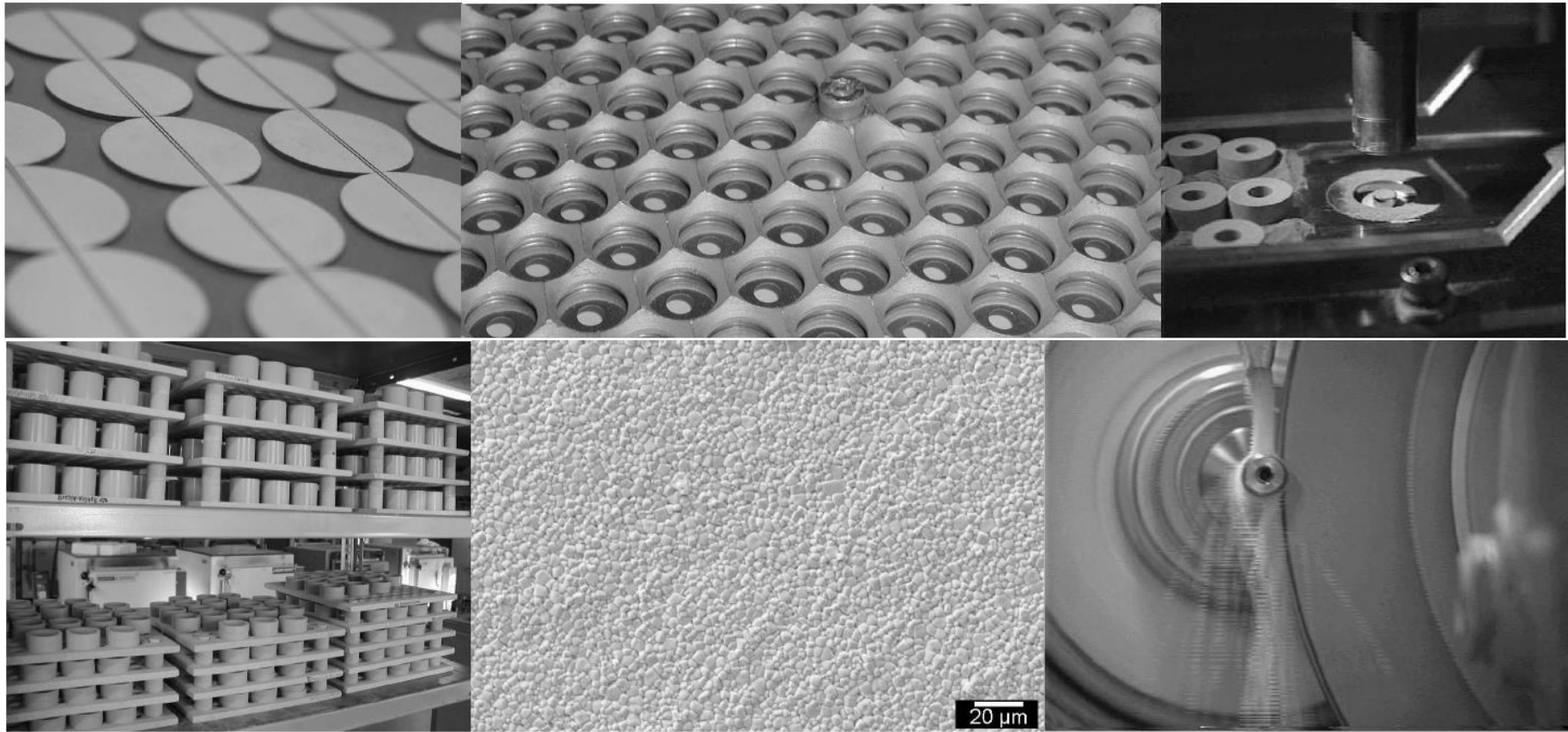

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Ultrasonic array based on PZT thick film

