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Electrothermally Actuated MEMS Based Gecko Foot for Robotics

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OVERVIEW :

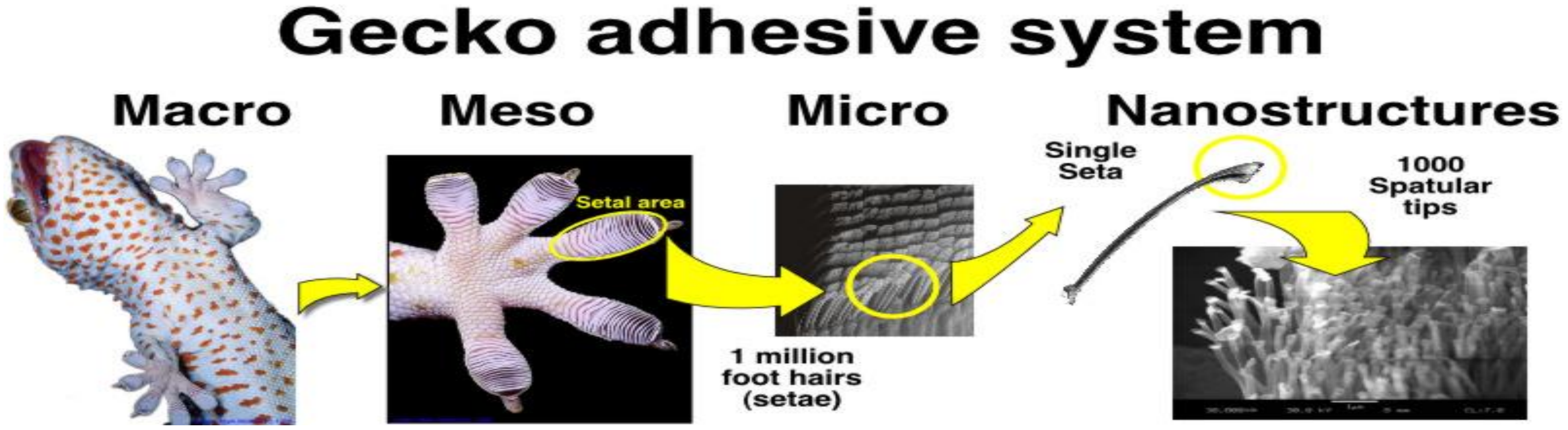
- Introduction: Gecko Foot
- Electrothermally actuated Gecko Foot
- Proposed Microhair Design
- Use of COMSOL
- Observations & Results
- Application
- Future Scope
- References

INTRODUCTION :

- MEMS → Micro-Electro-Mechanical-Systems
- It is the technology of very small devices.
- MEMS enables the combination of sensors, actuators, mechanical components and also electronics on a single base (Si or Ge).
- Has the most wide-spread applications.
- Lot of scope for inventions.

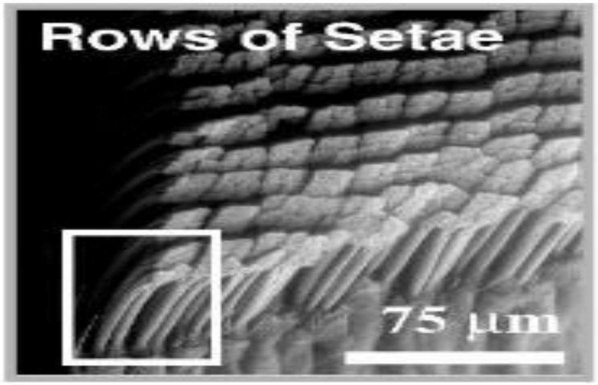
GECKO FOOT:

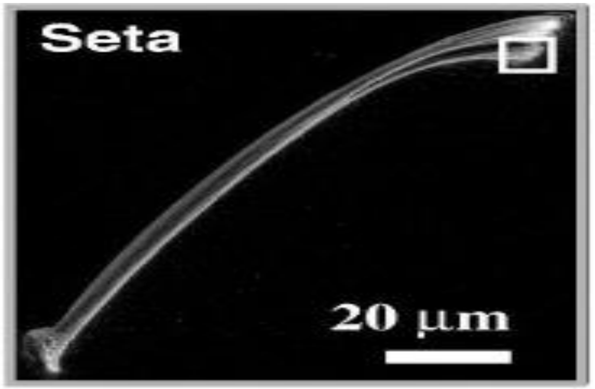
- Uses dry adhesion forces such as van der Waals forces to climb walls.
- This adhesion is achieved by Microhairs and Nanohairs present on Gecko foot.

