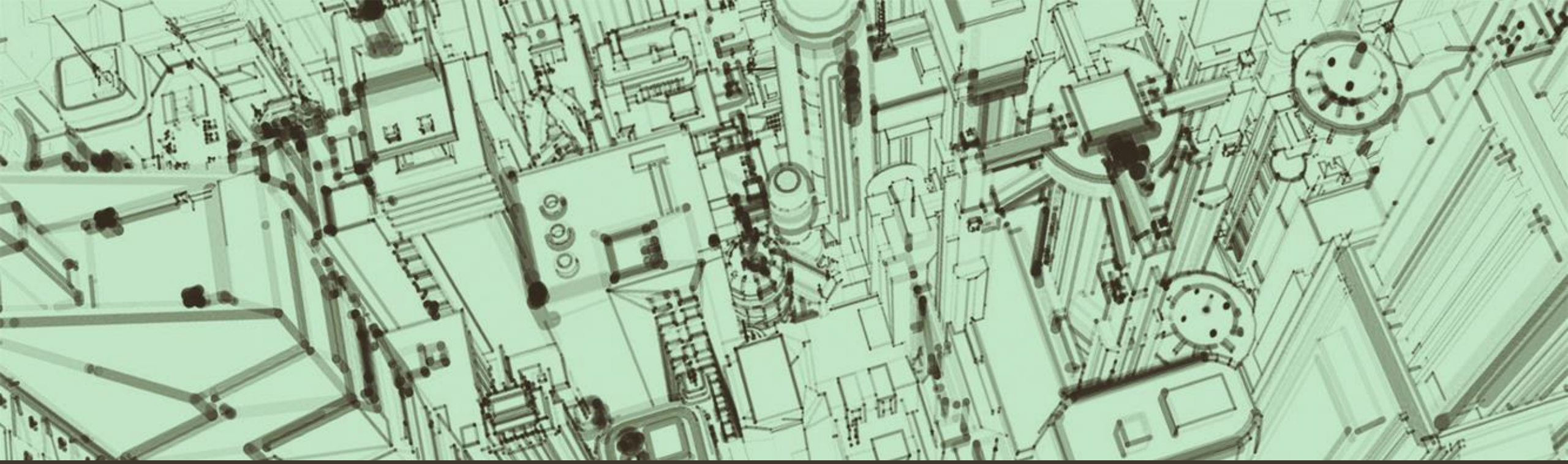

Electro-Thermal Actuator

Group 18

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Under the guidance of - Dr.-Ing. Tamara Bechtold

Device – Electro-Thermal Actuator

- The conventional MEMS polysilicon electro-thermal microactuator uses Joule heating to generate thermal expansion and movement.[1]
- Electrical boundary conditions determine how the device is actuated. Mechanical boundary conditions control how the device is constrained from movement.

Applications:

- Switches
- Stepper motors[2]
- Safety Shut Off Devices
- Radiator temperature control.

