

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

Wanda W. Wolny, Rasmus Lou-Møller, Andrzej Nowicki, M. Lethiecq,
J. Ketterling, F. Levassort



MEGGITT

© Meggitt Sensing Systems. This document and the information in it is proprietary and is the property of Meggitt Sensing Systems. It may not be copied or disclosed to a third party or used for any purpose other than that for which it is supplied without the express written consent of Meggitt Sensing Systems.

Information contained in this document is subject to certain Export Control regulations, specifically of the (choose as appropriate) United Kingdom, European Union, other national jurisdiction and / or the United States International Traffic in Arms Regulations and / or Export Administration Regulations. Each recipient of this document is responsible for ensuring that transfer or use of any information contained in this document complies with all relevant Export Control Regulations.

MEGGITT



Outline

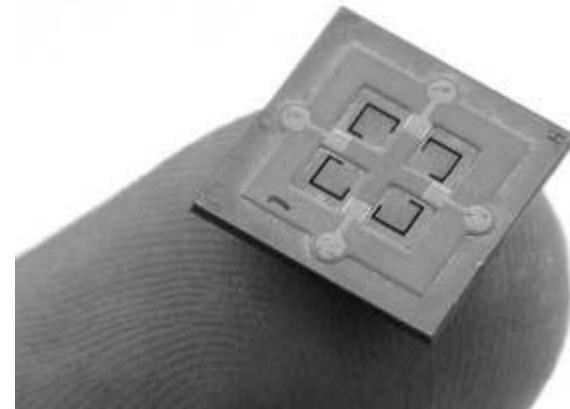
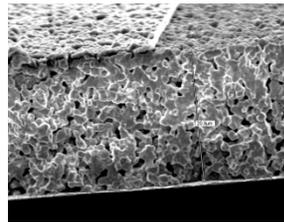
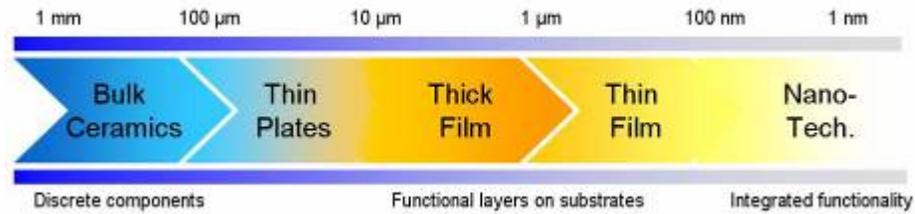
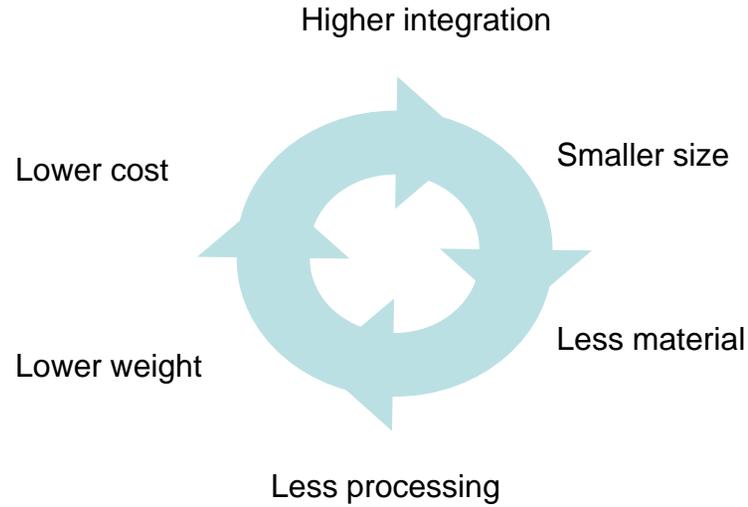
Ferroperm™ Piezoceramics

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



PZT thick-film technology

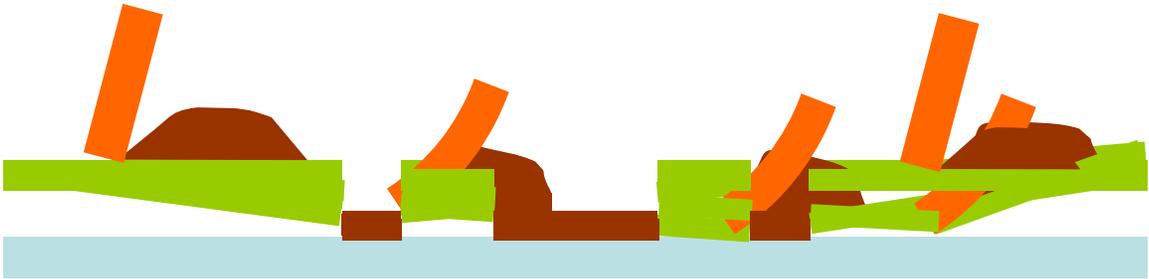
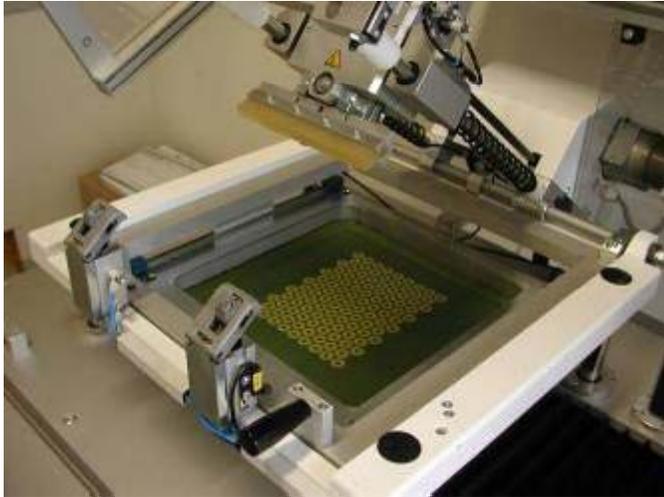
Ferroperm™ Piezoceramics





