Design, Manufacturing and Packaging of a Micro Ultrasonic Transducer for Medical Applications

Tønsberg, Norway

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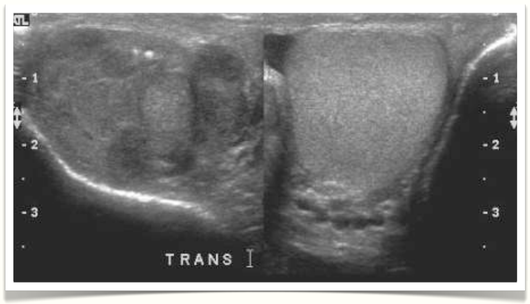
Ultrasound in a needle.

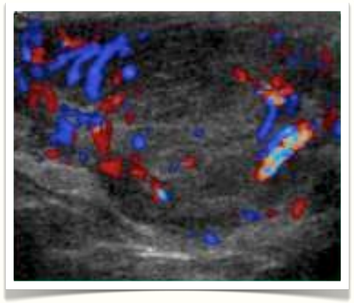
Ablation and imaging tissues.

High resolution for therapeutic ultrasound tumour treatments, and *in vivo* surgical guidance, using high frequency micro transducers.

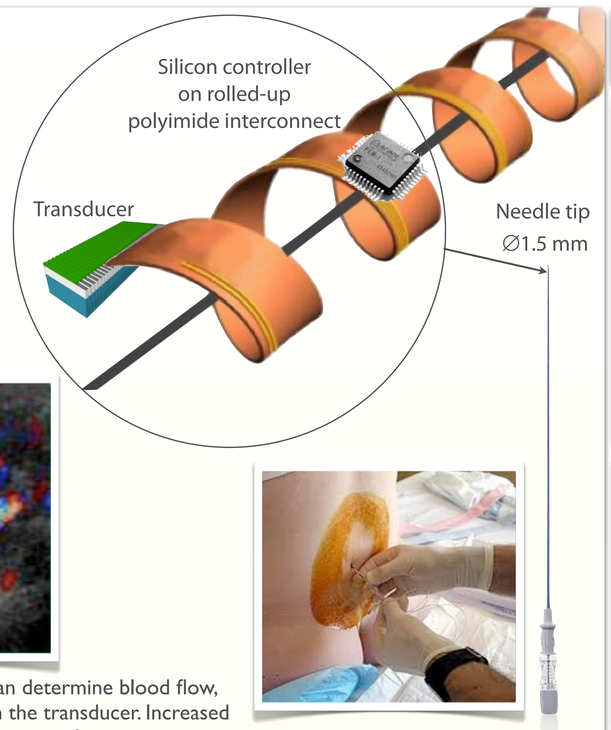
Higher than 25 MHz is capable of imaging biological cells.



(Left) Semioma - testicular tumour compared to (right) a normal testis.



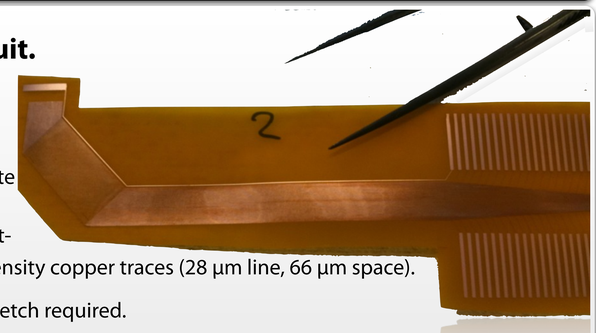
Doppler waveform of ultrasound can determine blood flow, towards (red) and away (blue) from the transducer. Increased blood flow in the testicle is characteristic of a semioma.



Packaging technologies.

High density flex circuit.

Novel wet etch.

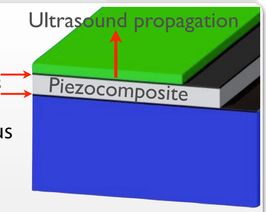


Specially devised agitation of fluid, movement of the substrate and generation of ultra fine air bubbles in the bath, allows cost-effective production of high density copper traces (28 µm line, 66 µm space).

No laser imaging or O_2 plasma etch required.

Low temperature bonding

Thin conductive layer .



