Thermal management enhancement solutions for medical ultrasound probes

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Background, Motivation and Objective

The last decade, medical sonography have seen the wide spread of many ultrasonic modes (SWI, High Frame Rate THI, High PRF Doppler,…) in which the transducers arrays are increasingly strained and, thus, subjected to thermal heating issues. In this context, thermal limits, with regard to safety compliance, are frequently reached before acoustics ones, making essential to have highly efficient thermal management solutions to fully exploit the capabilities now offered by both transducers and system. Among the three mechanisms of heat transfer, thermal conduction appears to be, within the confined volume of an US transducer, the overwhelming phenomenon compared to convection and radiation. As a consequence, we focus, in this work, exclusively on passive solutions involving the conduction way (inside the probe body) to drain the heat arising from the piezo electric component.

Statement of Contribution/Methods

Different thermal conduction path (central, peripheral, both), as well as different heat way out (probe nose housing, whole probe housing, probe cable braid shield) are investigated in this work. Starting from a standard acoustical stack for a 3 MHz single crystal phased array with typical acoustic design (80 elements with 240 µm pitch and 14 mm elevation), five mockups are derived, using solutions such as thermal fin, highly conductive backing (245 W/m/K), layers (85 W/m/K), resin (4.32W/m/K), etc… Thermal performances are then evaluated through IR measurements in air using a FLIR A-20 camera and following a measurement protocol based on IEC 601-2-37. A heating sequence consisting in a plane wave of 4 cycles at the center frequency of the probe is transmitted during 10 mins at high PRF (~2.34kHz), using a Verasonics Vantage system, while the IR camera records the temperature progress at the surface of the transducer. IR frames are then processed with Matlab to extract the hot spot profile along the heating process. As acoustic performances might change from a mockup to another, specific driving voltages are applied to each mockup in order to ensure a given Mechanical Index (MI=0.7 measured with ONDA-HGL0085 hydrophone in accordance with IEC 61157).

Results/Discussion

Following figure shows results obtained for 3 mockups, in which very efficient thermal management solutions are pointed out, as well as good insights on the impact of the different thermal paths investigated.

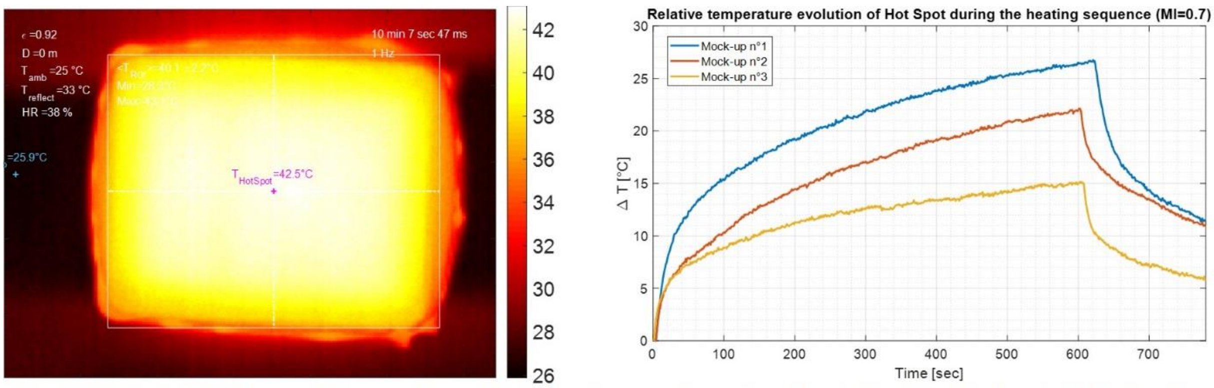

Fig. 1: On the left, IR frame of the mock-up n°3 surface temperature after 10 min heating. On the right, Hot spot progress for 3 different mock-ups during heating sequence. Mock-ups n°1 and n°2 explore peripheral conduction solutions only and Mock-up n°3 explores both peripheral and central conduction.