Screen printing

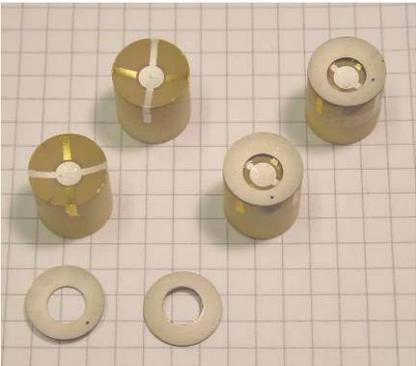
Ferroperm™ Piezoceramics





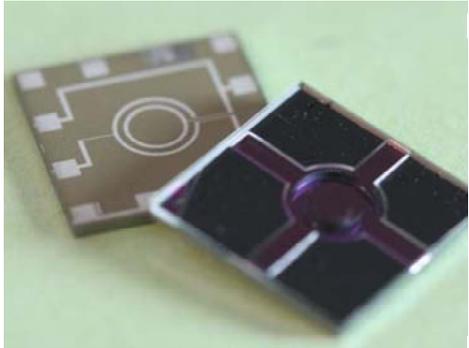
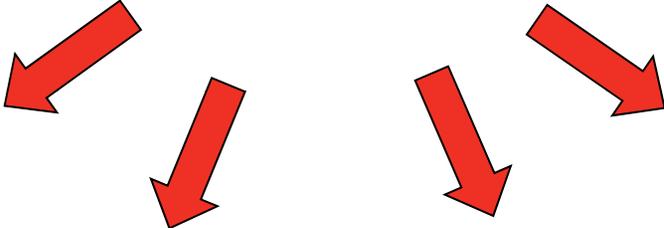
PZT thick film compatibility