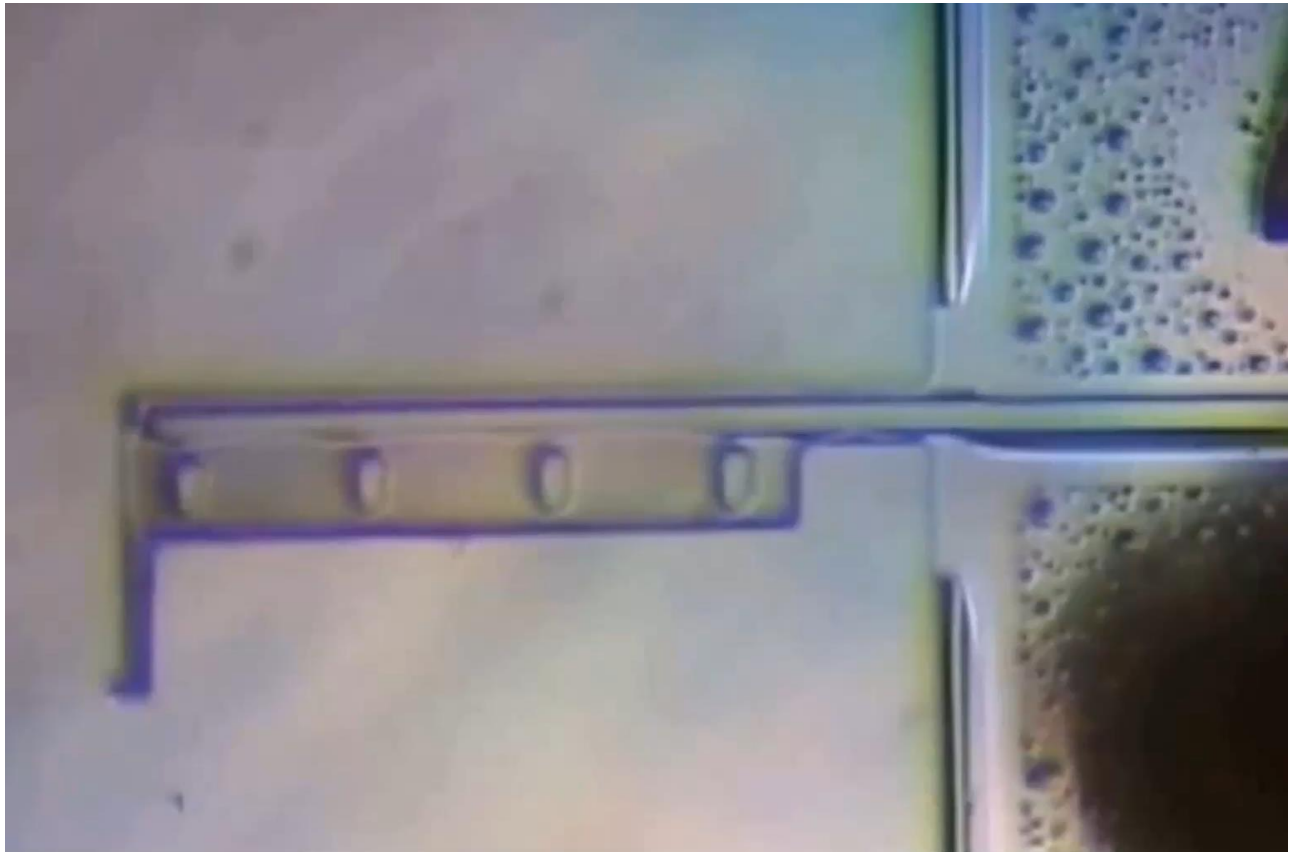

Fig.1: Thermal Actuator[*]

[*] Colorado Nanofabrication Lab., "*Thermal Actuator – 3*" . 2011, Available: https://youtu.be/N3lChvL3_Po

Case Setup

- Boundary Conditions
  - Thermal: 0 K temperature on both bottom pads.
  - Electrical: Voltage applied on top faces of pads 40 V on 1st pad and 0 V on the 2nd pad.
- Mesh
  - 89784 Nodes
  - 15650 Elements
  - Hexahedral mesh elements
- Static-Structural
  - Fixed support on bottom faces of both pads.
  - Frictionless Support on the bottom faces.
  - Fixed support on the edge of Actuator tip.(Dirichlet BC)

