FRAUNHOFER-INSTITUT FÜR BIOMEDIZINISCHE TECHNIK IBMT

1 *Combined transducer for acquisition of acoustic and optoacoustic data.*

2 *3-D reconstruction of optoacoustic signals acquired from human blood vessels.*

OPTOACOUSTIC IMAGING

Situation

Optoacoustic imaging is a new hybrid imaging modality that combines the advantages of acoustics and optics. Ultrasound signals are generated by the absorption of light. These signals can then be utilized for imaging in which the high contrast of optics and the high resolution of acoustics are combined. By adding appropriate biologically functionalized nanoscaled contrast agents, optoacoustic techniques can also be used for macroscopic molecular imaging.

The achievements of Fraunhofer IBMT in the field of optoacoustics range from contrast agent syntheses to design and assembly of entire imaging systems. By utilizing nanoscaled contrast agents, optoacoustic techniques allow molecular imaging with a relatively easy and cost-efficient technology.

Furthermore, this modality is optimally applicable for imaging vessel structures, even far beyond the resolution limits of Doppler ultrasound.

Solution

Fraunhofer IBMT has developed a hardware platform based on the DiPhAS (Digital Phased Array System, Fraunhofer IBMT), that allows combined ultrasound and optoacoustic imaging.

The device differs from conventional ultrasound imaging platforms regarding the availability of a laser for signal generation and adapted optics for targeted delivery of the light.

This setup allows the synchronization of laser pulse emission and acquisition of optoacoustic channel data for post-acquisition software-based image reconstruction.

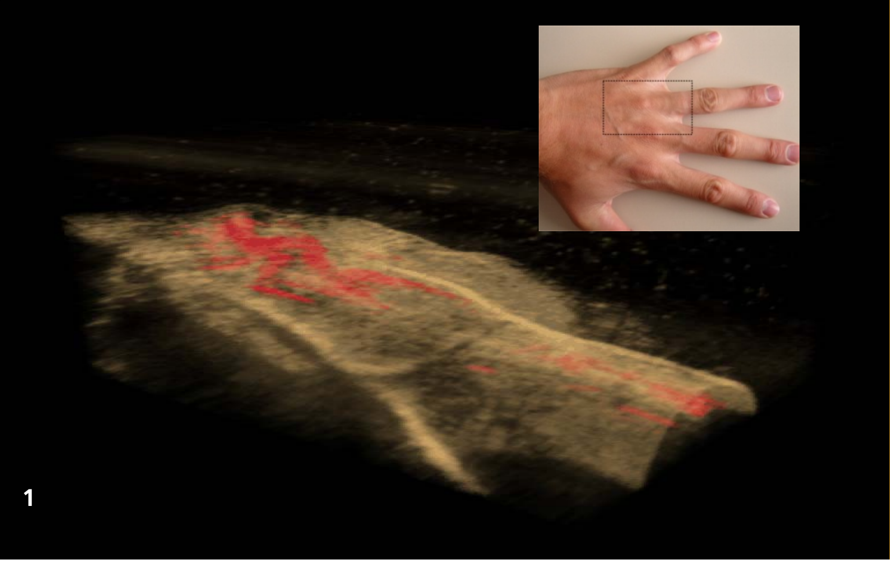
Due to the proportionality of the signal amplitude and the energy intensity of the laser, appropriate illumination geometry is of major importance. In order to optimize this geometry, a simulation based on Monte-Carlo-algorithms was developed that is able to simulate light propagation within tissue as well as the generation of optoacoustic signals.

