# Alternate Glucometer Bio-sensor Model Based on Ultrasonic MEMS Transceivers

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## Abstract

Regular monitoring of blood glucose level is an essential component of the treatment of diabetes. Ultrasonic transceivers (transmitter and receiver) can determine the glucose level of human blood. Ultrasonic transceivers generate high frequency sound waves and receive the echo produced in the medium. 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]. To design a light weight ultrasonic transceiver Micro-Electronics Mechanical Systems (MEMS), based on silicon technology is preferred. This technology has recently emerged and has advantages such as flexible geometries, reduced voltage requirements and mixing of different resonant frequencies for integration with supporting microelectronics circuits. MEMS based acoustic bio-sensing transducers commonly employ the piezo-electric technologies [2]. It is useful to study the nature and properties of the propagating ultrasonic wave in liquid medium of various densities before selecting the material in MEMS device. Therefore, design and simulation study has been carried out in this study, which is essential prior to fabrication of MEMS device, to avoid expensive time and cost. The goal of the present work is to describe the design of ultrasonic transceiver using lead-free piezo-electric material and study its performance with different density of glucose levels in the human blood. COMSOL Multiphysics® is used to design and solve the transducer device with 3D partial differential equations. Using COMSOL Multiphysics® the design and analysis of MEMS based different composite materials piezoelectric ultrasonic transducer was also reported earlier [3]. In this study, 2D axis- symmetric model geometry of piezoelectric transceivers was designed with Barium Titanate (BaTiO3)(BT) which is a lead free piezoelectric material and is capable of being fabricated as thin film [4]. The size of the piezoelectric sample of this transceiver MEMS device was optimized by varying width and thickness which produced maximum transmitting pressure as well as receiving pressure. Similarly, the fundamental frequency was optimized to 2 MHz. The potential of 1.6 Volts with 2 MHz frequency was applied to the device which was inside the geometry of cylindrical blood sample medium of 1 mm diameter, and 10 mm height. The surface and radial displacement of the transducer structure of the piezoelectric materials with pressure and stress are studied in blood medium (Fig. 1). Using the BT based material, the generated pressure at transmitting end and received potential at the receiving end were found to increase with respect to increase in the glucose concentration level of human blood (Fig. 2). The

glucose level of blood samples were compared with commercial glucose meter and were found to have close agreement. It is concluded that Barium Titanate (BT) being a lead-free piezoelectric material can be used as a better alternative ultrasonic MEMS transceiver compared to Lead Zirconate Titanate (PZT) material.

Keywords: COMSOL , Lead free materials, Barium Titanate, piezoelectric thin film, Bio sensor.

## Reference

1.Eun-Joo Park, Jacob Werner, Joshua Beebe, Samantha Chan, Nadine Barrie Smith, “Noninvasive Ultrasonic Glucose Sensing with Large Pigs (~200 Pounds) Using a Lightweight Cymbal Transducer Array and Biosensors” Journal of Diabetes Science and Technology, 3(3), pp-517-523, (2009).

2.P. Pattnaik, S. K. Pradhan, S. K. Kamilla, D. P.Das, ”Studies of Lead Free Piezo-Electric Materials Based Ultrasonic MEMS Model for Bio Sensor” proceeding of COMSOL User Conference, Bangalore, (2012).

3.T. Satyanarayana, G. Srinivas, M V V K Srinivas Prasad , Y. Srinivas , B. Sudheer, K. Srinivasa Rao, “Design and Analysis of MEMS based Composite Piezoelectric Ultrasonic Transducer” Electrical and Electronic Engineering, 2(6): pp-362-373, (2012) [DOI: 10.5923/j.eee.20120206.04]

4.Elena Aksel, Jacob L. Jones, “Advances in Lead-Free Piezoelectric Materials for Sensors and Actuators”, Sensors, 10, pp-1935-1954, (2010).

# Figures used in the abstract

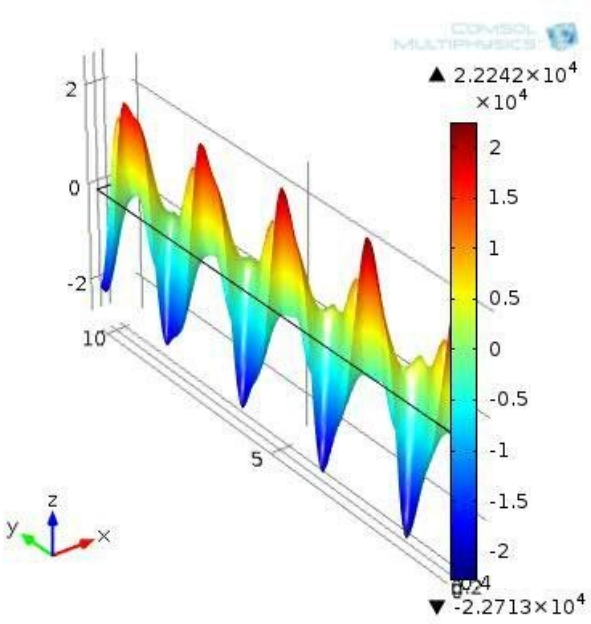


**Figure 1**: Simulated acoustic pressure plots using BT based devices in blood medium.

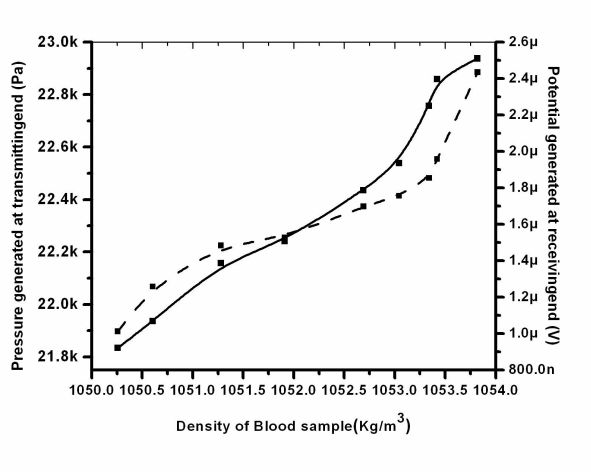


**Figure 2**: Acoustic pressure variation with glucose density in blood medium.