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Dice-and-fill single element octagon transducers for next generation 3D USCT

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At KIT a 3D USCT system is under development. The system is optimized for SAFT imaging and has a multistatic setup of 2041 ultrasound transducers with approx. 1MHz 3dB bandwidth and 36° 3dB opening angle for 2.5MHz. The USCT groups transducers in a semi-ellipsoidal aperture surrounding a ROI of $10 \times 10 \times 10 \text{ cm}^3$. To increase the ROI for a next USCT generation, the opening angle of a future transducer should be increased to approx. 60° while other characteristics should be preserved or improved.

(2) Material and Methods

The fundamental connection between a transducer's emission and reception sensitivity in the azimuth and elevation angle is its size. Finite element simulations showed that approx. half the side length of current generation transducer is required. A circular instead of the current rectangular aperture would result in additional homogeneity. Octagon shape transducers are therefore an improvement over previously used rectangular transducers. With the established dice-and-fill technique with 2 additional sawing cuts this form can be achieved. Inspired by compressive sensing, an irregular distribution is applied covering almost the full surface area of US transducer. Further improvements are introduced regarding connectivity and bandwidth.

(4) Discussion and Conclusion

First prototypes were assembled with the described process and first results are encouraging. Yet, the process is currently not as stable and reliable as aimed for. The currently not fully automatized process leads to variations and in result to the failure of a significant portion of the transducer elements. This is currently under intensive investigation with further test prototypes to improve and stabilize the process which promises to lead to an improved yield $>95\%$.

(3) Results

Transducer is built up from the backing on which top-side a flexprint is providing the connectivity for the individual transducer elements. Small PZT slabs are glued on copper pads of the flexprint with low temperature curing silver glue. On a matching layer the cured structure is glued also with conductive silver-glue providing the common ground connection, defined distance and parallelity is provided by a laser cutted precise spacer ring. The completed structure is water proofed and mechanical stabilized with a hard-rubber like PU. Electrical characterization was performed with a phase-impedance analyzer for all piezo fibres. Ultrasound characteristics were evaluated quantitatively with a hydrophone in a 3-axis water tank.

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