High frequency (20 MHz and above) therapeutic transducers based on piezoelectric thick film

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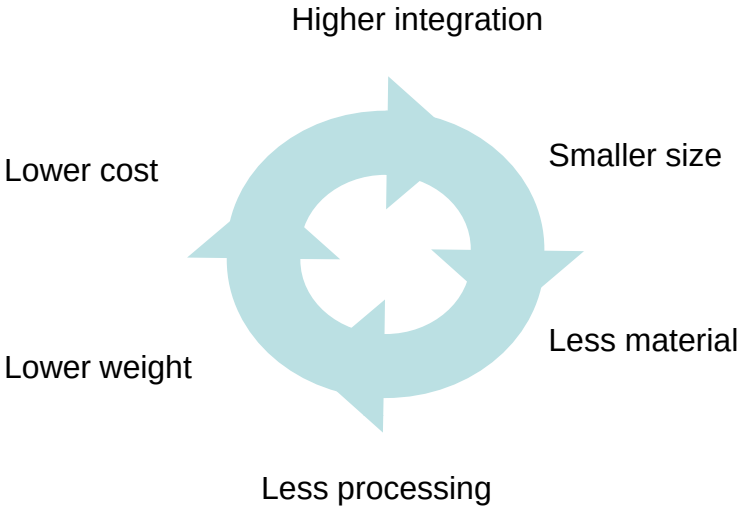
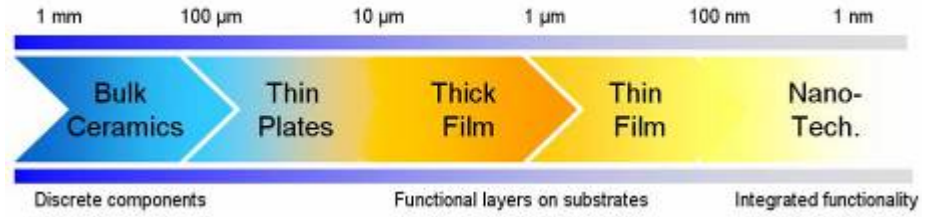
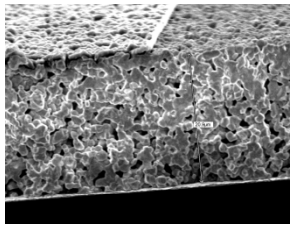
Outline

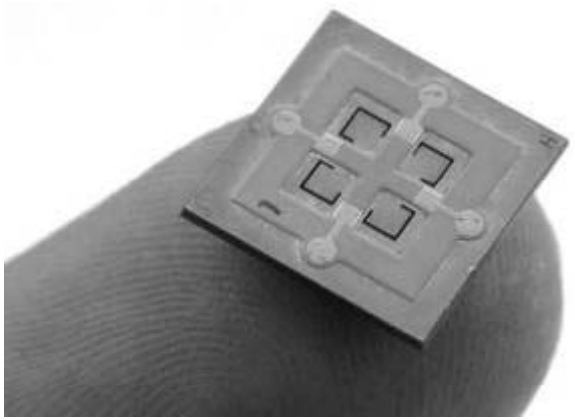
- Introduction of PZT thick film technology
- Pad printing
- High frequency imaging
- High frequency therapeutics
- Conclusion and outlook