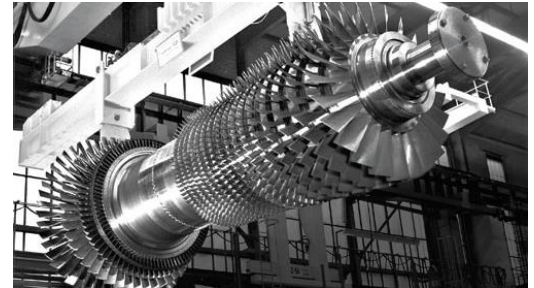
Louise M. Borregaard, Michele Guizzetti, Erling Ringgaard, Ruichao Xu and Tomasz Zawada
A/S, Kvistgaard

Outline

- 1 | **Company introduction**
- 2 | **High frequency ultrasound**
- 3 | **Ultrasonic array based on PZT thick film**
- 4 | **Conclusions and outlook**

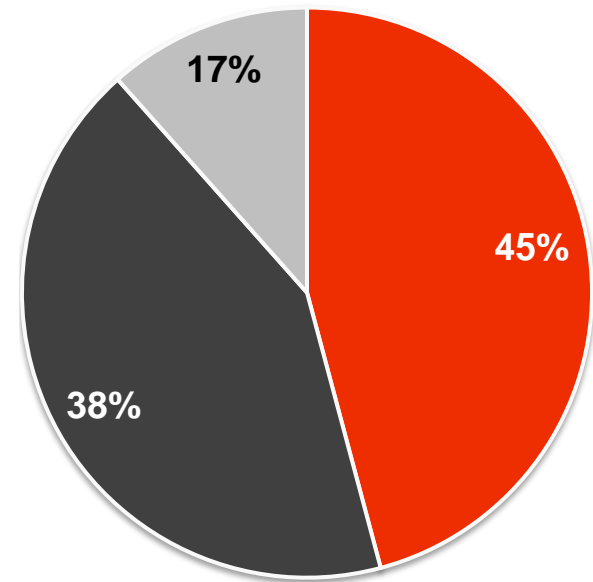
1

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
-

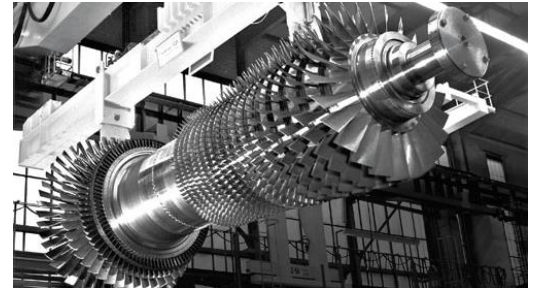
CTS | Ferroperm Denmark

- » 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



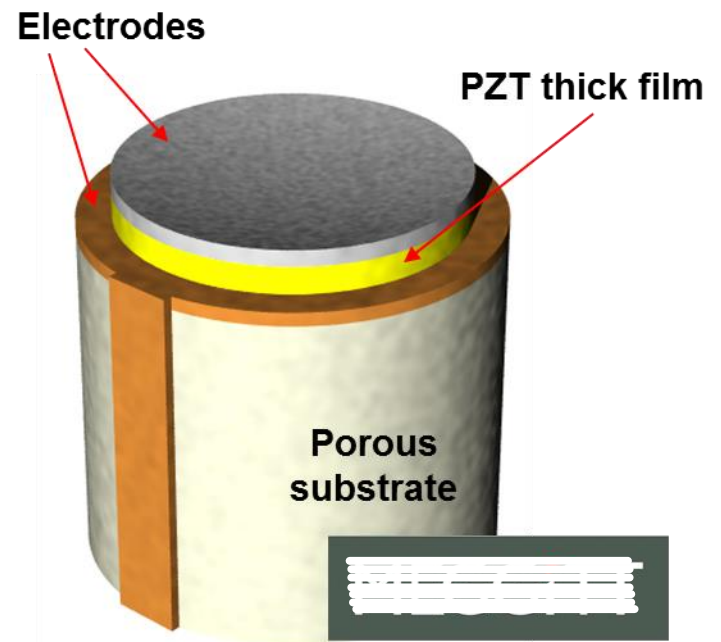
2

High frequency ultrasound



Printed Acoustic Transducers - Insensor™

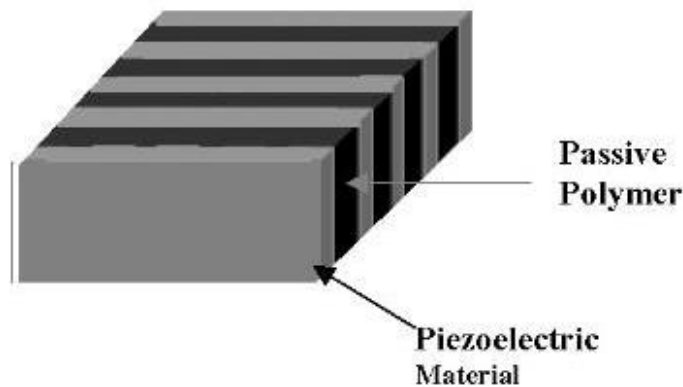