Ferroperm™ Piezoceramics



Ceramics

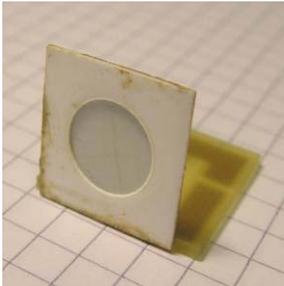
SUBSTRATES



Silicon/MEMS



Stainless steel



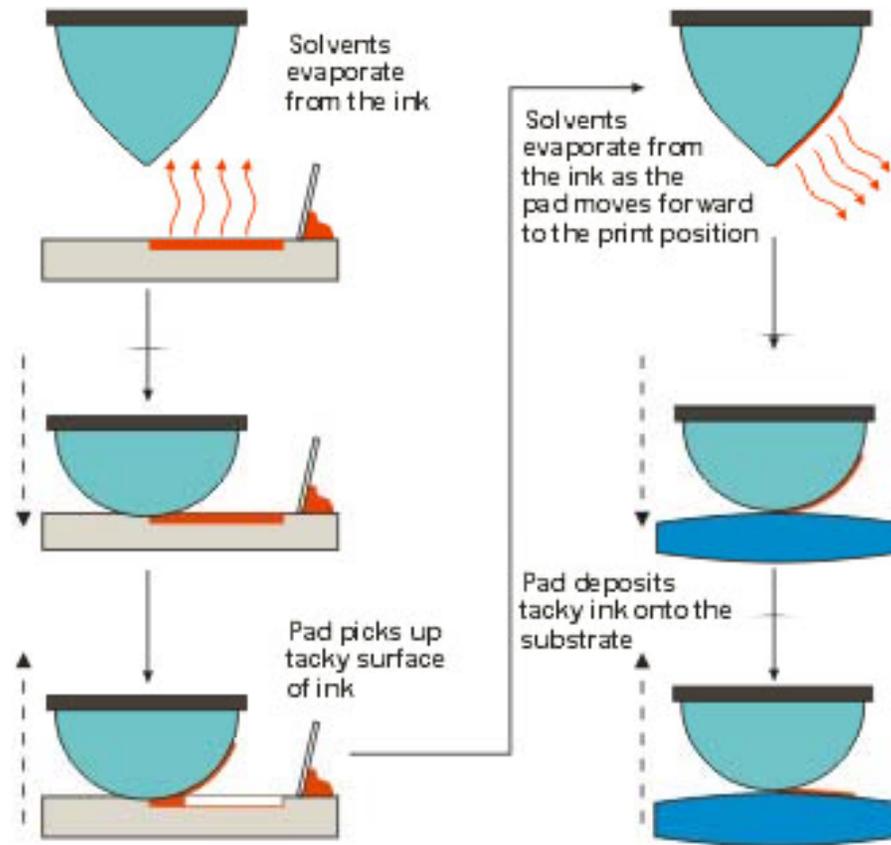
LTCC





Pad printing

Ferroperm™ Piezoceramics



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



Pad printing

Ferroperm™ Piezoceramics

