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PZT Composite 2D Array Integrated with OCT for OCE imaging

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Background, Motivation and Objective

Acoustic radiation force optical coherence elastography (ARF-OCE), has been successfully implemented to characterize the biomechanical properties of soft tissues such as the cornea and the retina with high resolution using single element acoustic transducers for ARF excitation. However, due to the fixed focal region in both elevation and lateral directions, the induced tissue deformation region is not controllable, resulting in limited strain imaging and shear wave propagation. A new method to create an electronically steered and dynamically focused beam to cover a broader region of interest of the retina, including the optic disk and fovea regions, would be a favorable solution. To achieve this goal, we propose an integrated 2D ultrasonic array OCE imaging system, utilizing a central opening in a custom-built 2D ultrasonic array, thereby realizing co-registered fully steerable ARF excitation and optical coherence tomography (OCT).

Statement of Contribution/Methods

The novel fabricated ARF-OCE device consists of a 2D array with 64 elements implemented in hard PZT type material which is optimized for power delivery for the ARF pushing beam co-registered with an optical fiber for OCE detection. The acoustic stack is mounted to a 3-D printed interposer for support. The PZT material was composited to increase the coupling coefficient, k_t, of the elements for improved power delivery. The 1-3 composite material (Fig. 1a) had a center frequency of 4.5 MHz and was further sectioned with the dicing saw to create the 2D array of elements at 720 μm pitch. The 2D array was bonded to the interposer and a hole (Φ = 3.5 mm) drilled for the OCE fiber (Fig. 1b). The completed stack was assembled to a PCB (Fig. 1c), which was interfaced to an ultrasound cable connected to a Verasonics Vantage 128 system.

Results/Discussion

Fig. 1c illustrates the completed ARF array mounted to the 64 channel PCB for testing. 3D scanning of the 2D array was implemented on the Verasonics using a custom script to steer the ARF beam. The emitted ARF field generated nm level displacements in the stimulated material (Fig. 1 d, and e) which was detected by the co-integrated fiber OCE system demonstrating a functional ARF-OCE system with 2D steering capability.

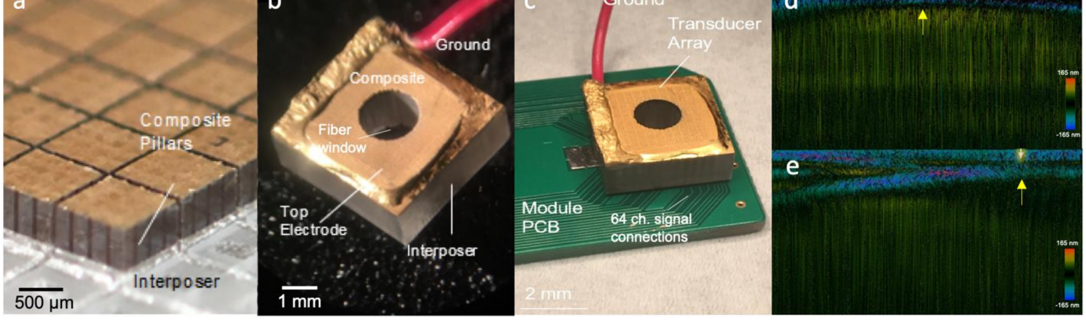

Fig. 1 (a) Oblique view of composite pillars mounted to interposer (b) acoustic stack with interposer, 64 channel 2D PZT array, and central fiber window for OCT access, (c) acoustic stack mounted to 64 ch. PCB for Verasonics interface (d) experimentally acquired ARF-OCE image steered directly ahead and, (e) by 4.5 degrees (color bar shows ARF-induced displacement in nm).