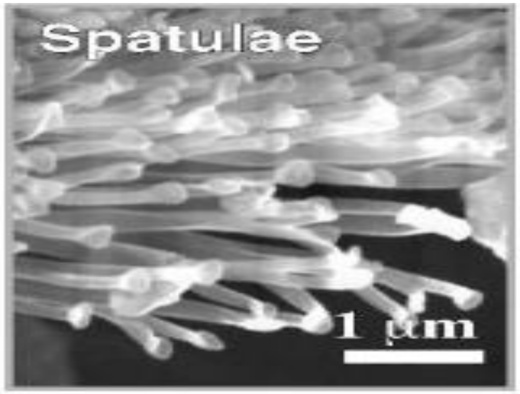


GECKO FOOT (Contd.)

- Microhairs(seta) on the gecko foot is an intricate biological structure with hierarchical nanosections and microsections
- It has billions of nanoscale hairs on its feet that are in contact with surfaces while it climbs.
- Nanohairs(spatula) attached to the microhairs are complex structures, and are responsible for dry adhesion i.e. Vander Waals forces.



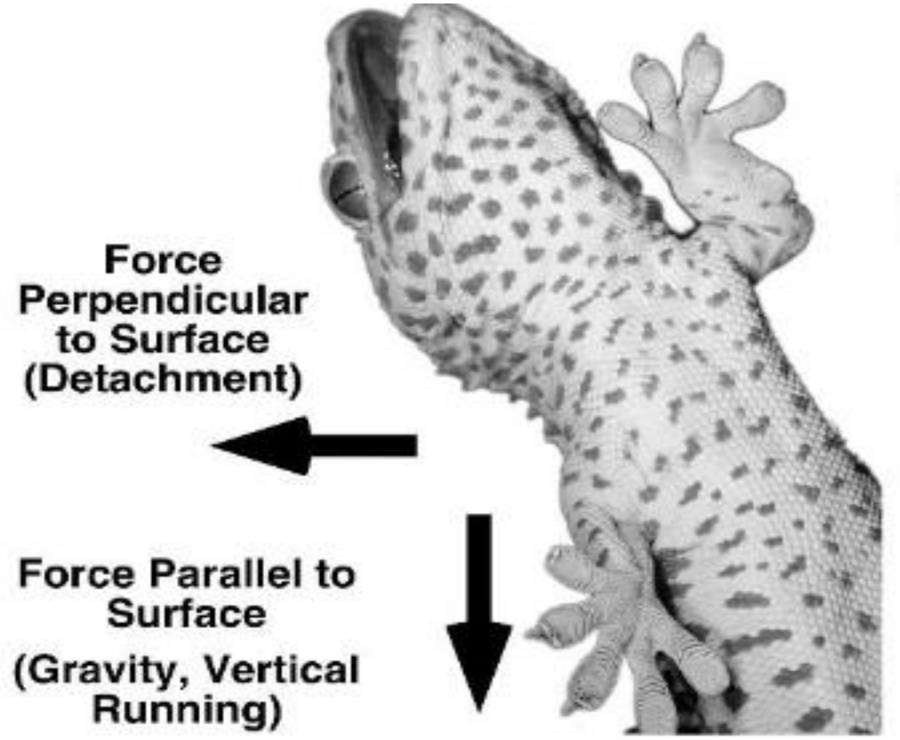




ELECTROTHERMALLY ACTUATED GECKO FOOT

- Microhairs are actuated to support Dry Adhesion.

- Electrothermal actuation of microhair counterbalances the reaction forces acting on it aiding the Dry adhesion mechanism.



ELECTROTHERMAL ACTUATION (WORKING PRINCIPLE)

- Deflection is produced by differential heating of the two arms which vary in thickness.
- Current is passed, the thinner arm heats up and expands more as compared to the thicker arm.
- Tip deflection is produced due to this asymmetric expansion.
- Provides greater displacements in comparison to electrostatic actuators.

