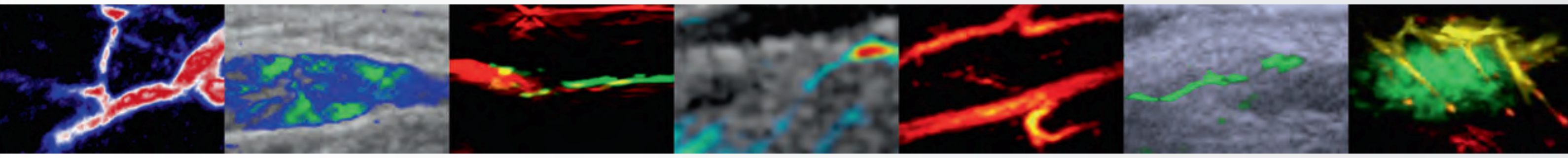

MSOT MULTISPECTRAL OPTOACOUSTIC TOMOGRAPHY ACUITY

MSOT Acuity | Acuity Echo

- Clinical imaging system for research and diagnosis
- Tomographic handheld real-time imaging
- Anatomical, functional and molecular contrast

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MSOT TECHNOLOGY

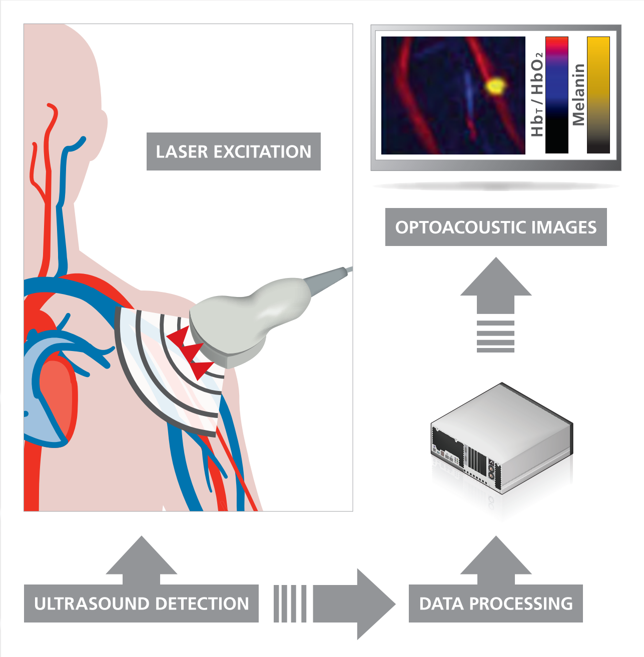
Imaging sequence:

- Illumination of tissue with laser pulses at multiple wavelengths
- Detection of induced ultrasound pressure waves
- Spectral unmixing to analyze individual absorbers

Technology benefits:

Combines the molecular specificity of optical imaging with the depth and spatiotemporal resolution of ultrasound

- **Molecular specificity:**
  Identify and quantify disease-related biomarkers, revealing endogenous absorbers and injected probes
- **Depth & spatiotemporal resolution:**
  Acquire soft tissue images, with a spatial resolution of up to 80 µm, *in vivo* and in real time



OPUS:
hybrid **OP**toacoustic & **U**ltra**S**ound imaging

Ultrasound imaging integrated in the MSOT Acuity *Echo* enables the visualization of both tomographic optoacoustic and ultrasound information at the same time, thus providing additional and complementary information on tissue morphology.

MSOT VS. OTHER IMAGING MODALITIES

Imaging is an essential tool for medical diagnosis. Various technologies have evolved over time, each one providing specific benefits – but also limitations. Innovation in biomedical imaging facilitates new avenues for diagnosis and treatment of diseases.

X-ray, ultrasound and magnetic resonance imaging (**MRI**) provide anatomical information at high spatial resolution but with limited molecular specificity and sensitivity. On the other hand, positron emission tomography (**PET**) is a molecular imaging modality with high sensitivity, but suffers from low spatial resolution.