Structural Height = 2 µm

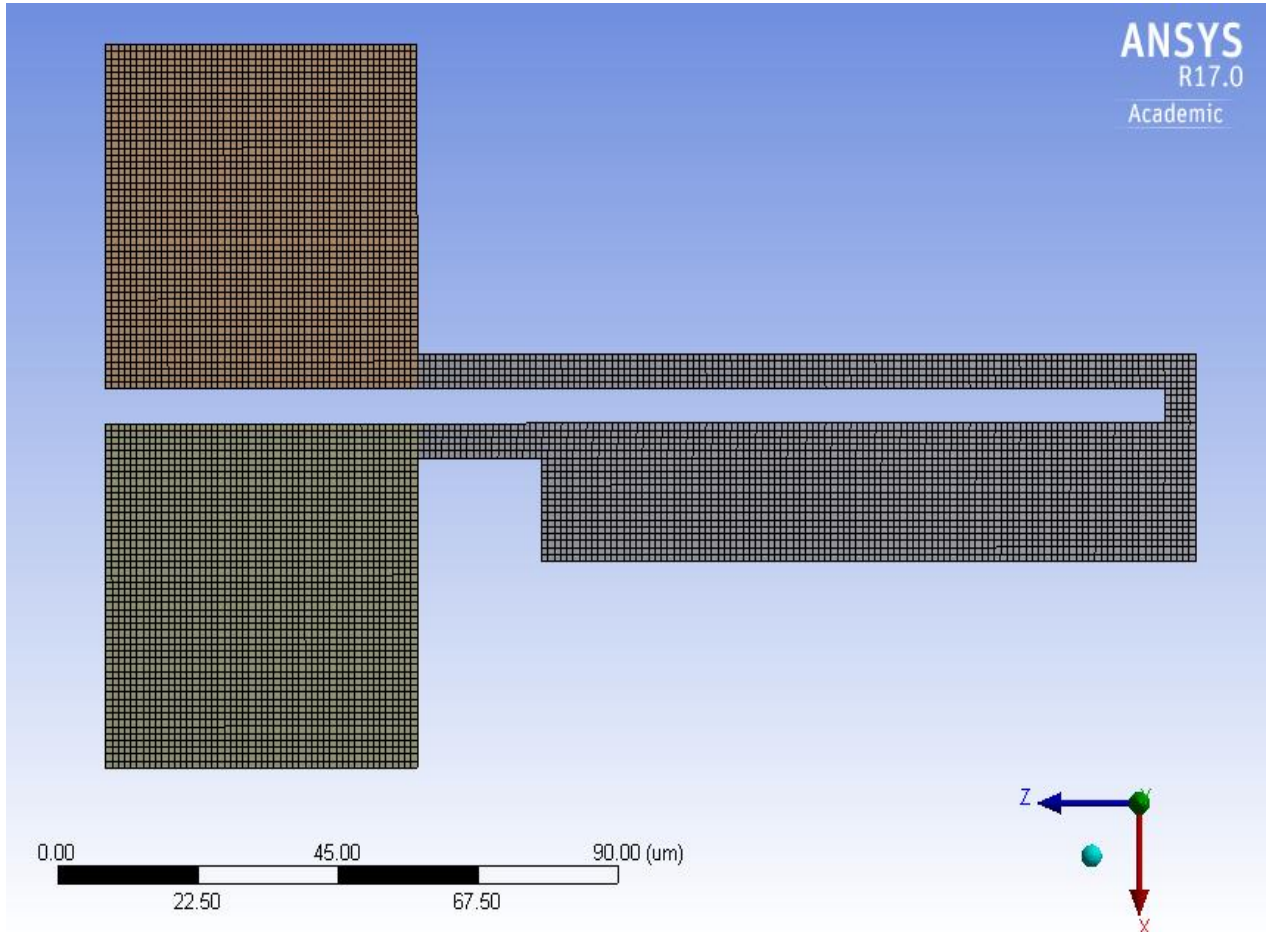

Fig.3: Project Schematic View

Thermal-Electrical Analysis

- Voltage provided to 1st pad and 2nd pad is grounded creating a potential difference and current flows.