WORKING PRINCIPLE :

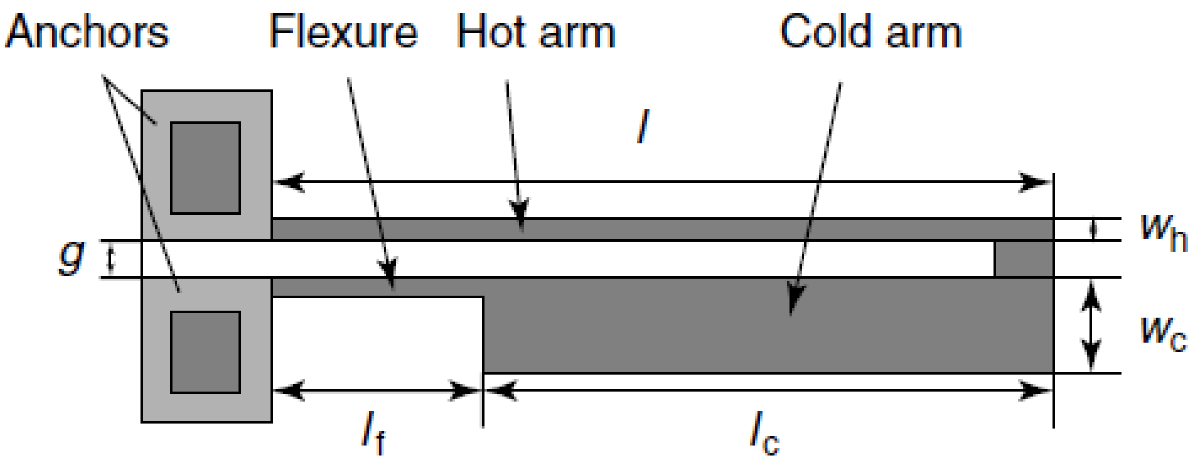


Fig. 1. Electrothermal actuator.

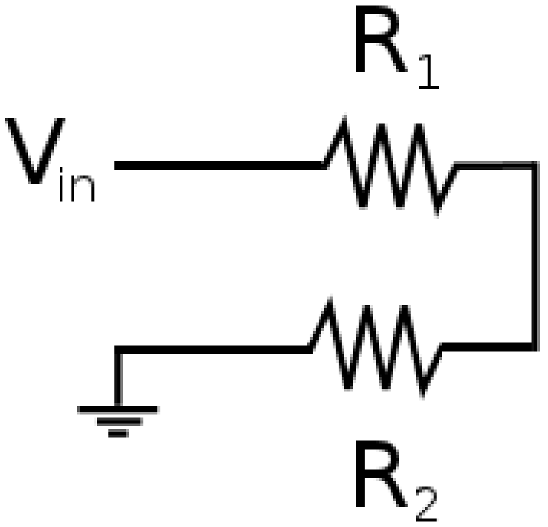


Fig. 2. Electrical equivalent of the actuator.

