Announcing the Final Examination of David Sadat for the degree of Master of Science

Title: Numerical Simulation of a Capacitive Micromachined Ultrasonic Transducer with a Parylene Membrane and Graphene Electrodes

Medical ultrasound technology accounts for over half of all imaging tests performed worldwide. In comparison to other methods, ultrasonic imaging is more portable and lower cost, and is becoming more accessible to remote regions where traditionally no medical imaging can be done. However, conventional ultrasonic imaging systems still rely on expensive PZT-based ultrasound probes that limit broader applications. In addition, the resolution of PZT based transducers is low due to the limitation in hand-fabrication methods of the piezoelectric ceramics.

Capacitive Micromachined Ultrasonic Transducers (CMUTs) appears as an alternative to the piezoelectric (PZT) ceramic based transducer for ultrasound medical imaging. CMUTs show better ultrasound transducer design for batch fabrication, higher axial resolution of images, lower fabrication costs of the elements, ease of fabricating large arrays of cells using MEMS fabrication, and the extremely important potential to monolithically integrate the 2D transducer arrays directly with IC circuits for real-time 3D imaging.

Currently most efforts on CMUTs are silicon based. Problems with current silicon-based CMUT designs include low pressure transmission and high-temperature fabrication processes. The pressure output from the silicon based CMUTs cells during transmission are too low when compared to commercially available PZT transducers, resulting in relatively blurry ultrasound images. The fabrication of the silicon-based cells, although easier than PZT transducers, still suffers from inevitable high temperature process and require specialized and expensive equipment. Manufacturing at an elevated temperature hinders the capability of fabricating front end analog processing IC circuits, thus it is difficult to achieve true 3D/4D imaging. Therefore novel low temperature fabrication with a low cost nature is needed.

A polymer (Parylene) based CMUTs transducer has been investigated recently at UCF and aims to overcome limitations posted from the silicon based counterparts. This thesis describes the numerical simulation work and proposed fabrication steps of the Parylene based CMUT. The issue of transducer cost and pressure transmission is addressed by proposing the use of low cost and low temperature Chemical Vapor Deposition (CVD) fabrication of Parylene-C as the structural membrane plus graphene for the membrane electrodes. This study focuses mainly on comparing traditional silicon-based CMUT designs against the Parylene-C/Graphene CMUT based transducer, by using MEMS modules in COMSOL. For a fair comparison, single CMUT cells are modeled and held at a constant diameter and the similar operational frequency at the structural center. The numerical CMUT model is characterized for: collapse voltage, membrane deflection profile, center frequency, peak output pressure transmission over the membrane surface, and the sensitivity to the change in electrode surface charge. This study took the unique approaches in defining sensitivity of the CMUT by calculating the membrane response and the change in the electrode surface charge due to an incoming pressure wave. Optimal design has been achieved based on the simulation results. In comparison to silicon based CMUTs, the Parylene/Graphene based CMUT transducer produces 55% more in volume displacement and more than 35% in pressure output. The thesis has also laid out the detailed fabrication processes of the Parylene/Graphene based CMUT transducers. Parylene/Graphene based ultrasonic transducers can find wide applications in both medical imaging and Non destructive evaluation (NDE).

Major: Mechanical Engineering

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Approved for distribution by Dr. Quanfang Chen, Committee Chair, on March 1, 2012.

The public is welcome to attend.