A novel acoustic lens for photoacoustic breast imaging

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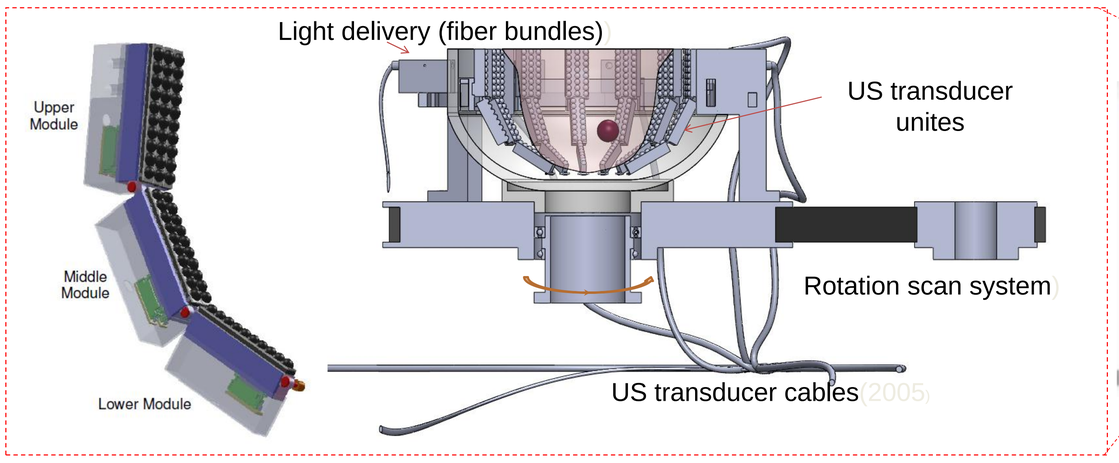
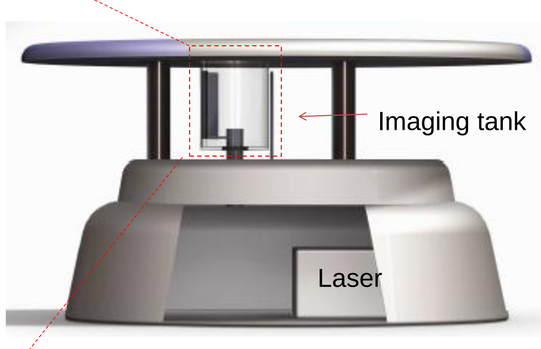
Second generation of the Twente Photoacoustic Mammoscope (PAM II)

PAM II characteristics

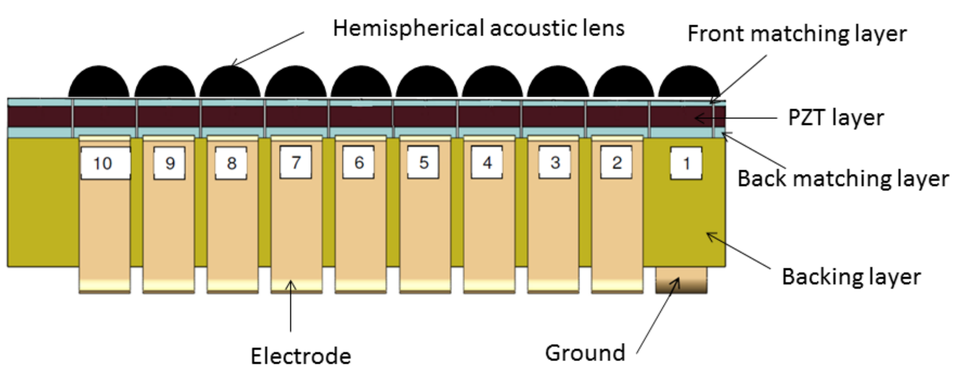
- Full breast imaging
- 128 channels
- Designed resolution: 1 mm
- Light source: 755 nm, 1064 nm (10 Hz)
- Custom-made sensitive, broadband detectors
- Speed-of-sound and acoustic attenuation imaging



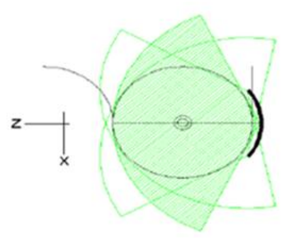


Patient-instrument interface

PAM II transducer design consideration

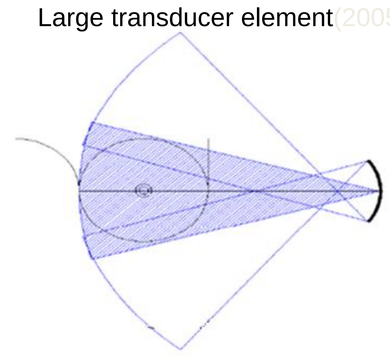


Small transducer element (2005)