Used for printing graphics on non flat surfaces



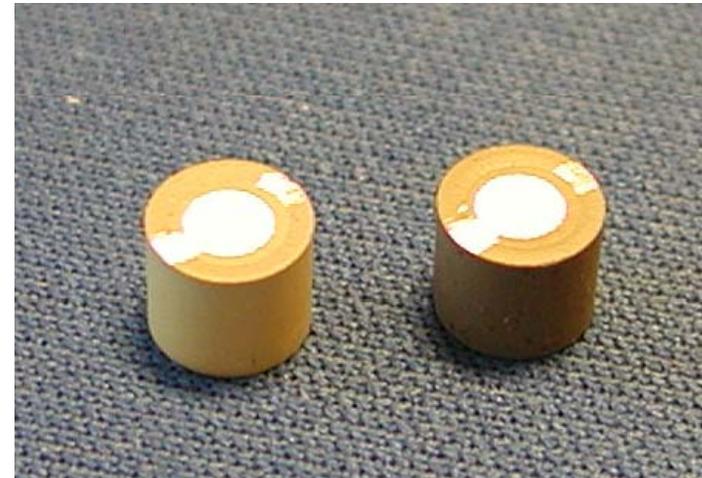
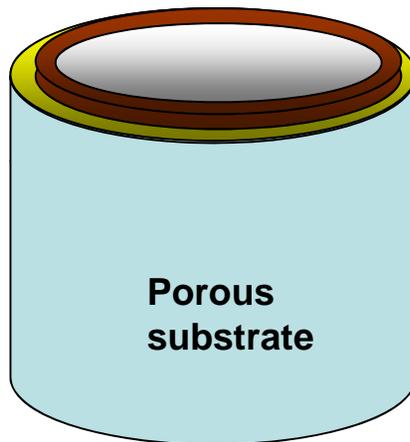
<http://www.printinginternational.com/en/taupon-printing-machines.html>

High frequency transducer manufacturing

Ferroperm™ Piezoceramics



MINUET

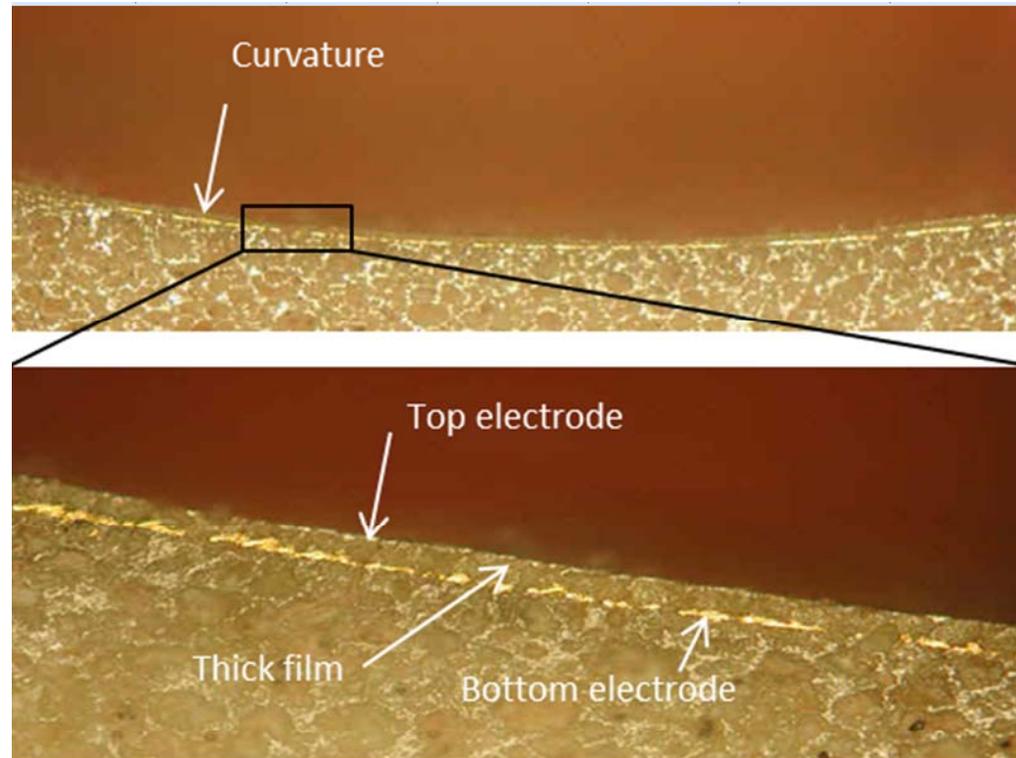


With IPPT, Warsaw (PL)

