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Tunable MEMS Capacitor for RF Applications

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Overview

- Radio Frequency MEMS devices have emerged to overcome the problem of high losses associated with semiconductors at high frequencies.
 - A tunable MEMS capacitor is a micrometre-scale electronic device whose capacitance is controlled through different actuation mechanisms which govern the moving parts.
 - This work proposes an electrothermally actuated tunable MEMS capacitor suitable for filters, oscillators, phase shifters and impedance matching networks.
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Use of COMSOL Multiphysics

- MEMS fabrication imposes design constraints on the structure and composition of any micro device.
 - This work has required trials with different materials and specification of material properties during simulation.
 - The simulation has been able to provide surface deformation, temperature distribution, stress distribution and current density distribution results.
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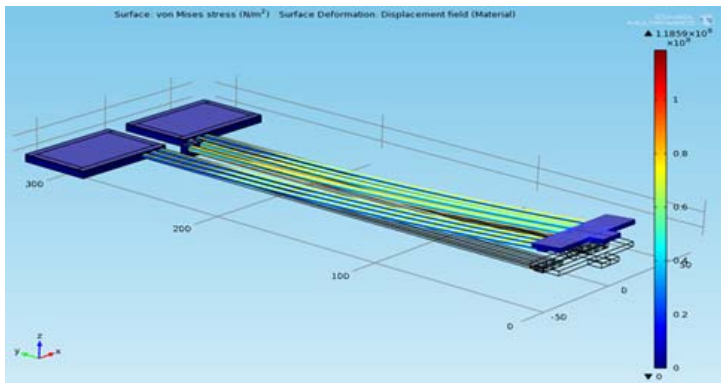
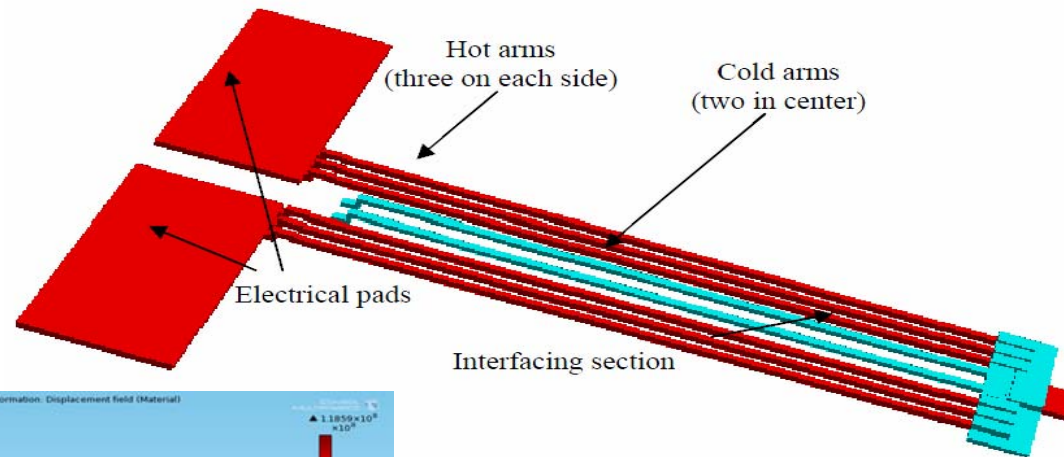
Actuation Mechanisms

