Pad-printed thick-film transducers for high-frequency and high-power applications

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Fabrication

The basic structure of the transducer is depicted in Figure 1a and a cross section of the active structure is seen in Figure 1b. Top and bottom electrodes and the active film were deposited using pad printing on the curved face of the cylinder and contact electrodes were added along the side of the cylinder using screen-printing. A thorough description of the manufacturing method can be found in [1].

Figure 1a

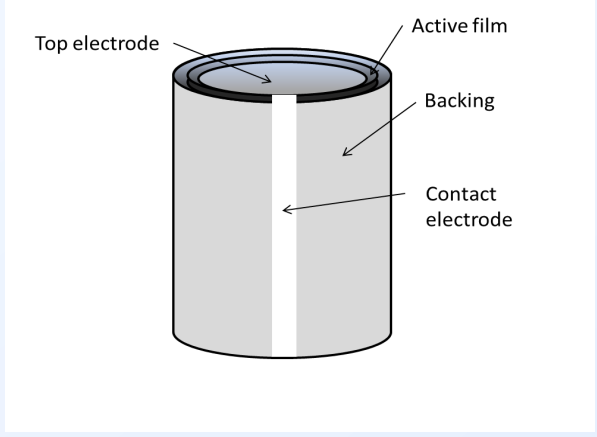

Figure 1a

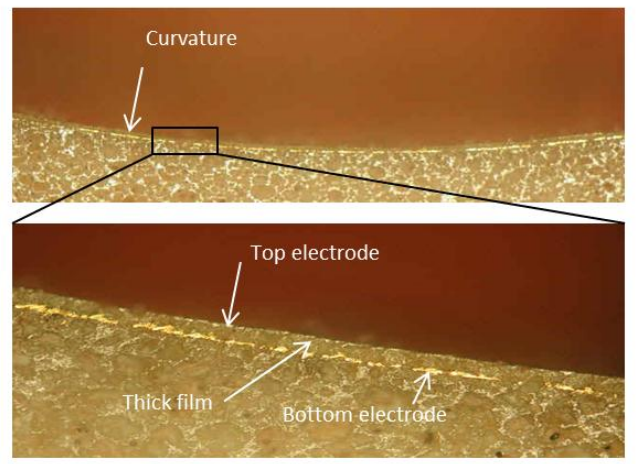

Figure 1b

Figure 2

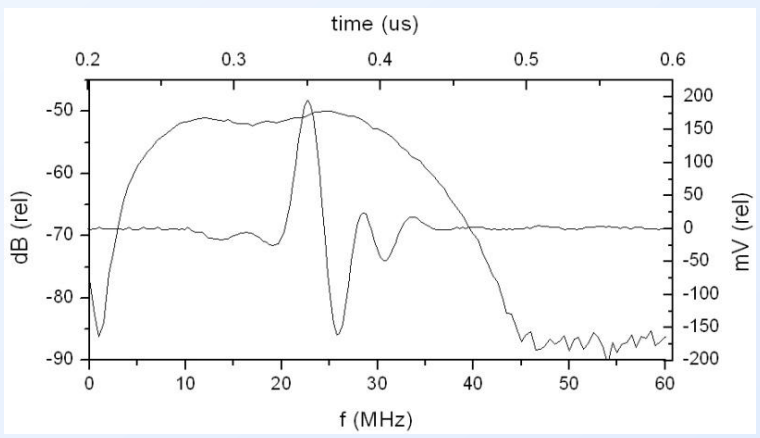

Figure 3

Results imaging

The pulse/echo response was characterized by placing a glass plate at the geometric focus of the transducer in a plane normal to the acoustic propagation. The response revealed a centre frequency of 19.5 MHz and -6 dB bandwidth of 135% (Figure 3).

Figure 4a shows an image of an ex vivo rabbit eye with the key anatomical features indicated. Figure 4b shows an externalized, in vivo mouse embryo with the embryo, umbilical vessels, and placenta visible. Figure 4c shows another image of a mouse embryo, this time with the embryo in utero. Finally, Figure 4d shows the left ventricle of an adult mouse heart.

