



Design and Implementation of MEMS based Blood Viscometer for INR Measurement

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INTRODUCTION

- Clotting is the normal function of blood in response to an injury.
- In abnormal conditions, anti-coagulant medications which delay the formation of blood clots should be administered to prevent thrombosis and embolism.
- The time that the blood takes to clot needs to be monitored regularly so that the drug dosage can be optimized.



- INR (International Normalized Ratio) is used to measure the effectiveness of anti coagulant medications.
- Thus to monitor patients drug dosage, this MEMS based Blood viscometer with a disposable strip can provide a convenient means to measure the blood clotting.

MATERIALS AND METHODS

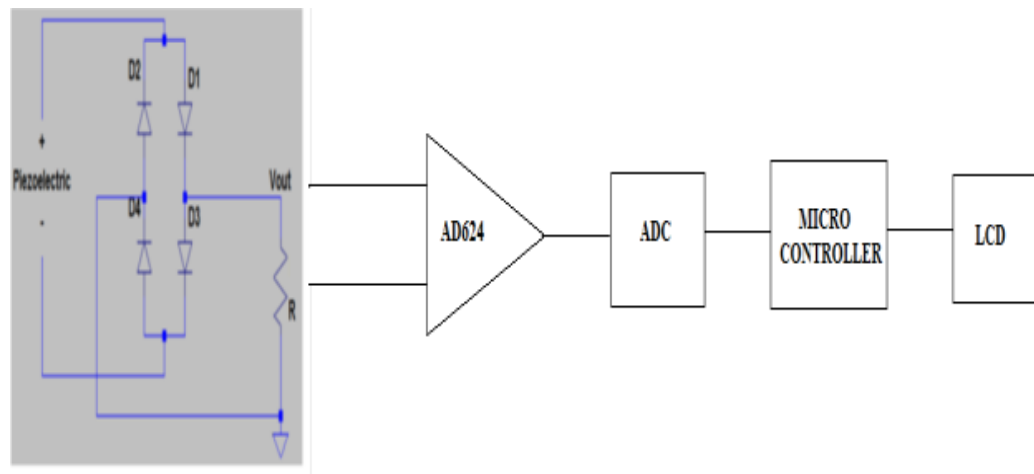
- Cantilever Array:

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.

- Signal Conditioning:

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.



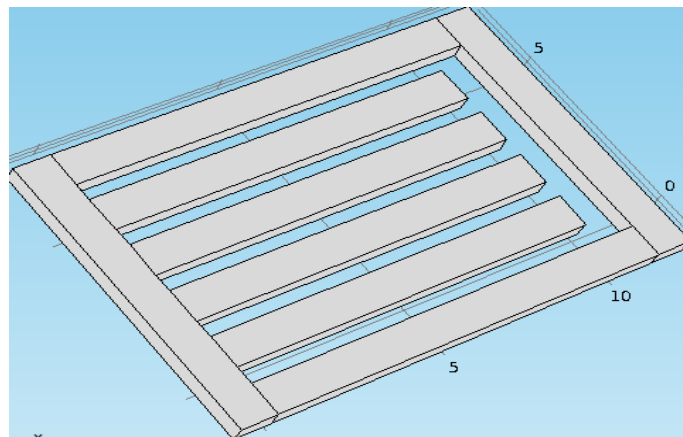


BLOOD PARAMETERS

- Weight of $5\mu\text{L}$ of blood of normal patient
 5.3mg
- Force exerted by $5\mu\text{L}$ of blood is
 0.000051N
- Density of normal human blood
 1.05Kg/L

USE OF COMSOL MULTIPHYSICS

- To design the cantilever array .
- To observe and analyze the effects of blood.
- To conclude the proper material for the cantilever array.