PZT thick-film technology

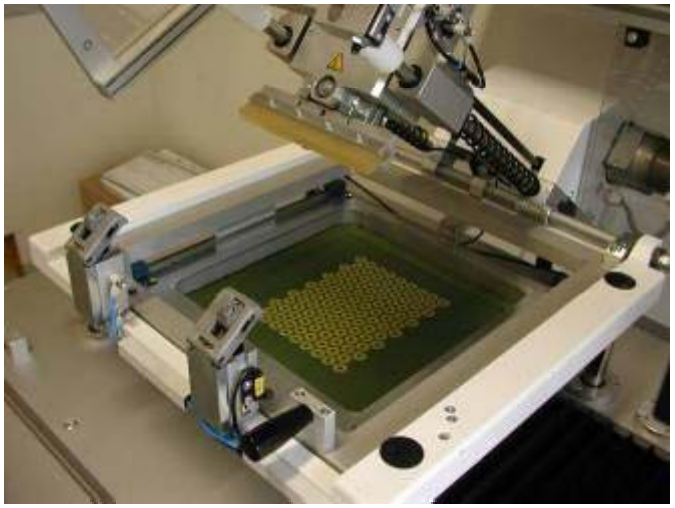


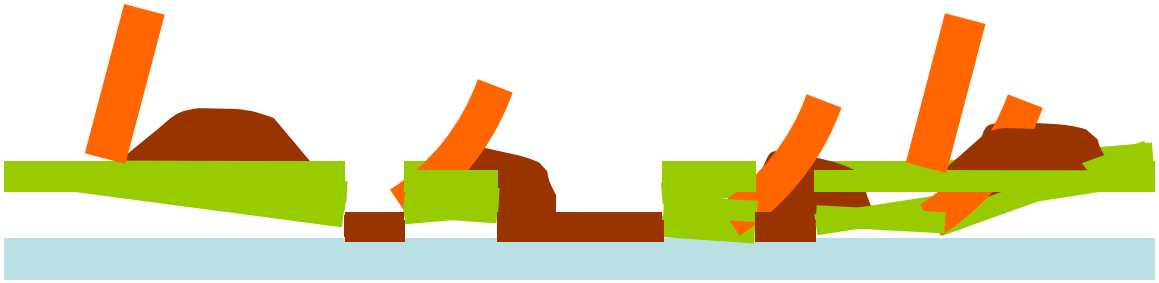






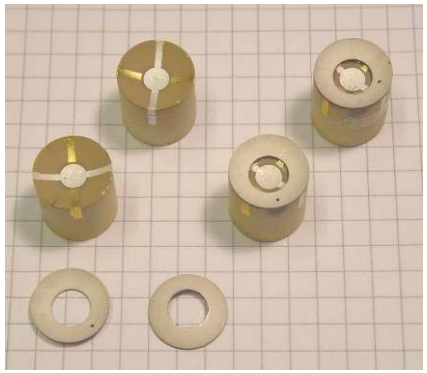
Screen printing



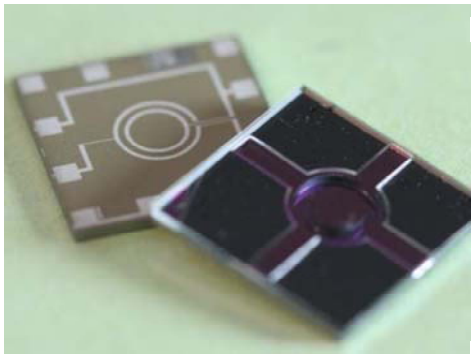


PZT thick film compatibility

SUBSTRATES

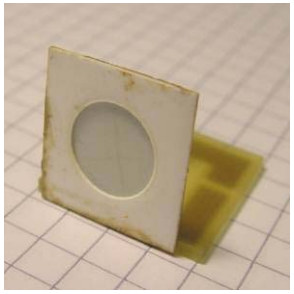


Ceramics



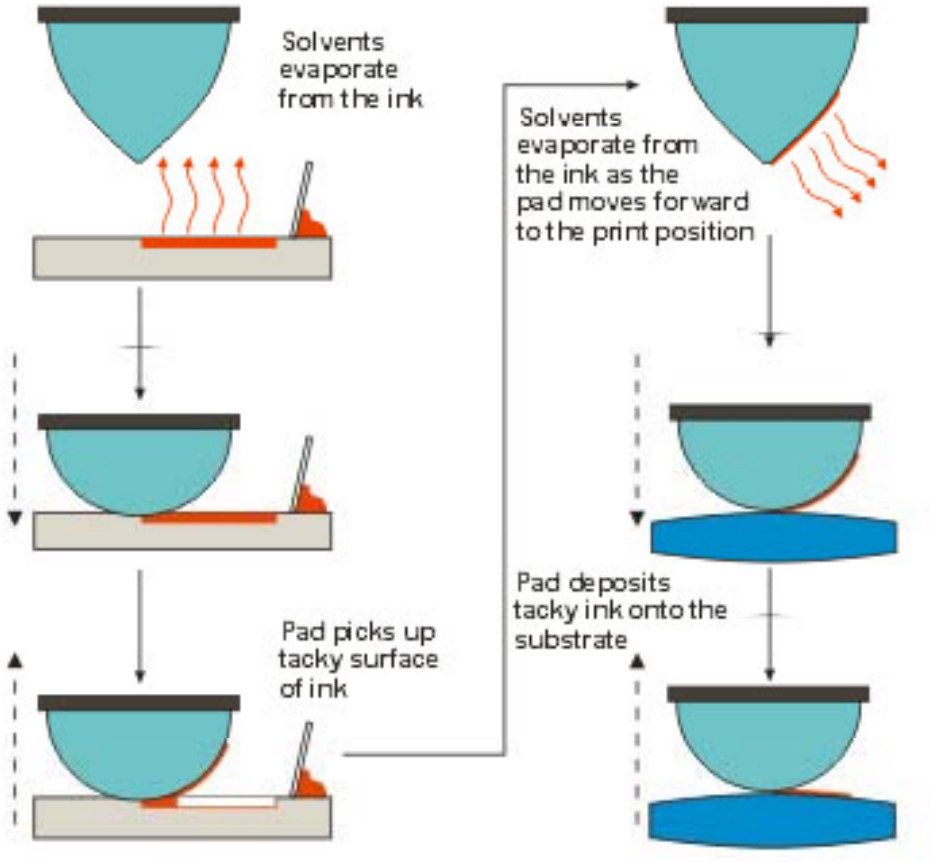
Silicon/MEMS

Stainless steel



LTCC

Pad printing



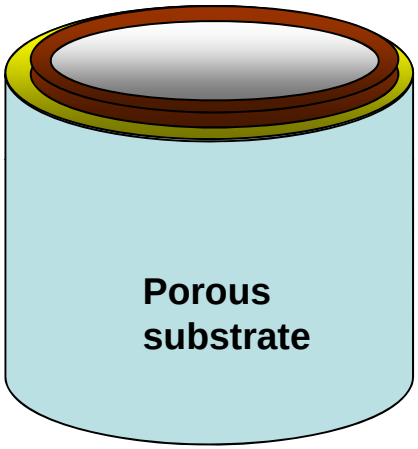
http://www.pdsconsulting.co.uk/2007/Library/Printing_Pad.asp