- » The porous structure of the film makes it a perfect candidate for medical imaging due to the following:
 - Low acoustic impedance
 - Low dielectric constant
 - High frequency (more than 20 MHz)
- » Expand to linear array to produce high frequency arrays.



Typical structure of a thick film based HF acoustic transducer

Current array technology

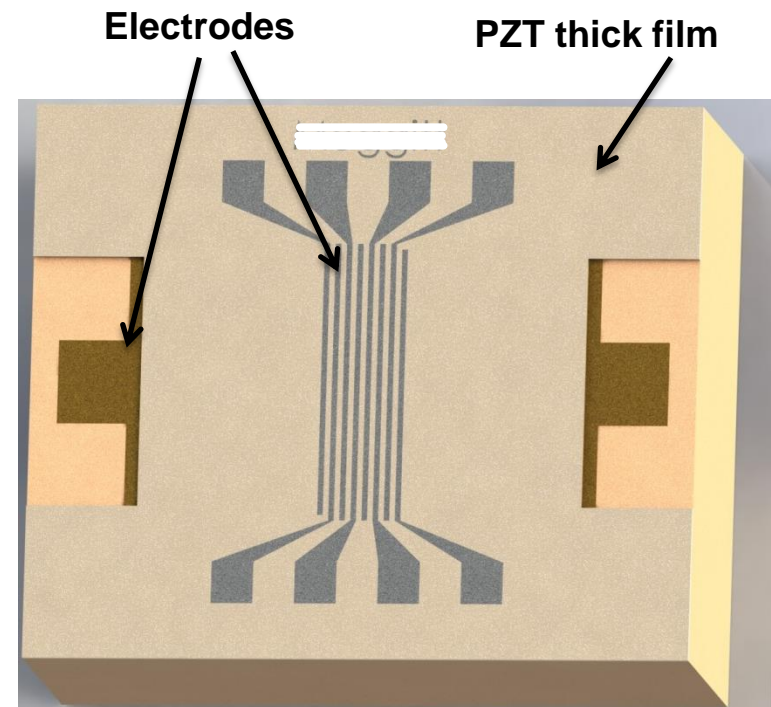
- » Array technology offers
 - No mechanical parts, fully electrical operation, beam forming, beam steering, synthetic aperture.
- » The leading technology for array manufacturing is by separating elements utilizing dicing and filling with a passive polymer material.
- » At certain frequencies and pitch 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/>