INPUTS PROVIDED

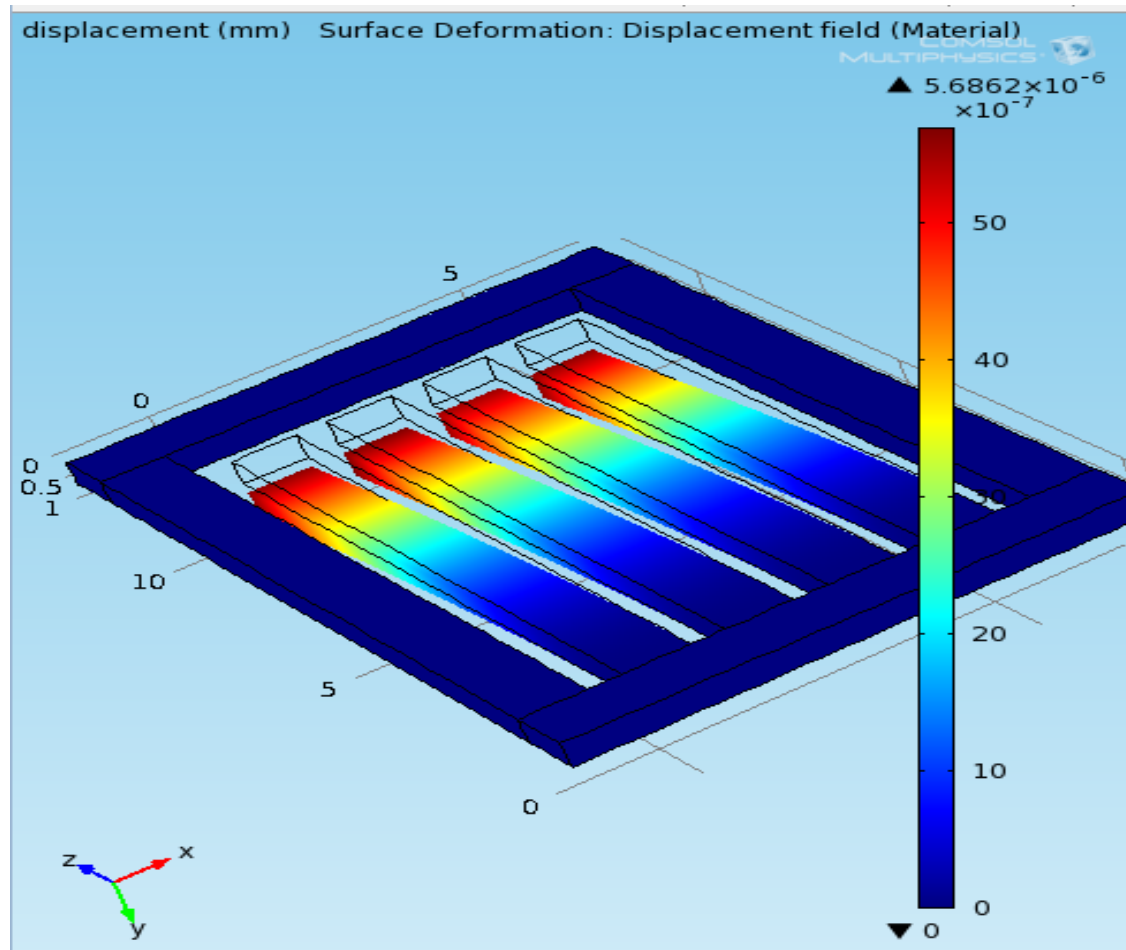
- Height of cantilever beam: 10mm
- Width of cantilever beam: 1.5mm
- Depth of cantilever beam: 0.5mm
- Force provided: 0.00005N
- Material used: Ammonium nitrate