High frequency imaging

Ferroperm™ Piezoceramics

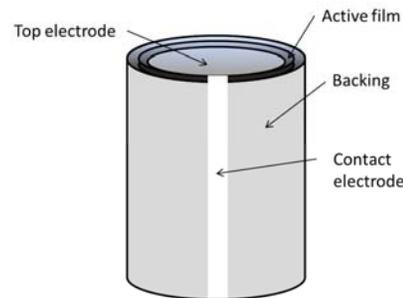
- Focus without introducing a lens
- Simple manufacturing process
- Flexible design



Transducer design

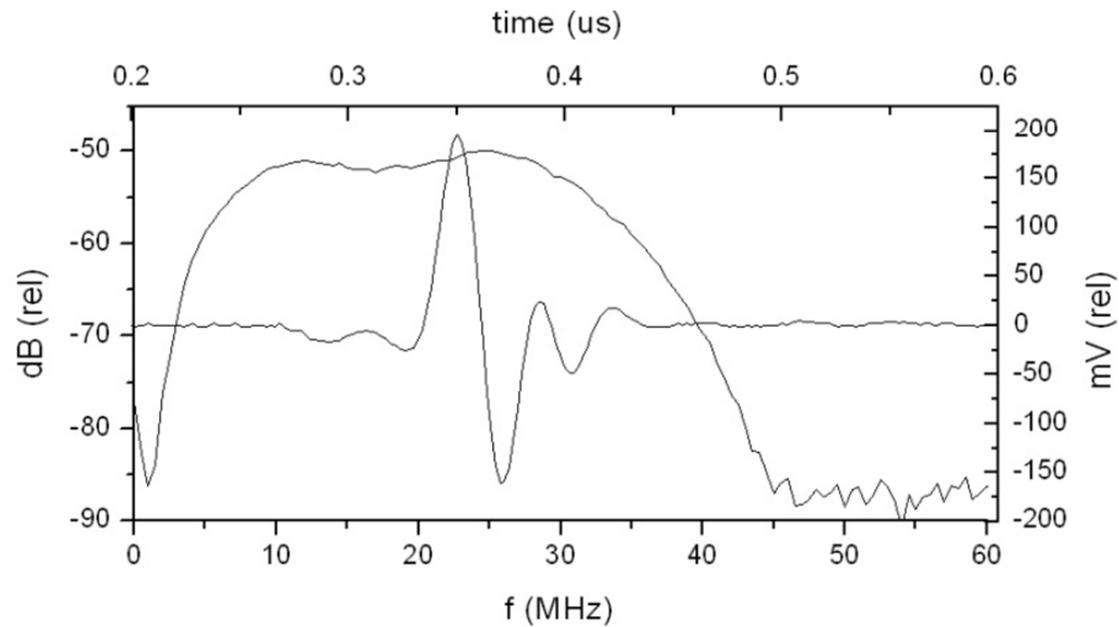
Ferroperm™ Piezoceramics

- ▶ 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





► Pulse-echo response

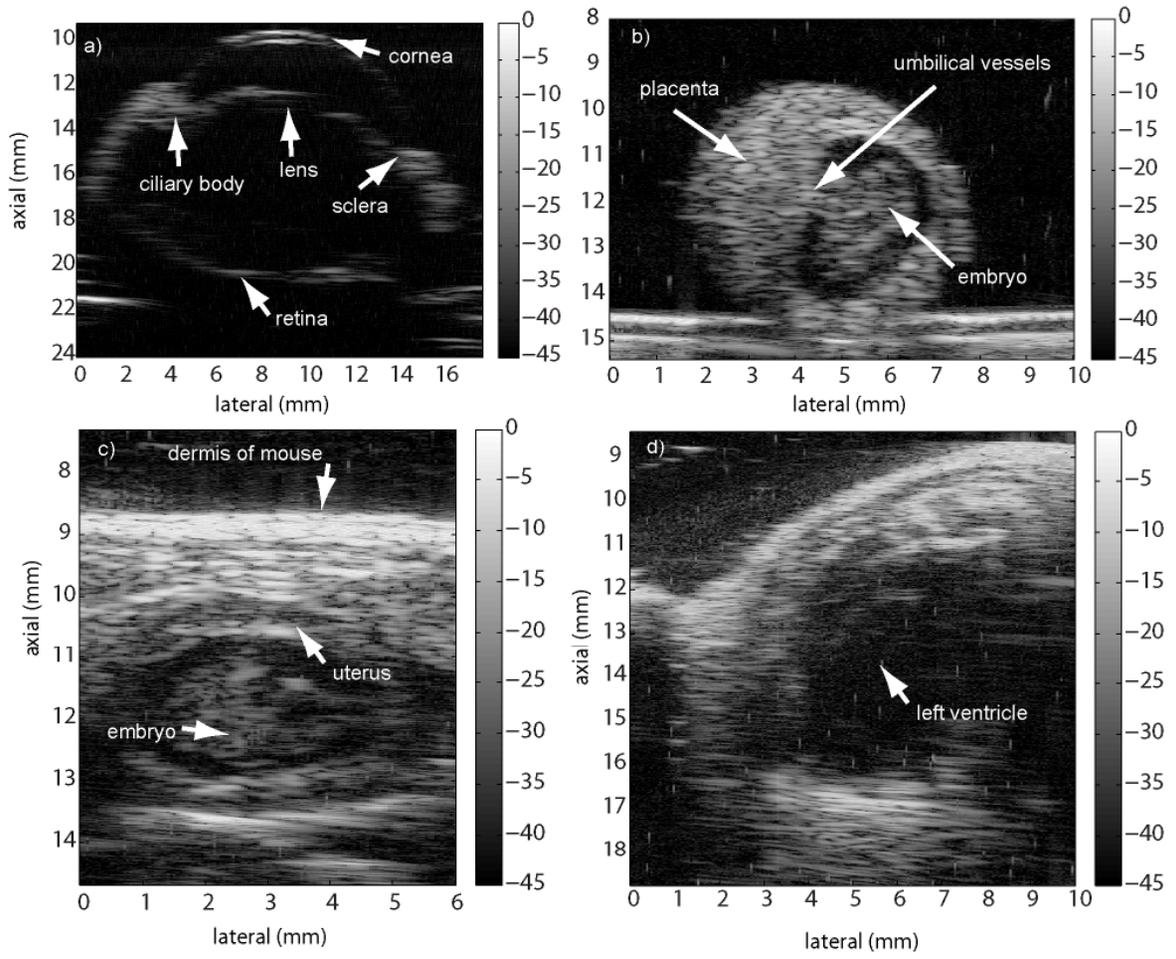


Glass plate pulse/echo response revealed a center frequency of 19.5 MHz and -6 dB bandwidth of 135%.



