Design and Implementation of MEMS based Blood Viscometer for INR Measurement

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Abstract- The paper brings out the designing and implementation of blood viscosity monitoring device that gives us the INR to measure the effectiveness of anti coagulant medications .When a blood vessel is damaged, clotting cascade begins that results in blood clot. This process is affected by several medical conditions where it becomes mandatory for a patient to intake anti-coagulants. Thus, this MEMS based Blood viscometer with a disposable strip can provide a convenient means to measure the blood clotting to assist patients in drug usage.

Keywords- INR, blood viscometer, cantilever, piezoelectric sensor

I. INTRODUCTION

Coagulation is the process by which blood forms clots. Coagulation begins almost instantly after an injury to the blood vessel has damaged the endothelium lining the vessel. . It is an important part of hemostasis, the cessation of blood loss from a damaged vessel, wherein a damaged blood vessel wall is covered by a platelet and fibrin-containing clot to stop bleeding and begin repair of the damaged vessel. Disorders of coagulation can lead to an increased risk of bleeding (hemorrhage) or obstructive clotting (thrombosis).

In abnormal conditions, anti-coagulant medications which delay the formation of blood clots should be administered to prevent thrombosis and embolism. To optimize the drug dosage, the time the blood takes to clot should be monitored regularly. Hence INR (International Normalized Ratio) is used to measure the effectiveness of anti coagulant medications.

Existing hand held devices for blood coagulation PST (patient self test) work by inducing a chemical reaction and consequently measuring the gradient at the electrodes coated with compounds - a technology that has not fundamentally changed in many years. In contrast, this study presents a device which uses a new technique that stems from futuristic research on micro-technology and exploits the potential of MEMS to achieve high accuracy, robustness and ease of use of its disposable Smart strip coagulation test

II.USE OF COMSOL MULTIPHYSICS

The main challenge of using COMSOL Multiphysics is the designing of cantilever beam and observing the effects of blood sample when placed over it. The cantilever array made of piezo-electric material is held rigid at one end and flexes at the other end. When the blood sample is placed over the cantilever, due to clotting of blood, the strain and consequently the electric potential across the beam gets altered. By measuring the changes in electric potentials across the piezo-electric layer due to the increase in blood viscosity, the handheld reader can calculate the time taken by the blood to change from a solution to gel form, which the unit then converts and displays.

III. HARDWARE CIRCUITRY

The output of the piezoelectric sensor has to be passed through some signal conditioning electronics in order to accurately measure the voltage being developed by the sensor. This is because the piezoelectric sensor typically has a very high output impedance, while the measuring device; a voltmeter for example, has much lower input impedance of the order of several MΩ. The primary purpose of the signal conditioning system is to provide a signal with low output impedance while simultaneously presenting a very high input impedance to the piezoelectric sensor. Therefore we connect the cantilever sensor in series with an appropriate bridge rectifier (Fig.1) to measure the output voltage.

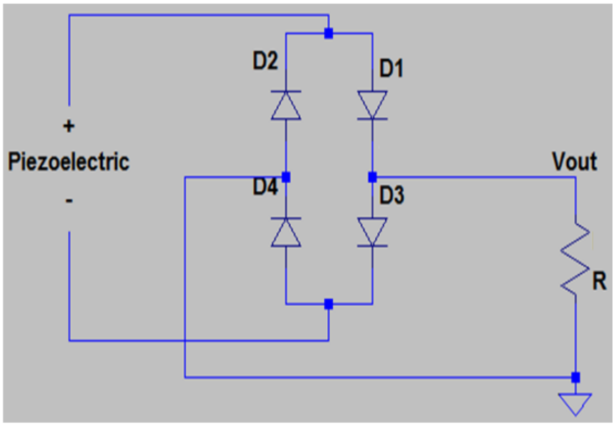


Fig.1. Full-bridge rectifier

A rectifier chip LTC3588-1 (Fig.2) was used in place of the rectifier circuit which need not to be powered by an external power source.

