High frequency annular array imaging system, based on piezoceramic thick film for HIFU applications

Andrzej Nowicki, Wojciech Secomski, Ryszard Tymkiewicz Institute of Fundamental Technological Research PAS, Warsaw, Poland,

Rasmus Lou- Moeller, Wanda W. Wolny, Kvistgaard, Denmark

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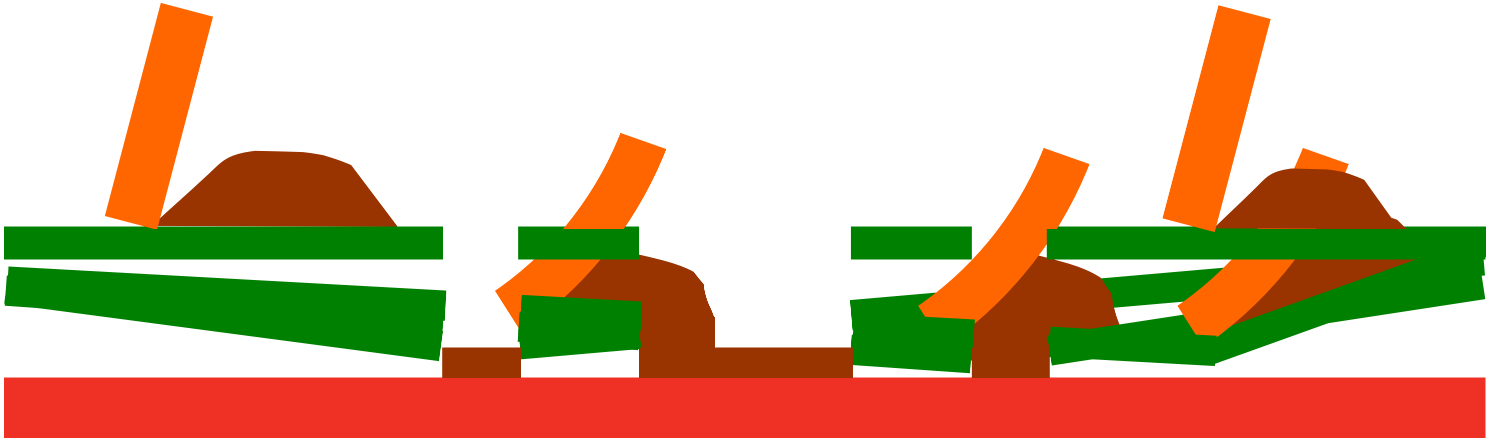
MTU Facility and ”Clean-Room” for Medical Line