$$R = 1/\sigma \cdot (l / A)$$

$$H = I^2 \cdot R = V^2 / R$$

PROPOSED MICROHAIR DESIGN

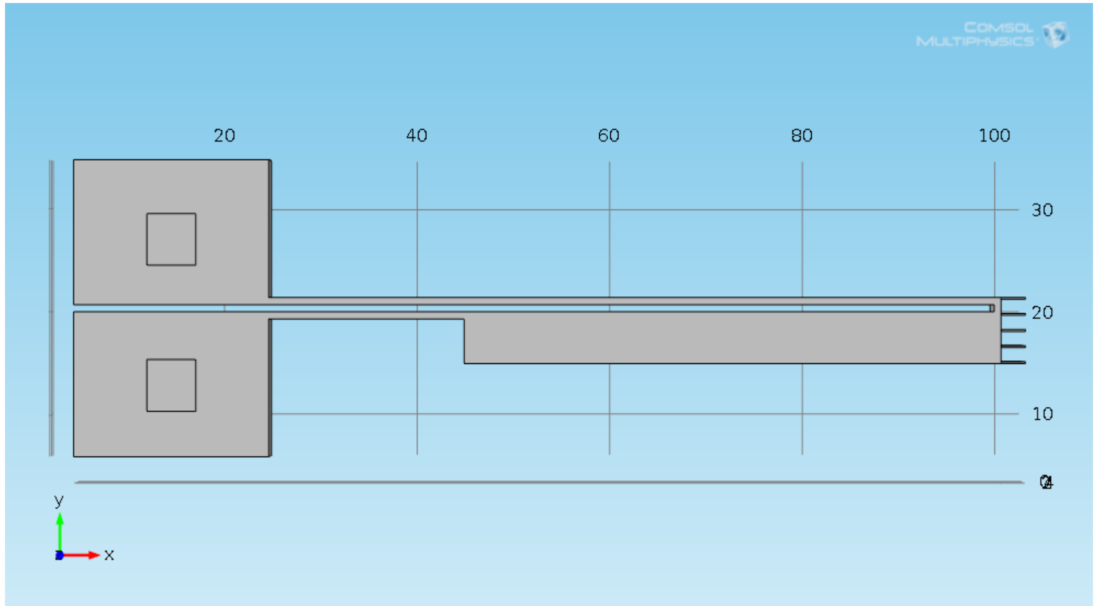


Fig.. Top View of the microhair in XY plane

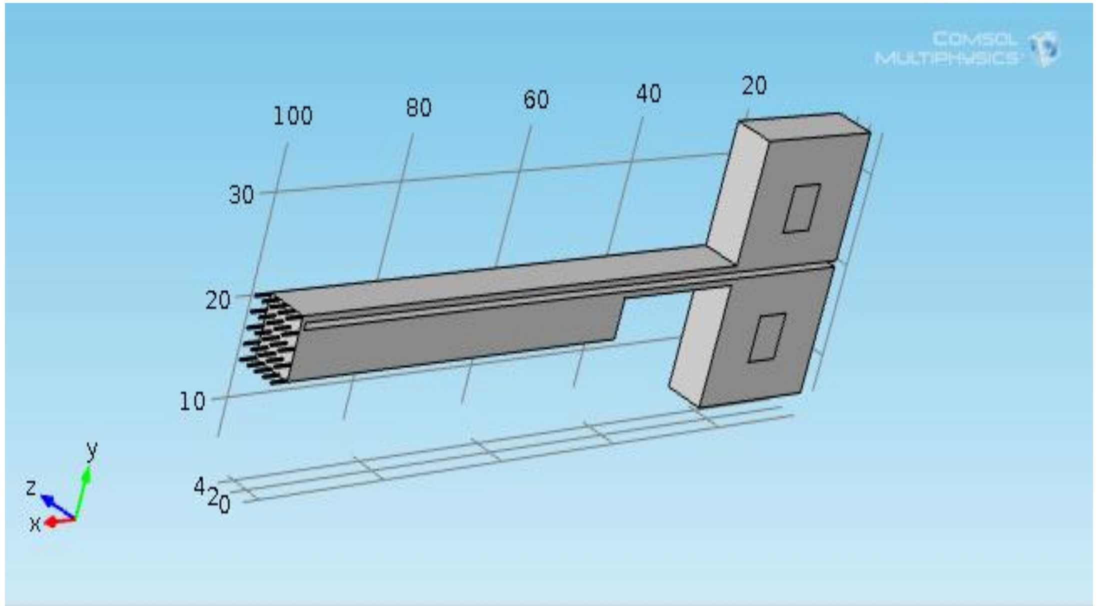


Fig.. 3-D View of the microhair

FINITE ELEMENT ANALYSIS :