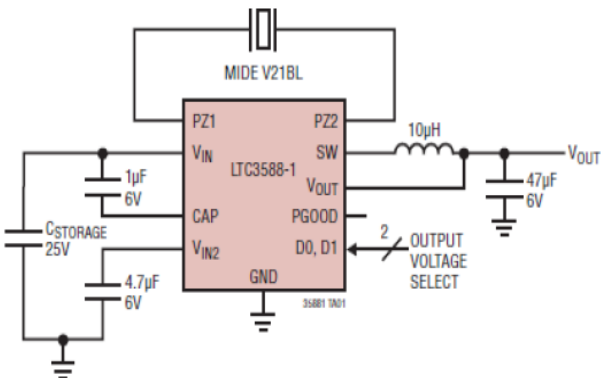


Fig.2. Rectifier Chip LTC3588-1

The output voltage is amplified by AD 624 which is a high precision, low noise, instrumentation amplifier designed primarily for use with low level transducers. The amplified analog voltage is fed to the ADuC831 to obtain the digital value of the voltage developed in response to strain on the cantilever. Finally a programmed ATMEL 89C52 microcontroller along with the LCD display provides the INR value (Fig.3).

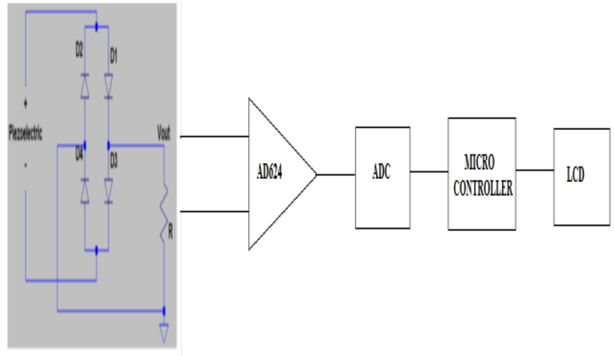


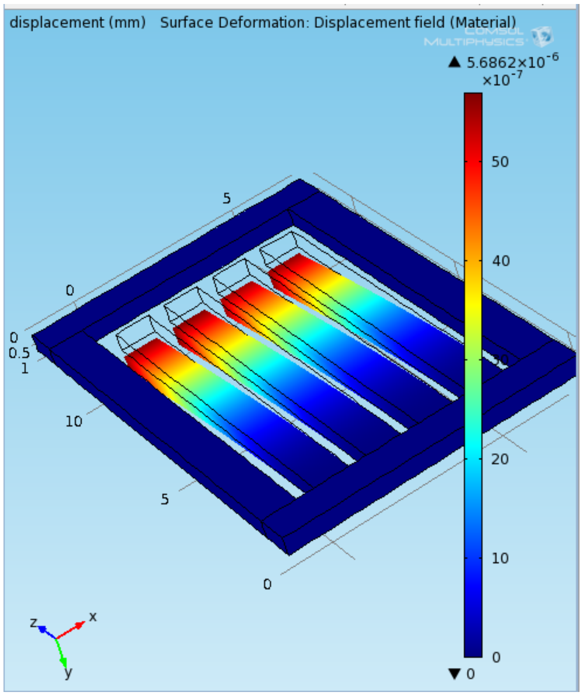
Fig.3. Block diagram of the hardware

IV. RESULTS

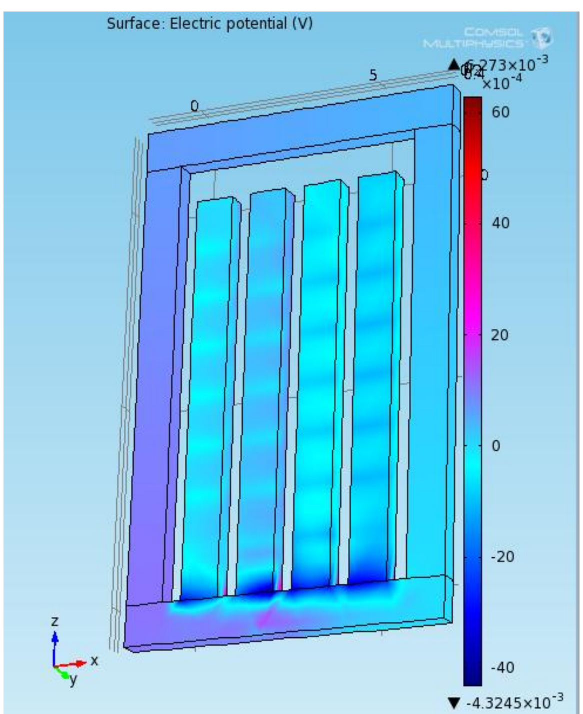
The cantilever is designed using COMSOL Multiphysics 4.2 and the corresponding effects of blood clotting are observed and analyzed by simulating a mass change on a cantilever surface as the sample blood droplet is dispersed and allowed to clot over time (Fig.4). Cantilever displacement shows a direct co-relation with the initial load applied, thus can variably relate the clotting mechanism to the physical parameters. Also, the potential developed across the piezo-electric cantilever beam can be obtained using an external circuitry which could be displayed in terms of INR.

