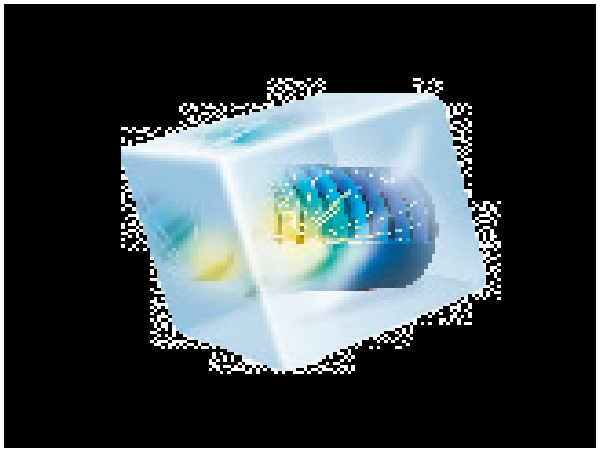
Analysis & Design Optimization of laterally driven Poly-Silicon Electro-thermal Micro-gripper for Micro-objects Manipulation



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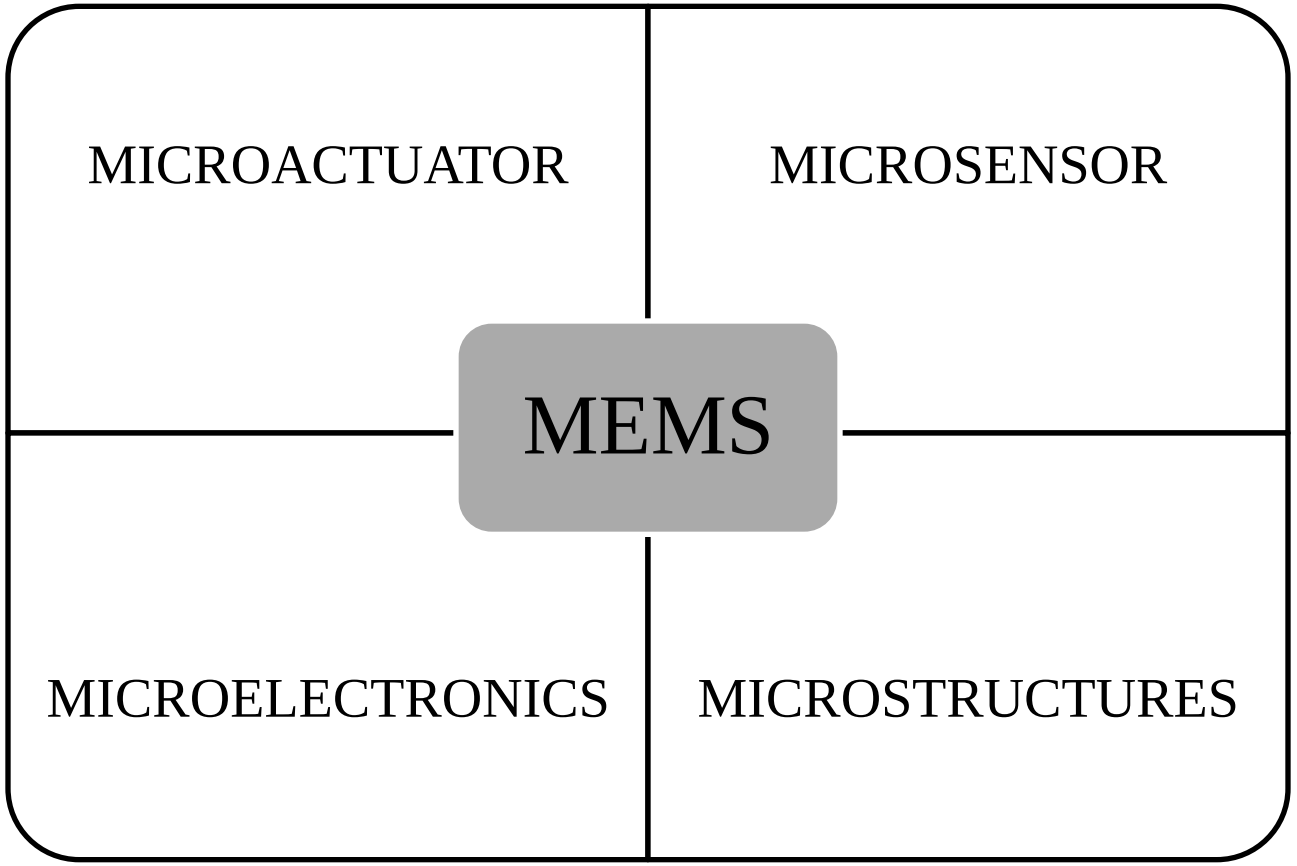
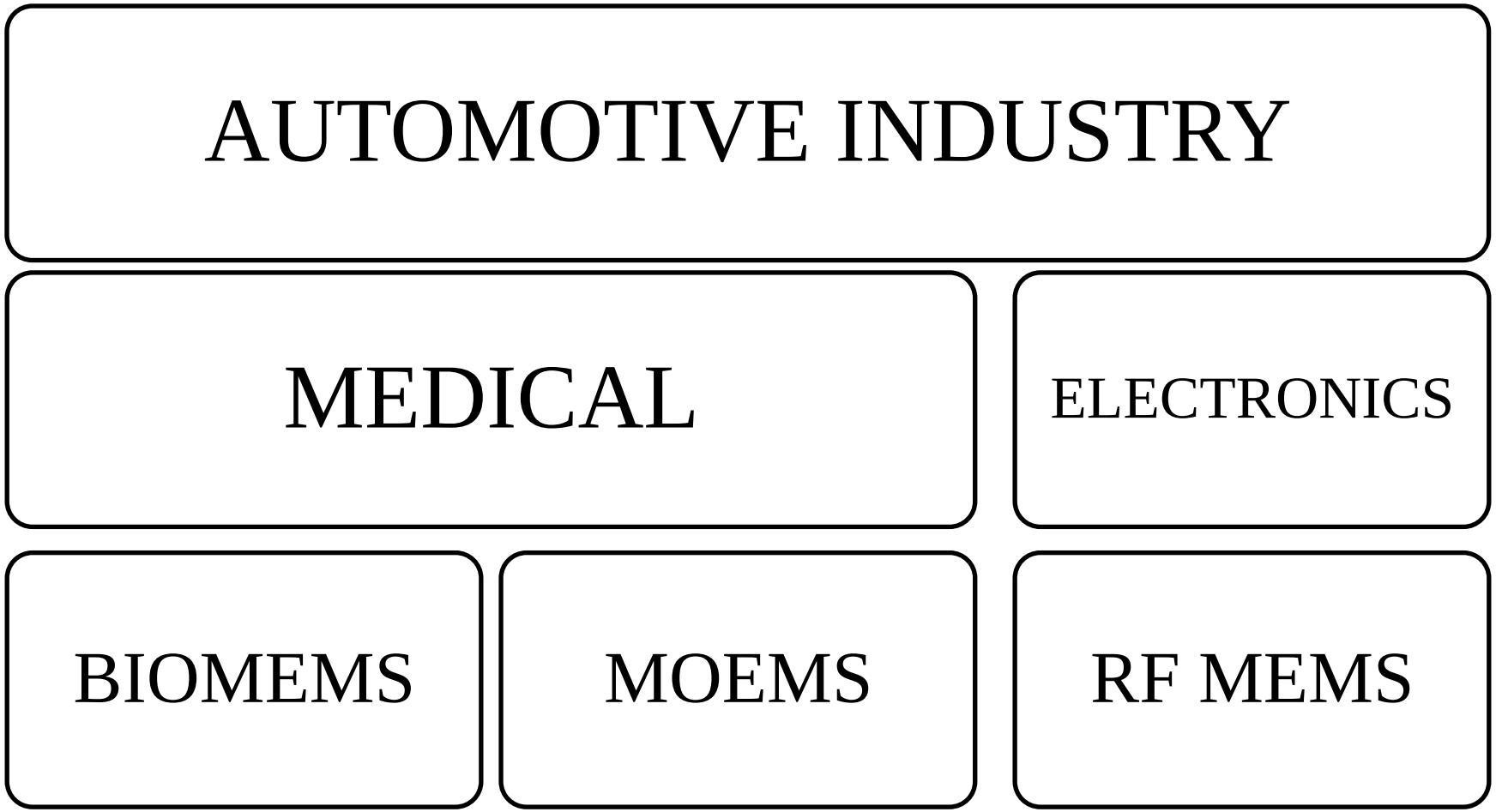
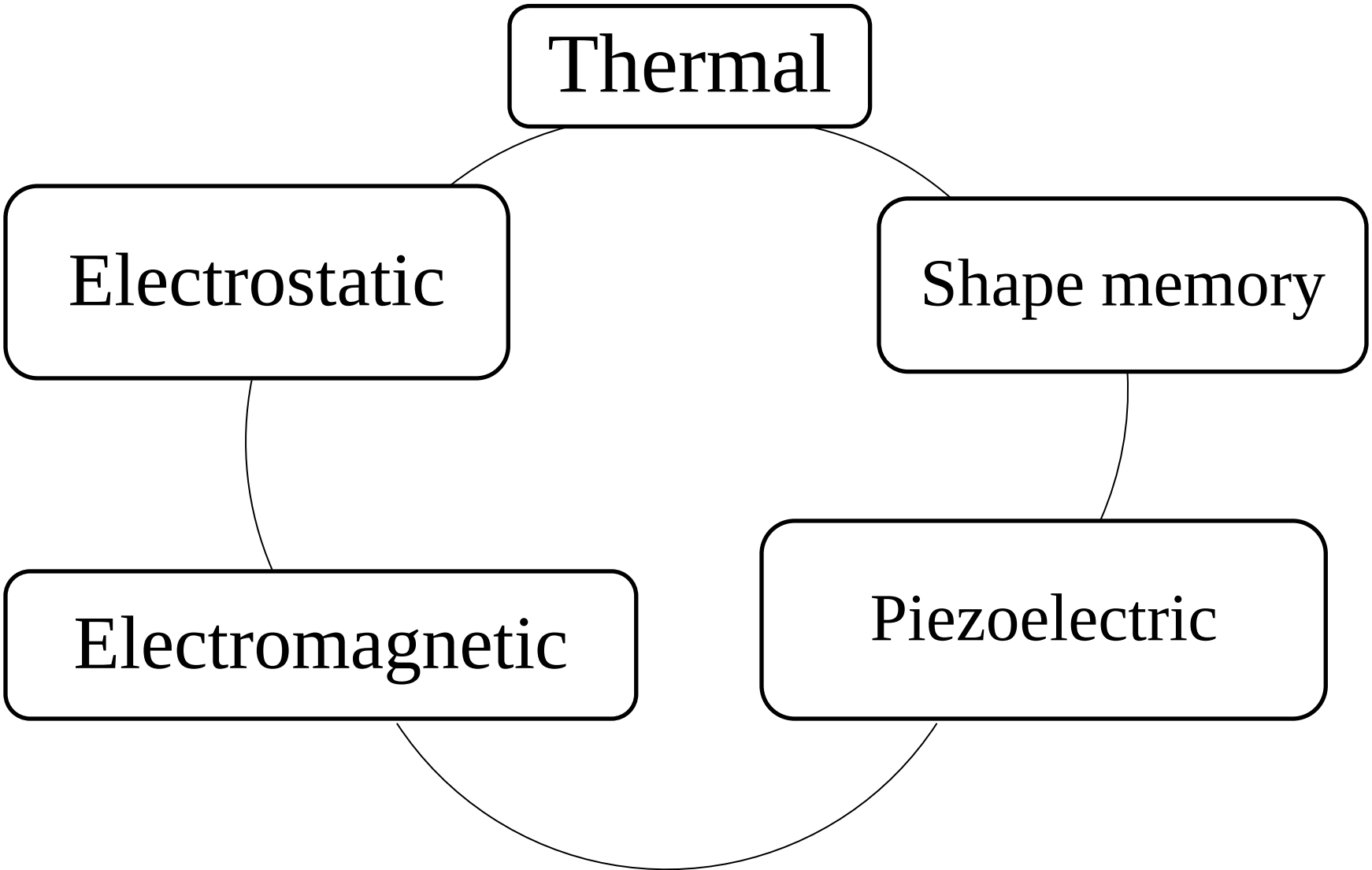
MEMS


