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Sitting posture health monitoring for scoliosis patients using capacitive micro accelerometer

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Recently, the accelerometer has taken on a vital role in health monitoring system. The monitoring of patients disease has been aided by the use of different diagnostics. These devices exist at the macro level and also in micro level for condition monitoring. Capacitive Micro-accelerometer is a wearable sensor for monitoring of scoliosis disease in patients by analyzing their sitting posture, asymmetrical balance of patients. A new approach for accelerometer , using an *L-shaped cantilever parallel plate MEMS accelerometer* design is proposed. This micro accelerometer is designed using INTELLISUITE 8.6. Static analysis is done using Thermo Electro Mechanical module to examine the performance. Proposed design is compared with the existing design. In the future , this can also be applied in NANO level applications with respect to its design and fabrication.

Keywords: health monitoring, scoliosis disease, sitting posture, micro-accelerometer.

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1. Introduction

MEMS accelerometers are widely fabricated on batch-fabricated silicon [1]. MEMS based accelerometers have been making a bigger impact over the last few years [2]. Different accelerometers are available, such as capacitive [3], piezoresistive and piezoelectric. The L-shaped cantilever type capacitive accelerometer is widely used for many applications in different areas, like health monitoring in the medical field [4, 5], automobile, communication., etc which gives better sensitivity [6].Scoliosis is a medical condition in which a person spinal axis has a three dimensional deviation, deals with problems like uneven musculature on one side of the spine, uneven hips or arms or leg lengths. Health monitoring of patients with this disease is essential, in such situations, the accelerometer is used as a health monitoring agent. Analysis will go by good and bad sitting posture. Good posture provides normal biomechanical functions of the musculoskeletal system. On the other hand, bad posture results in muscle imbalance and structural problems in the spine. Although many devices are invented for the health monitoring, accelerometers are the practical device to perform the function of health monitoring effectively by focusing on the human imbalance and posture control in real life. Good posture data are compared with the bad posture in improvising the data quality.

2. Design of accelerometer

The accelerometer design involves multiple steps like designing mask, fabrication, 3-D builder simulation, analysis etc.. These processes are carried out with help of the INTELLISUITE software. It possess intellifab for fabrication, intellimask for mask design. Mask specification is taken from l-*shaped cantilever parallel plate mems accelerometer design* [7]. By extracting the heart of the design and implementing in this work, the mask design specification is as follows:

$$\text{Proof mass size} = 463 \times 463 \times 2\ \mu\text{m}^3;$$
$$\text{Length of beam } (L_1) = 457\ \mu\text{m};$$
$$\text{Length of beam } (L_2) = 90\ \mu\text{m};$$
$$\text{Beam width } (W_1) = 2\ \mu\text{m};$$
$$\text{Beam width } (W_2) = 4\ \mu\text{m};$$
$$\text{Proof mass thickness} = 2\ \mu\text{m}.$$

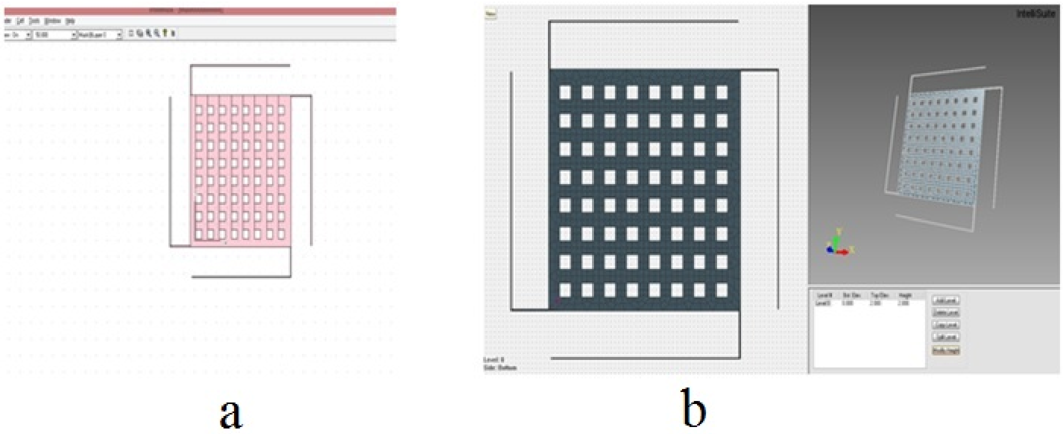

FIG. 1. (a) Design mask, (b) 3-D builder simulation

2.1. Mask design & simulation using 3-d builder

Fig. 1(a,b) shows the design mask created using intellimask and 3-D builder simulation. The L-shaped cantilever beams, created by calculating the x, y co-ordinates appropriate to the proof mass. Holes in the proof mass are created by using the array portion in the manner of matrix (8×8). A single layer mask (mask@layer0) is created. For simulation using 3-D builder, the mask has to be exported from the intellimask. In mesh type, non-Manhattan isotropic is enabled and the mesh size 30 μm is given. The height of the mask can be magnified by using modify height.

