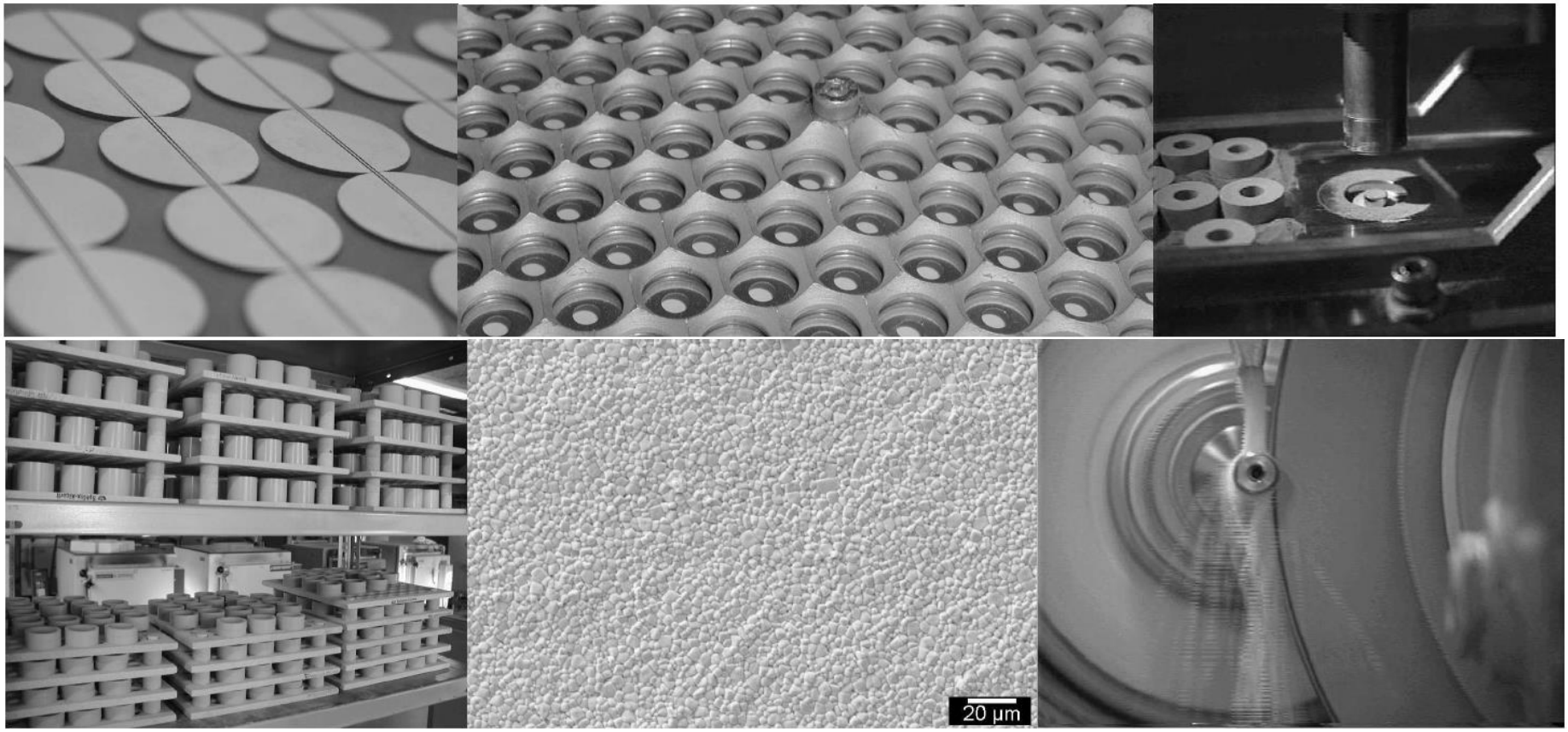


Ultrasonic array based on PZT thick film

Louise M. Borregaard, Michele Guizzetti, Erling Ringgaard, Ruichao Xu and Tomasz Zawada
A/S, Kvistgaard