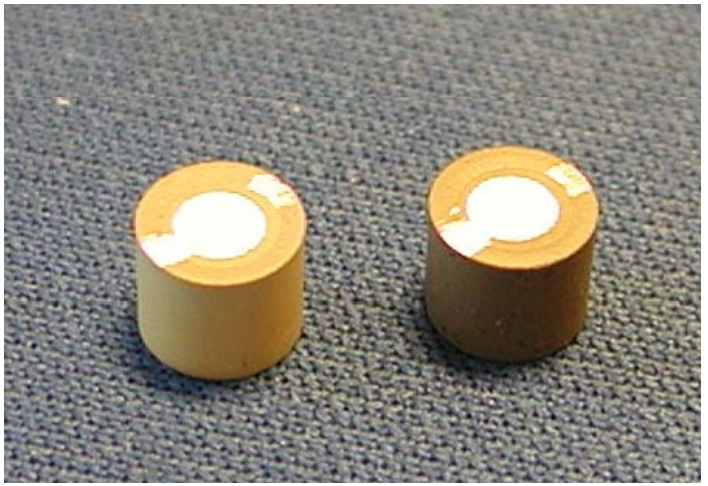
Pad printing

Used for printing graphics on non flat surfaces

http://www.printinginternational.com/en/tampon-printing-machines.html

High frequency transducer manufacturing

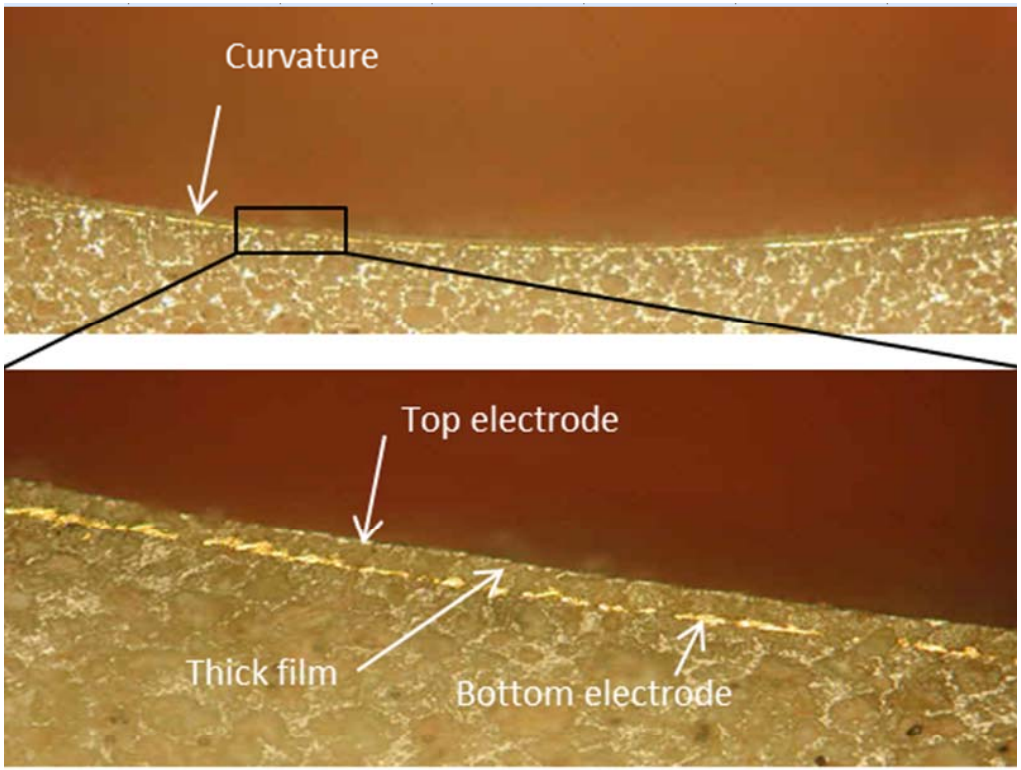




With IPPT, Warsaw (PL)

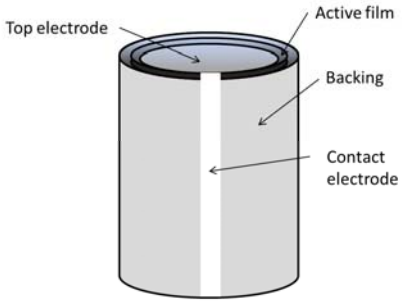
High frequency imaging

- Focus without introducing a lens
- Simple manufacturing process
- Flexible design