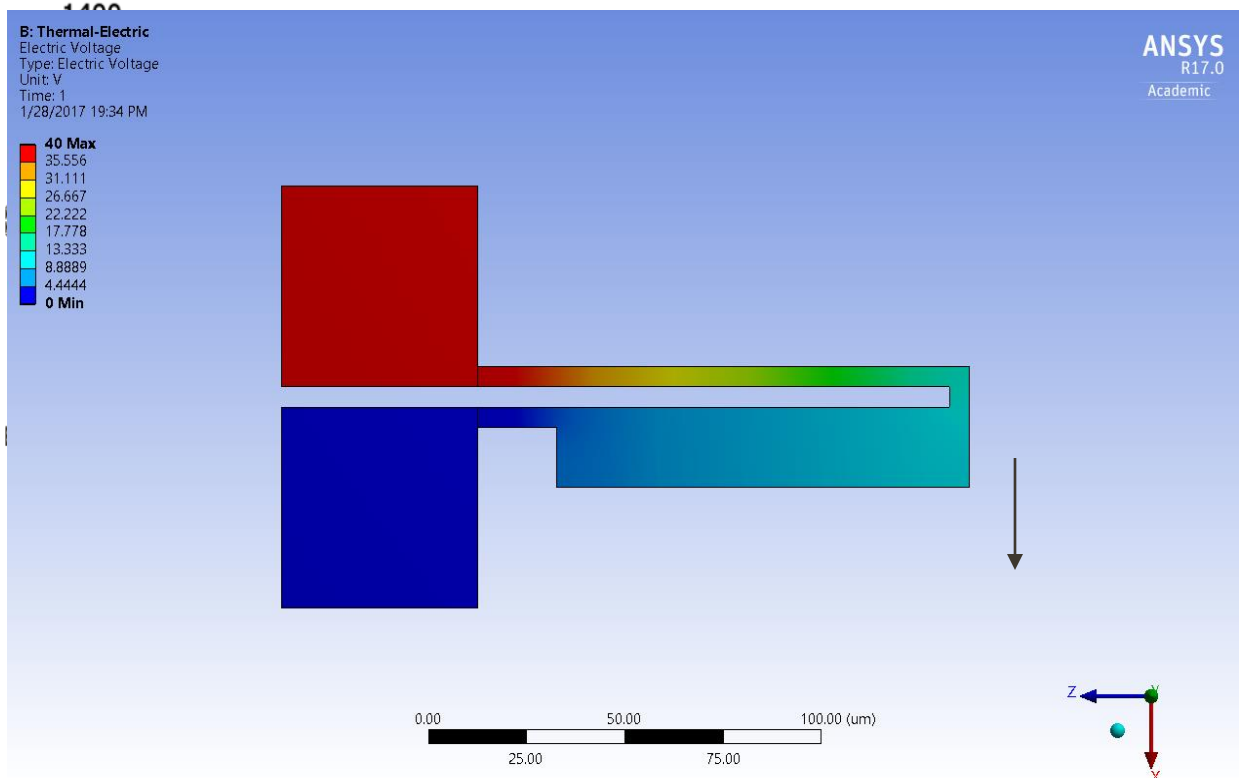

Fig.6: Temperature and Resistivity trend

- Current density is higher in the narrow section. This results in different thermal expansion between the two segments.
- Thin arm provides more resistance and thus heats up more than the thick arm.