Thick film technology

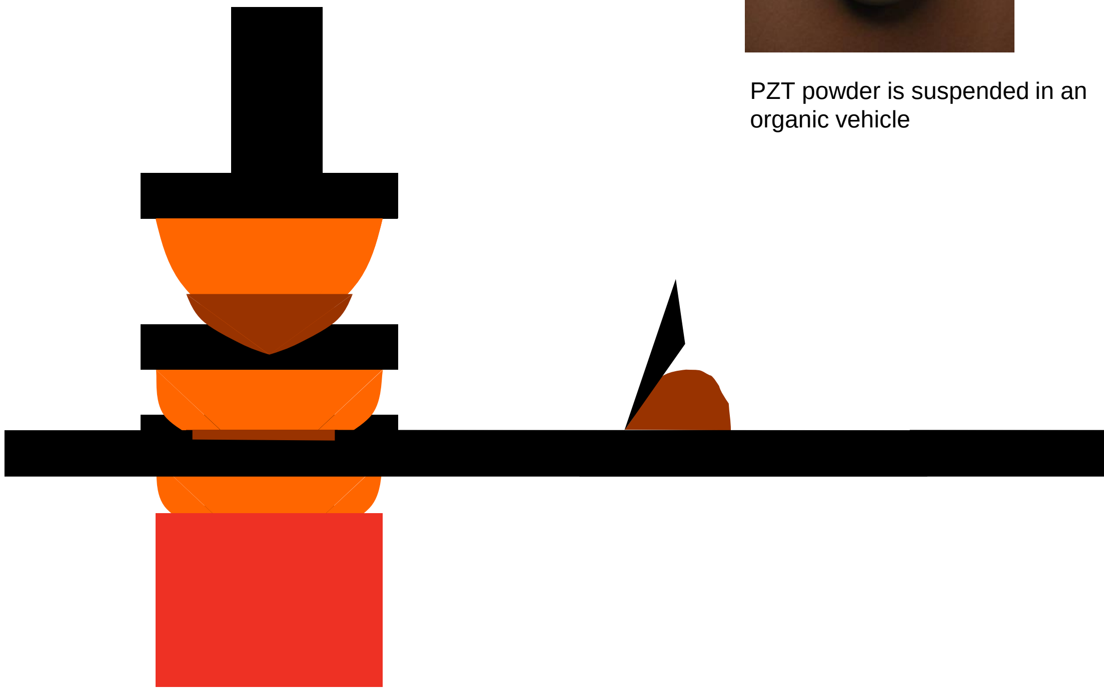
Screen printing

PZT powder is suspended in an organic vehicle



Thick film technology

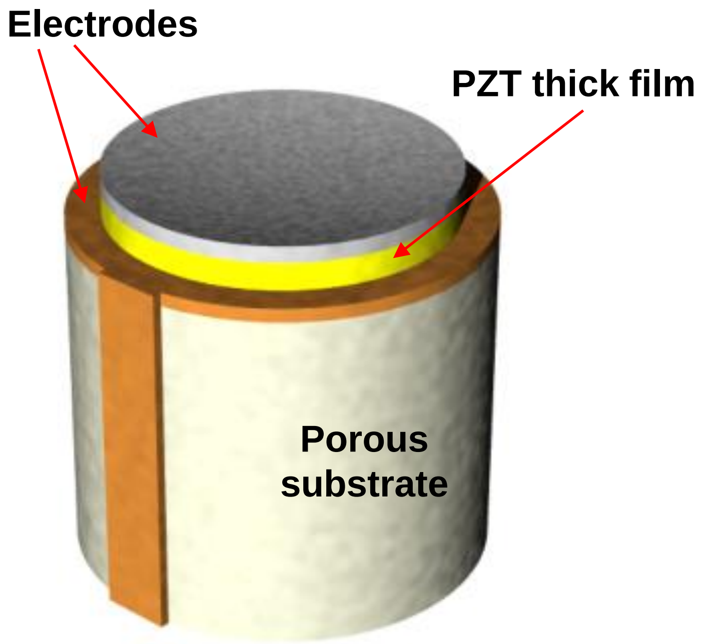
Pad printing



PZT powder is suspended in an organic vehicle

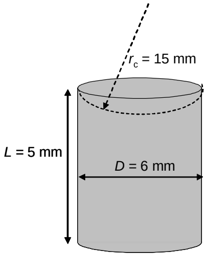
High Frequency Acoustic Transducers

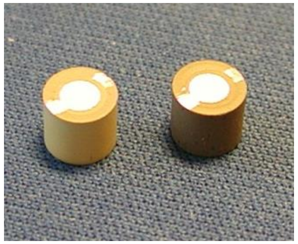
- The porous structure of the film makes it a perfect candidate for medical imaging due to the following:
  - Low acoustic impedance
  - Low dielectric constant
  - High frequency (more than 20 MHz)

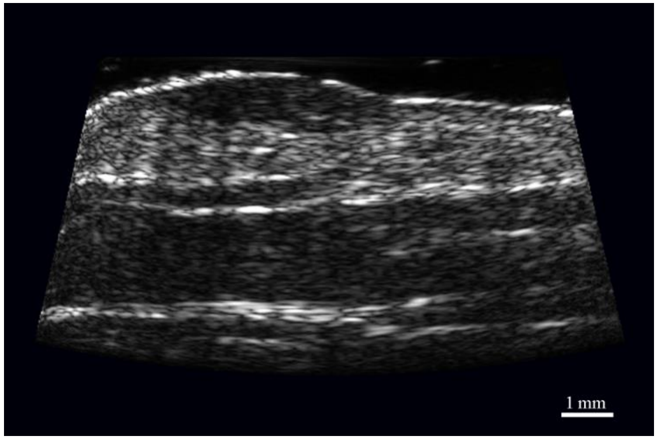


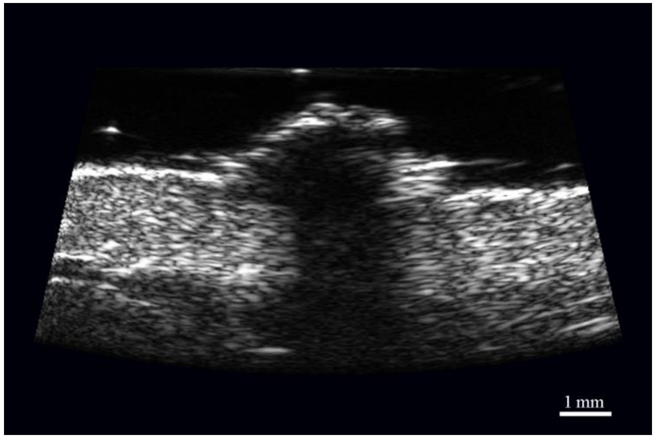
Typical structure of a thick film based HF acoustic transducer

TF2100 transducer





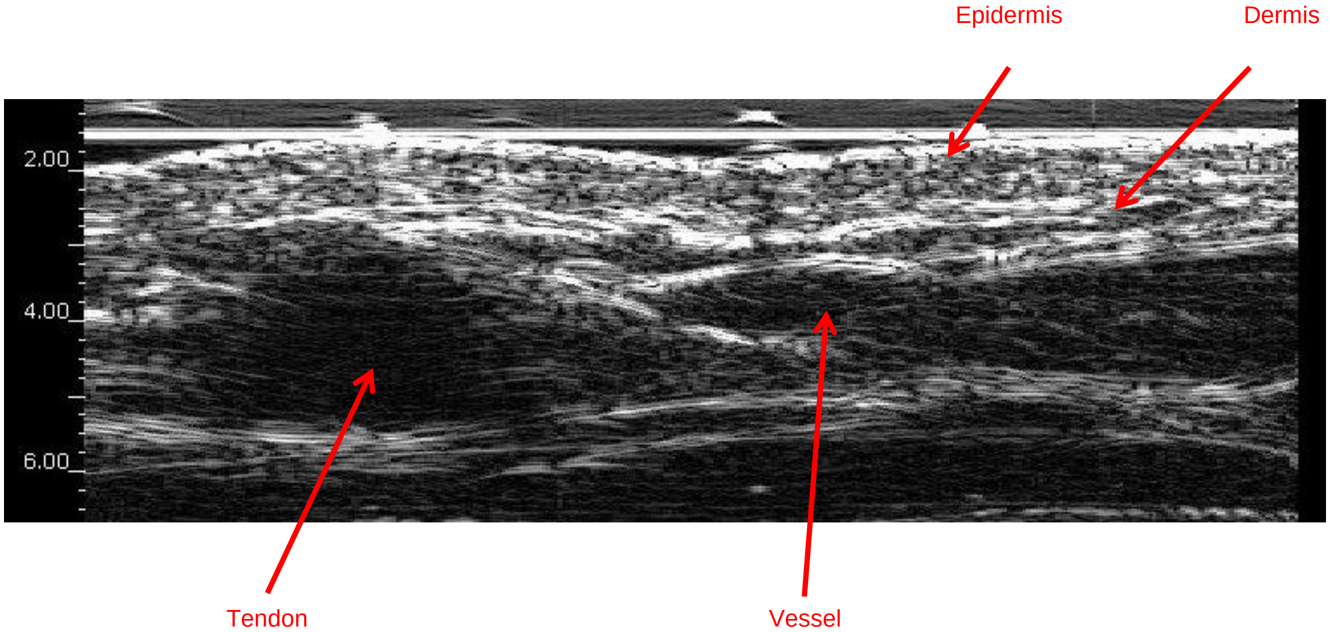




Ultrasonic image of the skin with anginoma.

Ultrasonic image of the skin cancer spinocellular carcinoma.