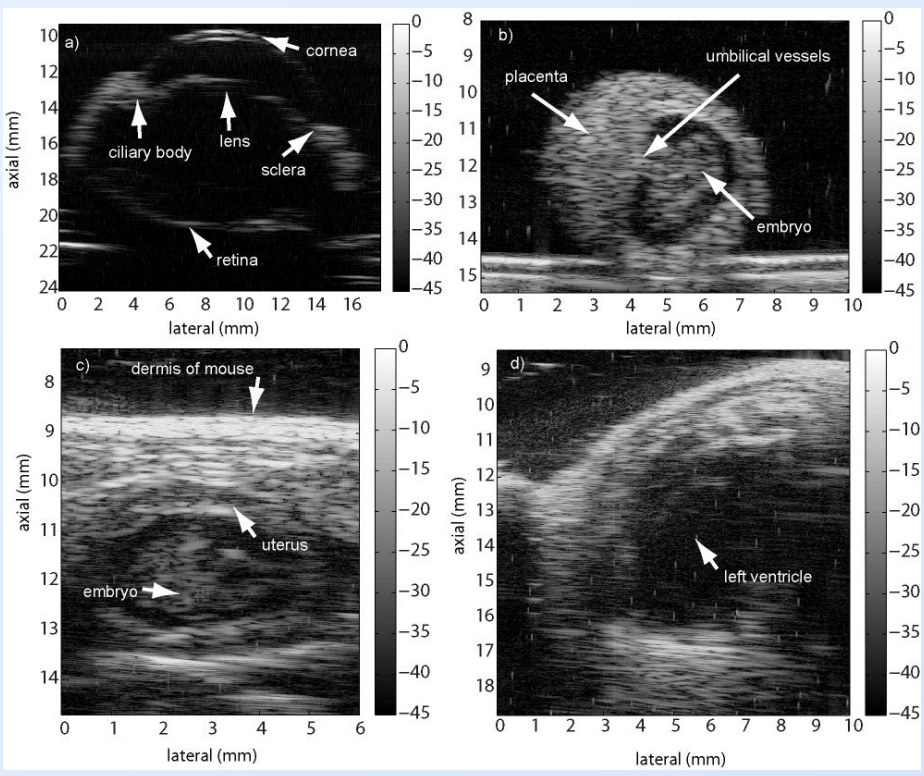

Figure 4

Results power

The piezoelectric thick-film transducer delivered high-pressure values over 3 MPa for an input voltage of 140 V_{pp}. Here, 140 V_{pp} was the maximum voltage that could be produced by our experimental set-up. A fairly linear pressure versus voltage curve with no saturation was observed. Considering that the thickness of the film was around 30 µm, the corresponding electrical field was around 5 kV/mm.

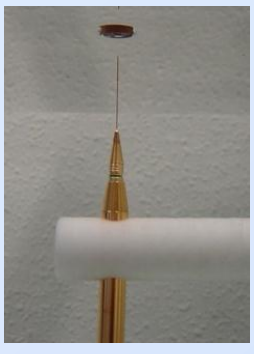

Figure 5

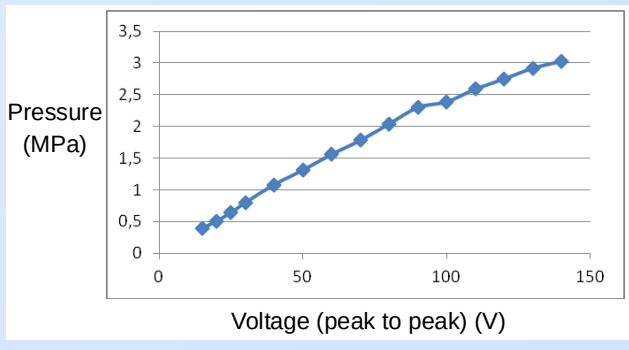

Figure 6

Conclusions

Results demonstrate that focused thick film transducers are capable of combining reasonable imaging performance and high-intensity generation. Despite a relatively high F-number, a peak-to-peak pressure of 3 MPa (corresponding to an intensity of 150 W/cm2) was measured for a peak-to-peak input voltage of 140 V_{pp} at frequencies close to 20 MHz. This opens the way to applications of high-frequency HIFU. The flexibility of the technology allows for further improvement through design optimization such as electrode/transducer configuration and alternative backing selection.

References

[1] F. Levassort, E. Filoux, R. Lou-Møller, E. Ringgaard, M. Lethiecq, A. Nowicki, ñCurved piezoelectric thick films for high resolution medical imagingò, IEEE International Ultrasonics Symposium, 2361-2364 (2006).