Piezo 2015, January 28th 2015

Outline

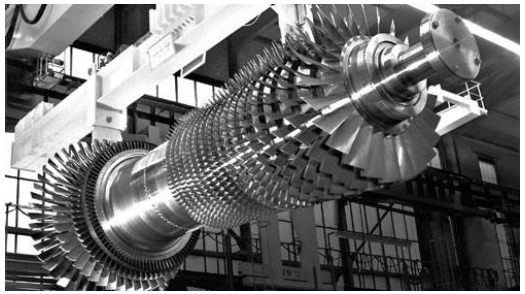
1 Company introduction

2 High frequency ultrasound

3 Ultrasonic array based on PZT thick film

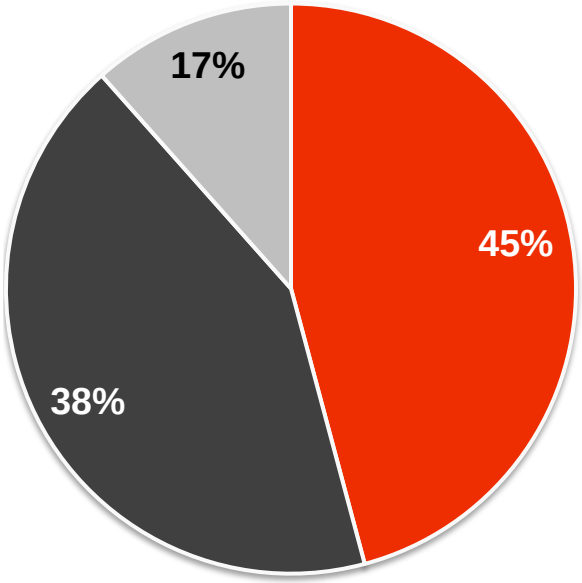
4 Conclusions and outlook

1 Company introduction



Overview

- Provides high technology products and systems for the aerospace, defence and other specialist markets, including: medical, industrial, energy, test and automotive
- 60 years experience of engineering for extreme environment
- Broad geographic footprint with 11.000 employees worldwide,
- Annual sales, $2.57B *[£1.64B]*
- Listed on London Stock Exchange (MGGT)

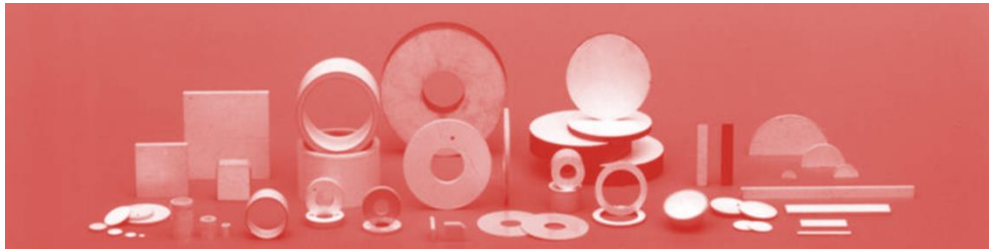


OE 55% / Aftermarket 45%

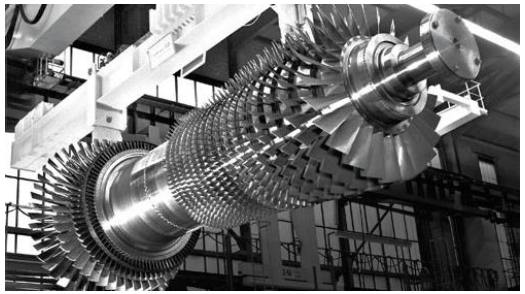
- Civil aerospace
- Military
- Energy and other

CTS | Ferroperm Denmark

- We are a manufacturer of piezoelectric materials, components, devices under Ferroperm™.
- 2-3 million units produced annually
- Major markets
  - Medical ultrasound
  - Underwater acoustics
  - Acceleration sensors
  - Flow meters
  - Energy Harvesting
  - NDT



