Design of FIDT for 3D Analysis of MEMS Based Gas Sensor Using SAW Technology

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Abstract

As energy can neither be created nor be destroyed but can be transformed from one form to other form, depending on application. In some cases energy released/ absorbed in any reaction sometimes will alter the process parameters and cause disturbance in normal flow of operation. This effect has its impact even in fundamental wave propagation properties and results in introduction of unwanted noise along with dissipation of energy into surrounding environment. Sensors that uses sound based energy for different engineering applications are influenced by factors like reflection phenomenon in waves at sensor edges, power dissipation problem etc., due to the design of energy generating devices. Few Microelectromechanical-systems (MEMS) technology based Surface Acoustic Wave (SAW) sensors devices for gas sensing utilizes uniformly placed IDT's (Inter Digital transducer) as referred in Figure 1, for generating the mechanical vibrations using RF power, faces these problem with the conventionally available IDT's designs. This paper focuses on such IDT's designs using COMSOL Multiphysics®. This SAW based sensor technology finds versatile applications in various engineering domains like aerospace industry for IVHM, chemical gas sensing in automobile, Microfluidics applications like Lab-on-a-chip, tire pressure monitoring sensors, cryogenic liquid level maintenance, vibration measurement, wing deflection sensing, humidity measurement, patient care diagnostics in hospitals, temperature monitoring in harsh environments, micro-pumps, micro-actuators etc., to name a few.

USE OF COMSOL MULTIPHYSICS: COMSOL Multiphysics software helps to design FIDT's referred in Figure 2, in SAW sensor which can be visualized three dimensional. Piezoelectric Devices Interface was selected (which comes under MEMS module) for simulation. This helps to simulate the external mass loading effect on the base material used i.e., piezoelectric material. The resultant surface displacement and generated electrical potential values at the predicted frequency are identified using this software. The Material Library within COMSOL Multiphysics helps to test the model for different piezoelectric materials along with subjecting the materials to elevated temperatures/ cryogenic conditions as per the application requirement. The options and GUI in COMSOL Multiphysics helps for finite element analysis of the model and in three dimensional representation of real model for enhanced understanding.

RESULTS: This study helps to identify the total surface displacement value due to the introduction of dichloromethane gas molecules of 100 ppm onto the Polyisobutylene surface as referred in figure 3. Energy required for acoustic wave's generation in SAW is obtained from the electrical potential values of IDT's as referred in figure 4. Electrical potential slices helps for finite element analysis of the micro-structure model.

CONCLUSION: This paper focuses on the MEMS based SAW gas sensor working using the FIDT design that helps in enhancement of the surface displacement values and ease of calculation of required phase shift in the amplitude/frequency, values after pumping in the required gas. Length of delay line, aperture length, electrode gap, thickness of the sensing layer, choice of piezoelectric material and selection of chemical coating depending on the application, ppm/ ppb level of gas concentration to be identified etc., are different possibilities that can be addressed using this design in COMSOL Multiphysics software.

Reference

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Figures used in the abstract

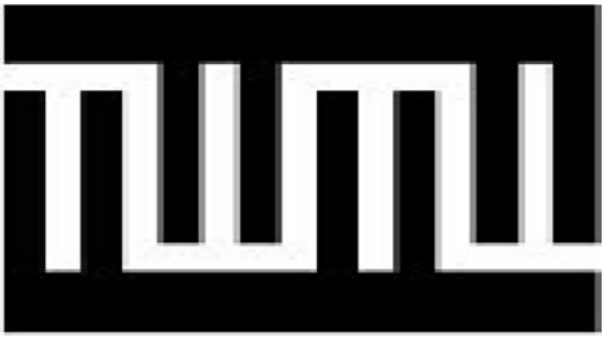

Figure 1: Conventional IDT Design.

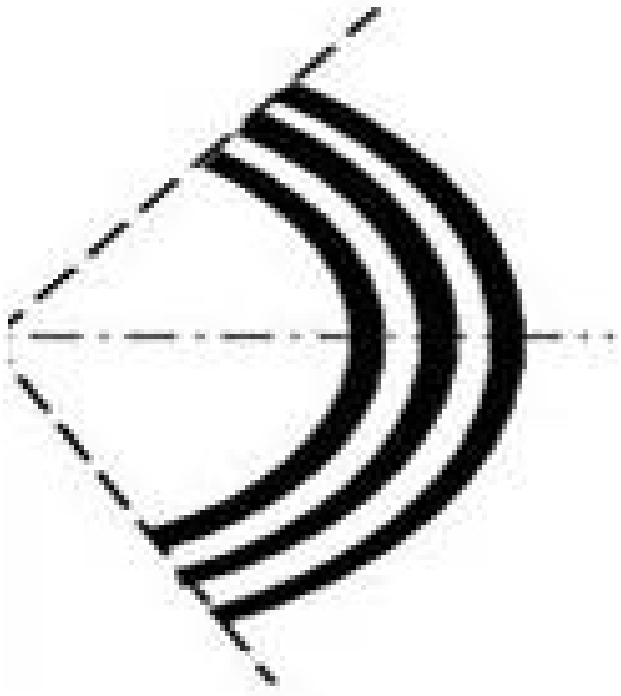

Figure 2: Focused IDT Design.

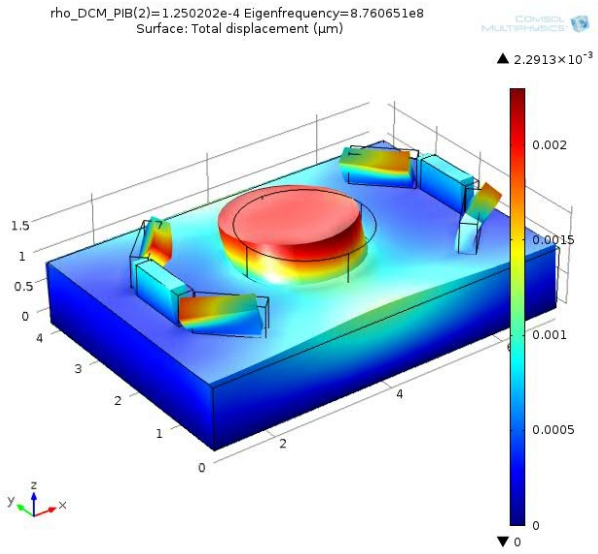

Figure 3: Total Surface Displacement at Resonance.

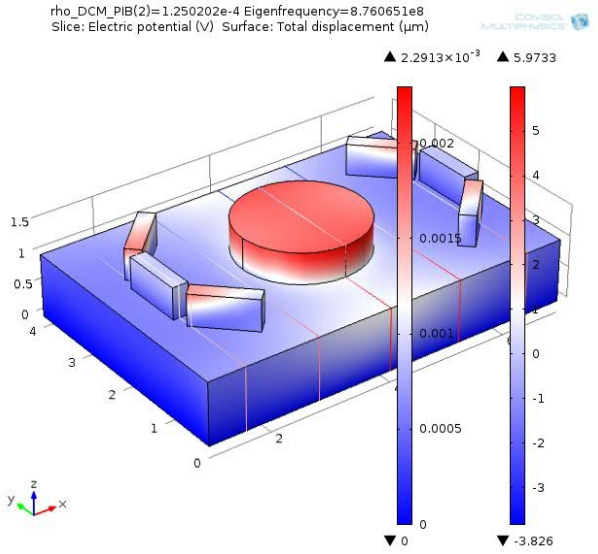

Figure 4: Electrical Potential at Resonance.