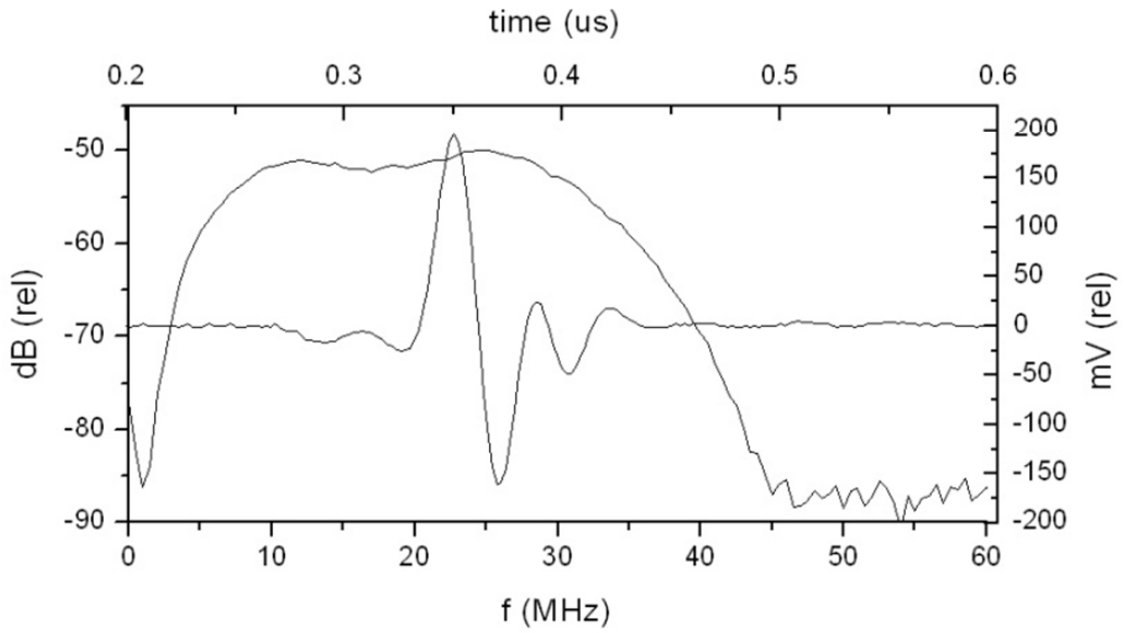
Transducer design

- Backing thickness: 5 mm
- Backing diameter: 3 mm
- Geometrical focus: 15 mm
- Aperture: 2.5 mm
- The transducer was mounted in a BNC conductor and encased in epoxy