Fraunhofer Institute for Biomedical Engineering IBMT
Prof. Dr. Heiko Zimmermann
Prof. Dr. Günter R. Fuhr
Joseph-von-Fraunhofer-Weg 1
66280 Sulzbach
Germany

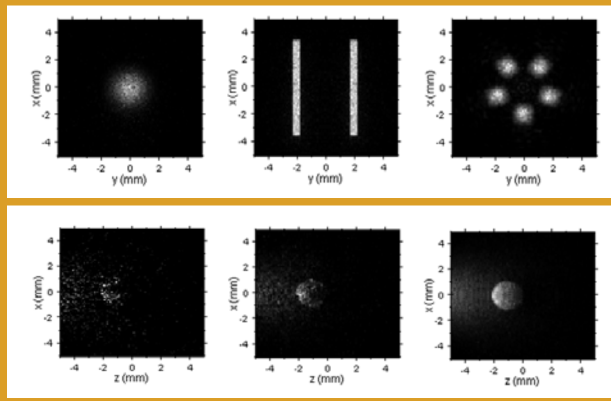
Contact

Ultrasound
Dr. Marc Fournelle
Medical Ultrasound
Telephone +49 6894 980-220
Fax +49 6894 980-234
marc.fournelle@ibmt.fraunhofer.de

www.ibmt.fraunhofer.de



1



2

Technical data

- digitization with 80 MSa/s for transducers with a centre frequency of up to 20 MHz
- simultaneous acquisition of channel data of up to 128 elements
- software-based reconstruction with beamforming or 2-D-FFT-algorithms
- different trigger outputs for various laser systems (Nd:YAG, OPO)
- real-time optoacoustical imaging with up to 20 frames per second
- fibre optics optimized for targeted light delivery

Macroscopic optoacoustic imaging system based on DiPhAS.

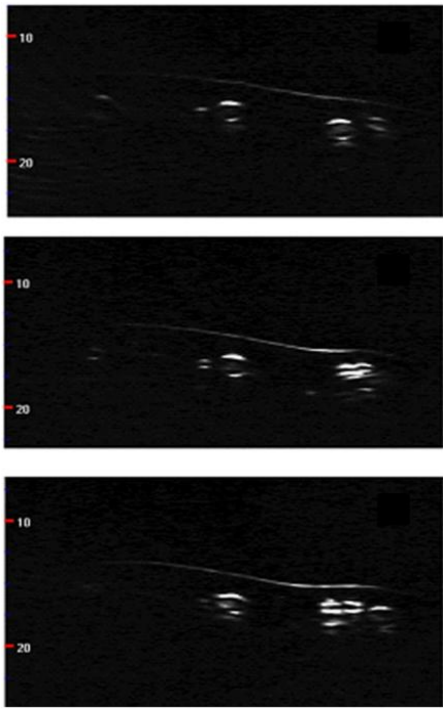
Applications – molecular imaging

Signals with molecular specifity can be acquired by optoacoustic techniques with only relatively low technical effort and without ionizing radiation. The detectability of low concentrations of nanoparticles (in a range from nMol down to pMol) has already been verified with this system.
So far clinical tests could not yet be performed due to the lack of clinically approved contrast agents. However, proof-of-concept experiments have already been performed in a small animal model.

Imaging of vascularization

Due to its high absorption coefficient, blood can be imaged with an extremely high contrast with optoacoustic techniques. This method is especially suitable when a resolution beyond the limits of Doppler ultrasound is in demand, or when there is only little blood flow or no blood flow at all.
Furthermore, optoacoustic techniques can be utilized for functional imaging. Since the oxygen saturation of blood has a direct influence on its absorption coefficient, signal amplitudes of arteries and veins are distinct. By utilizing a laser system with adjustable wavelength (OPO), multispectral optoacoustic data sets can be acquired.

Based on the known absorption distribution of oxyhaemoglobin and deoxyhaemoglobin, it is possible to determine whether a specific pixel belongs to an artery or to a vein.



Optoacoustic B-images of subcutaneous blood vessels in a human forearm.

1 *3-D reconstruction of opto-acoustic data of subcutaneous blood vessels.*
2 *Results of Monte-Carlo-simulations for optimization of optoacoustic illumination geometry.*