High frequency images

Ferroperm™ Piezoceramics



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

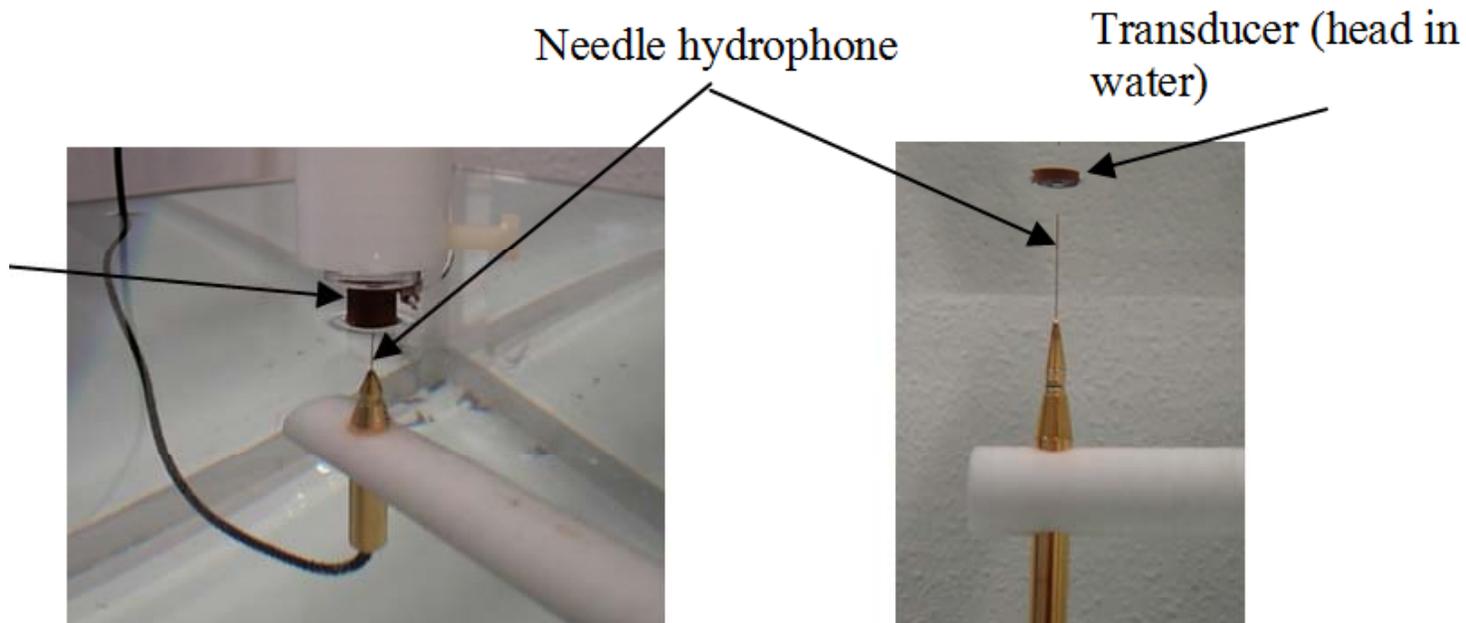
Ferroperm™ Piezoceramics

- ▶ 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

Ferroperm™ Piezoceramics

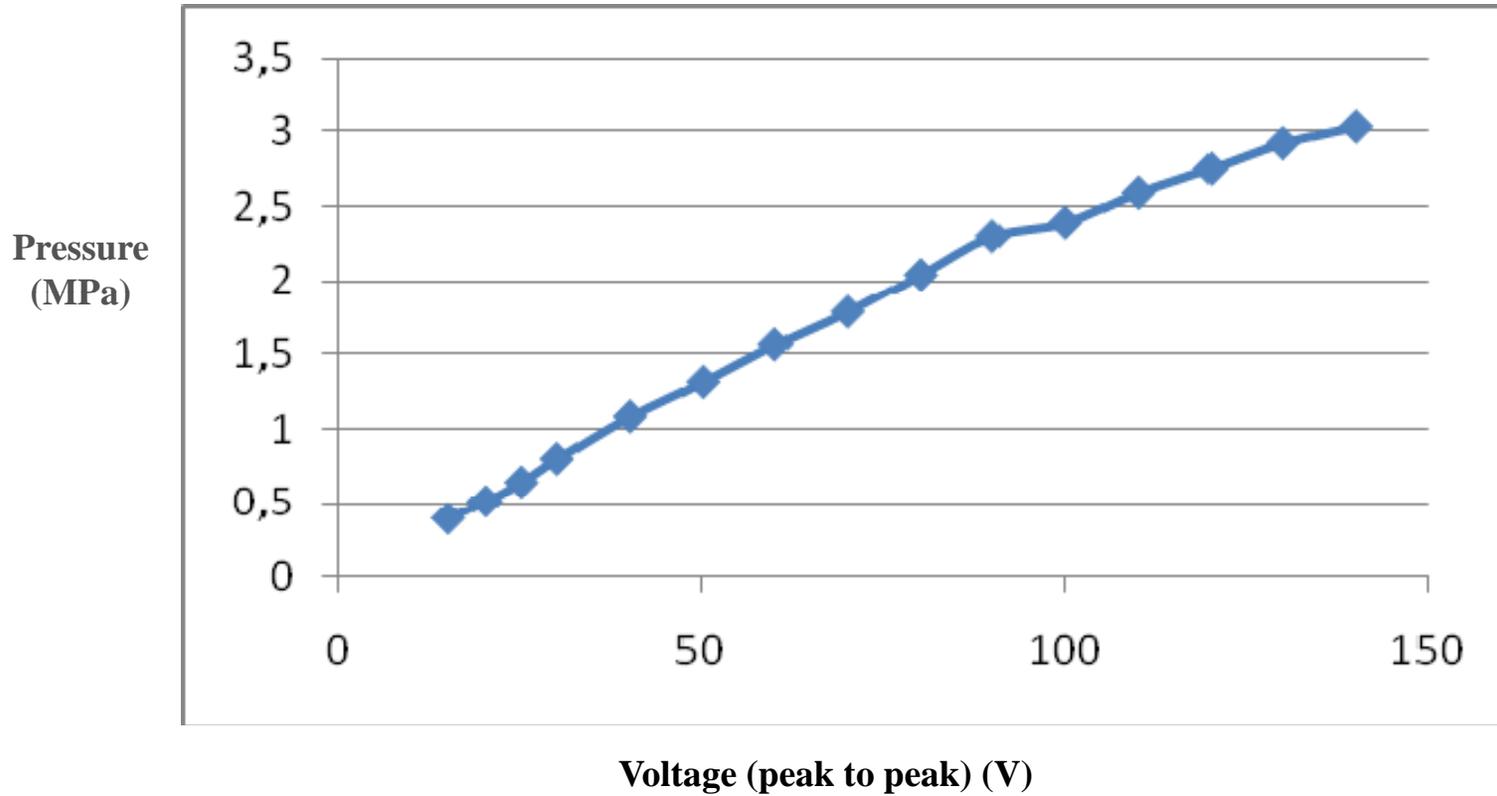
- A 200 μm aperture needle hydrophone (Precision Acoustics, Ltd., Dorchester, Dorset, UK) calibrated to slightly above 20 MHz was used