- For very fast, high voltage tuning, electrostatic actuation is the preferred mechanism.
 - Electrostatic actuation naturally results in a bistable response and is a well-suited actuation mechanism for switched capacitors.
 - Electrothermal actuators are preferable in case of low power, slow switching applications.
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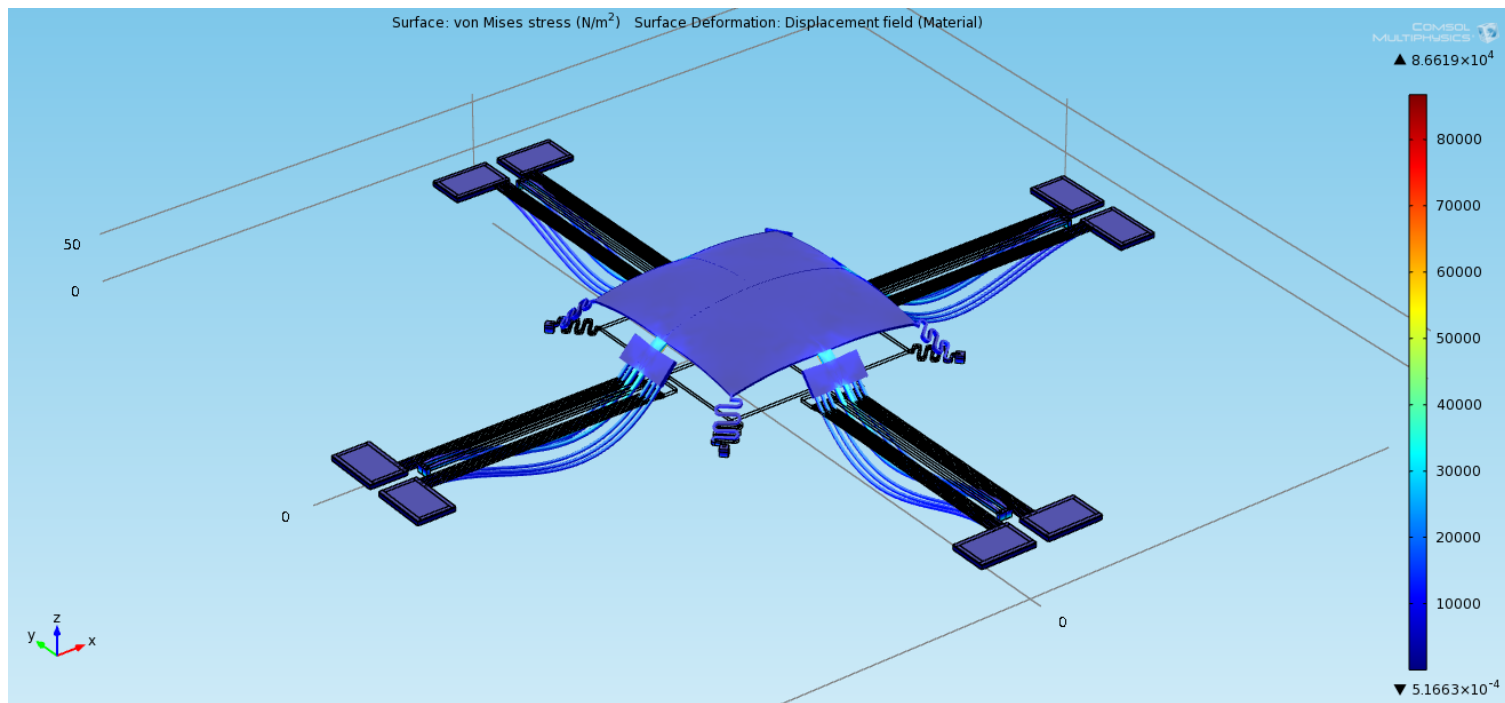
Electrothermal Actuation

- The conventional method of actuation is based on the asymmetric arm or a structure with non-symmetrically placed arms with different rates of thermal expansion, which results in a desired deformed state on electrothermal heating.
- The other actuation mechanism is the bimetallic strip actuation, which is less frequently used.
- This work proposes a tunable capacitor design based on bimetallic strip actuation, for the design goals including, finer and stable control mechanism, lesser capacitor plate deformation and easier fabrication.