2.2. Design analysis

Thermo Electro Mechanical (TEM) analysis done in the Intellisuite, the following properties are used for the analysis.

TABLE 1. Material properties

Material property	Silicon	Pyrex glass
σy (yield strenght) 10^9 N/m^2	7	0.5 – 0.7
E (Young's modulus) 10^{11} N/m^2	1.69	400
ν (Poisson's ratio)	0.28	0.17
α (thermal expanrion coefficient) 10^{-6} mt/mt °C	2.5	0.5
ρ (density) g/cm^3	2.3	2.225

Using material properties, the design has been analyzed for various pressure values.

Figure 2 shows the static analysis of micro accelerometer for various pressure values. Load is applied in the form of pressure, applied to the face of the design is 0.0001 MPa to 0.001 MPa. The boundary condition is fixed at all ends of the 4 beams and the static analysis mode is given. As a result, the change in displacement of 0.096 μm to 0.96 μm (x-direction) and deformed shape due to the load pressure is acquired. The changes in shape can be represented in a pictorial format as shown above. A pressure value of 0.002 MPa shows a breakage (1.92 μm) in accelerometer due to overload pressure.

Deflection can be well read through the graphical representation as shown below. Fig. 3 graph shows linearity in deflection with respect to the given pressure.

3. Conclusion

This paper concludes that the *L-shaped cantilever parallel plate MEMS accelerometer* is used to monitor the scoliosis disease in patients by analyzing their posture when seated, asymmetrical balance of patients. The static analysis shows the deformation in accelerometer. For the load conditions, 0.0001 MPa to 0.001 MPa, the