Modality	Spatial resolution	Temporal resolution	Sensitivity	Cost and infrastructure	Burden for patients
MSOT	●	●	○	●	●
X-ray	●	○	–	●	–
Ultrasound	●	●	–	●	●
MRI	●	○	–	–	○
PET/SPECT	–	–	●	–	–

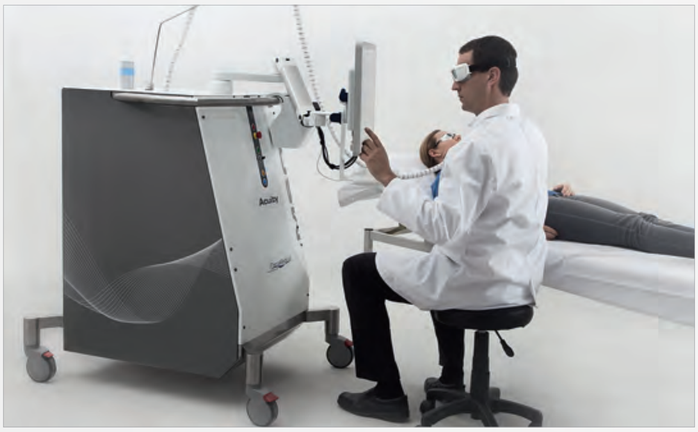
● = favorable ○ = medium – = unfavorable

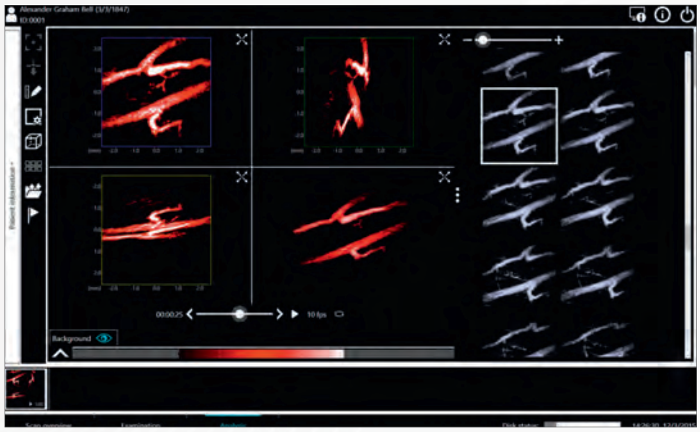
MSOT – Multispectral Optoacoustic Tomography is a novel imaging technology. Besides its high spatio-temporal resolution and sensitivity for optical contrast, MSOT imaging comes at relatively low cost.

Additionally, MSOT imaging poses no significant burden – particulary no ionizing radiation – on patients and users.

SYSTEM COMPONENTS, USE, ACCESSORIES/OPTIONS

SYSTEM COMPONENTS





MSOT scanner hardware

- Mobile imaging platform with integrated high-performance workstation and adjustable screen
- Graphical user interface controlled via touchscreen and customized keyboard
- Detectors for different applications with variable center frequency, geometry, and size

ViewMSOT™ software

- Intuitive software design
- Patient and study data administration
- Automated spectral unmixing and signal quantification
- Wide range of tools for data analysis and export
- Remote analysis support

SYSTEM USE

System design allows intuitive use:

- Workflow comparable to that of conventional ultrasound
- Handheld detectors for easy patient access
- Real-time spectral analysis of tissue chromophore distribution
- One click acquisition of single images and image sequences
- Detailed analysis and comparison of multiple images
- Export of image data and standard examination reports

ACCESSORIES AND OPTIONS

Standard accessories:

- Laser safety goggles
- User kit, incl. ultrasound gel, disinfectant wipes, sterile covers
- Calibration phantom

Options:

- 2D and 3D detectors customized for particular application needs (2.5-10 MHz, 1-512 elements)
- Advanced software tools for image analysis
- Device for imaging of tissue specimens

VISUALIZED CHROMOPHORES

MSOT detects and visualizes signals that represent the spectrally distinct absorbance of chromophores in tissue. Preclinical and clinical studies have proven the effective detection of endogenous chromophores such as hemoglobin, melanin and lipids as well as that of commonly used and clinically approved optical contrast agents such as ICG and methylene blue.

