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FRAUNHOFER-INSTITUT FÜR BIOMEDIZINISCHE TECHNIK IBMT

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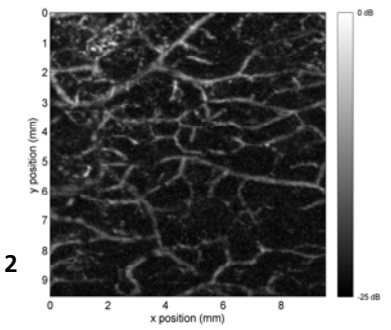

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1 Combined high-resolution optoacoustic / ultrasound imaging system.

2 Optoacoustic image of subcutaneous blood vessels in a human hand.

HIGH-RESOLUTION OPTOACOUSTIC IMAGING

Situation

Optoacoustic imaging is a new hybrid modality that combines the advantages of acoustics and optics. In optoacoustics, ultrasound signals are generated by the absorption of light. These signals can be used 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 be utilized for molecular imaging. Like in other ultrasonic imaging methods, the resolution of optoacoustics is highly scalable. With different imaging systems, it is possible to visualize both entire organs and organelles on a subcellular level. Especially in preclinical research and in certain fields of clinical practice, i. e. in dermatology, a high resolution and a high penetration depth beyond that of purely optical methods are necessary.

For such applications, Fraunhofer IBMT has developed an optoacoustic imaging system that combines these features and further supports contrast agent enhanced molecular imaging.

Solution

The hardware platform designed and assembled by Fraunhofer IBMT is operated with single-element ultrasound transducers in a confocal optoacoustic setup. Depending on the application, different transducers are available with centre frequencies ranging from 20 MHz to 100 MHz.
The generation of optoacoustic signals relies on different systems of pulsed lasers. Diode-pumped frequency-doubled class I Nd:YAG-lasers have been implemented as well as tunable OPO-systems and flash-lamp pumped NIR-lasers.

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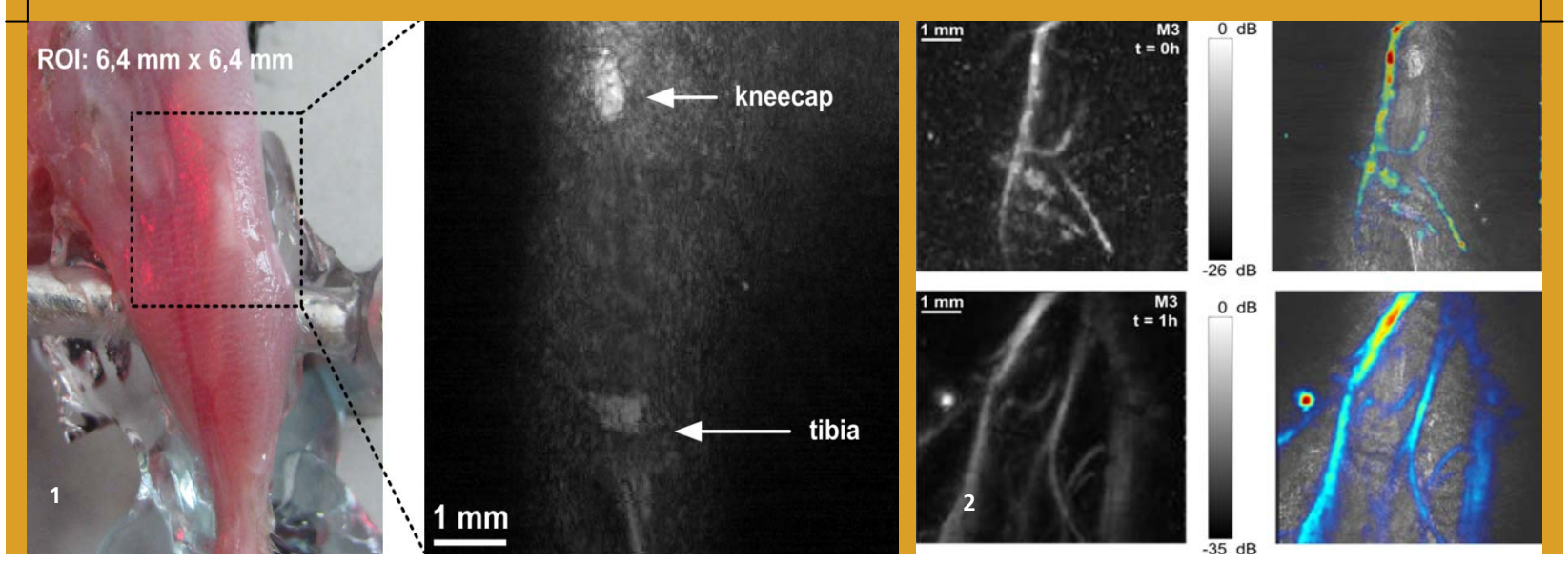
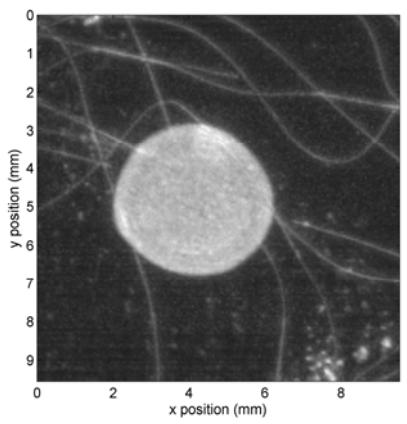


Technical data

Combined imaging system:

- ultrasound and optoacoustic imaging mode
- digitization with 800 MHz
- focused ultrasound transducers with frequencies ranging from 20 MHz to 100 MHz
- resolution of about 80 µm (lateral, with a 30 MHz transducer)
- combined imaging US/OA
- intrinsic 3-D imaging



Optoacoustic projection image of a tissue phantom (polyvinylchloridplastisol with 7 µm carbon fibres, round structure = stained PVCP).

Applications

The high-resolution optoacoustic imaging method can be used for any application that requires a resolution higher than 100 µm in conjunction with a penetration depth in the mm-range. In a clinical context, this is of special interest to the field of dermatology.

The integration of two different imaging modalities offers a special advantage:

Potential users can combine a clinically established method (ultrasound) with a new innovative imaging modality (optoacoustics).

With an appropriate choice of laser wavelength, optoacoustic techniques are particularly suitable for the imaging of vascularization.

Within the scope of multispectral optoacoustics it is possible to distinguish for example oxyhaemoglobin and desoxyhaemoglobin by choosing different wavelengths.

In this imaging modality the signal amplitudes of arteries and veins differ, since the oxygen saturation of blood has a major impact on its absorption coefficient.

Since the signal generation relies on the absorption of light, this method is particularly applicable when a resolution beyond the imaging limits of Doppler ultrasound is needed, or when there is little blood flow or no blood flow at all.

By using variant wavelengths, for example NIR, the imaging sensivity can be optimized for other tissue chromophores (for example melanin).

Further, the use of nanoscaled contrast agents allows to use optoacoustic techniques for molecular imaging. Specific biological ligands (antibodies, peptides) can be attached to the contrast agents and a specific cell targeting can be achieved. This allows in-vivo imaging with specific molecular contrast enhancement.

1 *Imaging of anatomical structures (tibia, patella) with high-resolution ultrasound.*
2 *Imaging of blood vessels with high-resolution optoacoustic imaging. Contrast enhancement by utilizing gold nano-rods (top: prior to injection, bottom: 1 hour after injection).*