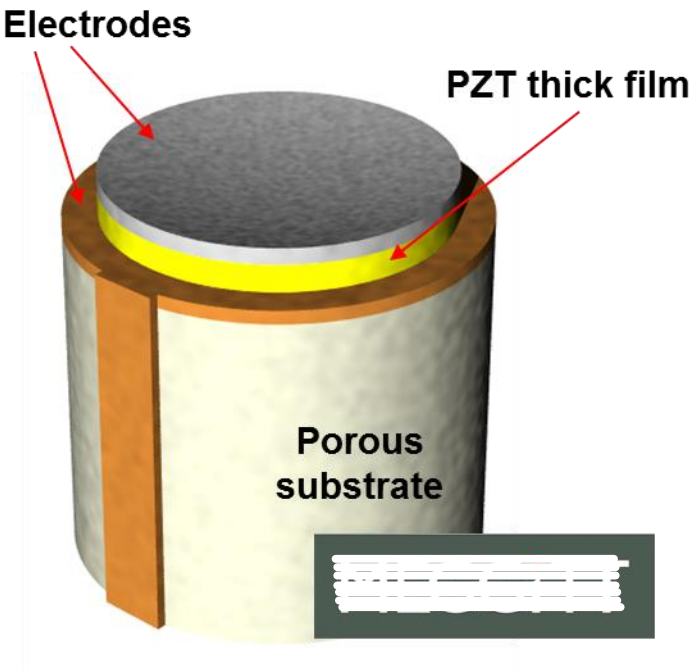
2 High frequency ultrasound



Printed Acoustic Transducers - Insensor™

- The porous structure of the film makes it a perfect candidate for medical imaging due to the following:
  - Low acoustic impedance
  - Low dielectric constant
  - High frequency (more than 20 MHz)

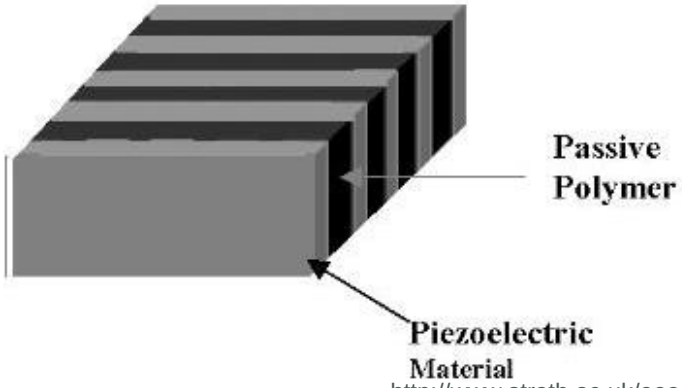
- Expand to linear array to produce high frequency arrays.



Typical structure of a thick film based HF acoustic transducer

Current array technology

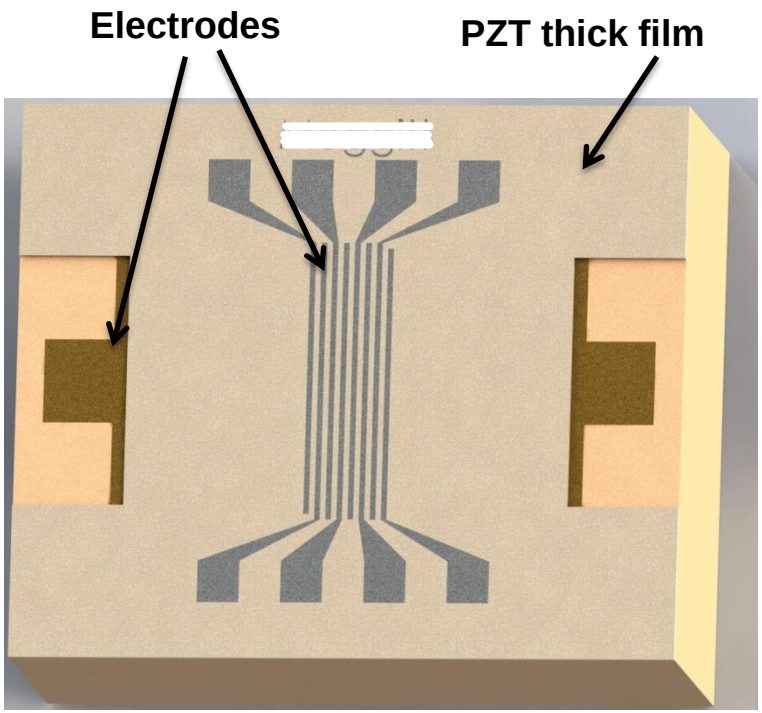
- Array technology offers
  - No mechanical parts, fully electrical operation, beam forming, beam steering, synthetic aperture.
- The leading technology for array manufacturing is by separating elements utilizing dicing and filling with a passive polymer material.
- At certain frequencies and pitch dimensions it becomes less cost-effective to minimize the dicing dimensions – which limits the frequency range