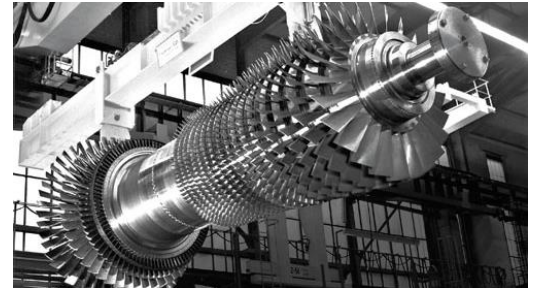
Concept of thick film based array

- » 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



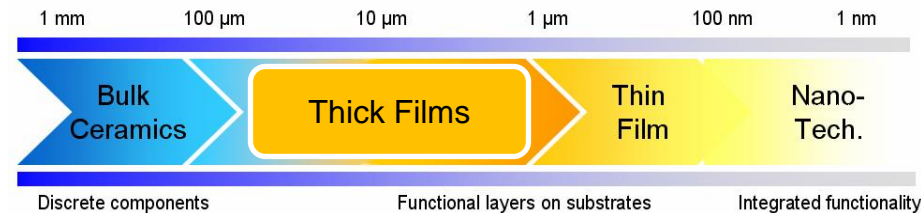
3

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)



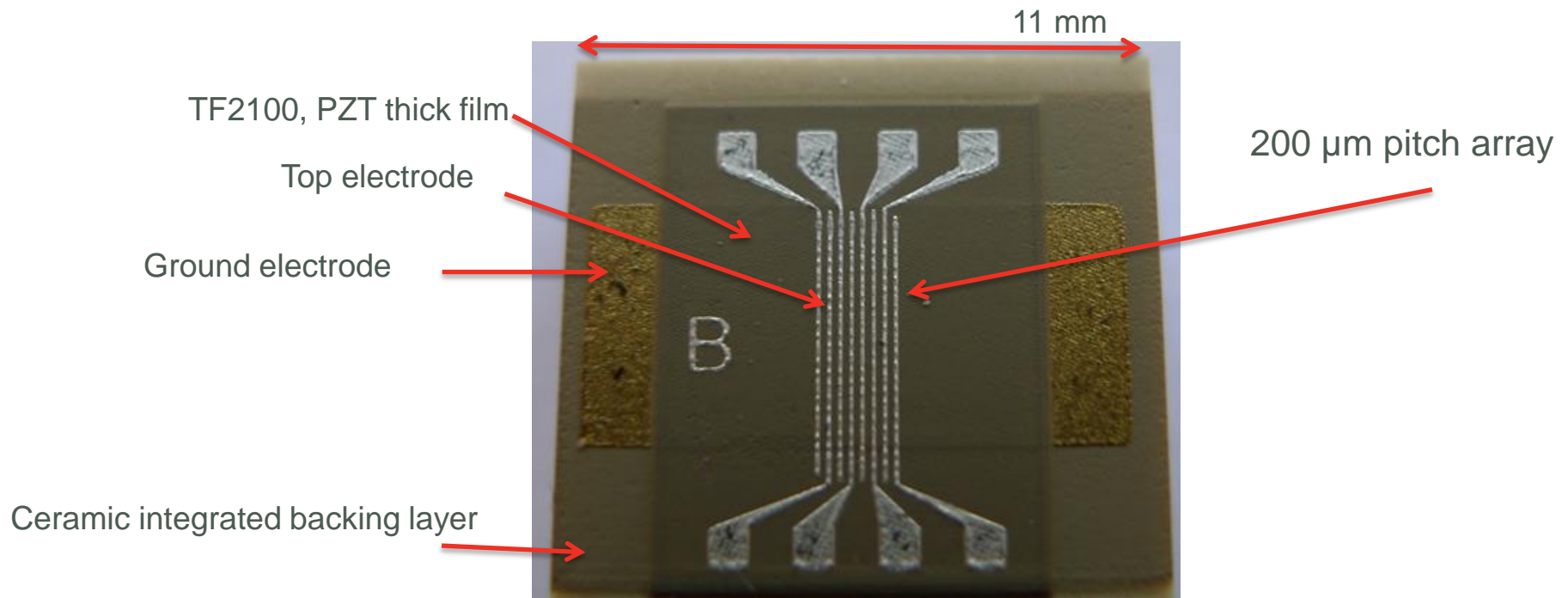
- » Key features of InSensor™ technology
- Capable of manufacturing miniaturized devices
 - Low prototyping costs
 - High volume production
 - High lateral resolution
 - High frequency
 - High response
 - Piezoelectric material can be deposited on a number of different substrates (compatible with MEMS)

