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DESIGN AND ANALYSIS OF NEONATAL BLOOD PRESSURE MEASURING SYSTEM USING MICRO-OPTO-ELECTRO-MECHANICAL SYSTEMS

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ABSTRACT: *This paper presents a blood pressure measuring system for neonates using Micro-Opto-Electro-Mechanical System (MOEMS) which can be used to monitor blood pressure for up to 32 weeks old neonates. This gadget uses mechanical pressure of the device as the input and converts the mechanical pressure into blood pressure. Silicon is taken for analysis, because of its physical and mechanical properties. The structure of Silicon diaphragm is created and analyzed in Ansys, which shows the deformation and normal stresses in all three directions. This result is utilized to formulate Refractive Index. Taking the Refractive Index as an input in OPTI FDTD, we can obtain a plot between Wavelength and Amplitude. That data is fed into MATLAB. Using the data, MATLAB gives the output mentioning the blood pressure in Mpa and the age of the neonate. Different test conditions are done and the results are presented.*

Keywords: **MOEMS, ANSYS, OPTI FDTD.**

1. INTRODUCTION

Micro-Electro-Mechanical Systems are utilized in the medical field for multipurpose, such as for hearing aids, insulation pumps for diabetics etc. The typical size of a MEMS structure is of about 1-100 microns. Micro-Electro-Mechanical Systems are of two categories, which are sensors and actuators. Sensors are used to gather information from the surroundings and actuators are used to execute commands given to them. MEMS are made by depositing a thin layer on base and etching away the unwanted particle, which forms a three-dimensional microscopic structure. MEMS contain electrical and mechanical elements within them. Electrical elements process the obtained data and the mechanical element responds to the data.

MOEMS are not a special class of Micro-Electro-Mechanical Systems (MEMS) but rather the combination of MEMS merged with Micro-optics; this involves sensing or manipulating optical signals on a very small size scale using integrated mechanical, optical, and electrical systems. MOEMS includes a wide variety of devices including optical switch, optical cross-connect, tunable VCSEL, microbolometers amongst others. These devices are usually fabricated using micro-optics and standard micromachining technologies using materials like silicon, silicon dioxide, silicon nitride and gallium arsenide. The common method of measuring blood pressure in neonates is using oscillometric method. The problem with this method is that these devices produces electromagnetic interference which may cause side effects to the child in future. To overcome this problem, MOEMS are used. Micro-Opto-Electro-Mechanical Systems (MOEMS) are not a special class of Micro-Electro-Mechanical Systems (MEMS) but rather the combination of MEMS merged with Micro-optics; this involves sensing or manipulating optical signals on a very small size scale using integrated mechanical, optical, and electrical systems. MOEMS includes a wide variety of devices including optical switch, optical cross-connect, tunable VCSEL, microbolometers amongst others. These devices are usually fabricated using micro-optics and standard micromachining technologies using materials like silicon, silicon dioxide, silicon nitride and gallium arsenide.

2. METHODOLOGY

2.1 Simulation

Silicon is selected as the diaphragm material. The obtained blood pressure data from literature is in terms of mmHg that has to be converted into Pascal []. Create the structure in according to the design data. The structure will be meshed in Ansys. Fix the all the sides of the structure and apply pressure which is the input to the system. The obtained results are Deformation, Normal Stress (X, Y &Z directions). Which will further be used for calculation.

2.2 Calculation

Calculate Refractive Index with respect to Normal stress.

$$n_X = [C_L\ \sigma X + C_T\ (\sigma Y + \sigma Z)] + 1$$

$$n_Y = [C_L\ \sigma Y + C_T\ (\sigma X + \sigma Z)] + 1$$

$$n_Z = [C_L\ \sigma Z + C_T\ (\sigma Y + \sigma X)] + 1$$

With reference to the obtained Refractive Index, select the larger value.