Lead free transducer



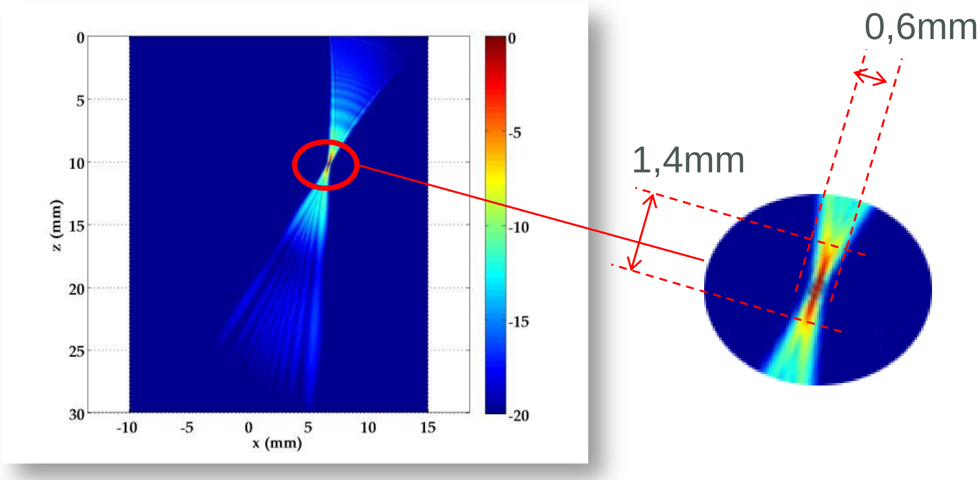
HIFU – High Intensity Focused Ultrasound

Ultrasonic waves focused in a point
Lesion in focal point due to local heating to 42 – 50ºC
No lesion outside focal point

Body will heal lesion ”from the inside”

Potential uses for a wide variety of conditions
- Brain Cancer
- Skin cancer
- Fat reduction
- Cosmetology treatments
- Eye deceases

Typically single-use transducers
- No ageing concerns
- Sterility



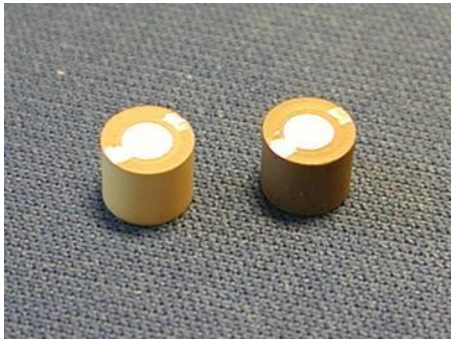
Ulthera – Skin treatment

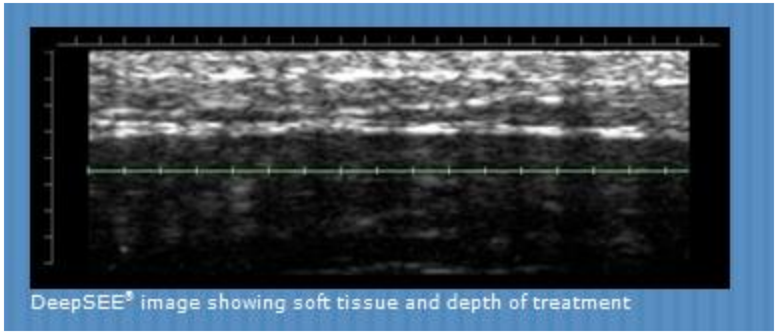
Limited use cartridge containing HIFU and imaging transducers

3 models depending on treatment type (4 – 10 MHz)

Treatment elements from traditional Ferroperm bowls

Imaging element from unique InSensor Thick-film elements





Assessment of skin pathologies using ultrasound
Cellulite

About 90% of womens have cellulite - aetiopathogenesis is no clear.

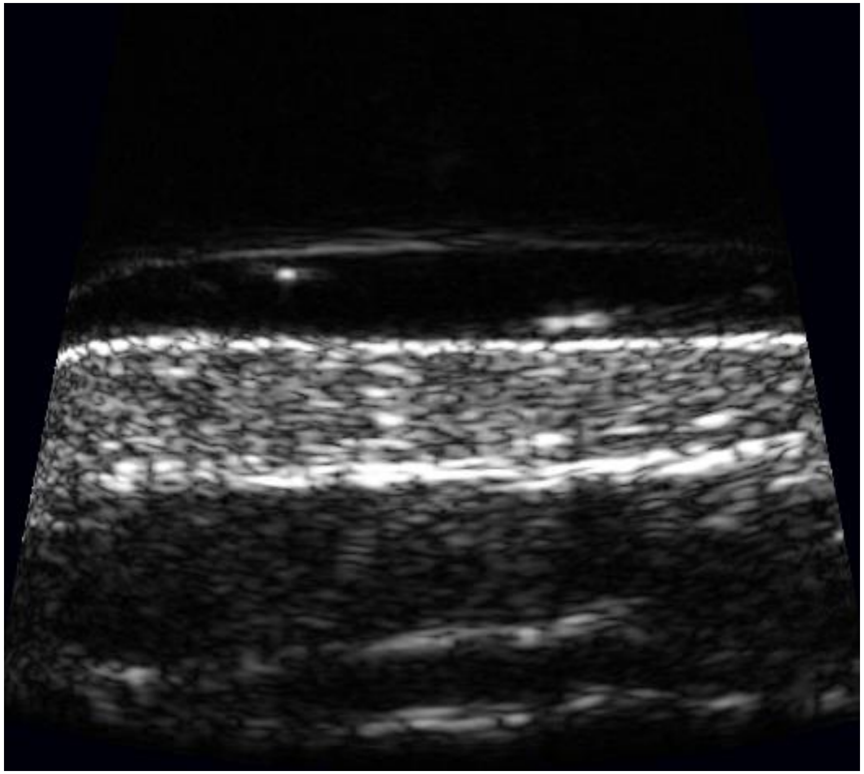
- hormonal disorders
- disorders in blood circulation in capillary vessels
- incorrect lifestyle.