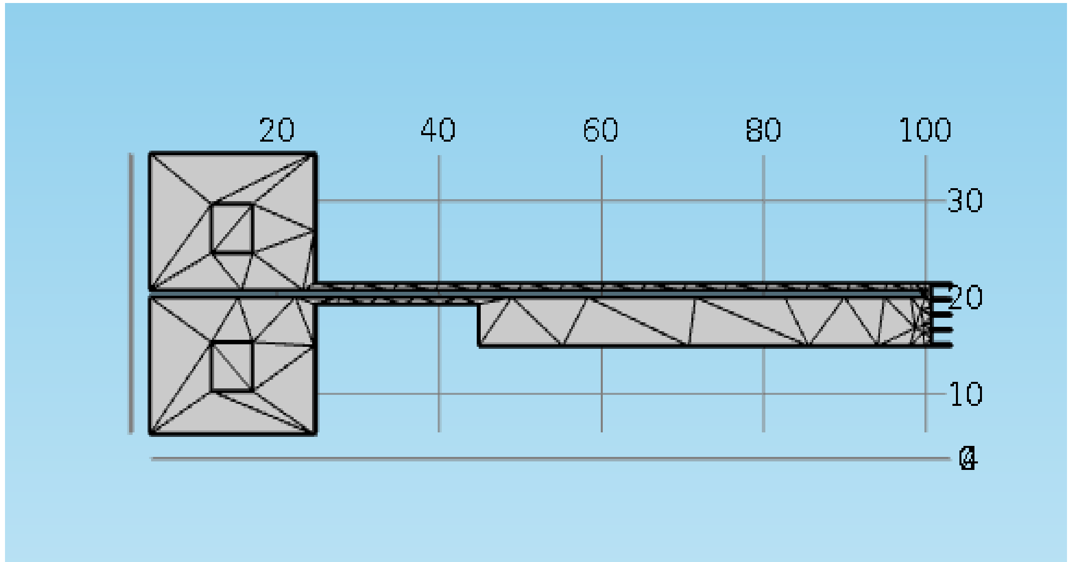


Fig. Top View of the microhair after applying a mesh.

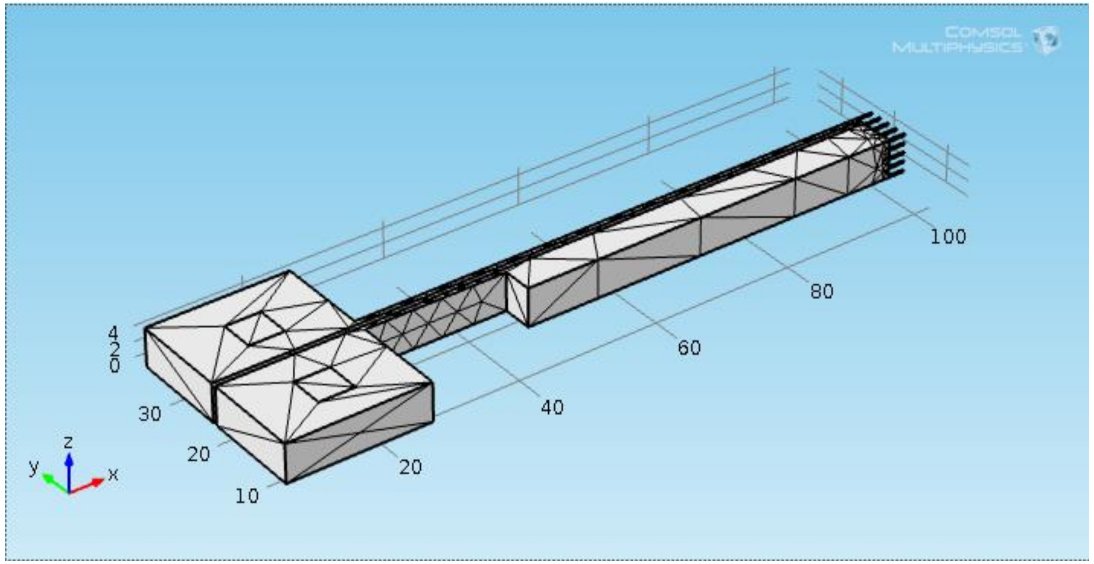


Fig. 3-D view of the microhair after applying a mesh.

MODAL ANALYSIS

- Modal analysis is the study of the dynamic properties of structures under vibrational excitation.
- Its purpose is to find the shapes and frequencies at which the structure amplifies the effect of a load.
- It gives specific information on the characteristics of the structure instead of reporting a response.
- It determines the critical points of a structure and the responses under various constraints.
- Helps in finding flaws or weakness of the structure.