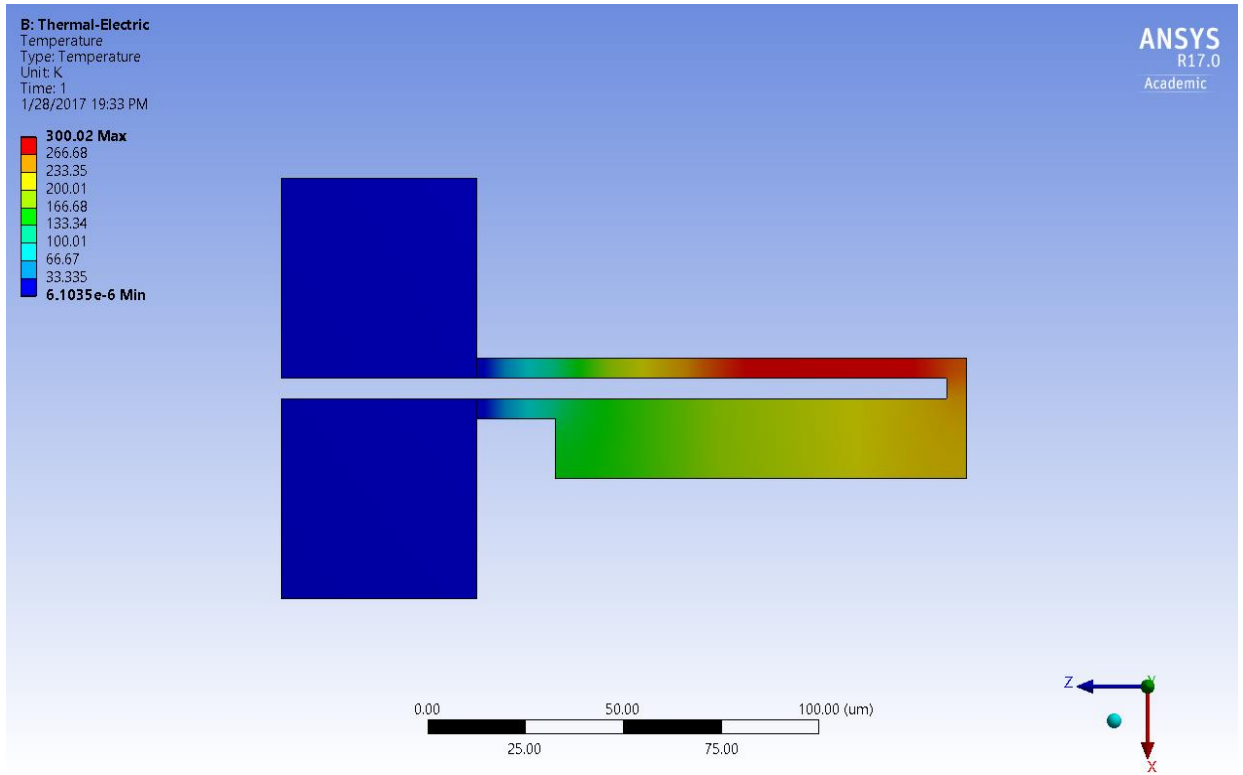

Fig.4: Temperature distribution

Static-Structural Analysis

Local heating and thereby thermal expansion of a beam-based geometry leads to defined deformation and to actuator deflection.[3]