RESULTS

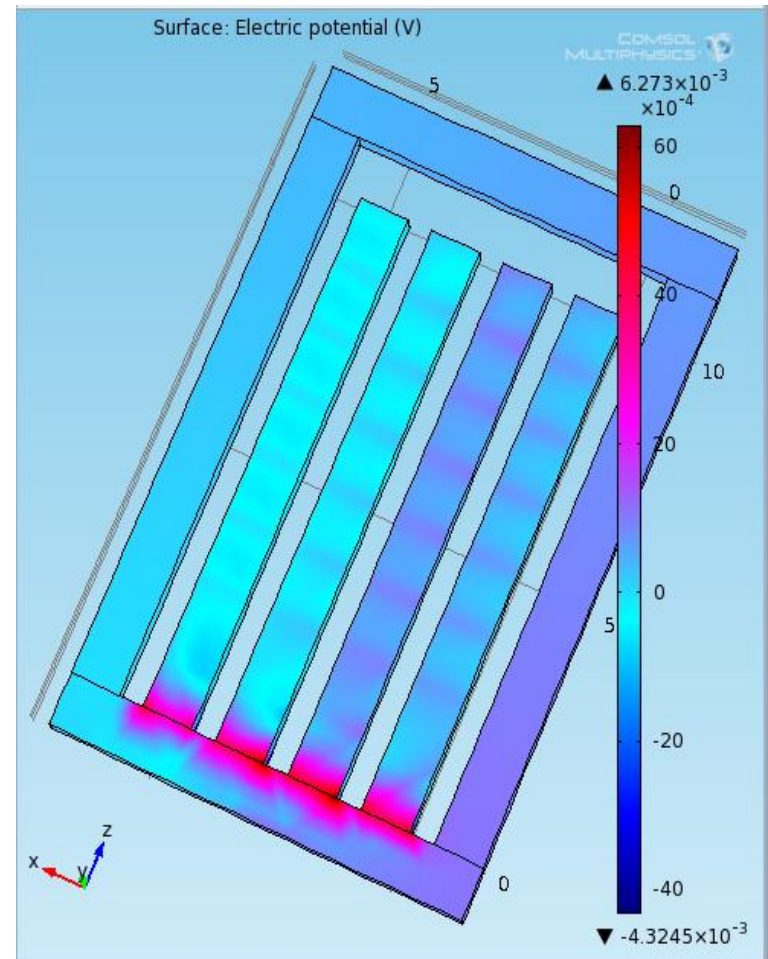
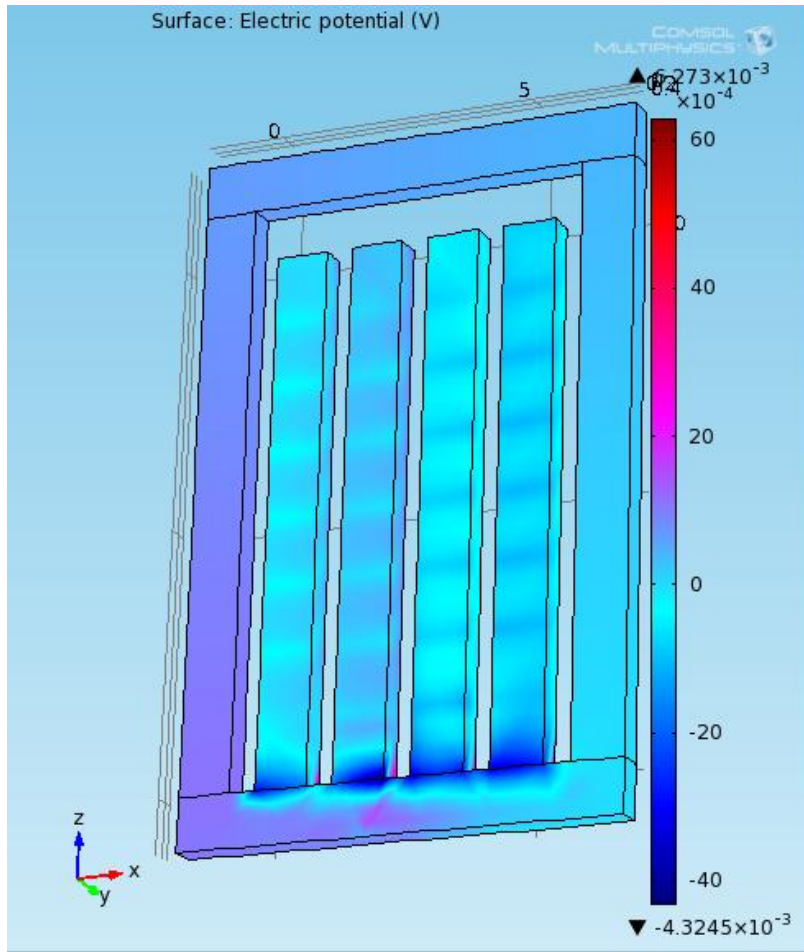
- The cantilever array is designed using COMSOL Multiphysics 4.2 and the corresponding effects of blood clotting are observed and analyzed by simulating a mass change on a cantilever surface as the sample blood droplet is dispersed and allowed to clot over time.

- Cantilever displacement shows a direct correlation 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.

Surface Displacement



Electric Potential





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 with integrated MEMS assembly which shall display the INR value of blood within minutes.

SUGGESTED HARDWARE MODEL





FUTURE WORK

- Standardization of blood properties for both normal and abnormal patients.
- Implementation of blood as a material.
- Integration of MEMS circuitry.

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