Deposition - Screen printing

PZT dispersed in an organic vehicle

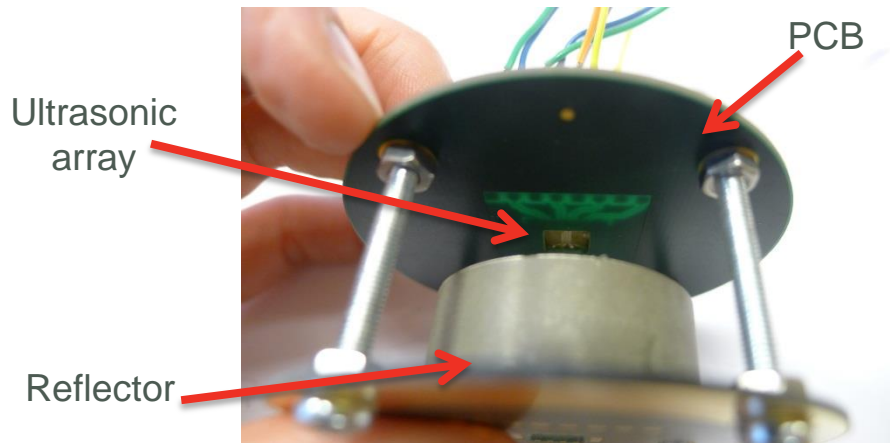


8 element thick film ultrasonic array

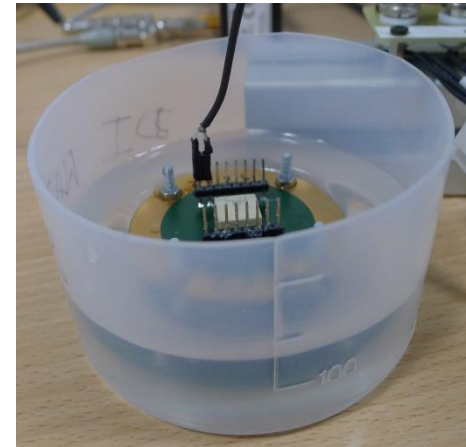


Pulse echo measurement setup