Deformation with clamp on tip : 7.4549e-002 µm

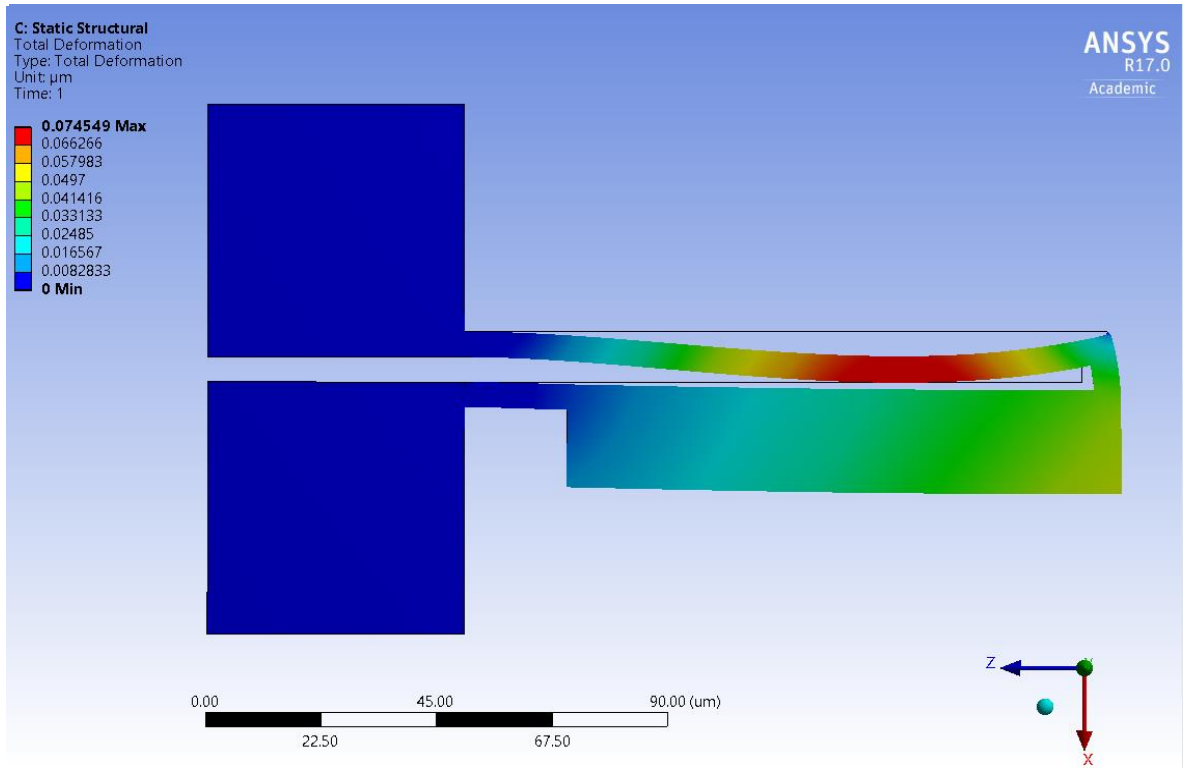

Fig.8: Deformation with clamp

Reaction Force generated at the tip due to expansion

- X: 16.974 µN, Y: -63.609 µN, Z: 544.45 µN
- Total 548.41 µN

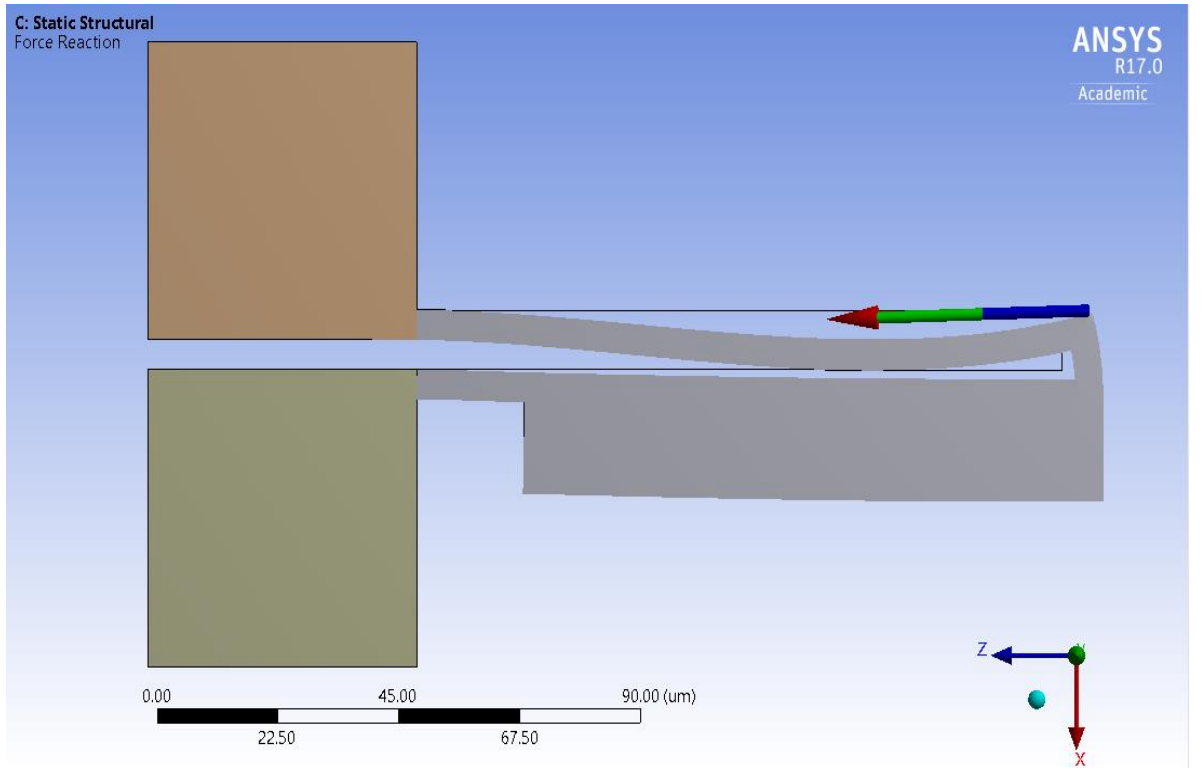

Fig.9:Reaction Force generated

Results

- The Electric Resistivity required to achieve the target maximum temperature of 300K is 4.4445 ohm-mm.
- The Reaction Force generated at the actuator tip due to the heating effect is 548.41 μN

Observations

- Changing the environmental temperature from 295.13 K to 0 K in the Static-Structural Analysis results in a varied deformation state.