RESULTS

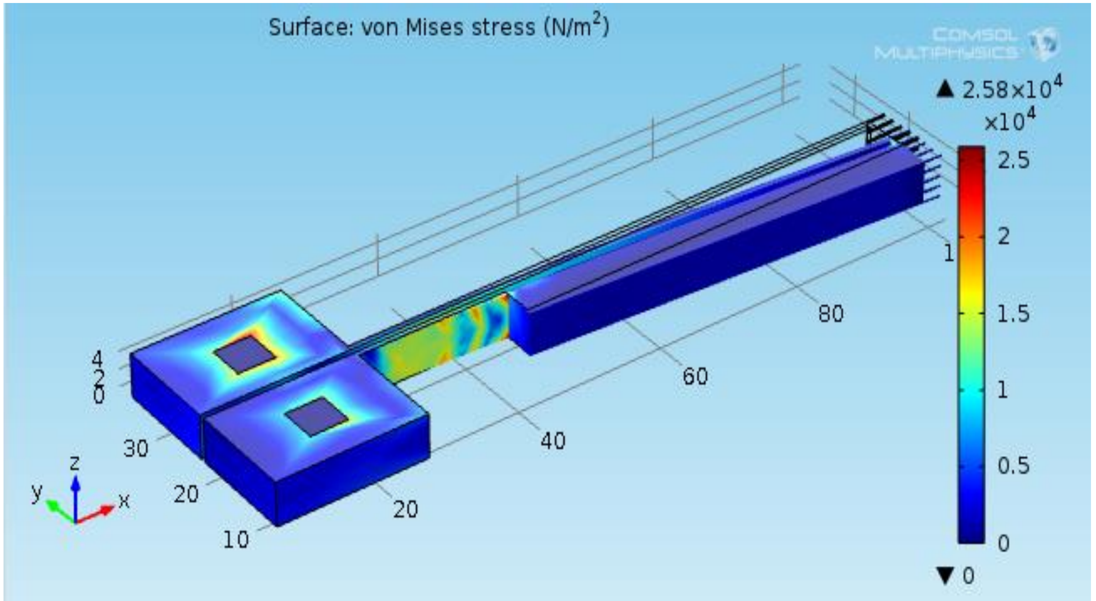


Fig. Stress Analysis Result

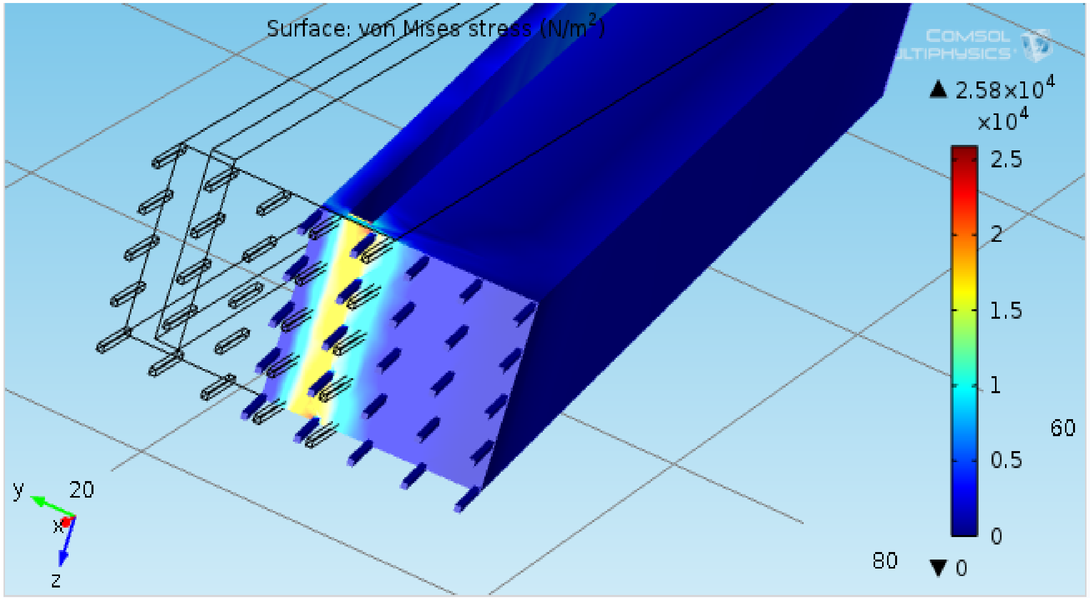
