Studies of Lead Free Piezo-Electric Materials Based Ultrasonic MEMS Model for Bio Sensor

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Abstract

The biologically sensitive elements are combined with physical transducer by biosensors, which are analytical devices. This is done to discern specific compounds from a biological environment. Improved performance of biosensors is not only important from technological point of view but also important so far as human life is concerned. To prevent complications in diabetes, proper management of blood glucose levels is essential. Unlike the commercially available glucose meters where pricking fingers or other area of the skin is required, a noninvasive method for monitoring blood glucose levels is desired [1]. Using a ultrasonic transducer with which detections can be made through wireless operations the glucose levels of humans can be determined. The imitation of this biosensor will not become very bulky and power hungry. Hence we switched over to ultrasonic Micro-Electronics Mechanical Systems (MEMS) which has shown significant importance for miniaturized mechanical system, based on silicon technology. MEMS based acoustic biosensing transducers commonly employ the piezo-electric technologies to study the various nature and properties of the propagating ultrasonic wave in liquid medium of various densities to calibrate and compare. Piezoelectric materials are employed because they offer a high pressure per density ratio for the actuator, high stability in hostile environment and chemically they are very stable [2-4]. Prior to fabrication of MEMS device, design and simulation are extensively needed to avoid expensive time and cost. The goal of the present work is to describe the design of ultrasonic transducer using different lead free piezo-electric materials and their performance with different density of glucose levels in the human blood. COMSOL Multiphysics 4.2a is a versatile tool and is used to design and solve the transducer device with 3D partial differential equations. In this paper, 2D axis- symmetric model geometry of piezoelectric transducer was designed with different lead free piezoelectric materials like Barium Sodium Niobate (Ba2NaNb5O15)(BNN), Barium Titanate (BaTiO3)(BT) and Lithium Niobate (LiNbO3) which are capable of being used as thin film [5-7]. The potential of 10 Volts with 140 KHz frequency was applied to the device which was inside a geometry of cylindrical blood sample medium of 20 mm dia, and 30mm height. The surface and radial displacement of the transducer structure of the materials with pressure and stress are studied in liquid blood medium. Each material used was observed showing a different characteristic of the transducer with different density which was treated as different glucose levels in the human blood.

Hence it is concluded that BNN, BT and LiN material as an ultrasonic transducers are not upto the mark compared to conventional PZT material based transducers, but it has an edge over Lead Zirconate Titanate (PZT) material as BNN, BT and LiN are free from lead contain and BT has showed better performance compare to others. The glucose levels of blood samples will be comparing with commercial glucose meter.

Reference

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Figures used in the abstract

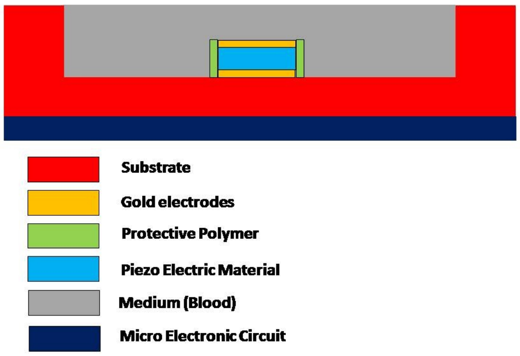

Figure 1: Layer structure of Ultrasonic Transducer MEMS.

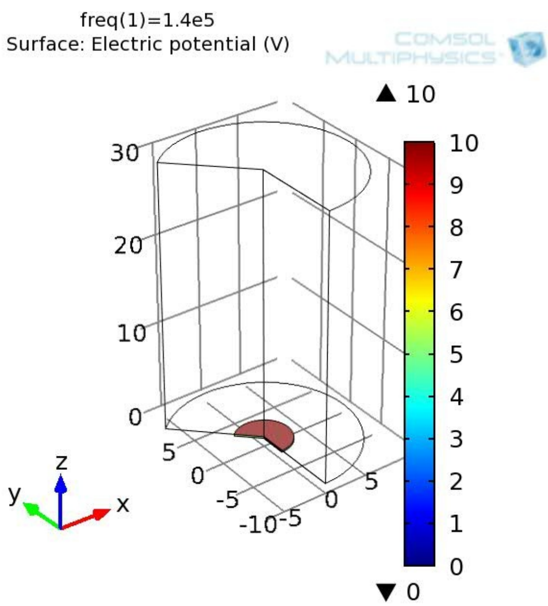

Figure 2: 3D structure geometry of piezoelectric materials with blood glucose medium at frequency and potential 140KHz and 10V respectively.

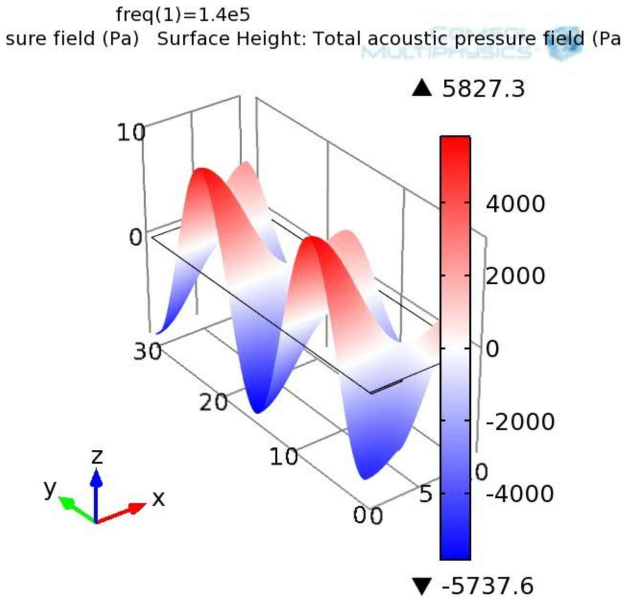

Figure 3: BT in human blood medium.

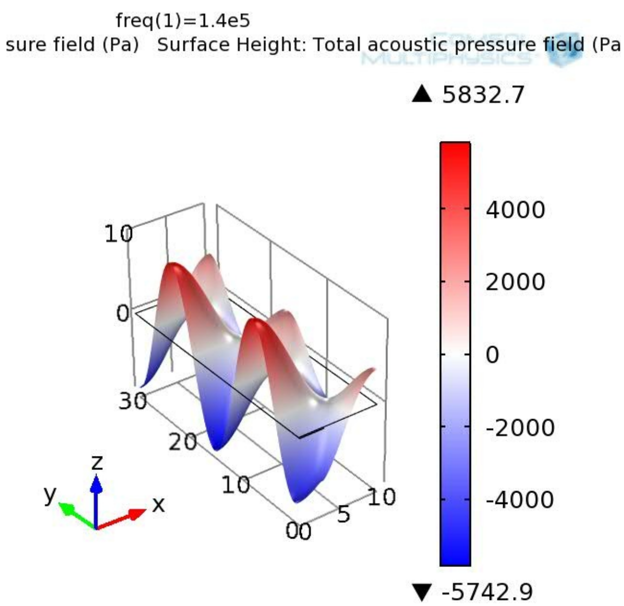

Figure 4: BT in human blood with glucose medium.