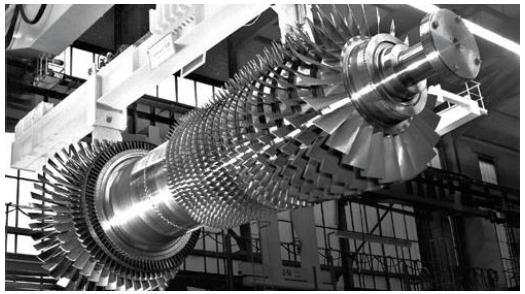
http://www.strath.ac.uk/eee/research/cue/research/transducers/piezoelectriccomposites/

Concept of thick film based array

- Fabrication with in-house techniques
- PZT thick film special characteristics opens for
  - High frequency > 10 MHz
  - An integrated backing layer
  - Large bandwidth
- Fully printed design
  - Huge implication for cost reduction
  - Arbitrary patterning possible

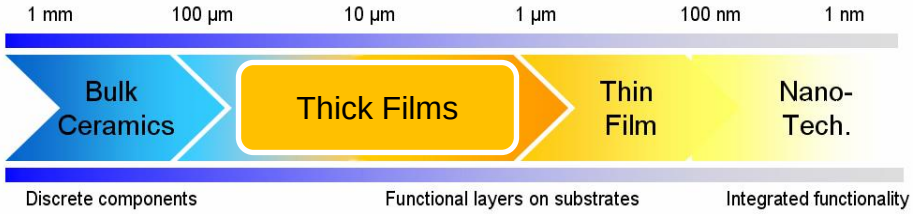


3 Ultrasonic array based on PZT thick film



PZT (Lead Zirconate Titanate) Thick Films – InSensor™

» Technology of piezoelectric thick films (InSensor™) – enabling deposition and integration of piezoelectric layers (10 to 100 µm in thickness) with high lateral resolution (100x100 µm)

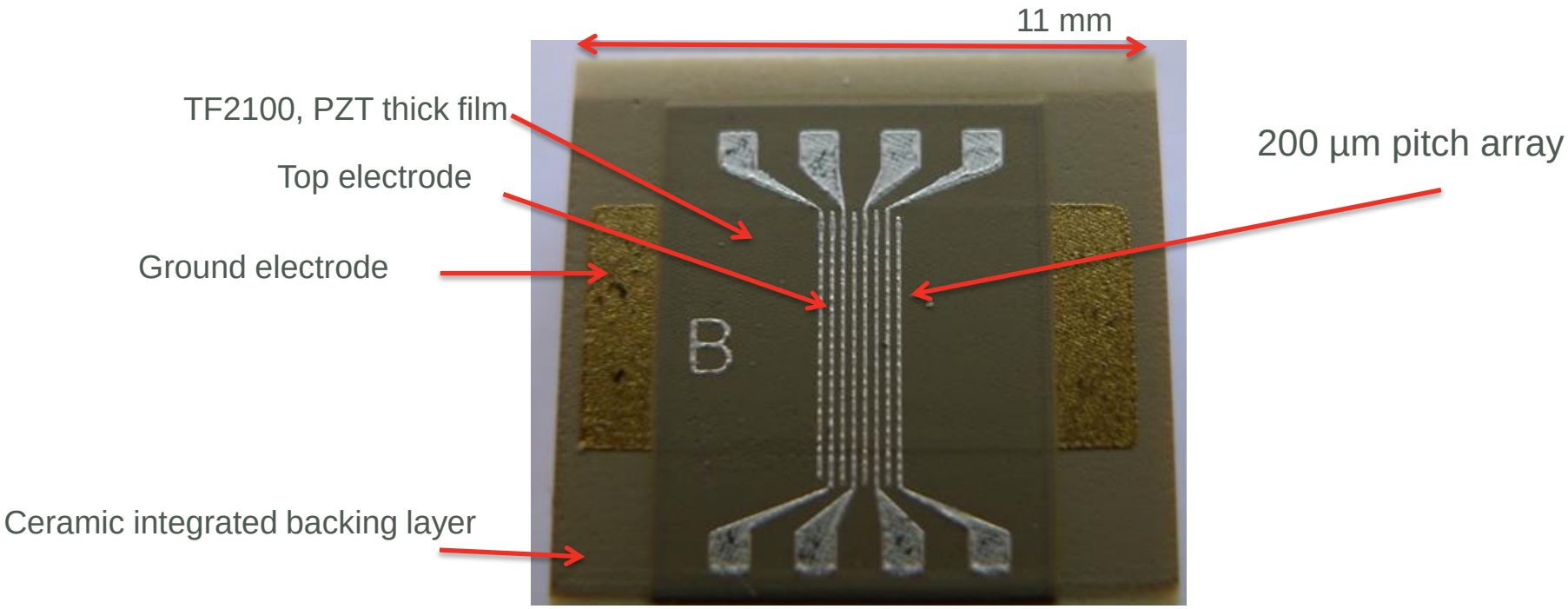


» Key features of InSensor™ technology
- Capable of manufacturing miniaturized devices
- Low prototyping costs
- High volume production
- High lateral resolution
- High frequency
- High response
- Piezoelectric material can be deposited on a number of different substrates (compatible with MEMS)

