Reception Performance Enhancement of Capacitive Micromachined Ultrasonic Transducers via Modified Membrane Structures

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Abstract

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Capacitive Micromachined Ultrasonic Transducers (CMUTs) were invented in 1990s and developed rapidly in recent years. Compared to the traditional piezoelectric transducers (PZT), CMUTs own many advantages such as lower cost, easier to fabricate, broader bandwidth and more compatible with current IC technology. CMUTs have a very bright prospect and wide application fields in both daily life and researching fields. Generally, CMUTs can act as either a transmitter or a receiver. The reception performance of CMUTs is as important as the transmission one to the overall performance; however, few published papers have researched on the reception behavior of CMUTs.

This thesis focuses on the reception performance of CMUT via FEM simulations of COMSOL Multiphysics. In consideration of ultrasound attenuation and device safety, the simulated CMUTs receiver work in water immersion under conventional mode. Membrane deflection and output voltage across the external resistor can be obtained through simulation results. Then, the electromechanical coupling coefficient and receiving sensitivity can be calculated, accordingly. For enhanced CMUTs performance, two main approaches can be implemented by either operating mode change such as collapse snapback or deep collapse and structure innovation such as non-uniform

membrane. This thesis concentrates on structure innovation and proposes two kinds of modified membrane structures, namely slotted membrane and corrugated membrane. Theoretically, the application of modified membrane structures will lead to the effective membrane thickness decrease, which results in the decline of overall system stiffness, thus increases the membrane deflection. To verify this, COMSOL Multiphysics FEM simulations are performed. As a result, both static membrane deflections biased by DC voltage and dynamic membrane displacement caused by external acoustic pressure increase. This will lead to the enhancement of reception performance in receiving sensitivity and coupling coefficient.

Keywords: CMUT receiver, sensitivity enhancement, modified membrane structures.

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