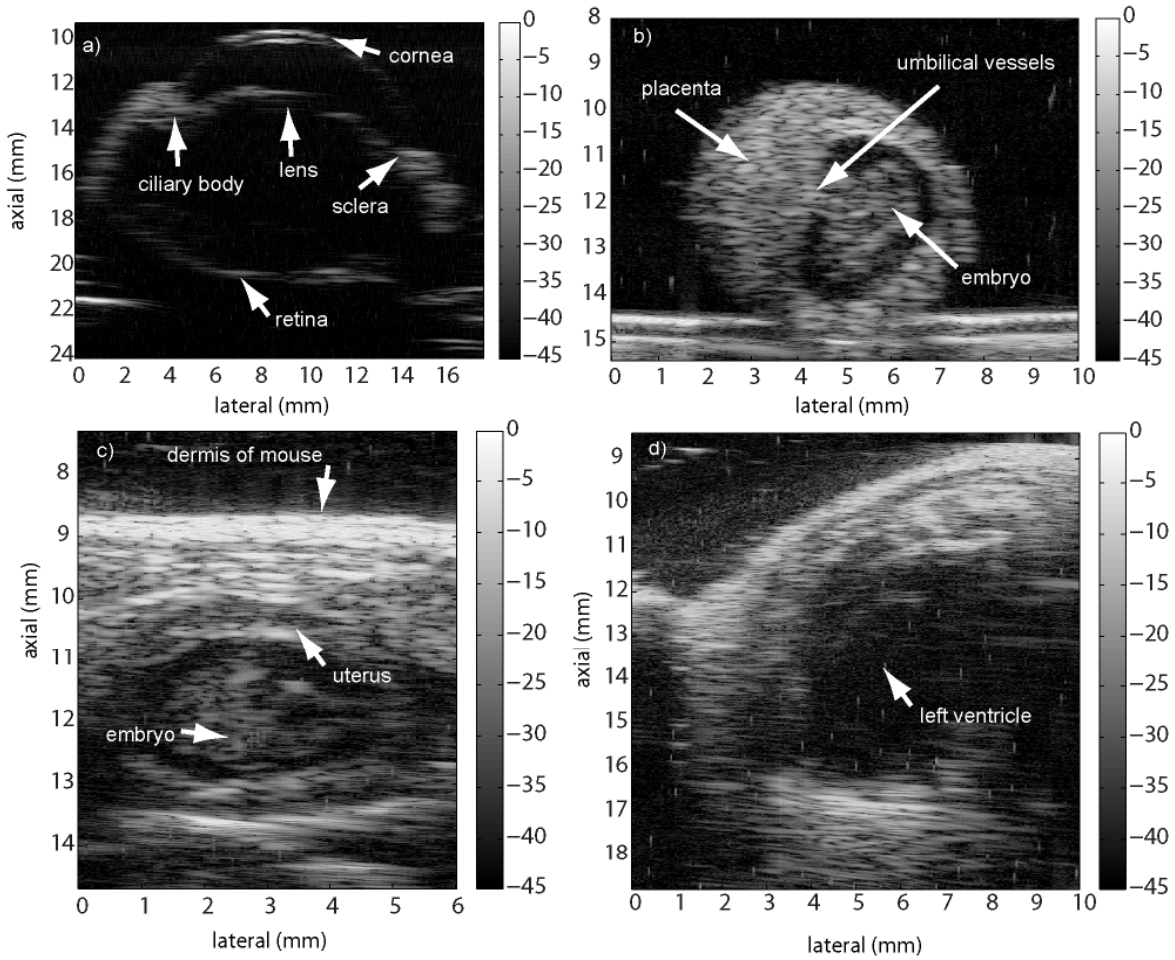
High frequency imaging

- Pulse-echo response



Glass plate pulse/echo response revealed a center frequency of 19.5 MHz and -6 dB bandwidth of 135%.

High frequency images



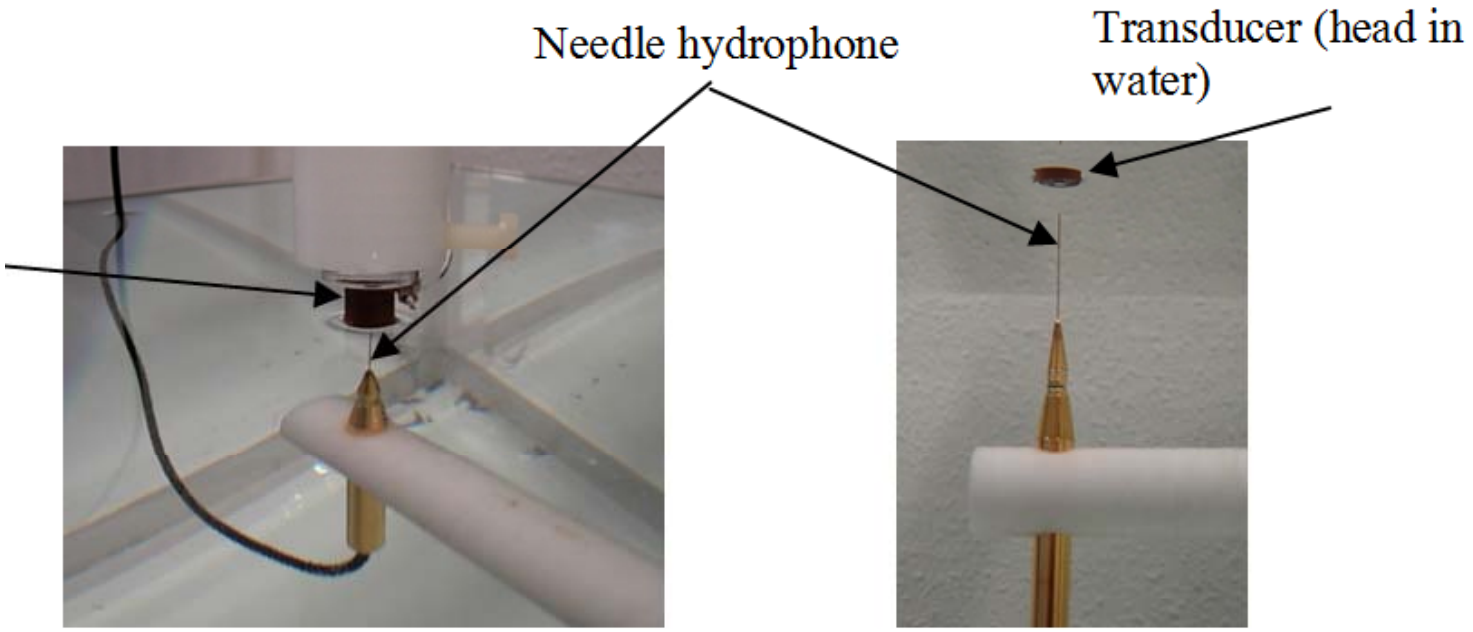
a) *Ex vivo* rabbit eye, b) externalized *in vivo* mouse embryo, c) *in vivo* and *in utero* mouse embryo, and d) *in vivo* adult mouse heart.