2.3 Programming

A structure is created in Opti FDTD with same design data. Simulate the Opti FDTD structure in 2D with respect to Refractive Index. From the Opti FDTD Analyzer, a graph is plotted that is wavelength vs amplitude. Data file is generated from the graphs for four different weeks. The file is introduced in MATLAB software, a program is developed with respect to Data files. Application data is generated in MATLAB. This application data compares the values of different weeks when we give inputs in terms of wavelength and amplitude. MATLAB sends input to the Arduino and micro-controller and it shows the result in LCD display. Micro-controller is also connected with LED, which indicates different colours for different weeks.

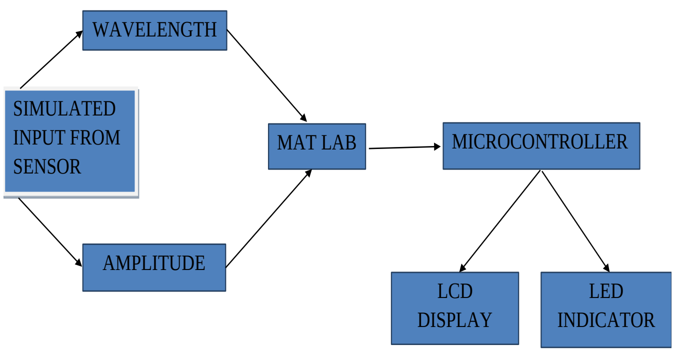

Fig-1: Typical flowchart of the system.

3. RESULTS

3.1 Ansys Simulation

3.1.1 Week <24

Table-1: Normal stress and Deformation

Weeks	Pressure (Pa)	Deformation (µm)		Normal Stress (Mpa)					
				σ_x		σ_y		σ_z	
		Max	Min	Max	Min	Max	Min	Max	Min
24	6399.47e-6	0.041108	0	48.463	-49.627	63.702	-63.917	13.894	-14.305
	8399.31e-6	0.053954	0	63.608	-65.135	83.609	-83.891	18.235	-18.775
	7399.39e-6	0.047531	0	56.035	-57.381	73.655	-73.904	16.065	-16.54
	6899.4315	0.04432	0	52.248	-53.504	68.679	-68.911	14.979	-15.422
	7899.3515	0.050743	0	59.822	-78.898	78.632	-61.528	17.15	-17.657

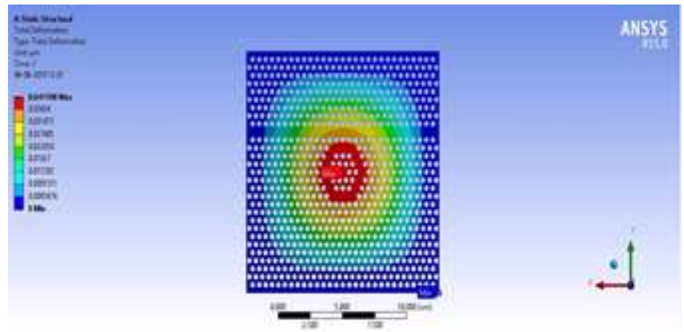

Fig-1: Total deformation of the structure

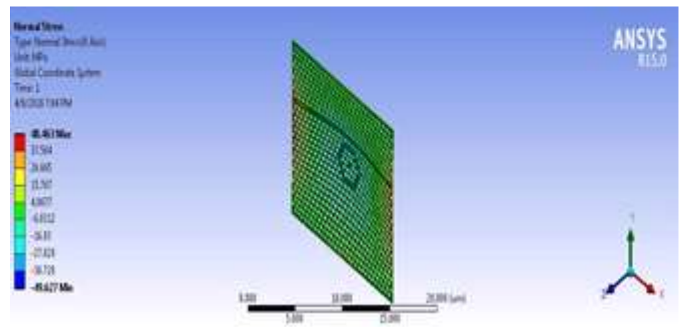

Fig-2: Normal stress in x- direction.