High frequency therapeutics

Ferroperm™ Piezoceramics





Improvements

Ferroperm™ Piezoceramics

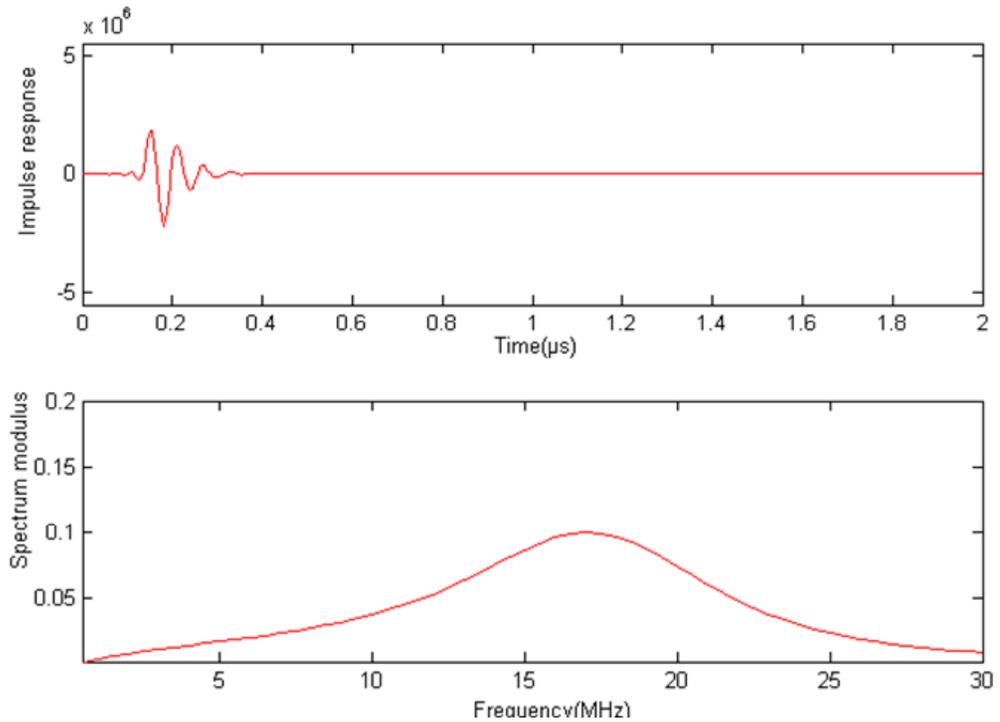
- ▶ The transducer is designed for imaging and not for therapeutics
- ▶ Improvements towards better HIFU performance such as lower damping would deteriorate the imaging performance
- ▶ In a combined HIFU/imaging device a compromise is needed
- ▶ In an integrated HIFU/imaging device this can be accommodated



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



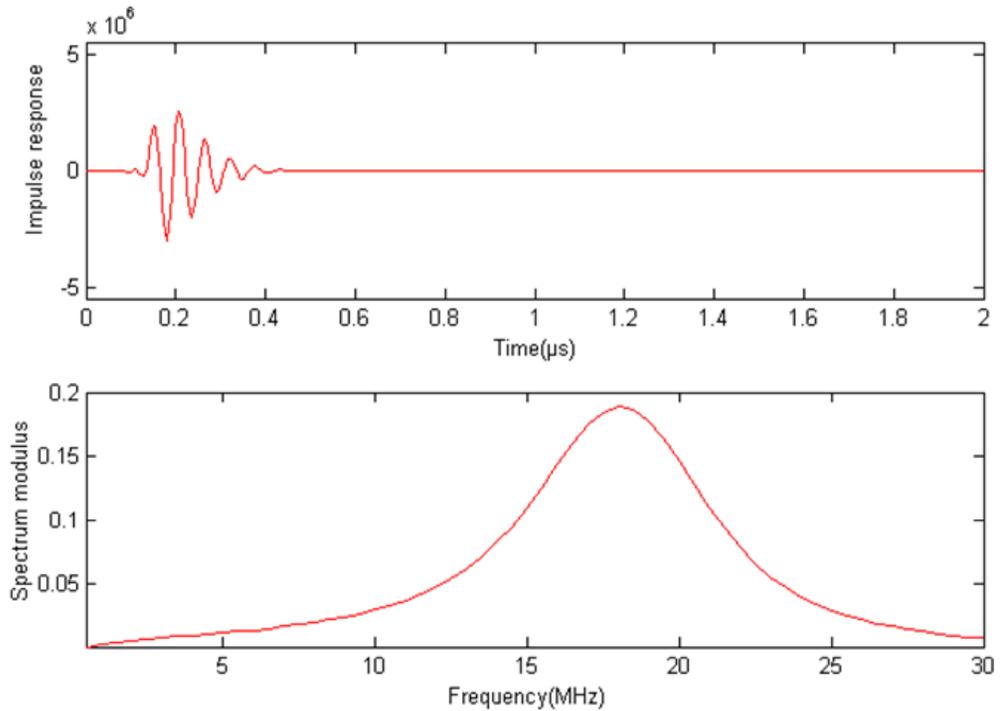
- ▶ Bottom electrode: 5 μm
- ▶ Porosity: 20 %