Deposition - Screen printing

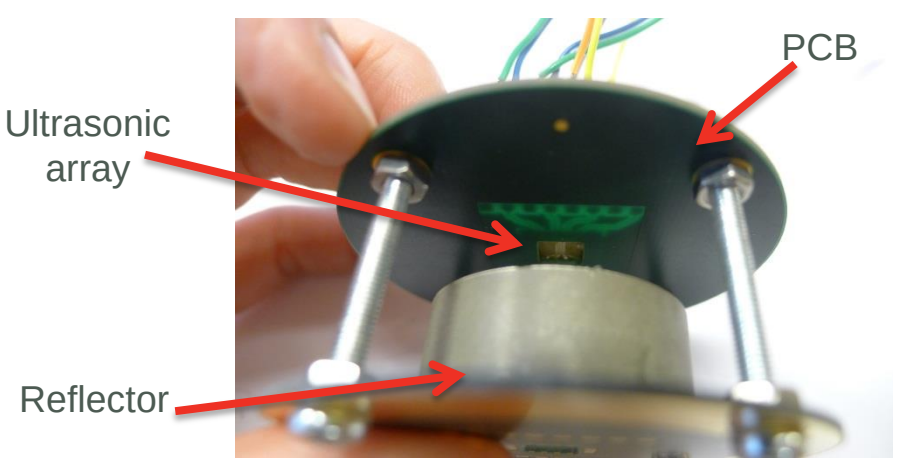
PZT dispersed in an organic vehicle

8 element thick film ultrasonic array

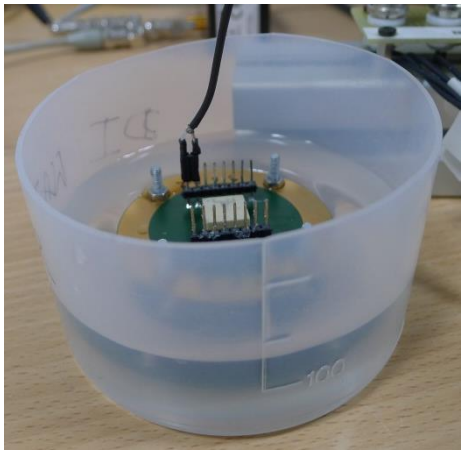


Pulse echo measurement setup

- Thick film ultrasonic array on PCB combined with reflector to fix the distance
- PCB with array and reflector immersed in DI water
- JSR 500 + oscilloscope to measure the pulse echo response

