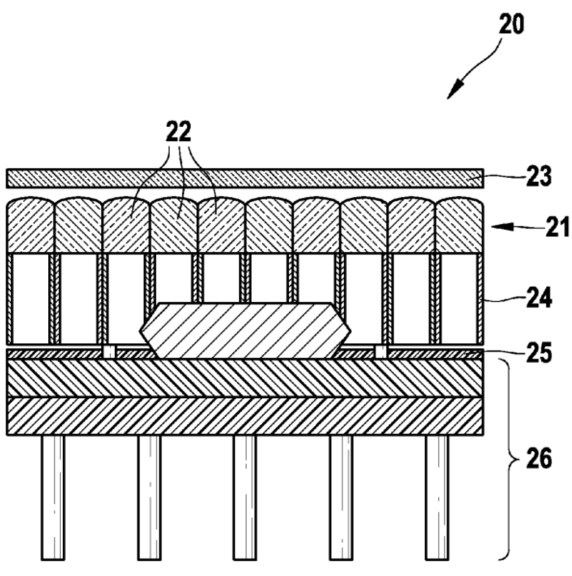

Figure 1: Optical detector with micro lenses

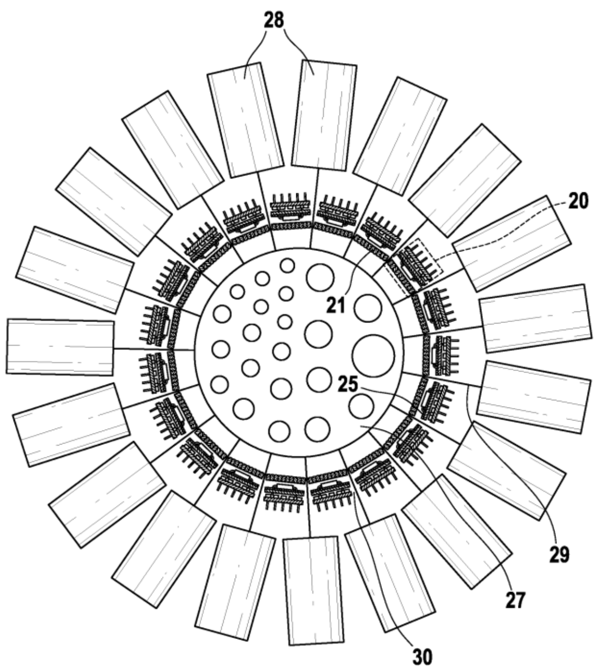

Figure 2: A schematic cross-section of the OT-detector

Figure legend: the elements in detail:
(20) Detector block, (21) Micro-lens array, (22) Micro-lenses, (23) Filter, (24) Optical collimator. (25) Photo detector, (26) Electronic parts and signal transmission elements, (27) Imaged object, (28) Light sources, (29) Light ray, (30) Gaps