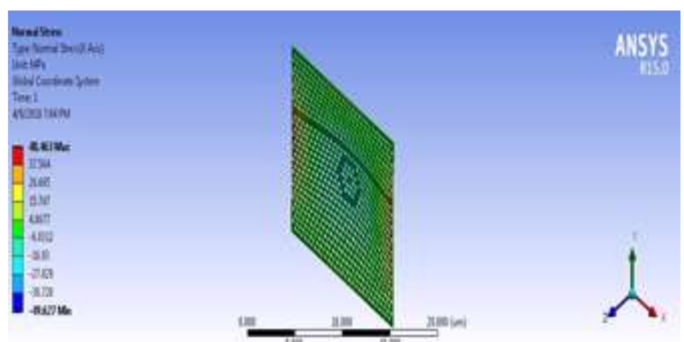

Fig-3: Normal stress in y- direction

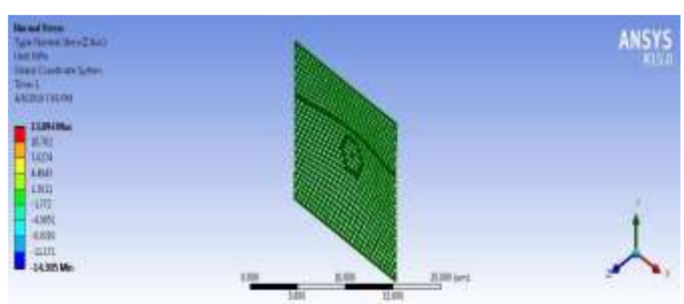

Fig-4: Normal stress in z-direction

3.1.2 Week 24-28

Table-2: Normal stress and Deformation

Weeks	Pressure (Pa)	Deformation (µm)		Normal Stress(Mpa)					
				σ_x		σ_y		σ_z	
		Max	Min	Max	Min	Max	Min	Max	Min
24-28	6399.47e-6	0.041108	0	48.463	-49.627	63.702	-63.917	13.894	-14.305
	7732.7e-6	0.049672	0	58.56	-59.965	76.973	-77.233	16.788	-17.285
	7066.09e-6	0.04539	0	53.511	-54.796	70.338	-70.575	15.341	-15.795
	6732.78	0.043249	0	50.987	-52.211	67.02	-67.246	14.617	-15.05
	7399.395	0.047531	0	56.035	-57.381	73.655	-73.904	16.065	-16.54

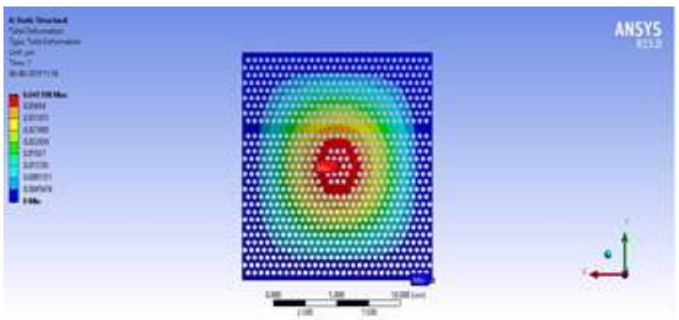

Fig-5: Total Deformation of the structure

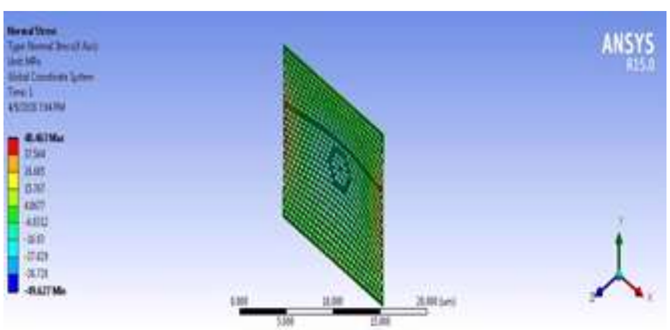

Fig-6: Normal stress in x-direction.