MICROACTUATOR
MICROSENSOR
MEMS
MICROELECTRONICS
MICROSTRUCTURES

Applications of MEMS

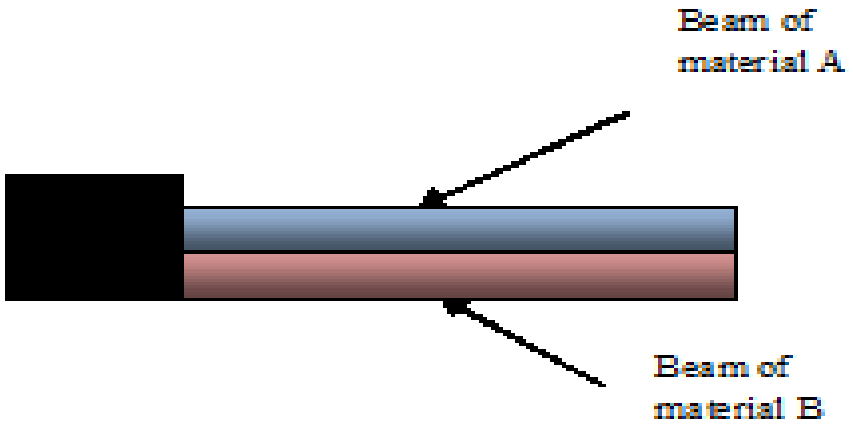


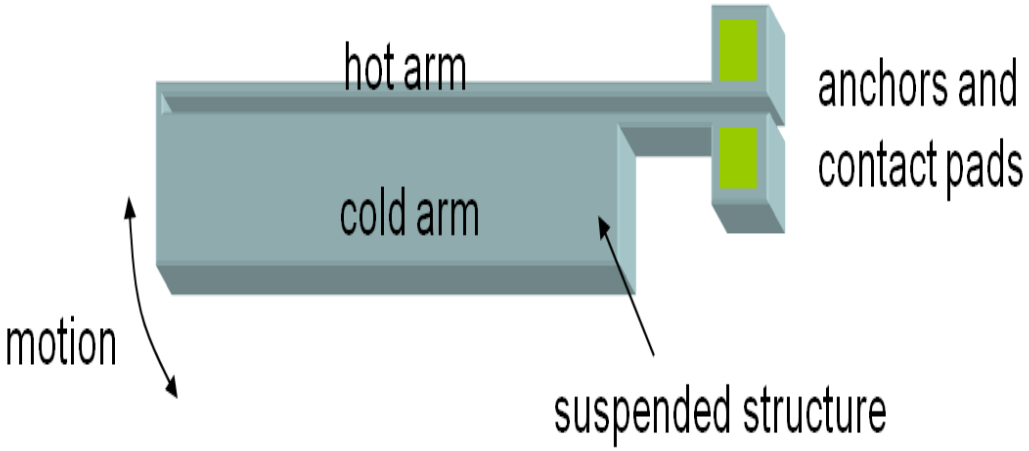
Microactuators



Types of Electrothermal Actuators

- Bimorph Actuator
- U-Beam Actuator