Typical Symptoms:

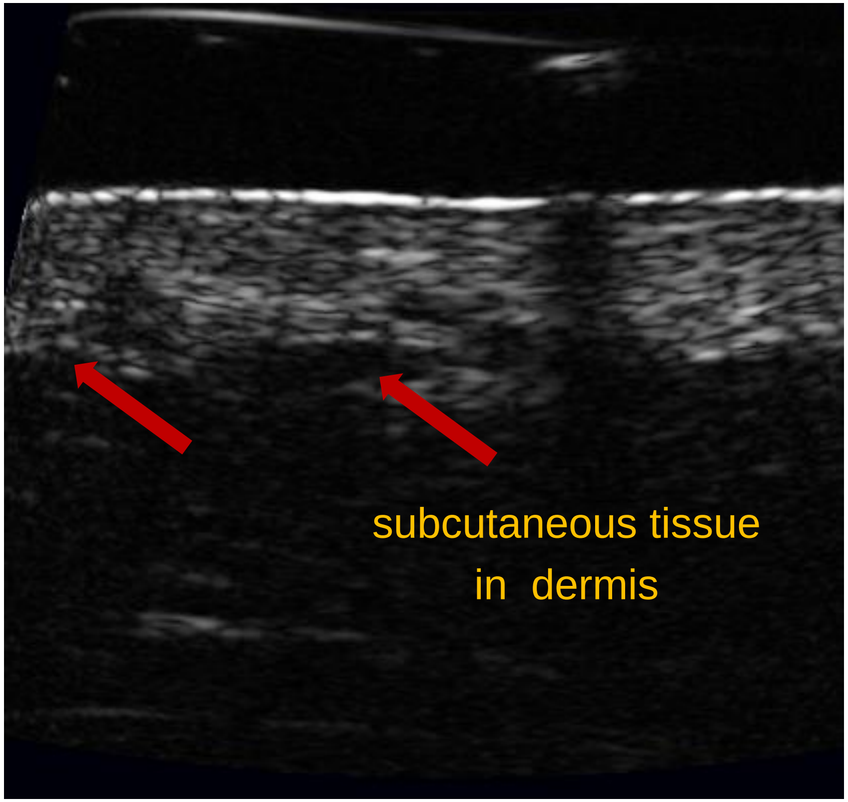
- **edema changes**
- **fibrosis**
- **sclerosis of the subcutaneous tissue**

Using the high frequency ultrasound in diagnostic of cellulite the morphology can be evaluated evaluate and the therapy monitored.

Imaging cellulite using US high frequency.

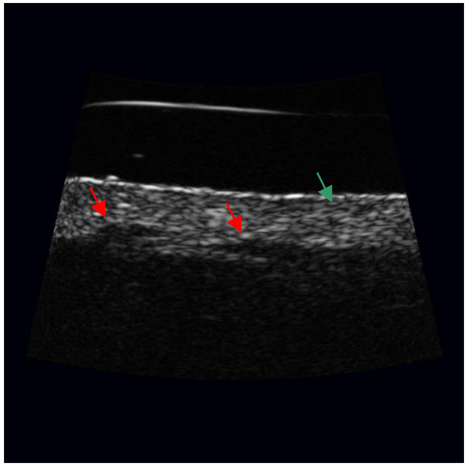


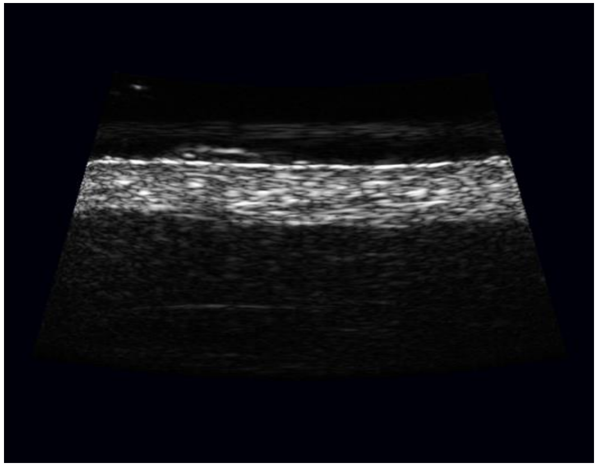
NORMAL SKIN



CELLULITE

Woman, age 34, 3 weeks after treatment.

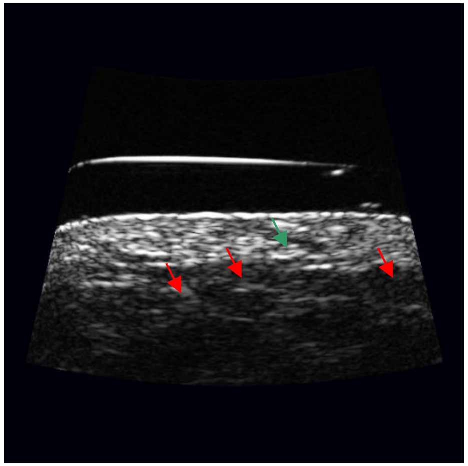




- Red arrows show the sites of the subcutaneous tissue ingrowing into dermis.
- Green arrows – local swelling.

R.K. Mlosek, W. Woźniak, S. Malinowska, M. Lewandowski, A. Nowicki, The effectiveness of anticellulite treatment using tripolar radiofrequency monitored by classic and high-frequency ultrasound, Journal of the European Academy of Dermatology and Venereology, (26):696-703, 2012.

Woman, age 60,   3 weeks after treatment



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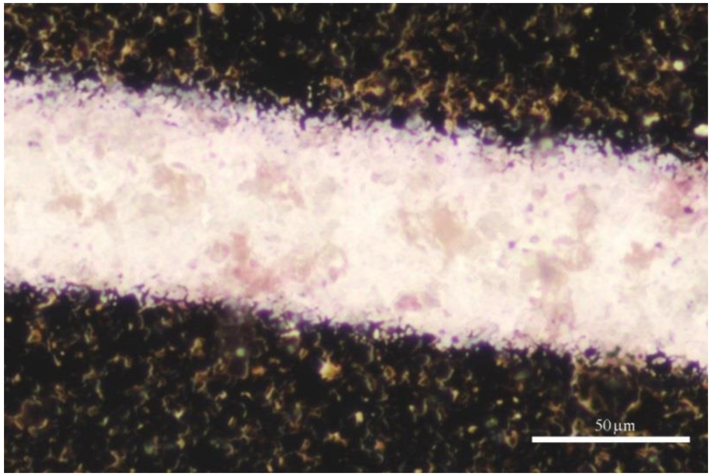
Concave substrate, gold electrodes