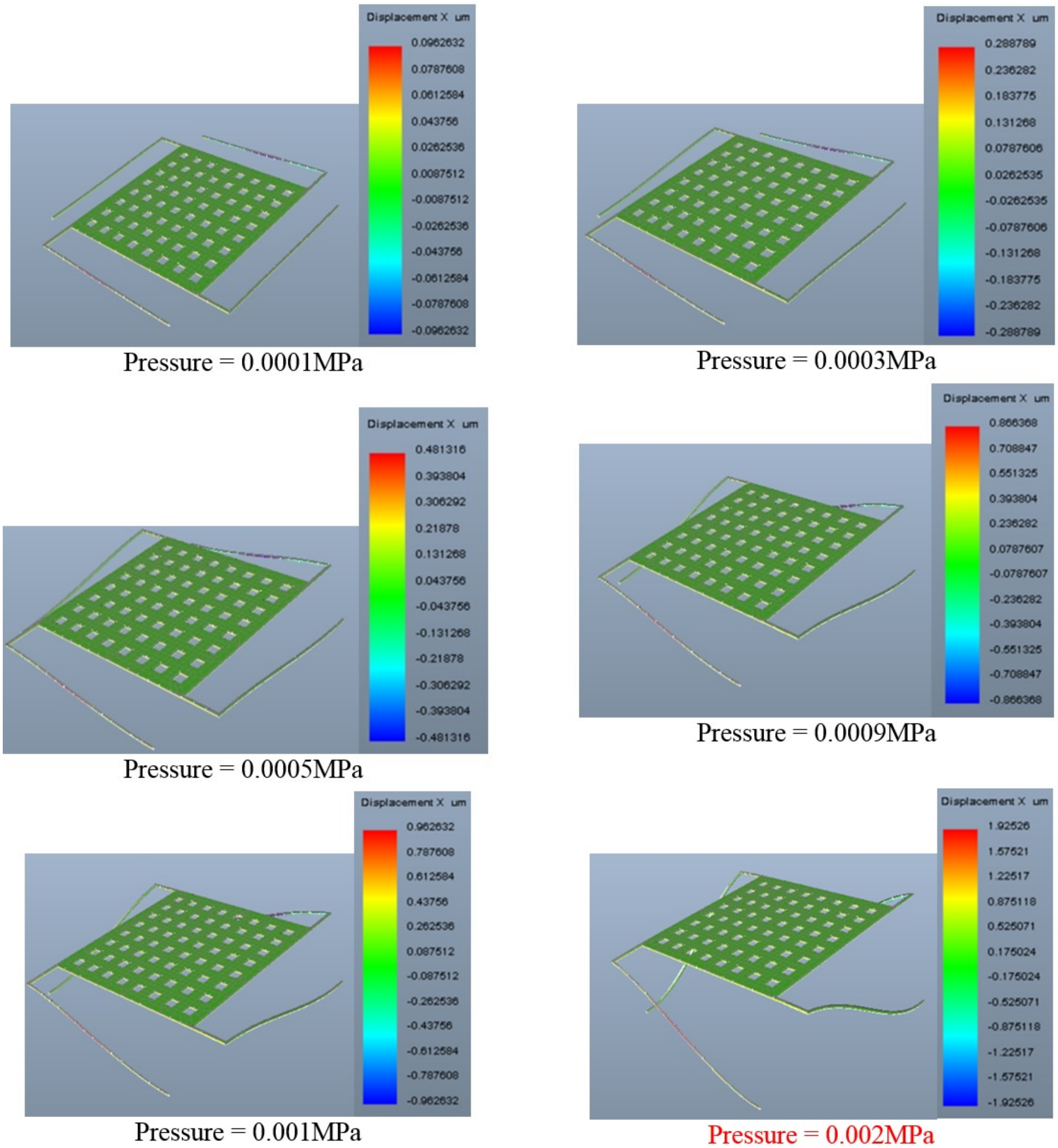

FIG. 2. Static analysis of micro accelerometer for various pressure values

displacement varies from 0.096 μm to 0.96 μm in x-direction respectively. Based upon the results obtained, the design has the limit pressure up to 0.001 MPa, thus it is capable of monitoring for scoliosis patients. This design and simulation belongs to the micro level category devices, further work can be done to create nano level devices. The same design can be applied for the nano level with changes in design specifications.

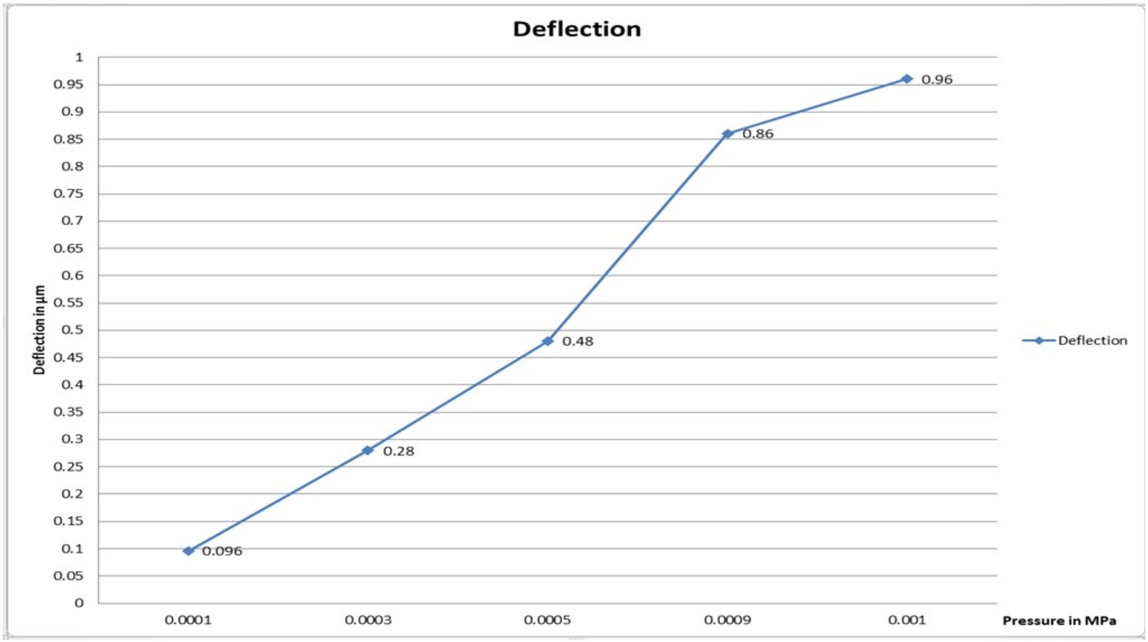

FIG. 3. Pressure vs deflection

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