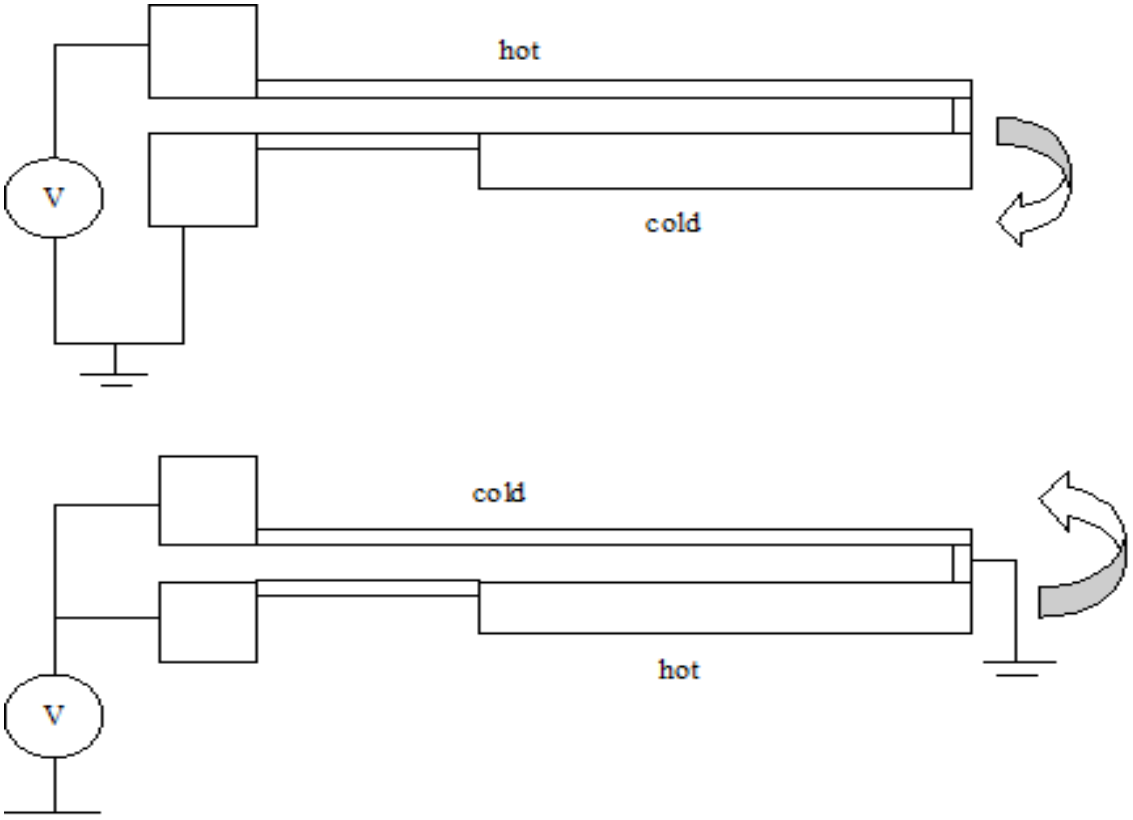
Eletrothermal Actuation

- Thermal Expansion due to non-uniform Joule Heating

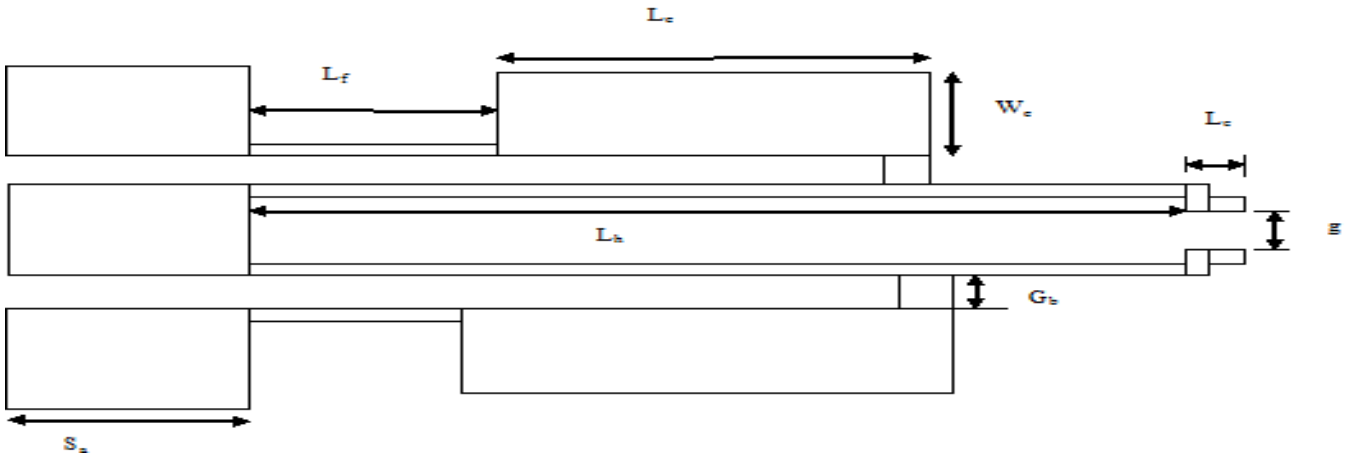
$$\Delta L \propto L \Delta T \qquad R = \rho \frac{L}{A} \qquad P = VI = I^2 R$$