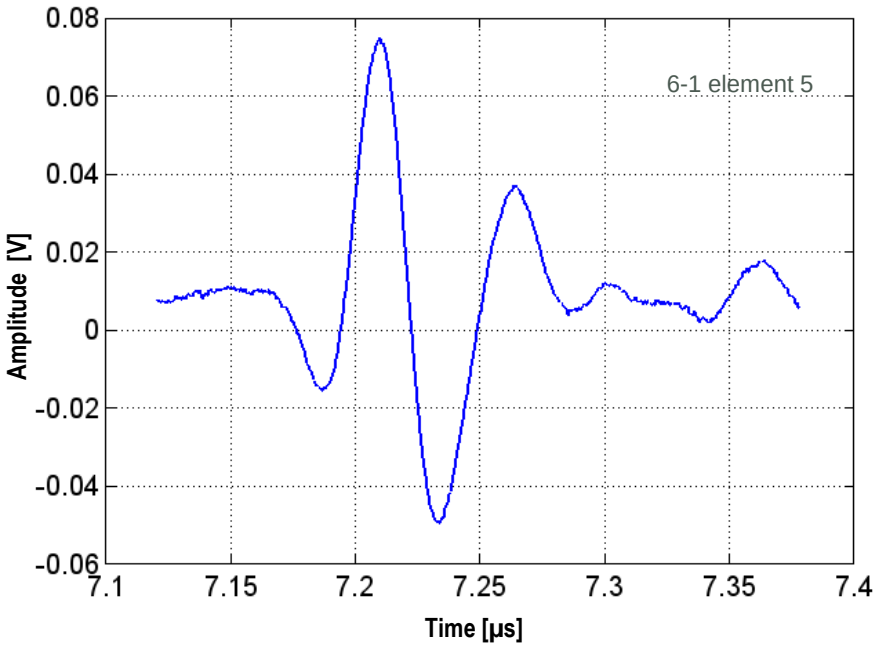


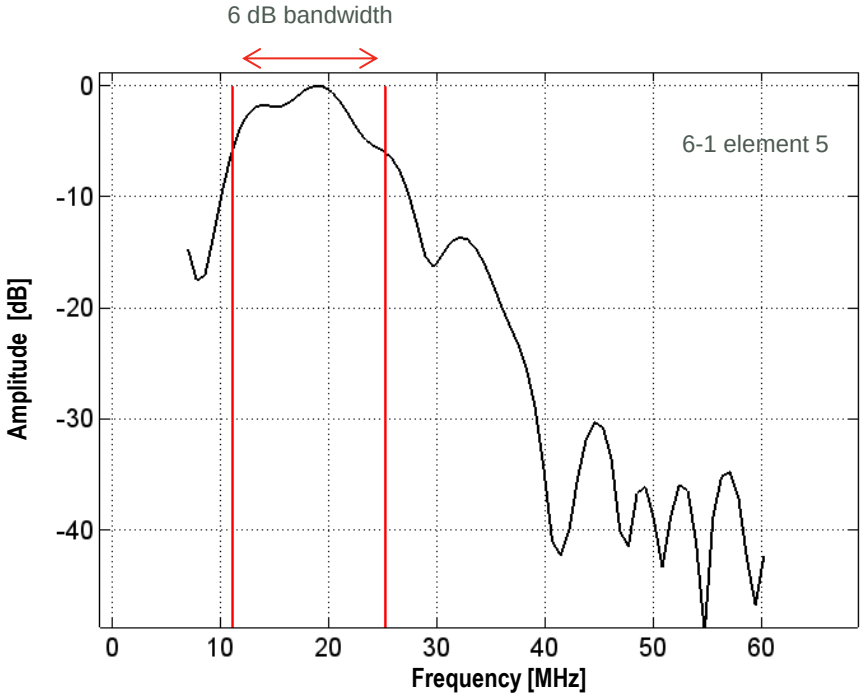
PCB and ultrasonic array combined with reflector