High frequency therapeutics

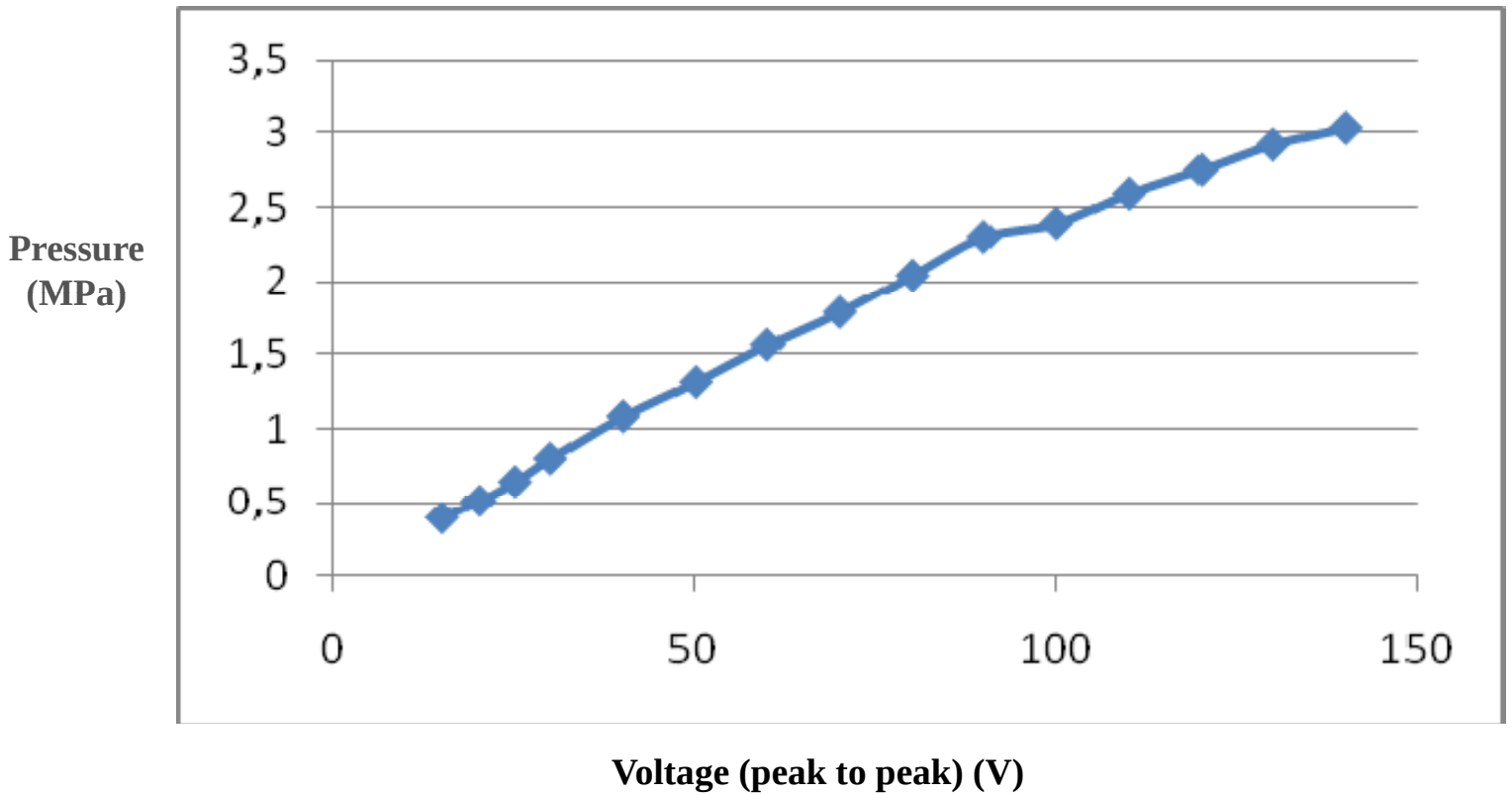
- PZT thick film used in therapeutics opens the possibility of using the same transducer for imaging and treatment
- The pad printing manufacturing process enables the manufacturing of complex structures such as integrated imaging and therapeutic transducer in one device

High frequency therapeutics

- A 200 µm aperture needle hydrophone (Precision Acoustics, Ltd., Dorchester, Dorset, UK) calibrated to slightly above 20 MHz was used