GREEN LASER –
1532nm, beam 30 μm,
focus 160 mm



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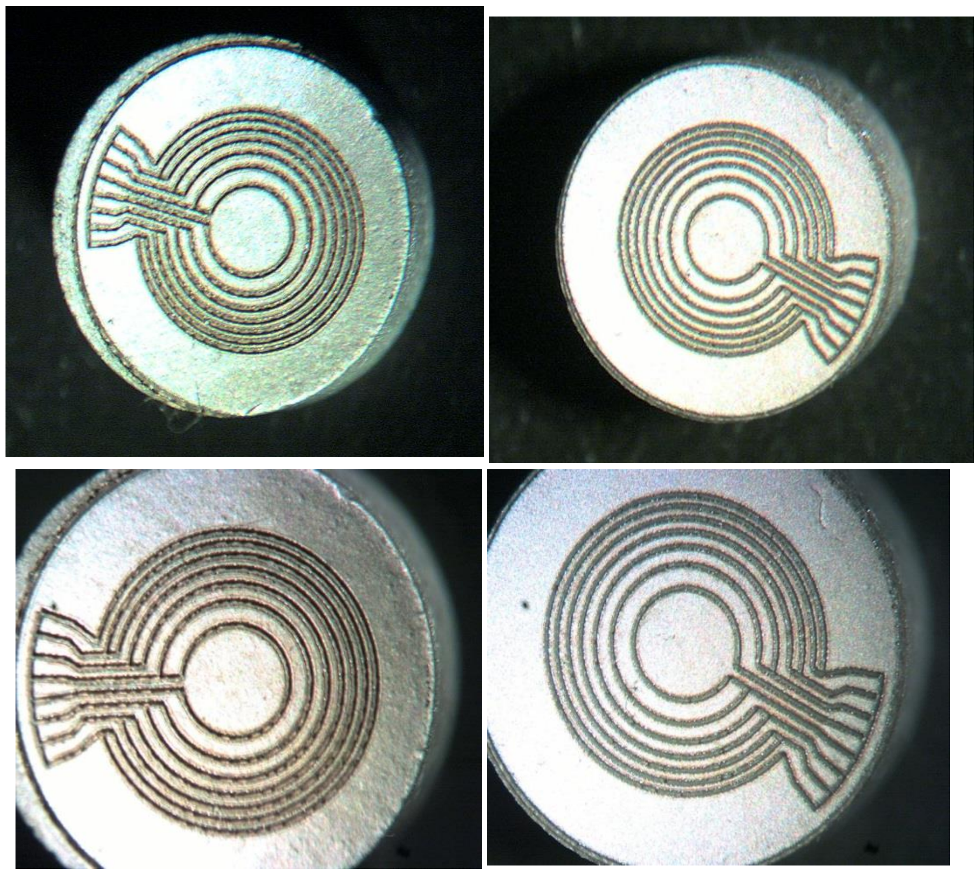
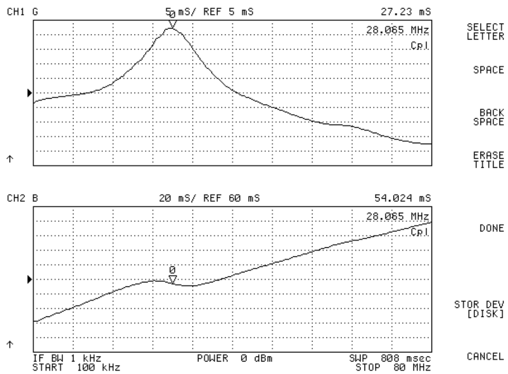
Concave substrate, platinium electrodes

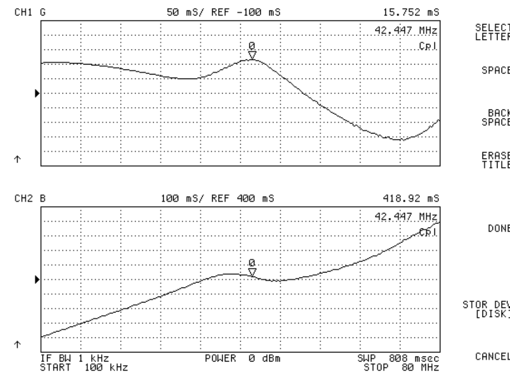


FIBER LASER –
1064nm, beam 30 μm,
focus 160 mm

FLAT Transducers

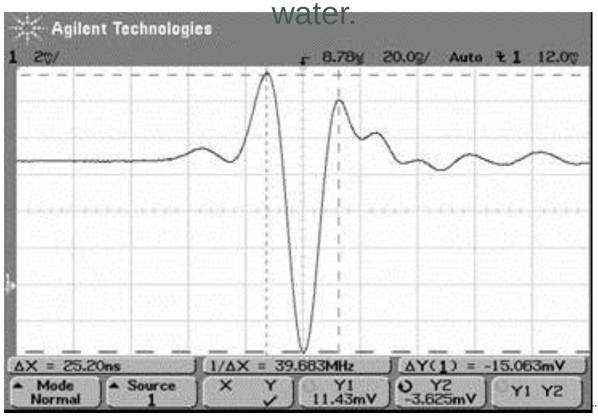
Thick film	Pz 26	Pz 26
Film thickness	20-45 um	25-36 um
Active film diameter	2 mm	4,5 mm
Substrate material	Pz 37	Pz 37
Substrate thickness	7,5 mm	7,5 mm



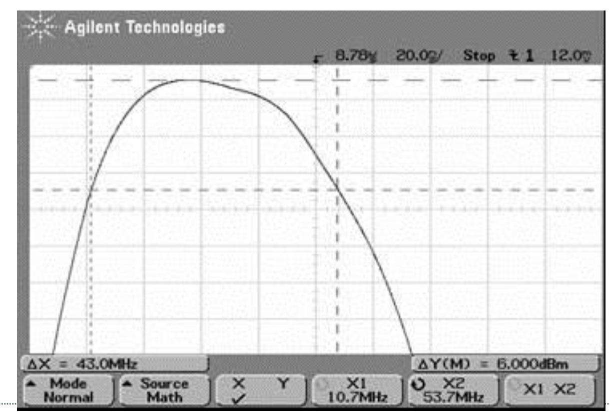


Measurement of reflected impulse from a thick metal plate. Transducer was measured in a small tank with a water.