- **Advantages of Electrothermal Actuation:** Provides easily controlled microactuation compatible with standard microelectronics, Simple in operation, Easy to design and fabricate, Provide large forces, made from single material
  - **Disadvantages:** Large power requirements, Narrow beam may reach melting temperatures at high voltages.

Series and Parallel Arrangement



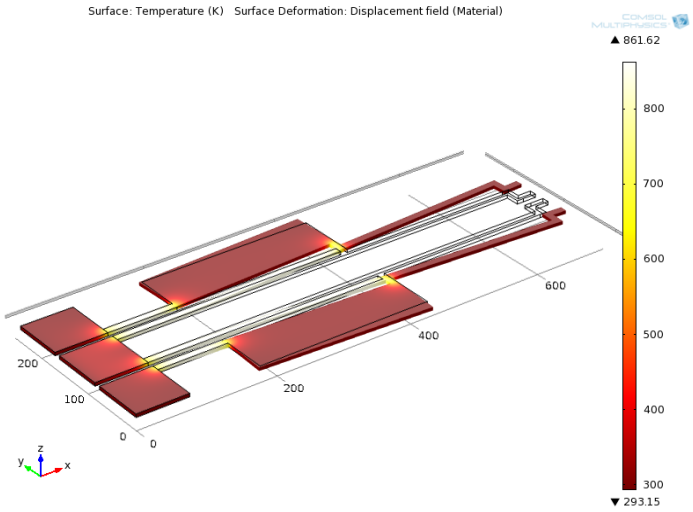
DESIGN OF MICROGRIPPER

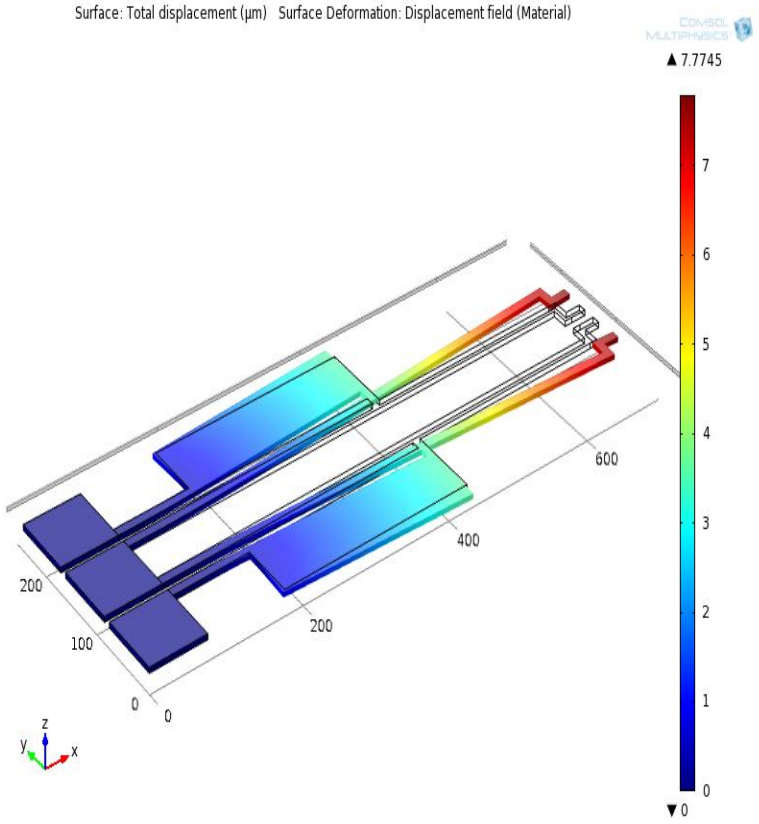


Parameter	Value
Length of the hot arm (L_h)	600µm
Length of the cold arm (L_c)	250µm
Flexure Length (L_f)	100µm
Width of the arms (W_h, W_c, W_f)	10µm
Gap between the arms (G_b)	10µm
Initial Opening (g)	15µm
Thickness	5µm