High frequency therapeutics



Improvements

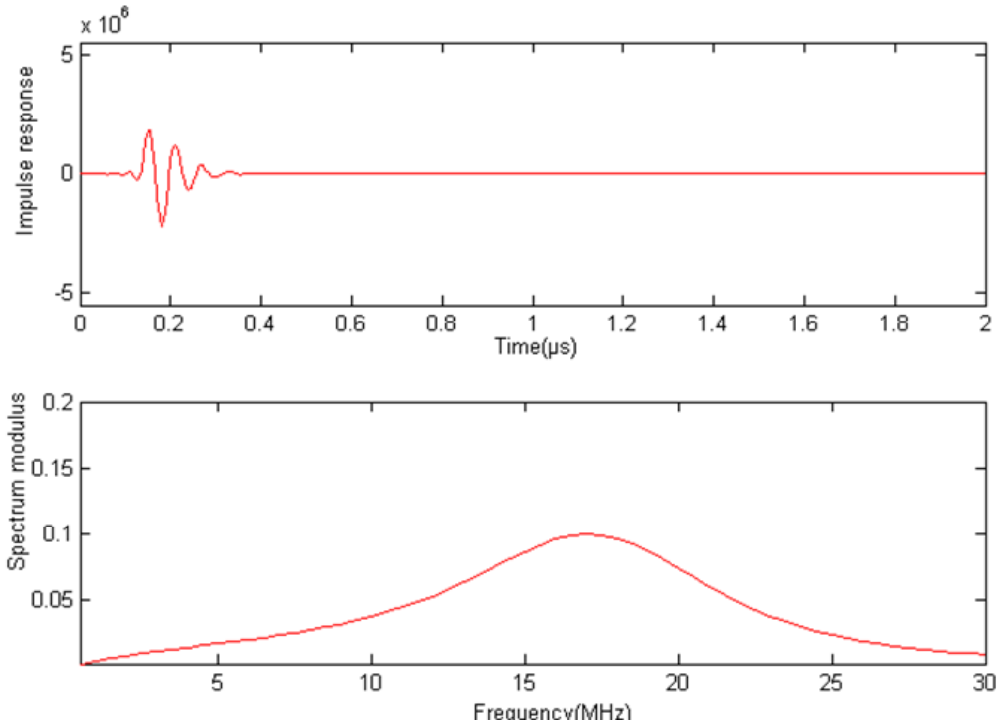
- The transducer is designed for imaging and not for therapeutics
- Improvements towards better HIFU performance such as lower damping would deteriorate the imaging performance
- In a combined HIFU/imaging device a compromise is needed
- In an integrated HIFU/imaging device this can be accomodated

Simulations

- Simulations using a KLM model was performed
- Bottom electrode thickness and backing porosity was changed

Simulations

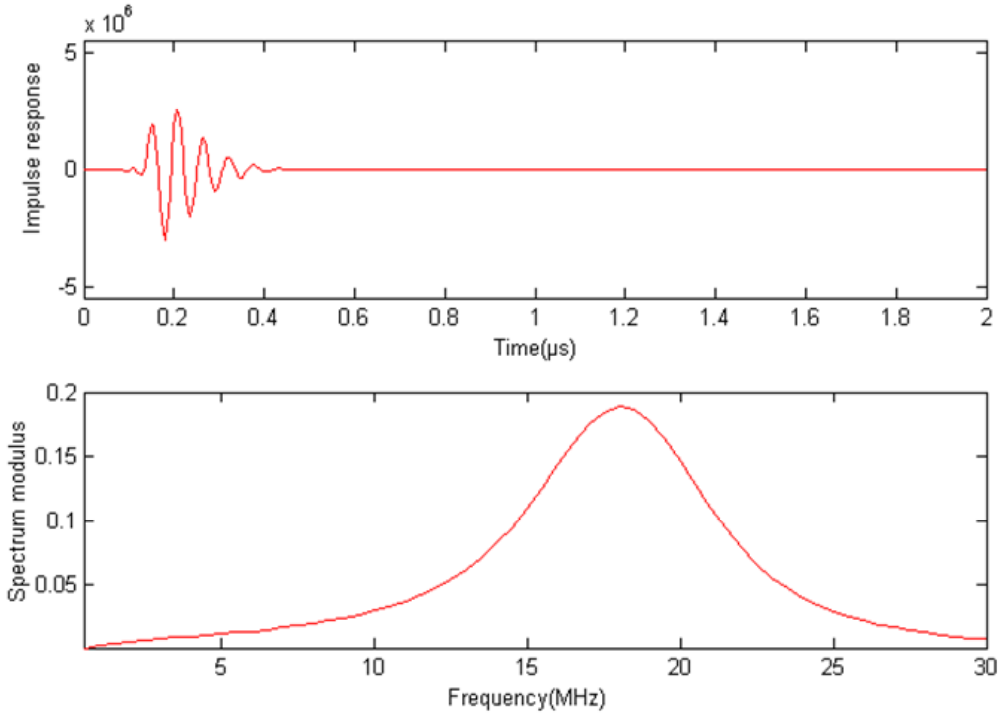
- Bottom electrode: 5 μm
- Porosity: 20 %



Pulse-echo impulse response and spectrum of reference transducer (designed for Imaging). Bandwidth 60%, efficiency 11%.