Details of "Static Structural (C5)"	
Definition	
Physics Type	Structural
Analysis Type	Static Structural
Solver Target	Mechanical APDL
Options	
Environment Temperature	0. K
Generate Input Only	No

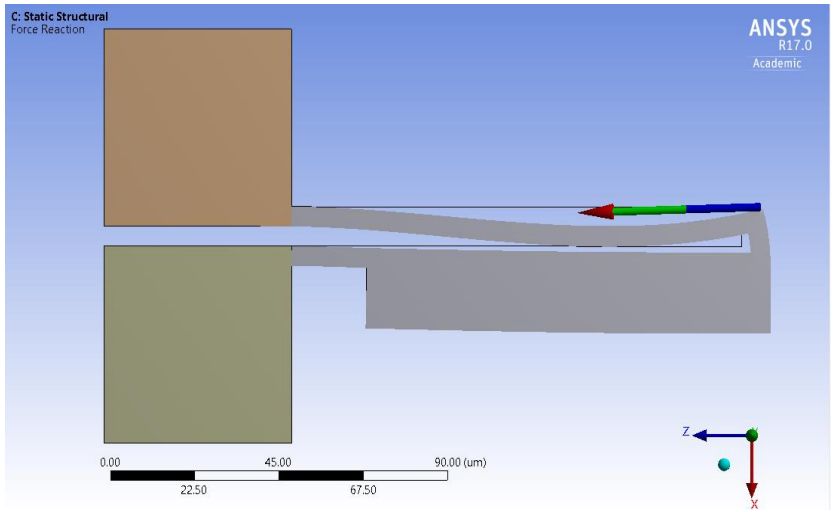

Fig.10: Environmental Temp: 0 K

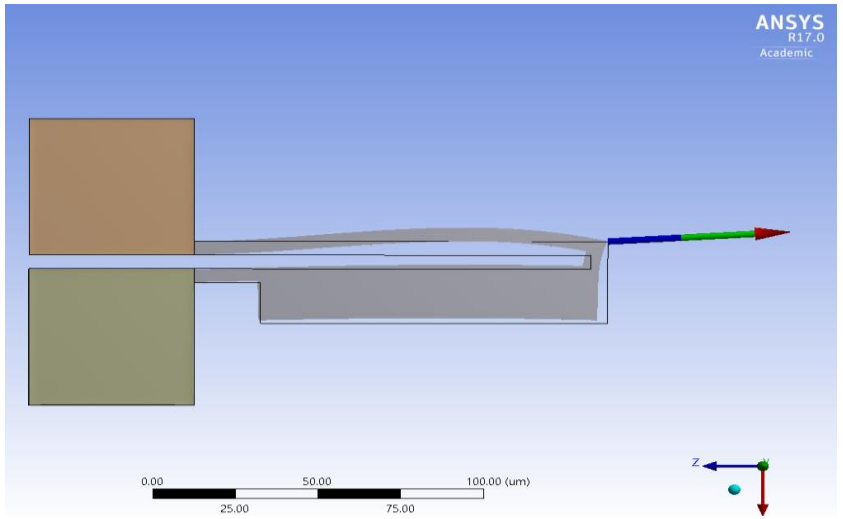

Fig.11:Environmental Temp: 295.13 K

Reference

[1] E.S. Kolesar, P.B. Allen, J.T. Howard and J.M. Wilken, J. Vac. Sci. Technol. A, 17 (1999) 2257-2263.

[2] Kaur, Sandeep, Sukhdeep Kaur, and Subhash Poonia. "APPLICATION OF THERMAL ACTUATOR". *International Journal of Advanced Research in Computer and Communication Engineering* 2.10 (2013): 3. Print.

[3] Winterstein, Thomas et al. "SU-8 Electrothermal Actuators: Optimization Of Fabrication And Excitation For Long-Term Use". *Micromachines* 5.4 (2014): 1310-1322. Web.