SIMULATION- TEMPERATURE PROFILE AND DISPLACEMENT

Temperature at 3V	861K
Displacement at 3V	7.7μm

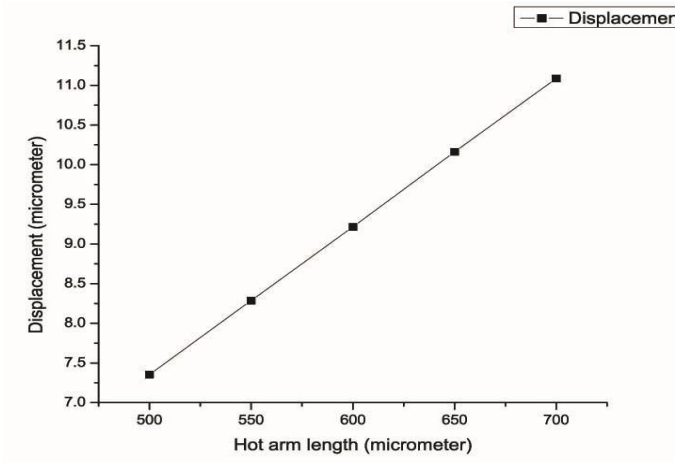


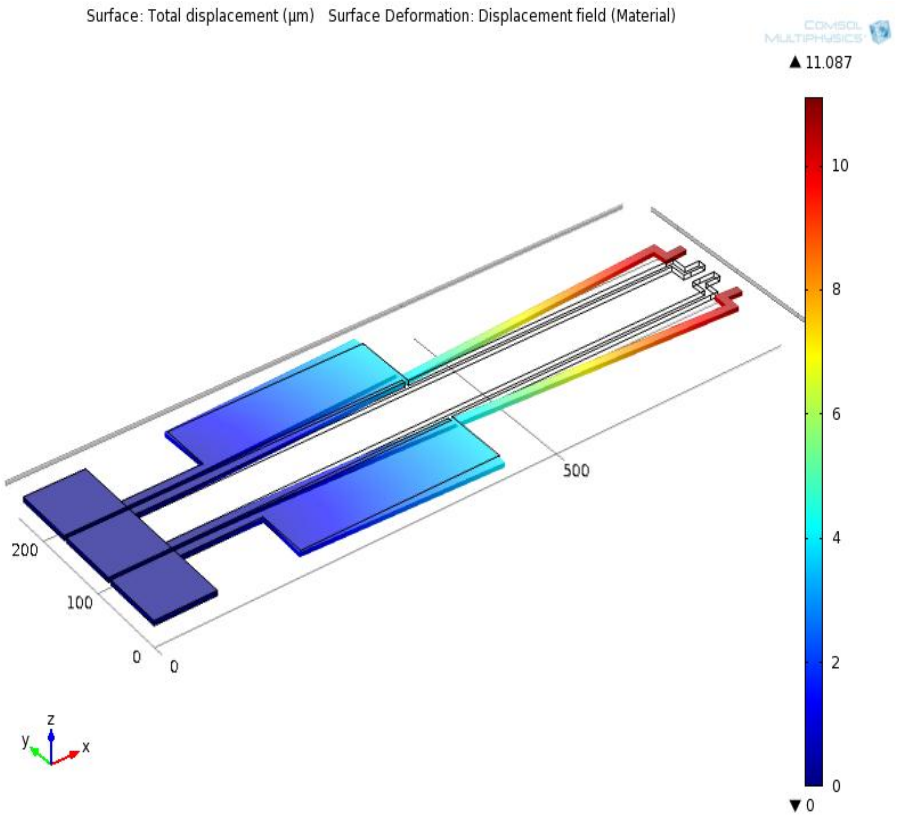


OPTIMIZED PARAMETERS

- LENGTH OF THE HOT ARM (L_h)

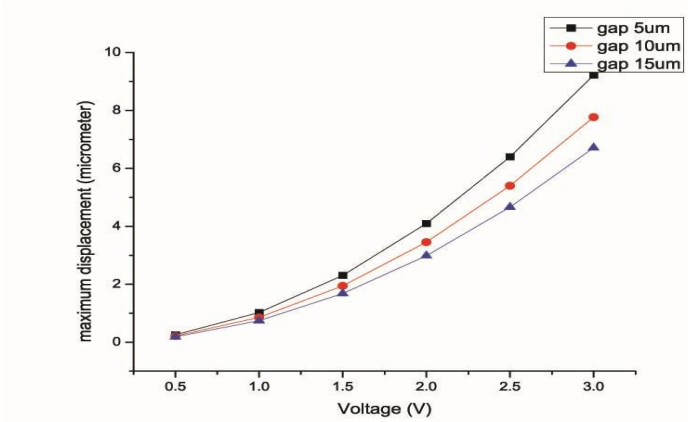
Length of the hot arm (µm)	Displacement (µm)
500	7.36
600	7.7
700	11.08

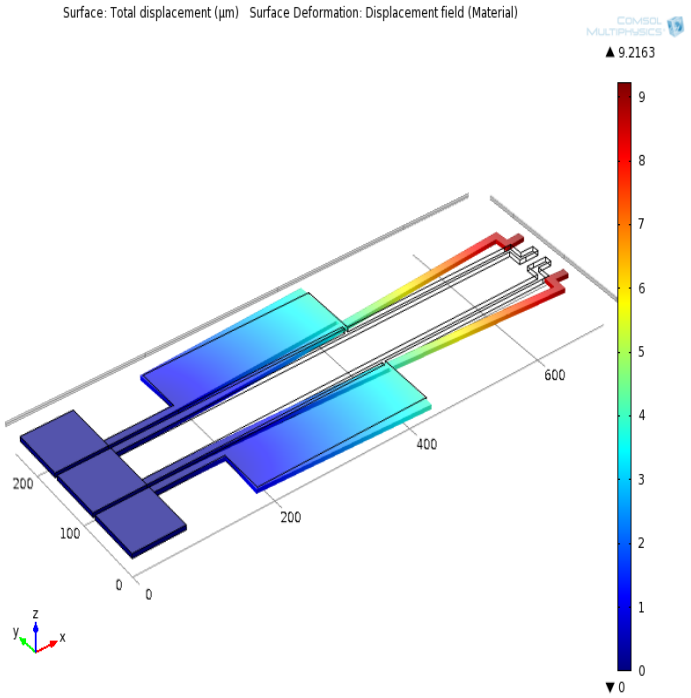




- GAP BETWEEN THE HOT AND COLD ARM (G_b)

Gap between the arms (µm)	Displacement (µm)
15	6.71
10	7.7
5	9.22





Applications of Microgripper

- Pick and place operations
- Micromanipulation of microparticles, microcomponents and cells in medical applications.

Conclusion

- Performance of electrothermal microgrippers is greatly affected by the dimensional variation.
- Longer hot arms and narrower gap between the hot and cold arm results in larger displacements.

Future work

- In this work, only the effect of length of the hot arm and gap between the arms is realized. Further improvements can be realized by varying the other dimensions of the gripper like width of the cold arm, thickness. Also different materials can be used.

Thank You!