Simulations

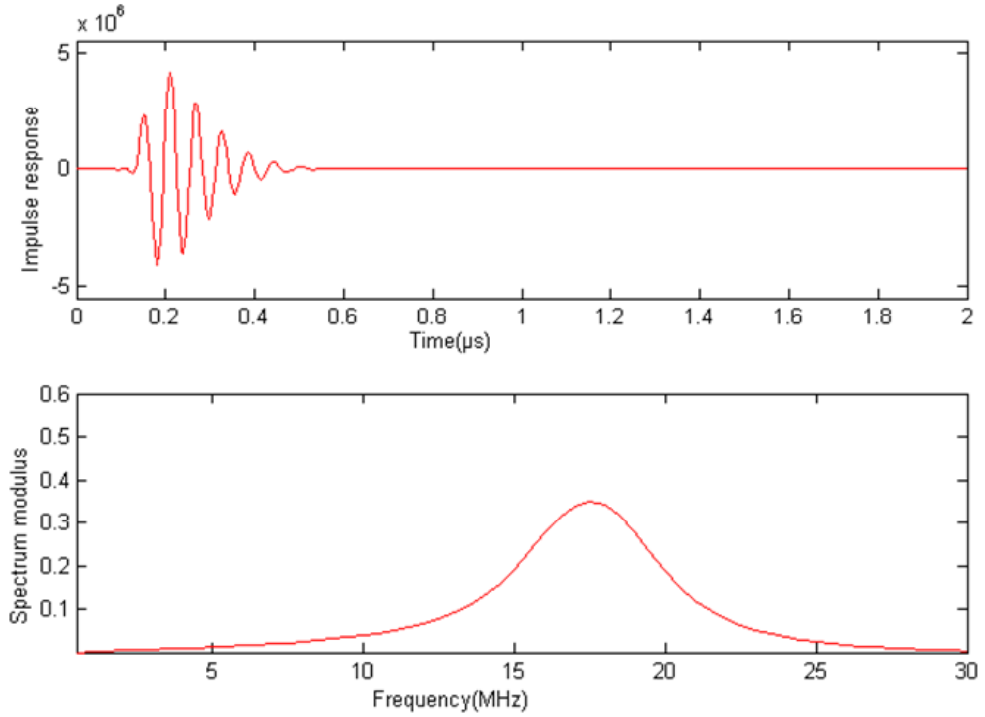
- Bottom electrode: 5 μm
- Porosity: 30 %



Pulse-echo impulse response and spectrum of transducer with high porosity backing and standard rear électrode. Bandwidth 37%, efficiency 15%.

Simulations

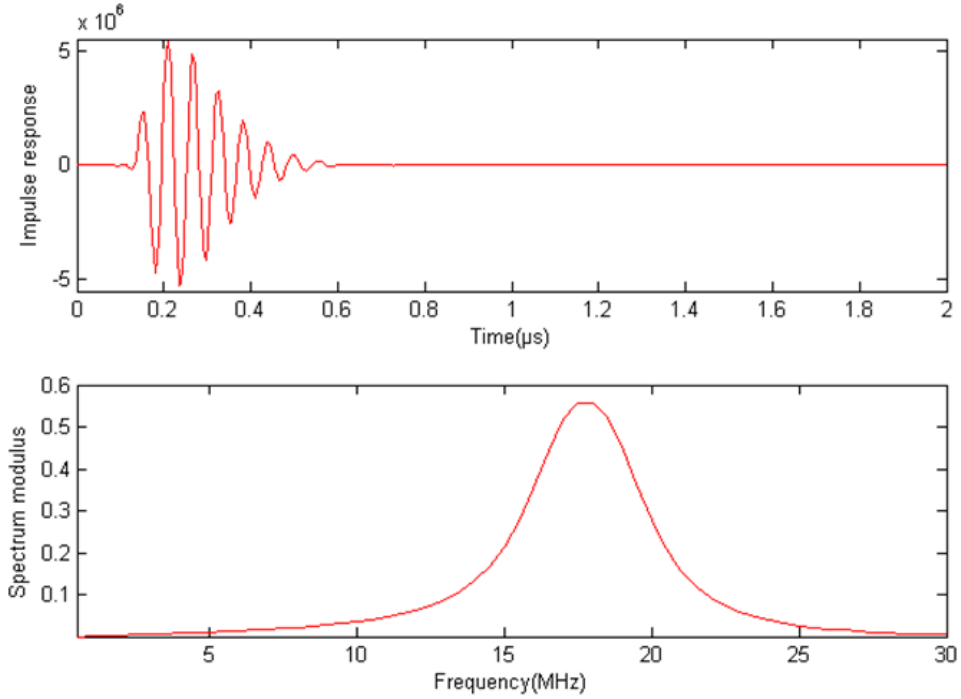
- Bottom electrode: 15 μm
- Porosity: 20 %



Pulse-echo impulse response and spectrum of transducer with standard backing and thick rear électrode. Bandwidth 31%, efficiency 23%.

Simulations

- Bottom electrode: 15 μm
- Porosity: 30 %



Pulse-echo impulse response and spectrum of transducer with high porosity backing and thick rear électrode. Bandwidth 25%, efficiency 31%.

Conclusion and outlook

- PZT thick film technology was presented along with printing technologies
- High frequency imaging transducer has been manufactured and is a commercial product
- Therapeutic performance was characterised indicating good performance, but a need for improvements
- Simulations showing how to design a imaging/HIFU transducer was shown
- Transducer using the suggested design alterations will be manufactured in the near future

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Acknowledgements

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Thank you