Less sensitive, large acceptance angle

Large transducer element (2005)



sensitive, small acceptance angle

Design:

Large area detector + acoustic lens* = Large acceptance angle + high sensitivity

- High sensitivity active mateiral: CTS 3203 HD.
- High sensitivity element: large active surface area (5 mm x 5 mm), and low resonance frequency (1 MHz) (8 Pa minimal detectable pressure).
- Large acceptance angle: acoustic lens (60 degree).
- Large bandwidth: two impedance matching layers (90% fractional bandwidth).
- Low lateral resonance: subdicing

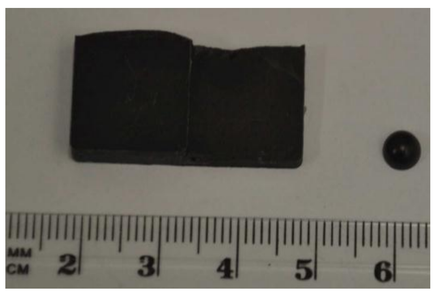
*C. Li et al, *Phys. Rev. E* **78**, 021901 (2008)

Acoustic lens material characteristics

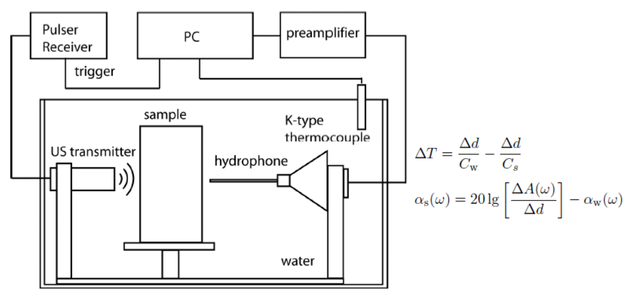
Lens material requirements:

- Large speed of sound compared to speed of sound of water (ensures a strong lens effect according to Snell's law) .
- Low acoustic attenuation (Minimize the attenuation loss).
- Impedance ($Z=\rho_L C_L$) close to that of tissue or water (Minimize the reflection loss).

A novel acoustic lens material:

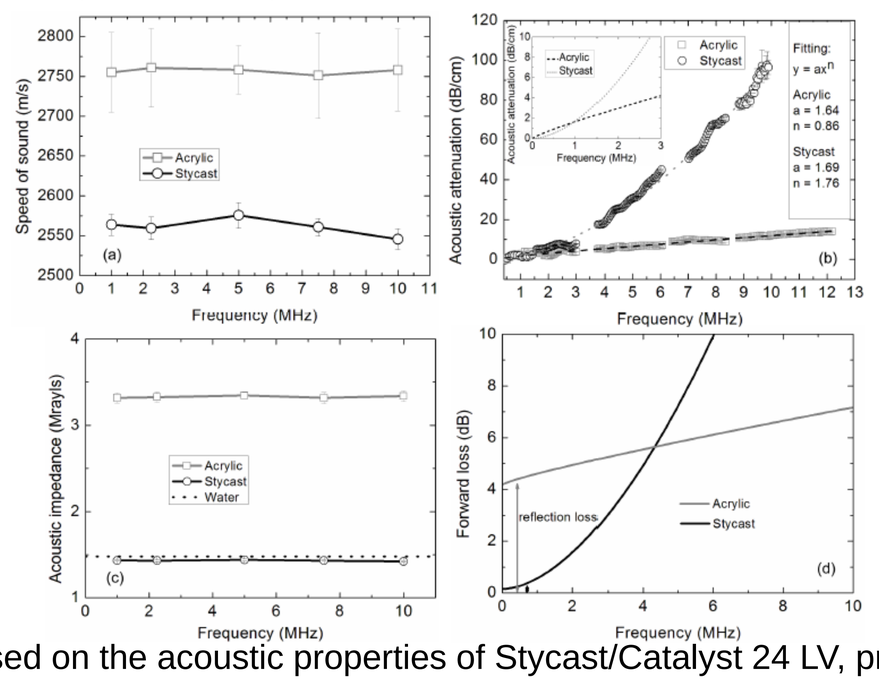


Stycast / Catalyst 24 LV



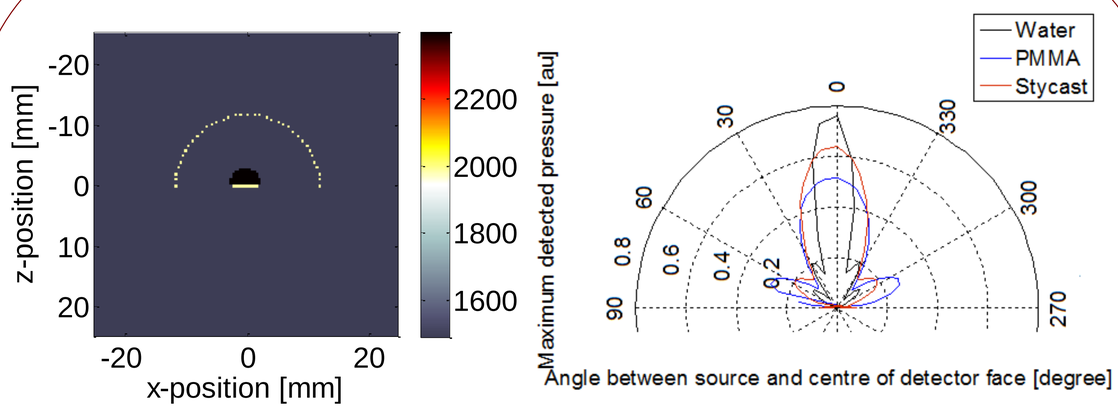
$$\Delta T = \frac{\Delta d}{C_w} - \frac{\Delta d}{C_s}$$

$$\alpha_s(\omega) = 20 \lg\left[\frac{\Delta A(\omega)}{\Delta d}\right] - \alpha_w(\omega)$$



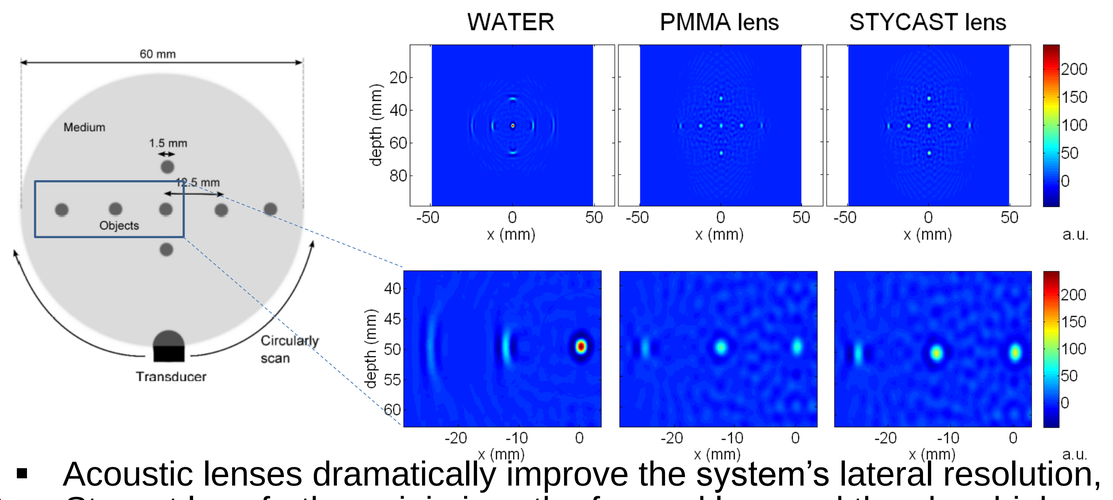
Based on the acoustic properties of Stycast/Catalyst 24 LV, proposed lens has lower forward loss for frequencies up to 4 MHz as compared to the common used lens material PMMA (acrylic).

Enlarged acceptance angle



B. T. Cox *et al*, *J. Acoust. Soc. Am.* 117(6) (2005)

Improved lateral resolution



- Acoustic lenses dramatically improve the system's lateral resolution,
- Stycast lens further minimizes the forward loss and thus has higher image contrast compared to PMMA (acrylic) lens

Future plans

- Experimentally study the enlargement of the acceptance angle using lens.
- Acoustic lens validation in photoacoustic tomographic experiments.
- Compare simulation and experiment results.

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