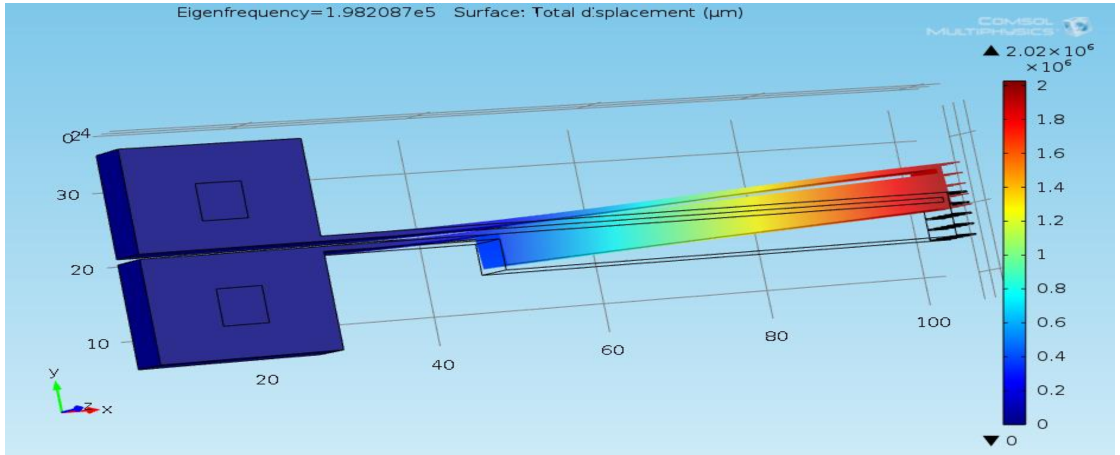
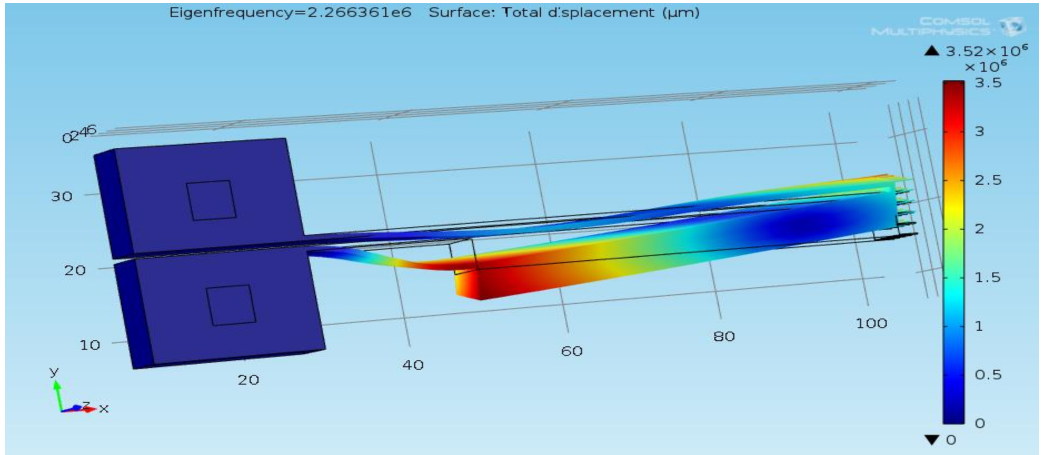
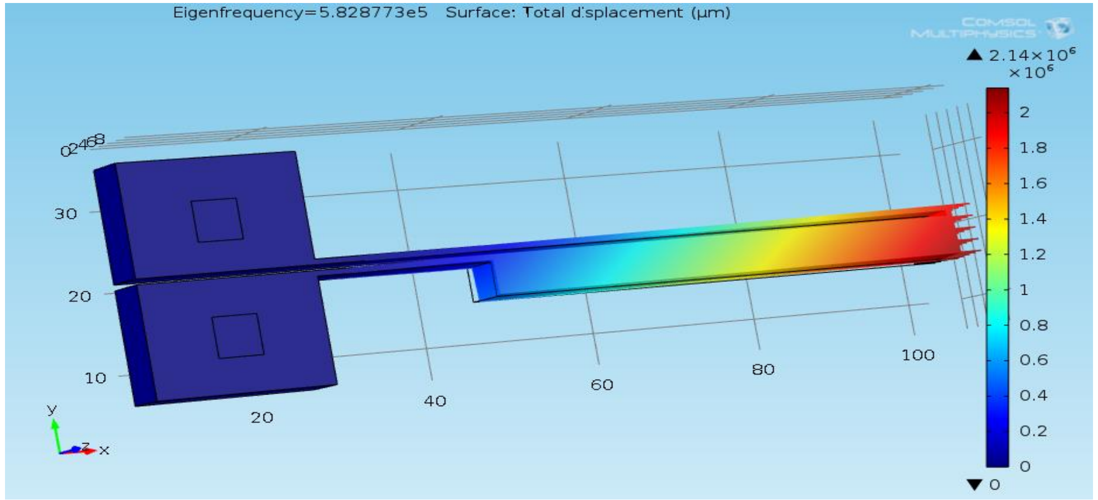