- » 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

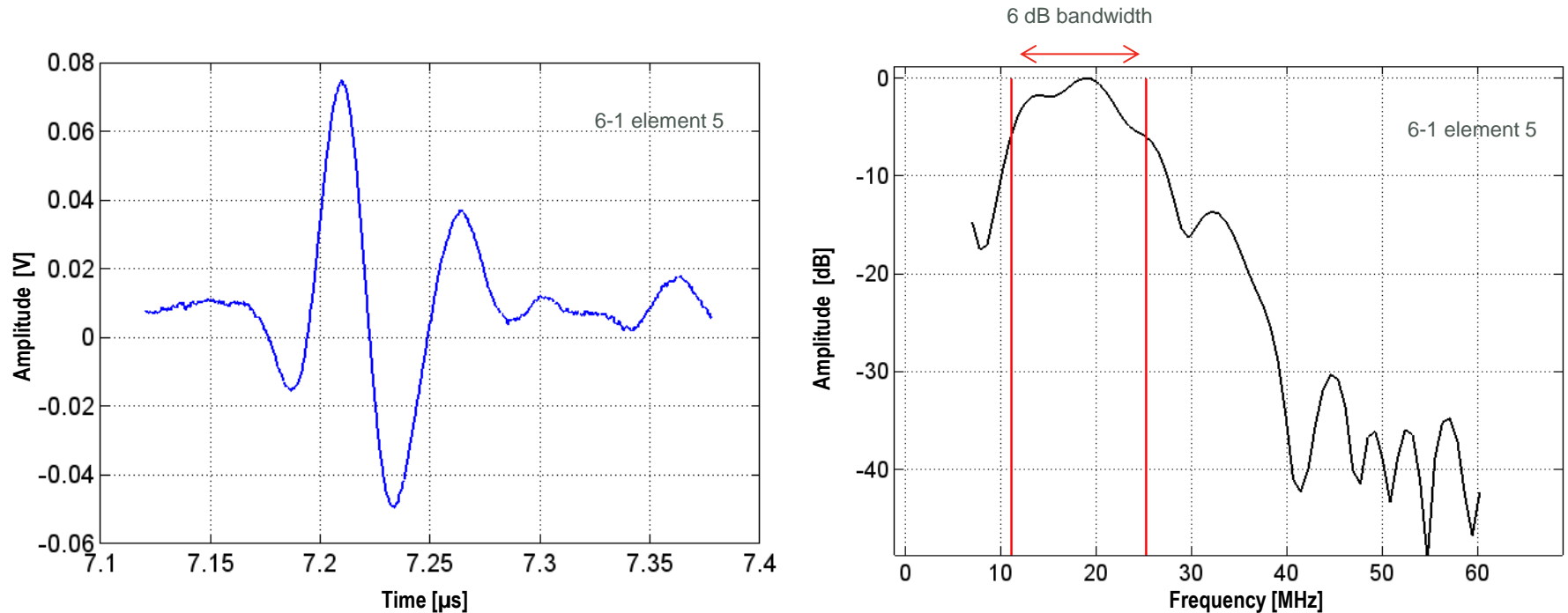


PCB and ultrasonic array combined with reflector



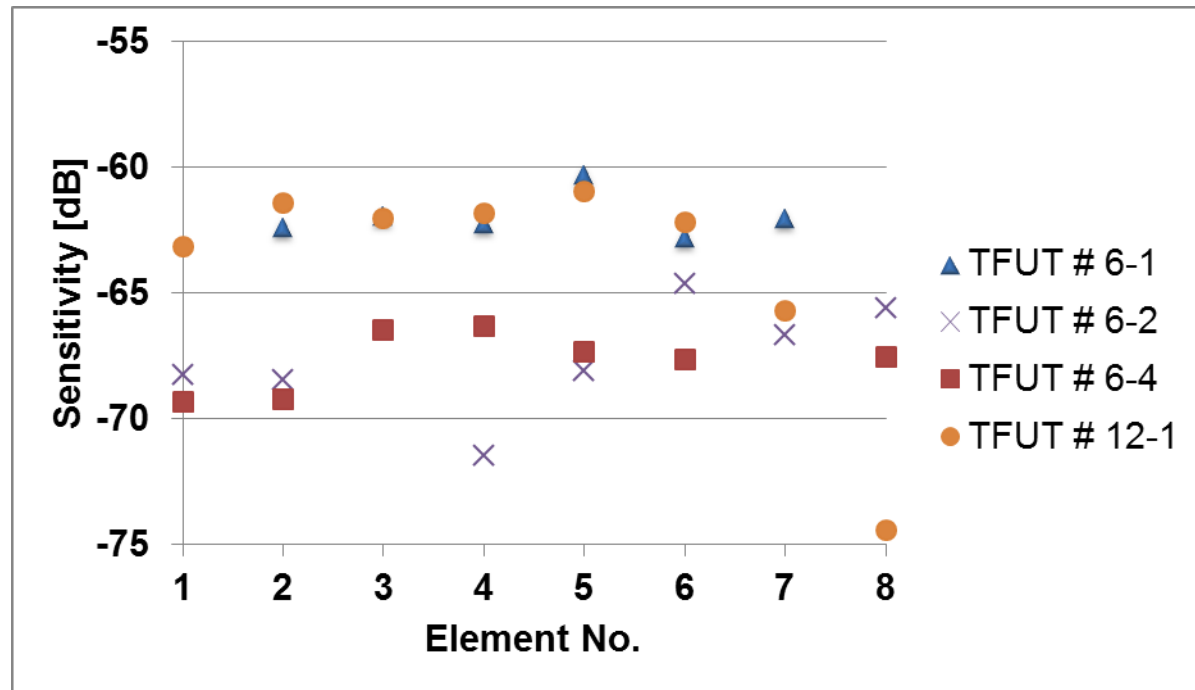
PCB and ultrasonic array combined with reflector immersed in DI water

