Progress on cost-effective screen printed linear arrays for medical imaging

Louise M. Borregaard[1], Rasmus Lou-Møller[1], Tomasz Zawada[1], Erling Ringgaard[1], Ruichao Xu[1], Michele Guizzetti[1], Jan P. Bagge[2], Lars N. Moesner[2]

[1]Meggitt A/S, Kvistgaard, Denmark
[2]BK Ultrasound, Herlev, Denmark

Screen- and pad-printed single element ultrasonic transducers have been successfully commercialized over the recent years. Typically, PZT (Lead Zirconate Titanate) thick films are pad- or screen-printed on a curved ceramic substrate acting as integrated backing layer and providing mechanical pre-focus. Center frequency ranges between 8 MHz and 80 MHz. The devices are characterized by good sensitivity as well as high relative bandwidth.

The main objective of the presented work has been to apply similar technology to manufacture multi-element transducers enabling novel cost-effective fabrication of imaging arrays for medical applications. It has been assumed that due to low lateral coupling of the printed PZT the elements can be defined only by the top electrode pattern leading to kerf-less design and low cross-talk between the elements.

In this work PZT thick film technology has been applied for manufacturing of linear arrays. Linear arrays have been fabricated using InSensor TF2100 thick film. The arrays have been printed on acoustically matched ceramic blocks acting both as the backing as well as substrate for deposition. The electrodes and the TF2100 film have formed a sandwich structure deposited by screen printing. 32 element transducers have been fabricated with center frequency around 12 MHz. The pitch has been equal to about 200 micrometers with an element width of about 45% of the pitch. The devices have been packaged using flip-chip method.

The arrays have been characterized at the transducer level using a pulse echo system consisting of a JSR DPR500 system and digital oscilloscope. The samples have been immersed in demineralized water with an acoustic reflector. Several arrays have been tested showing center frequencies ranging from 11 MHz to 13 MHz. In average insertion loss of -66.4 dB and a bandwidth of 53.6% have been achieved. The measured cross-talk has been equal in average to -38.2 dB. The transducers are characterized by good reproducibility of the properties. For example the capacitance variation between the elements is less than 14% in average.

The thick film arrays have been integration-tested using a commercial ultrasound scanner (BK Ultrasound – bk3000). The integration test revealed that the 32 element thick film transducers have been compatible with a commercial scanner, had a frequency range of 7.5 MHz to 12 MHz, and a TX bandwidth of 70%. Moreover the transducers support delay and sum beamforming as well as they can support phased array beamforming.

The performance of the tested linear arrays tested at the device as well at the scanner level show that printed PZT technology is suitable for cost effective manufacturing of high- and mid-frequency linear arrays for medical imaging.