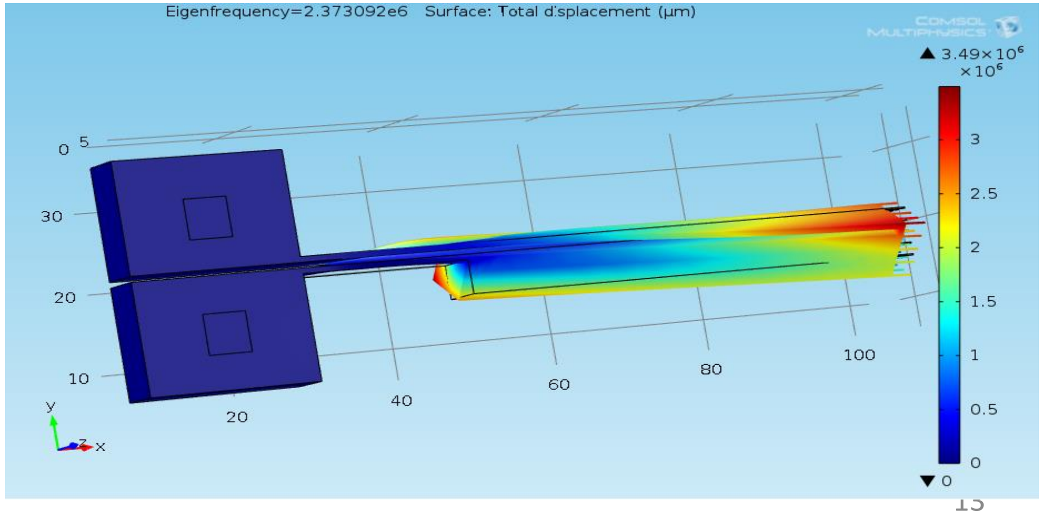
Fig. Nanohair Displacement

MODAL ANALYSIS RESULTS









OBSERVATIONS

	Stress (N/m^2)	Max Deflection (µm)	Max Strain
Without Actuation	1.08e6	0.293	8.85e-3
With Actuation	5.85e5	7.2e-3	6.87e-7

DISCUSSION

- Both the designs have achieved the requisite objective.
- The number of nanohairs in actuated structure is significantly lesser.
- The actuation model has a superior performance compared to non-actuation model.
- It decreases the complexity of structure by reducing the no. of naohairs.
- This leads to simplification of the fabrication process manifolds.

APPLICATIONS

- Microhairs can be triggered using VLSI circuits to build a functional microbot.
- By controlling the trigger pulses motion of the bot can be controlled.
- Nano robotics and Micro robotics.
- Medical application: Minimal invasive surgeries.
- Space application: inspect and repair space vehicles
- Industrial application : Petroleum Industries and Nuclear Power Plants

FUTURE SCOPE :

- More composite actuation systems can be implemented.
- Efficient performance yielding materials can be used.
- Fabrication and implementation in real time scenarios, will reveal more drawbacks.
- These can be rectified by slight alterations in the model design.

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THANK YOU