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POS-30 - Broadband Vibration Detection in Tissue Phantoms using a Fiber Fabry-Perot Cavity

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The biomedical imaging community has recently seen a tremendous development of novel ultrasound-based tissue characterization techniques. These methods often involve the application of an external stimulus and the measurement of the tissue response, from which tissue properties can be inferred. To further the development of these tissue characterization techniques, one needs to characterize the applied external stimulus and the resultant ultrasound waveforms as they travel through the tissue or the phantom.

To address this need, we developed and characterized a fiber optic vibration sensor with an ultra-wide dynamic sensing range, from a less than 1 Hz to clinical ultrasound frequencies. The vibration sensor consists of a matched pair of fiber Bragg gratings coupled to a custom built signal processing circuit. The wavelength of a laser diode is locked to one of the many cavity resonances using the Pound-Drever-Hall scheme. A calibrated piezoelectric vibration element was used to characterize its strain, temperature, and noise responses. To demonstrate its sensing capability, an ultrasound phantom with built-in low frequency vibration actuation was constructed. The fiber optic senor was shown to simultaneously capture the low frequency vibration and the clinical ultrasound transmission waveforms with nanostrain sensitivity.

The developed miniaturized and sensitive vibration sensor can provide invaluable correlation between the low frequency strain deformation and the ultrasound transmission. This correlation is useful for characterizing strain deformation under an applied external strain. Therefore, this sensor can be applied to study tissue deformation in ultrasound elastography and high intensity focused ultrasound. Laser-locked FBG cavities can also provide useful information regarding ultrasound transmission in tissues or tissue surrogates. The ability to implant a strain sensor of this bandwidth and sensitivity into tissues and tissue surrogates can permit the ready determination of mechanical properties, such as the speed of sound and bulk modulus, which are useful for modeling ultrasound propagation in such media.

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