SUPERB BANDWIDTH AND NO CLUTTER



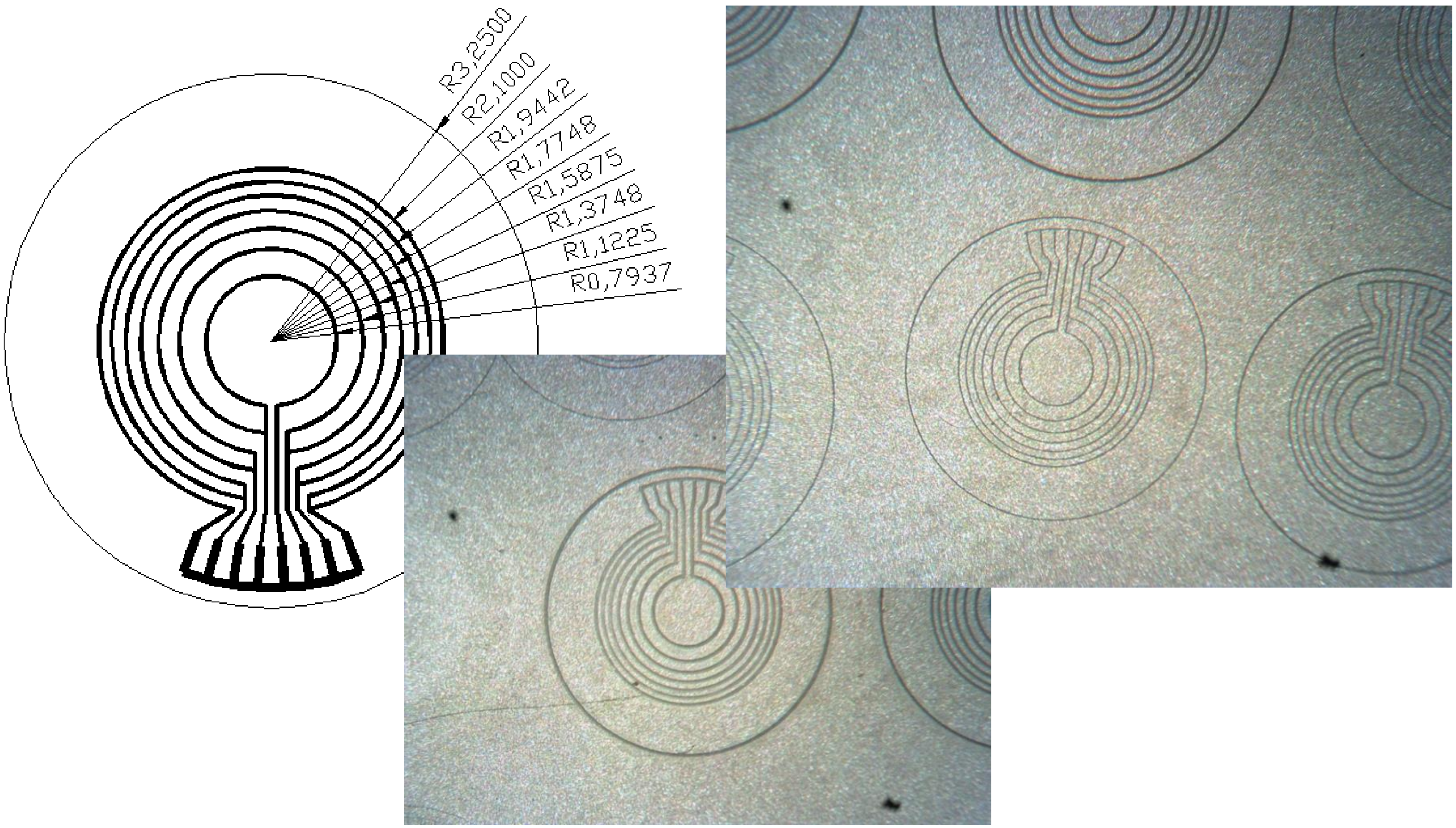
Transmitter Avtech (4 nS) + Ritec diplexer



39 um

25 um

Flat substrate, platinium electrodes



FIBER LASER – 1064nm, beam 30 µm, focus 160 mm

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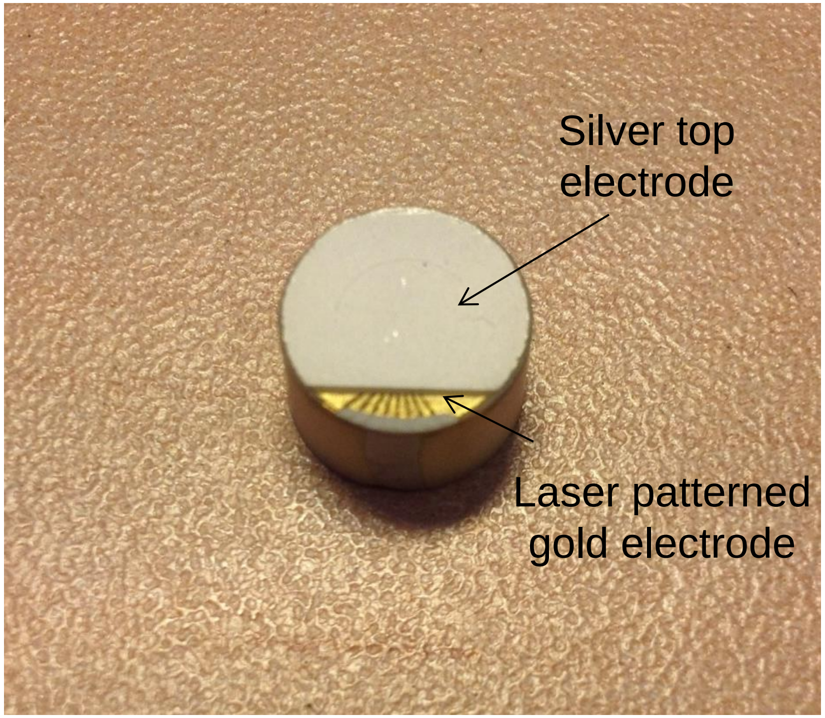
Flat substrate, gold electrode thick film and silver top electrode