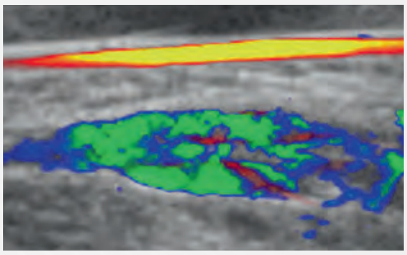
CASE STUDIES

MSOT has already been applied in a variety of clinical applications, including the examples listed below:

Nodal assessment in malignant melanoma [1]

MSOT has shown the potential for non-radioactive localization of sentinel lymph nodes (SLNs) by tracking the lymphatic drainage of ICG in melanoma and other cancers where SLN biopsy is a routine diagnostic procedure.

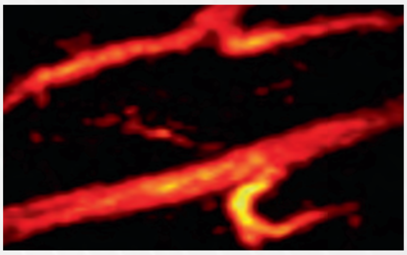
In melanoma, the absence of a melanin signal in the SLN can potentially rule out the presence of metastasis, and thereby spare many patients an unnecessary surgical procedure.



Peripheral vascular diseases (PVD) [2]

MSOT has the ability to image vessels with a diameter of less than 100 µm in real time and contrary to other imaging modalities such as X-ray, CT and MRI, without the need for contrast agents.

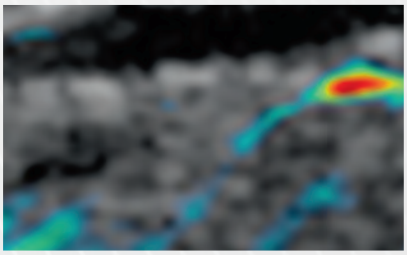
Images acquired by MSOT can show vascular malformation and blood/tissue oxygenation state, for example in PVD patients, thereby supporting the assessment of disease progression.



Thyroid nodules [3]

Only 5% of all biopsied thyroid nodules are malignant. Optoacoustic tomography could help to distinguish malignant and benign nodules non-invasively by determining perfusion and tissue oxygenation of the nodules and showing vascularization patterns.

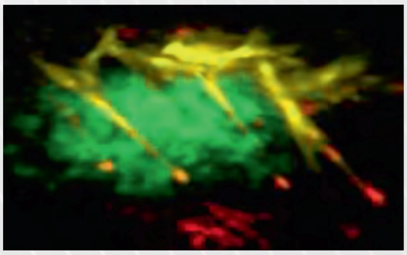
Similar methods are used to assess malignancy of other cancerous lesions, e.g. in breast cancer patients.



Alopecia [4]

Monitoring of viable hair follicles over time is crucial for understanding hair pathophysiology and discovery of novel therapies for alopecia, but also other follicular diseases.

MSOT provides structural information and functional properties of the entire hair follicle, such as vascularization and oxygenation of the bulb and the lipid volume of the associated sebaceous glands.



1) Stoffels I et al., **Metastatic status of sentinel lymph nodes in melanoma determined noninvasively with multispectral optoacoustic imaging,** Sci Transl Med. 2015 Dec 9;7(317):317ra199. DOI: 10.1126/scitranslmed.aad1278.

2) Deán-Ben XL and Razansky D, **Functional optoacoustic human angiography with handheld video rate three dimensional scanner,** Photoacoustics. 2013 Nov 12;1(3-4):68-73. DOI: 10.1016/j.pacs.2013.10.002.