PCB and ultrasonic array combined with reflector immersed in DI water

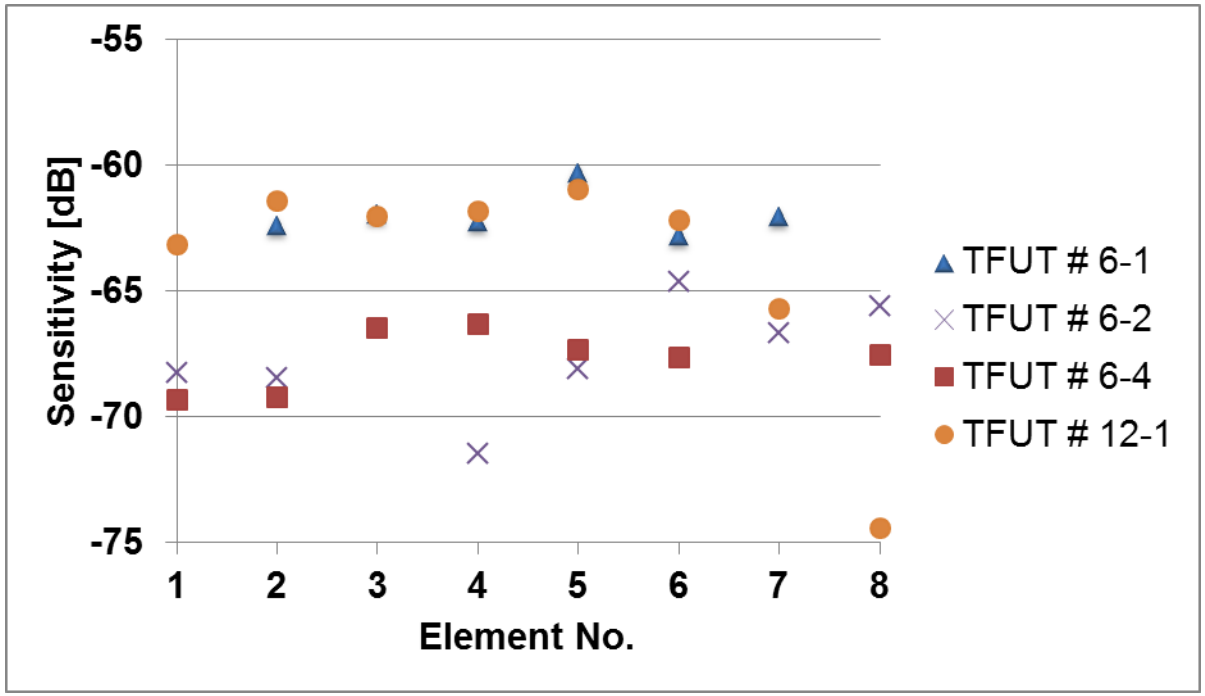
Pulse echo measurements





- Excitation profile 200 V negative peak, pulse width 30 ns
- Sensitivity = -60.8 dB, 6 dB bandwidth = 74.3 % and frequency 17.4 MHz

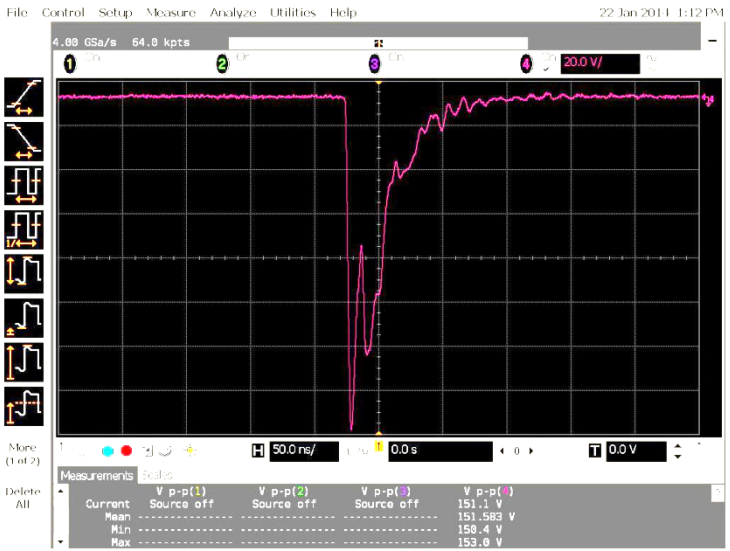
Sensitivity of arrays



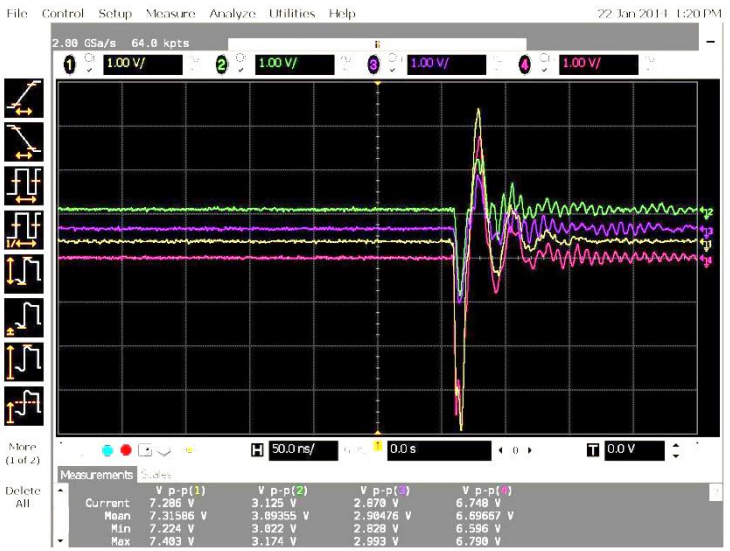
Sensitivity of each element for four 8-element arrays

Cross talk

- Cross talk is measured at time zero by comparing the voltage amplitude for the four closest elements to the exited element
- The average cross talk is found to be -31.2 dB

