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# Simultaneous measurement of pressure and temperature in a focused ultrasound field with a fiber optic hydrophone

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The characterization of high intensity focused ultrasound (HIFU) fields is important for both clinical treatment planning as well as for regulation of HIFU medical devices. In previous work, we have used a 100-$\mu$m fiber optic probe hydrophone (FOPH) to measure pressure waveforms from a 2-MHz HIFU source with 42-mm aperture and 44-mm focal length. The formation of shock waves with peak positive pressure of up to 80-MPa were measured and modeled in transparent tissue-mimicking gel phantoms and boiling was achieved in milliseconds [Canney MS, et. al., J. Acoust. Soc. Am., 120:3110 (2006)]. In this work, the FOPH was also used to measure temperature changes in tissue phantoms from HIFU at peak focal intensities of 5000-20,000 W/cm$^2$. Temperature measurements were obtained by first low-pass filtering the voltage signal measured from the FOPH to remove the acoustic part of the measurement. Then, calibration of voltage to temperature was performed using results from a separate calibration experiment. Experimental measurements were compared with numerical modeling using a KZK-type model for acoustic propagation coupled with a heat transfer model. In summary, temperatures of 100°C were measured at the HIFU focus in milliseconds, in agreement with modeling [Work supported by NIH DK43881, NSBRI SMS00402, and RFBR.]