3) Dogra VS et al., **Preliminary results of ex vivo multispectral photoacoustic imaging in the management of thyroid cancer,** AJR Am J Roentgenol. 2014 Jun;202(6):W552-8. DOI: 10.2214/AJR.13.11433.

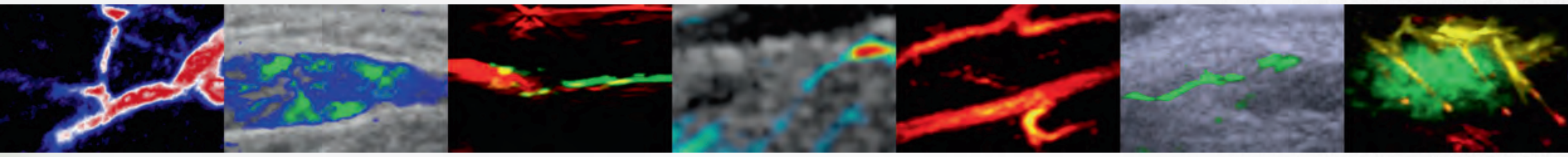
4) Ford SJ et al., **Structural and functional analysis of intact hair follicles and pilosebaceous units by volumetric multispectral optoacoustic tomography,** J Invest Dermatol. 2015 Dec 29. DOI: 10.1016/j.jid.2015.09.001.

TECHNICAL SPECIFICATIONS

Specifications	MSOT Acuity [1]	MSOT Acuity *Echo* [2]
Image acquisition		
Image rate (live display)	up to 50 fps	
Acquisition time	< 10 ms (single wavelength) | < 100 ms (multispectral)	
Key system components		
SpectraPULSE™ illumination system		
Laser wavelength spectrum	Standard: 680-980 nm | Optional: 670-1250 nm	
Pulse repetition rate	10-50 Hz (adjustable)	
Maximum pulse energy @ 750 nm	30 mJ	
PulseCRTL™	Pulse energy control, laser performance monitoring	
Wavelength tuning	Tuning time: < 10 ms | Minimum step size: 1 nm	
RapidSCAN™ data acquisition electronics		
Channels for simultaneous acquisition	up to 512	
Sampling rate	up to 40 MS/s	
OPUS™ hybrid ultrasound mode		
Transmit frequency	n/a	2-8 MHz
Advanced imaging methods	n/a	Synthetic aperture beamforming, spatial compounding
ViewMSOT™		
Data management	Patient/study data administration, creation of reports, data export	
Data acquisition	2D/3D, single images, image sequences, multispectral data sets	
Data processing	Image reconstruction, spectral unmixing, signal quantification	
Data analysis	Measurements, spectral analysis, color maps, image filters	
General technical specifications		
Hardware scanner console	Intel Core i7/Xeon, 32 GByte RAM, 4 TByte HDD data storage, 24'' TFT touchscreen	
Operating system	Windows 8 embedded	
External Interfaces	1 GBit Ethernet, remote interlock connector	
Dimensions (width x depth x height | weight)	73 x 91 x 152 cm | 290 kg	
Power	16A/230VAC, 50/60 Hz	
Laser classification	Class 4	

TomoARC™ detectors	Standard 2D	Standard 3D	Optional detectors
Angular coverage	125°	110°	90-180°
Center frequency	3 MHz	2.5 MHz	2.5-10 MHz | > 50%
Number of elements	256	384	1-512
Field of view	25 mm	15 x 15 mm	up to 30 | 20 x 20 mm
Depth penetration (MSOT)	up to 30 mm	up to 25 mm	up to 30 mm
Maximum resolution	275 µm	390 µm	80-390 µm

1) MSOT Acuity will be CE marked in 2016. Please contact us for further information.
2) MSOT Acuity Echo is currently only available as a research platform.



SELECTION OF RELATED PUBLICATIONS

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