Finished transducer with PZT thick film and silver top electrode

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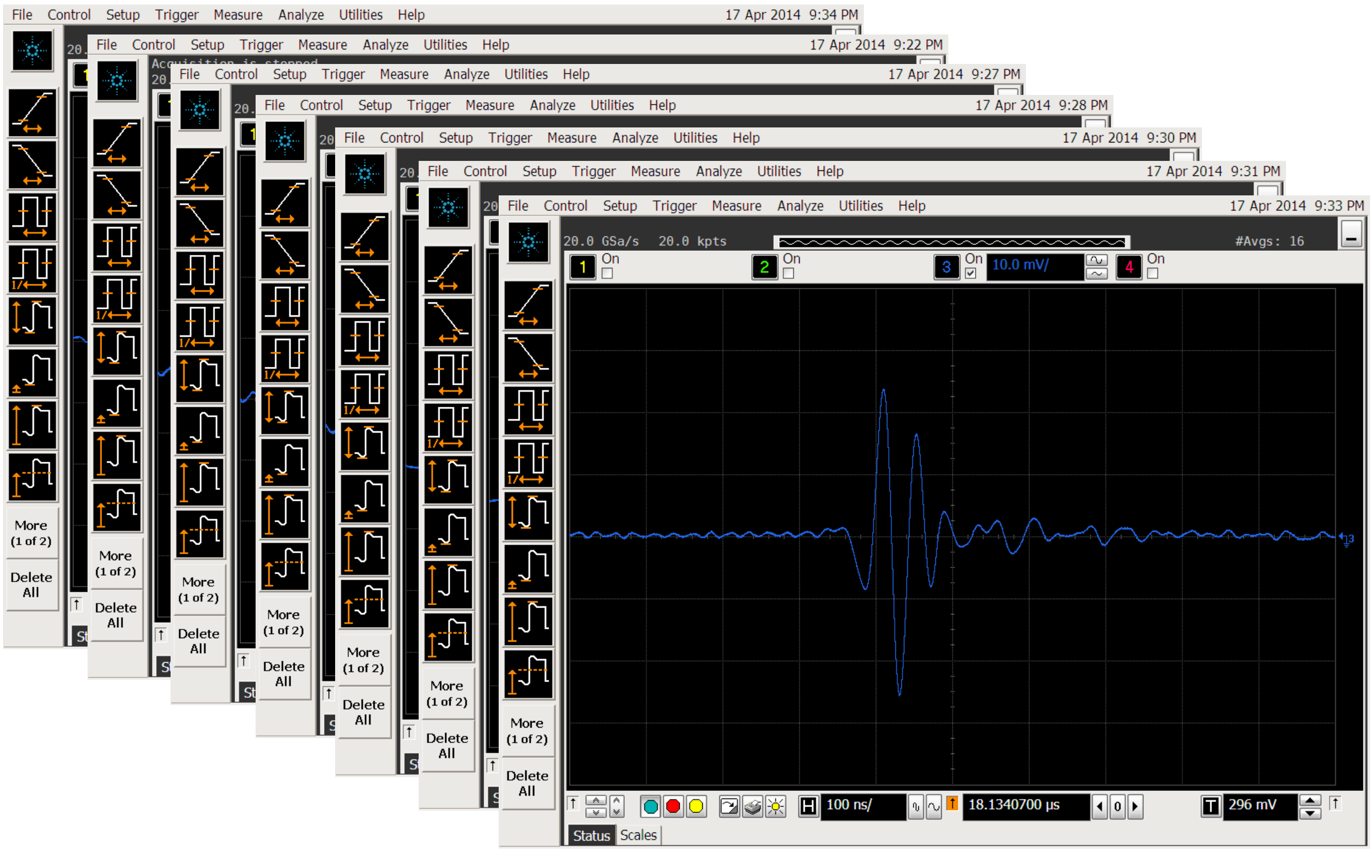
Pulses on individual elements: from central disk to outer ring



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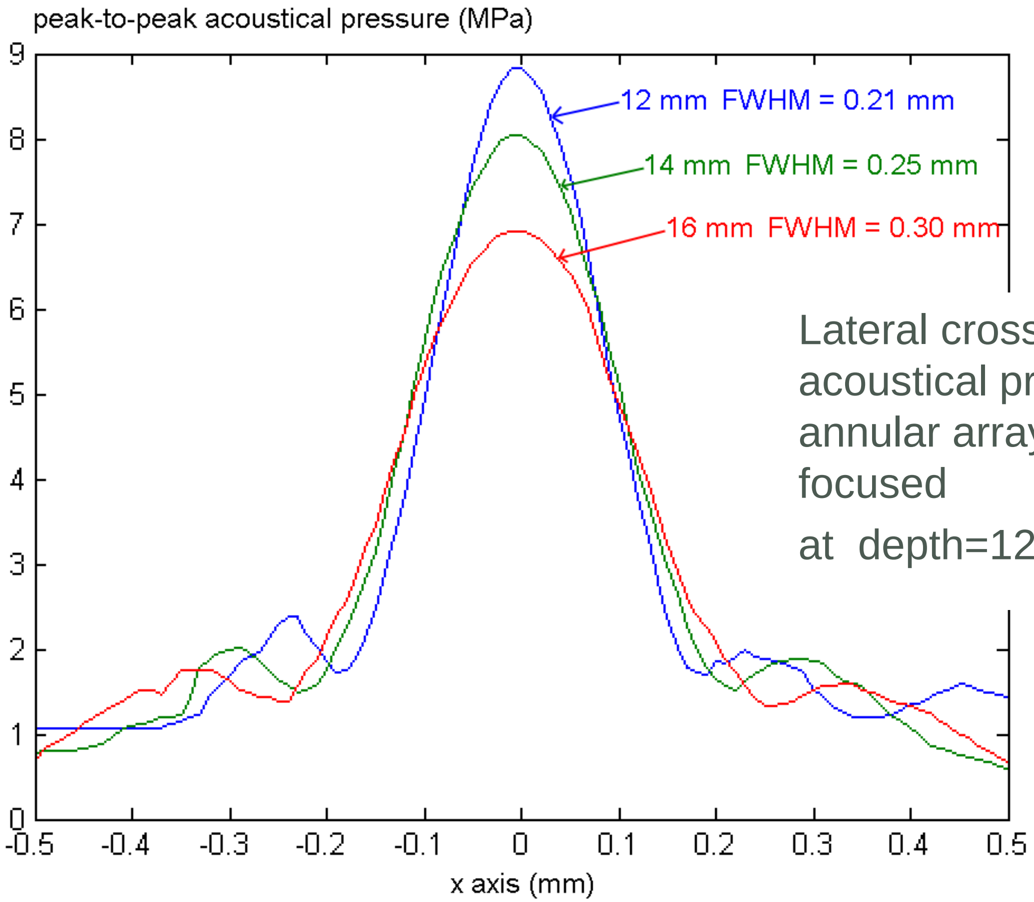
-6 dB beamwidth FWHM = 0.21mm at 12 mm depth,
= 0.25 mm at 14 mm depth
= 0.30 mm at 16 mm depth

measured using Precision Acoustics 0.040 mm needle hydrophone + Ritec BR640A amplifier + LeCroy 62Xi digital oscilloscope