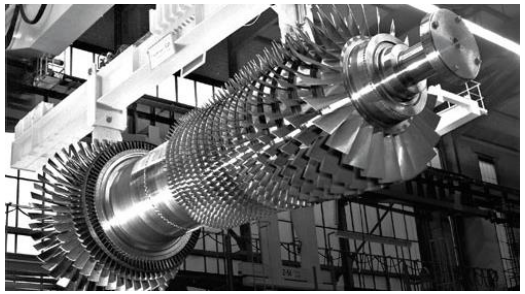


Voltage amplitude of the exited element at time 0



Voltage amplitudes of the four closest element to the exited element at time 0

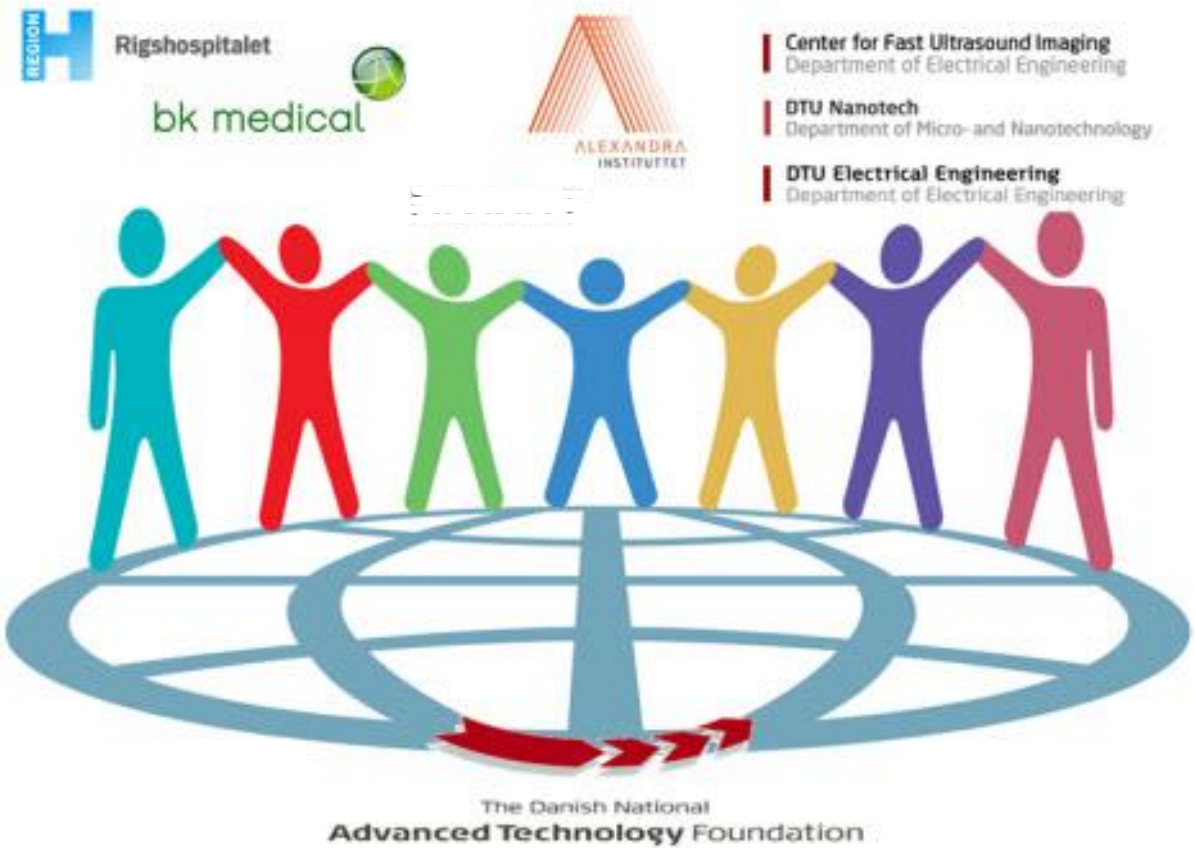
4 Conclusions and outlook



Conclusion and outlook

- Thick film ultrasonic arrays are successfully produced
- Integrated design for cost effective packaging
- 8 element array
  - Well defined pulses with good performance
  - Stable sensitivity over array elements and arrays
  - Cross talk low enough to validate the concept of an ultrasonic array with a continuous PZT layer
- Further studies of cross talk on the way
- Look at arrays with higher number of elements and smaller pitch in different frequency ranges

Acknowledgments



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Thank you