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

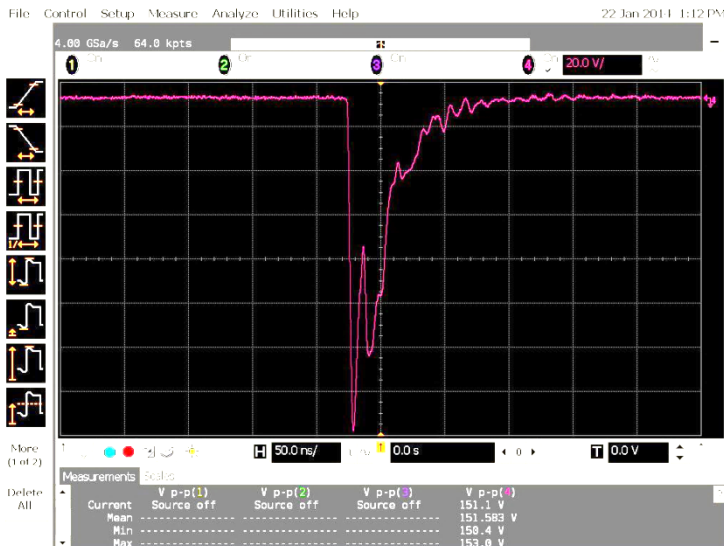
Sensitivity of arrays



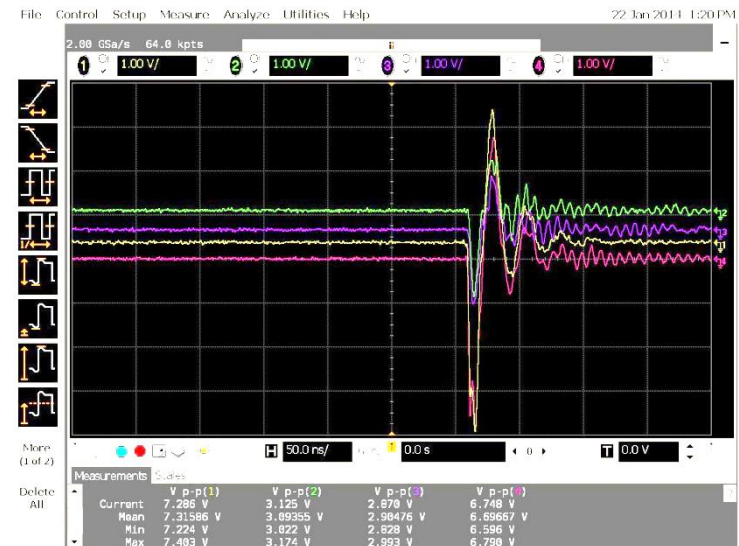
Sensitivity of each element for four 8-element arrays

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



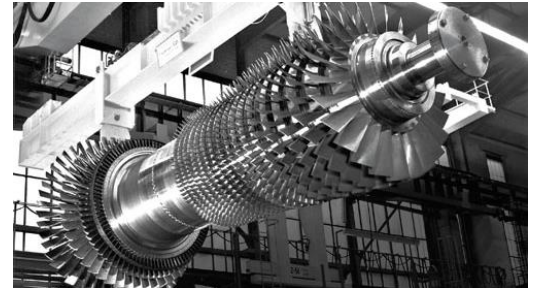
Voltage amplitude of the exited element at time 0



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



The support from the Danish National Advanced Technology Foundation (DANATF) through contract No. 82-2012-4, FutureSonic (A new platform and business model for on-demand diagnostic ultrasound imaging), is gratefully acknowledged.

Thank you



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