# Handheld probe combining laser diode and ultrasound transducer array for ultrasound/photoacoustic dual modality imaging

K. Daoudi[1*], P. van den Berg[1*], O. Rabot[2], A.Kohl[2], S. Tisserand[3], P. Brands[4] and W. Steenbergen[1]

[1]Biomedical Photonic Imaging Groupe, MIRA institute, University of Twente, Enschede, The Netherlands;
[2]Quantel Laser Diode, Les Ulis, France; [3]SILIOS Technologies, Peynier, France; [4]ESAOTE Europe, Maastricht, The Netherlands.
k.daoudi@utwente.nl; w.steenbergen@utwente.nl

**Introduction** Ultrasound and photoacoustics can be utilized as complementary imaging techniques to achieve more valuable clinical diagnosis. Photoacoustics provides optical contrast and functional information while ultrasound provides mechanical and anatomical structure. Unfortunately, photoacoustic imaging still uses large and expensive systems compared to ultrasound, which limits their clinical application.

**Objective** Development of a cost effective portable device combining ultrasound and photoacoustic imaging modalities by designing end developing a compact handset, integrating ultrasound transducer array and pulsed laser module.

## System design

System was designed in collaboration with Quantel Laser Diodes, SILIOS technologies and ESAOTE Europe. It consists of:

1) Modified commercial portable ultrasound scanner (MyLabOne).
2) Hand held probe integrating ultrasound transducer and laser module.


Portable imaging scanner combining photoacoustic and ultrasound dual modality imaging

The probe integrates ultrasound transducer, laser module and beam shaping optics in compact and ergonomic design:

Ultrasound probe:

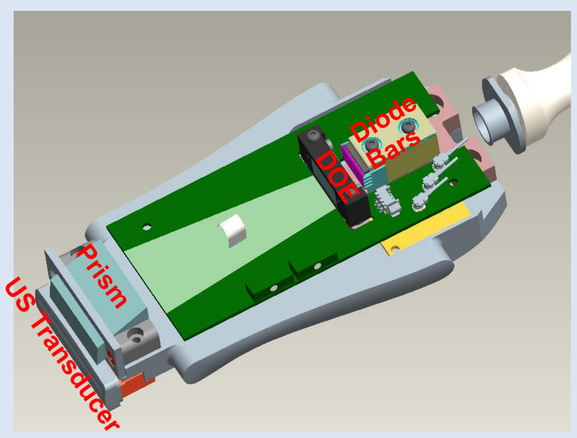
- 128 transducer elements of 5 mm x 0.245 mm.
- 7.5MHz Central frequency, bandwidth from 2.7 Mhz to 10.0 Mhz.
- Minimum detectable pressure about 2 Pa at central frequency

Laser module :

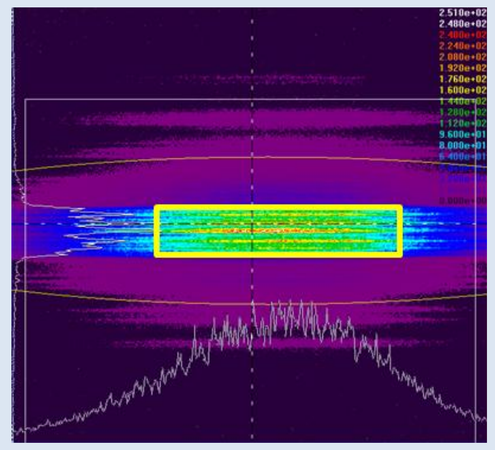
- The laser module contains 2 diode bars (each bar composed of 64 light sources) delivering 0.5mJ per pulse at front end.
- Highly efficient electrical driver, running with high frequency repetition rate up to 10 kHz, emitting at 800nm wavelength with pulse width of 100 ns.
- The electrical driver can be triggered by the ultrasound scanner with high stability.

Beam shaping optics:

- Diffractive optical elements (400 µm diffractive cells integrating 8 phase levels) were integrated into the probe for beam collimating and shaping to a rectangular with 20mm length and 5mm width.
- To ensure a better coupling between the laser light and ultrasound detection, the beam was deflected by 40 degrees via a prism.



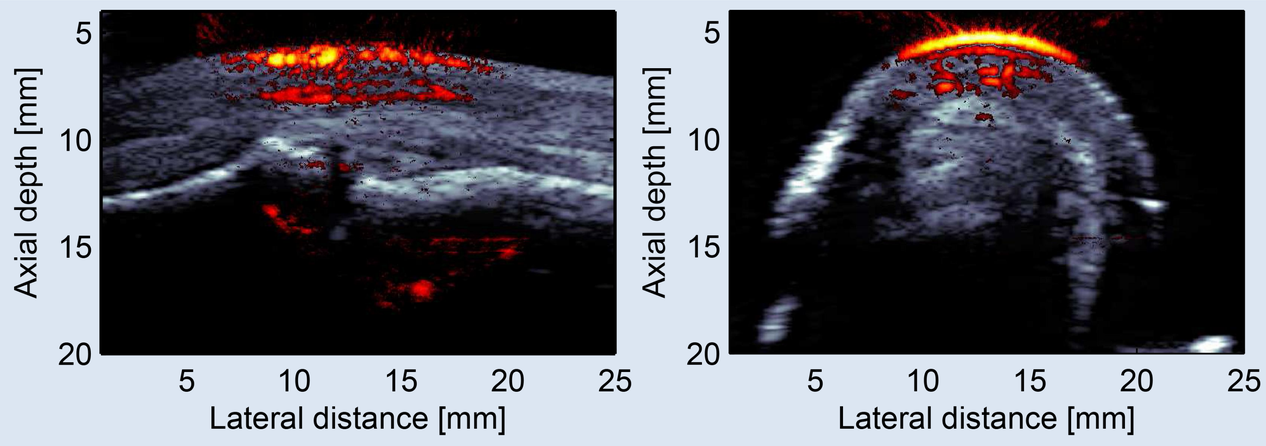

Hybrid probe integrating laser module, diffractive optical elements and ultrasound transducer



Spot shape at the front-end of the probe

## In vivo measurements

In vivo measurements were performed by imaging proximal interphalangeal (PIP) joint of a healthy subject. The figures show overlay of the ultrasound and photoacoustic images of cross section and along the finger joint.




Superposition of ultrasound and photoacoustic images obtained by imaging along (left) and cross section (right) of a proximal interphalangeal finger joint.

## Conclusions

- We realized an ergonomic and compact handheld probe integrating ultrasound transducer, laser module and beam shaping system.
- In-vivo measurements of PIP finger joint were realized to demonstrate the performance of the system.

## Perspectives

- Use higher energy per pulse by integrating higher efficient diode bars.
- Development of multi wavelength handheld probe for functional imaging.

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