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



- ▶ Bottom electrode: 5 μm
- ▶ Porosity: 30 %

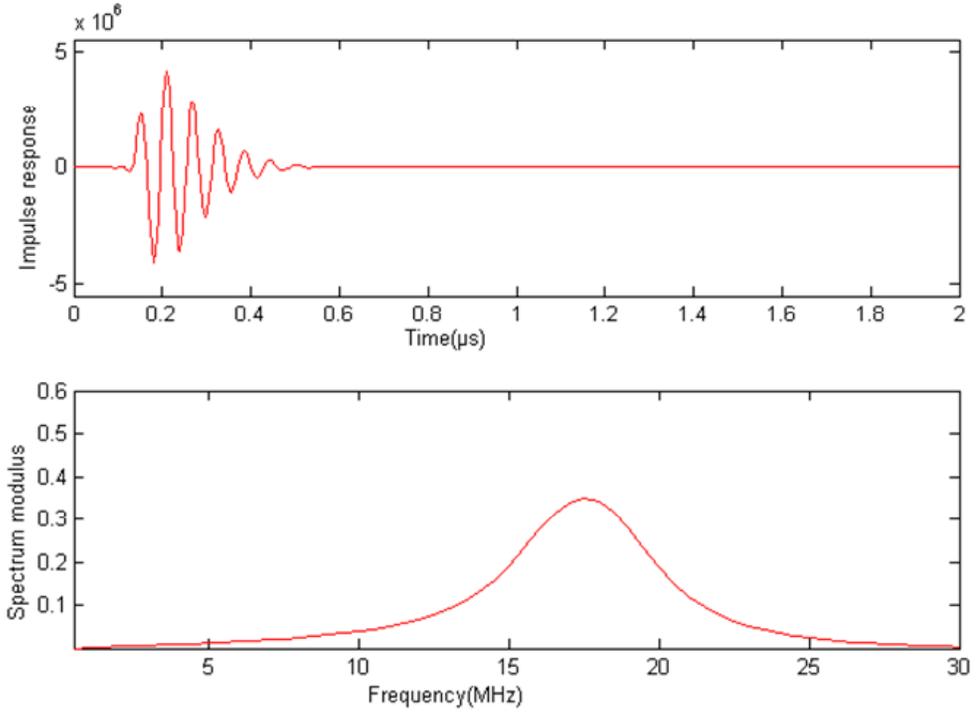


Pulse-echo impulse response and spectrum of transducer with high porosity backing and standard rear electrode. Bandwidth 37%, efficiency 15%.



Simulations

- ▶ Bottom electrode: 15 μm
- ▶ Porosity: 20 %

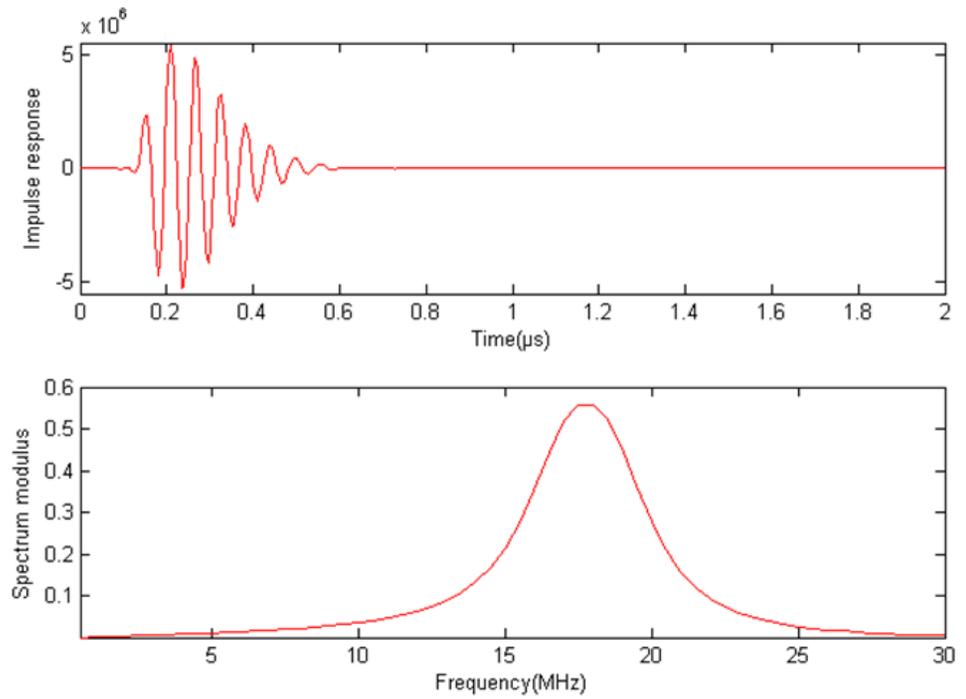


Pulse-echo impulse response and spectrum of transducer with standard backing and thick rear electrode. Bandwidth 31%, efficiency 23%.



Simulations

- ▶ Bottom electrode: 15 μm
- ▶ Porosity: 30 %



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



- ▶ 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



Acknowledgements

Ferroperm™ Piezoceramics

EC through the MINUET project (6th Framework Programme, Contract No. NMP2-CT-2004-505657) and the NoE MIND (6th Framework Programme, Contract No. NMP2-CT-2004-505657)

Organisers of UIA 2011



Thank you

Ferroperm™ Piezoceramics

The information contained in this document is the property of Meggitt Sensing Systems and is proprietary and/or copyright material. This information and this document may not be used or disclosed without the express authorization of Meggitt Sensing Systems. Any unauthorized use or disclosure may be unlawful.

The information contained in this document may be subject to the provisions of the trade compliance regulations (including those regulations governing transfer to a dual national or third country national, export and re-export) of various countries; see the first page for specific requirements. The recipient acknowledges that licences from the applicable regulatory agency or agencies may be required before the recipient may further disclose such information to others, and that such licences may impose restrictions on further disclosure of such information. The recipient agrees to comply with all applicable governmental regulations as they relate to the transfer, export and re-export of information disclosed in this document.'