Transducers (rings) excited with 130 V_{p-p} , 25 MHz, 2 periods bursts

Dynamically focused 7 elements thick film annular array transducer outer diameter D = 5 mm, f = 25 MHz



Lateral cross-section of the acoustical pressure generated by annular array transducer dynamically focused

at depth=12, 14 and 16 mm.

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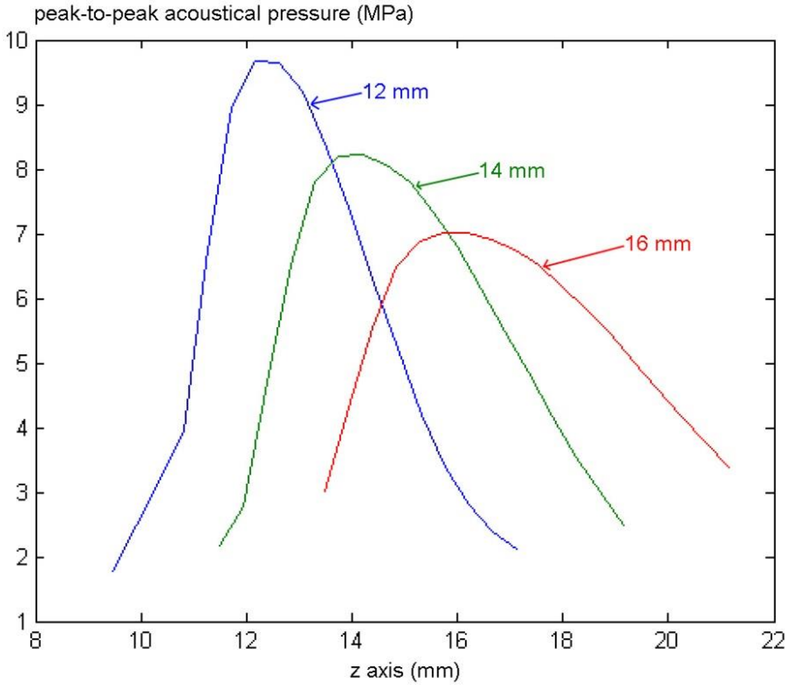
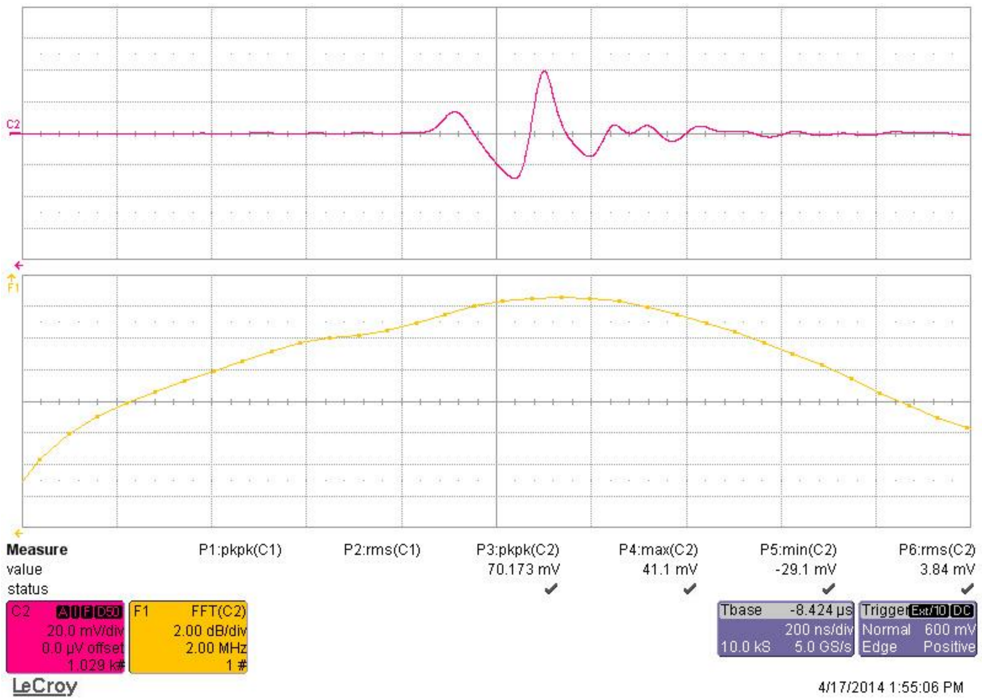


Axial beam pattern for annular array focused at f = 12, 14 and 16 mm.



Ultrasonic pulse and its FFT spectrum generated by annular array focused at 12 mm

pulse 70 $mV_{p\text{-}p}$ amplitude = 9.2 $MPa_{p\text{-}p}$, (very efficient electromechanical coupling)

21 MHz center frequency, beamwidth_{-3dB} = 12.4 MHz

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Conclusions

- Thick film (piezoceramic film deposition) technology can be successfully combined with ” semiconductor technology (laser patterning of the bottom electrode)
- Both technologies are industrial and easy to scale up
- Radiation pattern (axial and lateral pressure) consistent with theoretical calculations
- Controlling the fixed transmitting focusing and dynamic receiving focusing will improve the image resolution
- Very high electromechanical coupling coefficient
- Wide bandwidth allows using encoded transmission (Golay, Barcer, chirp)
- **Very good annullar arrays for high frequency can be produced at relatively low cost and high volume**

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Thank you