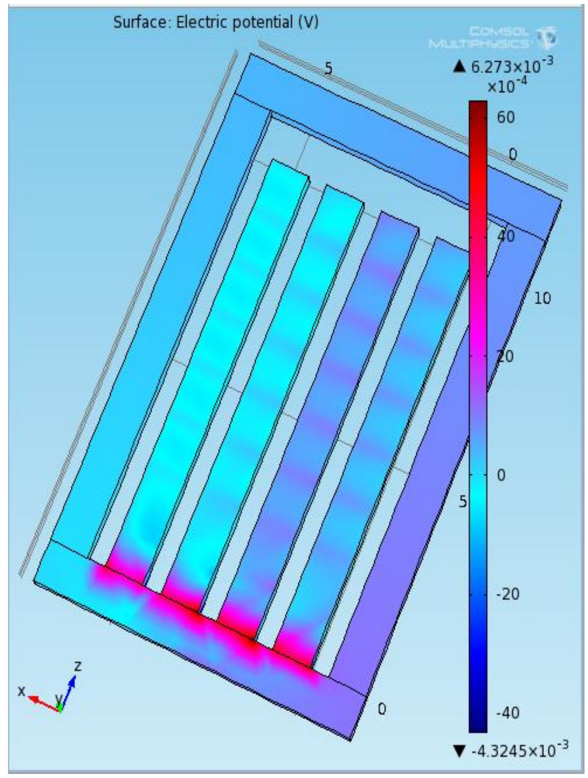
Fig.4 (a-b). COMSOL Multiphysics based simulation studies

a) Surface displacement:



b) Electric potential:





Comparative analysis of currently available methods with our proposed device has been done and tabulated (Table 1).

FACTORS	CURRENT TECHNOLOGY	PROPOSED TECHNOLOGY
COST per test	Rs 170	Rs 50(approx)
BLOOD SAMPLE REQUIREMENT	3mL	5μL
TIME TAKEN	3-4 hrs	30 sec(approx)
EXTERNAL ANTI-COAGULANTS	Required	Not required

Table.1.Comparative analysis

V. CONCLUSION

Thus the device designed shall be capable of monitoring the level of anti coagulants with a small blood sample quantity as low as a few µL using a disposable strip. We expect to implement the suggested hardware (Fig.5) with incorporated MEMS assembly which shall display the INR value of blood within minutes.

Fig.5. Suggested device prototype

VI. ACKNOWLEDGEMENT

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VII. BIBLIOGRAPHY

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