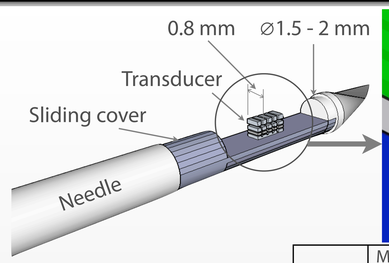
Isotropic conductive adhesive (ICA) is to be incorporated into various parts of the transducer where a thin conductive layer is required without scattering the ultrasonic beam. Low temperature is also required to process the sensitive single crystal piezoelectric ceramic "lead magnesium niobate - lead titanate" (PMN-PT) below 50ºC.

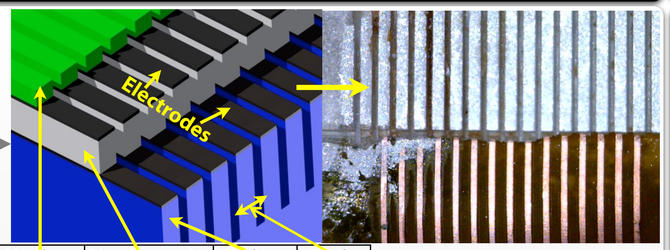
Anisotropic conductive bonding.

Options open.

Anisotropic conductive films / adhesives, (ACF / ACA), for bonding chip on flex (COF) and possibly components directly on to the sensitive PMN-PT. Particularly interesting are adhesives containing magnetic conductive particles and UV curable epoxy.

Design and manufacturing.





Linear array.

Fine pitch. 128 elements.

	Matching	Piezocomposite	Backing	Pitch
	Thickness			Width
15 MHz	50 µm	100 µm	500 µm	100 µm
25 MHz	27 µm	80 µm	250 µm	60 µm
50 MHz	14 µm	40 µm	200 µm	30 µm

Each element in the linear array transducer consists of a piezoelectric ceramic - epoxy composite layer, sandwiched by a thin acoustic matching layer on top and an absorbing backing layer at the bottom, both made of 15 vol% alumina filled epoxy. The thickness for these layers and element pitch size are calculated for different operating frequencies.

The flex circuit is bonded onto the electrodes on the backing layer before precision dicing, which aligns to the gaps between the copper tracks on the flex and create the kerfs between each element. It is important to minimise mechanical and electrical cross talk between individual element.

Flex circuit (bottom) aligned to the dicing of the linear array transducer (top).

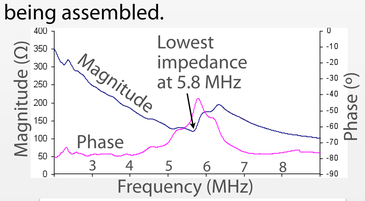
Precision dicing.

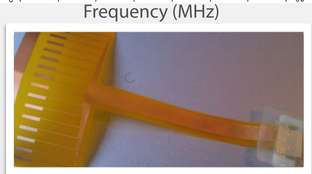
First prototypes.

5.8 - 15 MHz.

Up to 64 elements.

A bonded prototype operating at 5.8 MHz was measured prior to dicing. The element pitch (thus the frequency) achievable is limited by the resolution of the flex circuit. Another prototype using ~100 µm pitch flex circuit is currently being assembled.





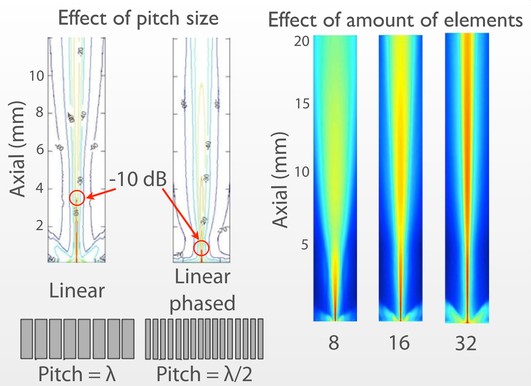
Simulation.

Beam forming.

Lower noise. Deeper view.

Simulated for 30 MHz using Field II. The contour map (left) shows much better beam depth for full wavelength pitch at -10 dB.

A less diverging beam shape (right) travels much further with increasing number of elements in the transducer.



λ = wavelength in the tissue.

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Collaborators: PCT, Logitech, AFM Ltd, Loadpoint, PZFlex, NHS Tayside, University of Strathclyde Glasgow, University of Dundee

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