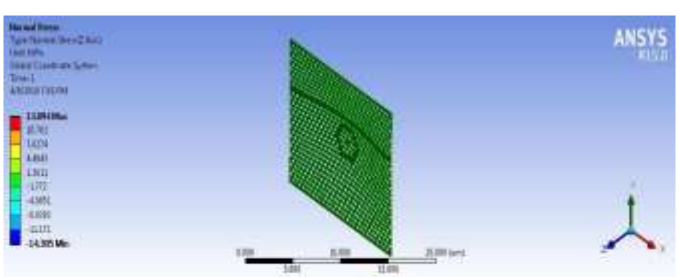

Fig-7: Normal stress in y-direction

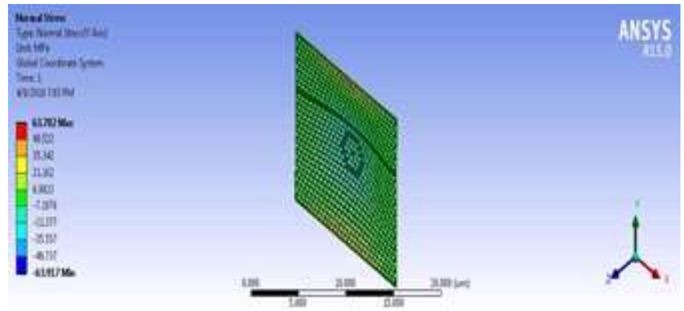

Fig-8: Normal stress in z-direction

3.2 Graphs

3.2.1 Week <24

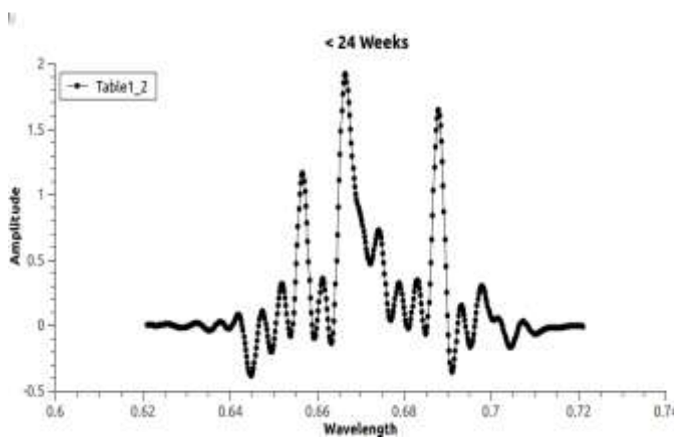

Chart-1: Amplitude vs Wavelength

3.2.2 Week 24-28

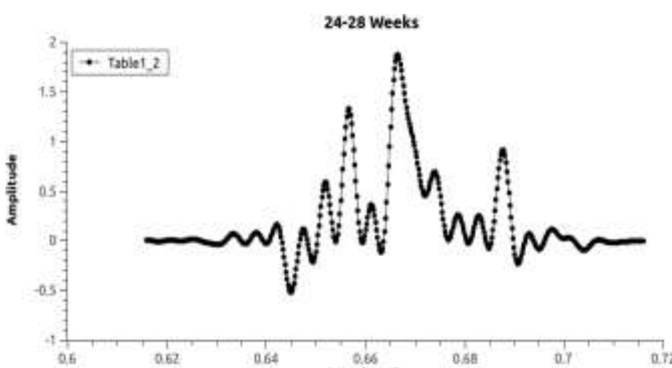

Chart-2: Amplitude vs Wavelength

3.3 Hardware Output

Fig-9: Result obtained which contains the age and blood pressure in Mpa

4. CONCLUSION

Proposed work consists of design and analysis of silicon photonic crystal sensing layer for blood pressure measuring system in neonates. Design and analysis of photonic crystal sensing layer by using FEA and execution of code for Finite Difference Time Domain software. Total deformation, normal stress obtained from FEA analysis has been integrated with FDTD simulation. In future this proposed work will have a remarkable benefit in finding the blood pressure of neonate without any health effect in future.

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