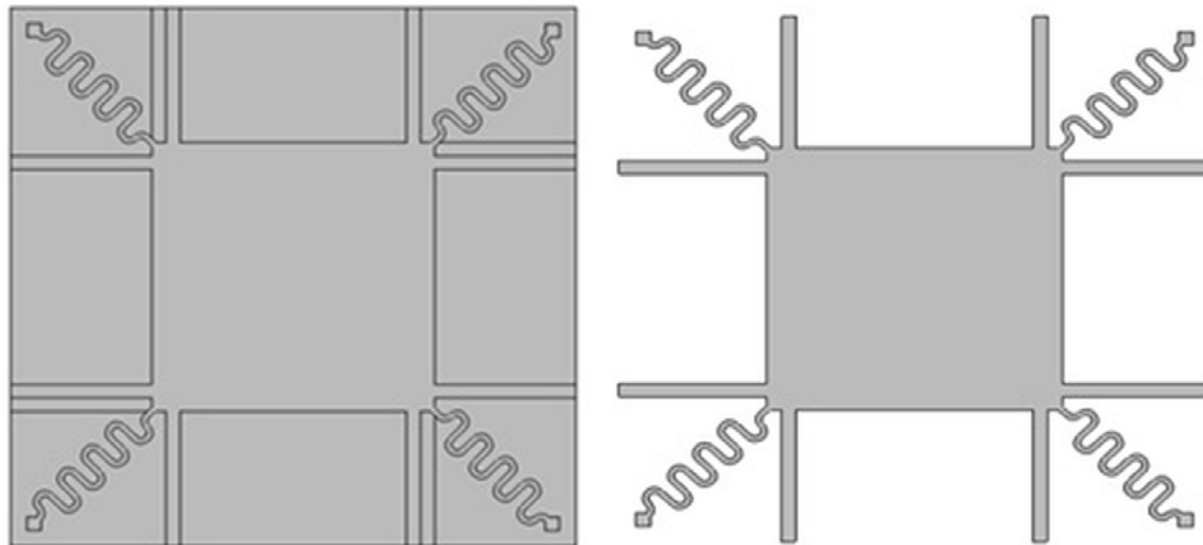
Asymmetric Arm Actuator



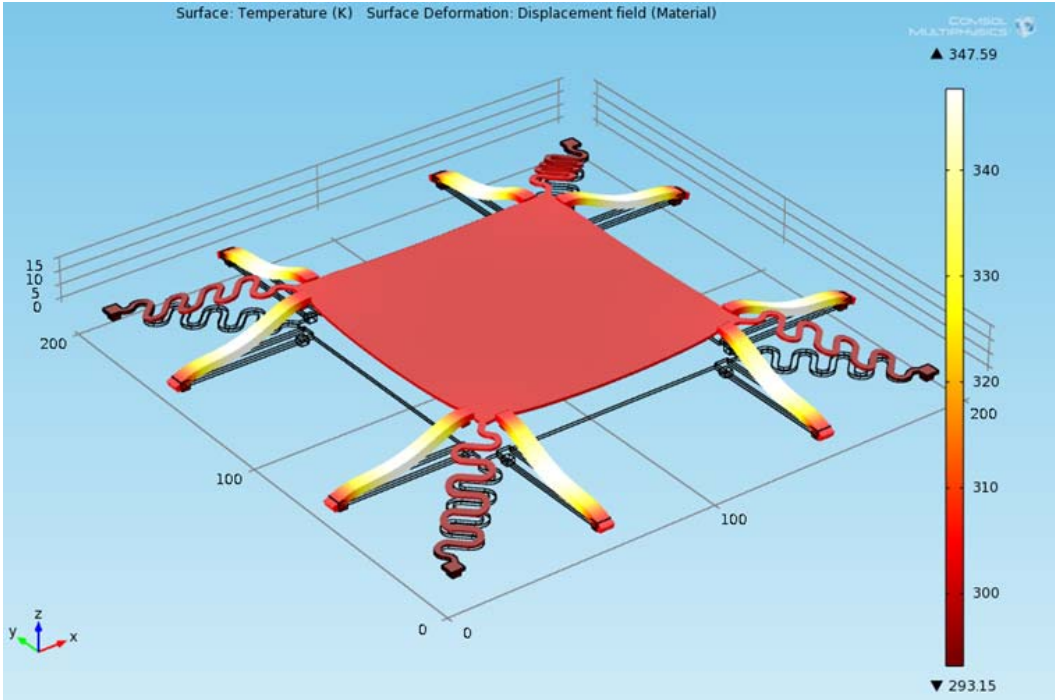
Stability Issues



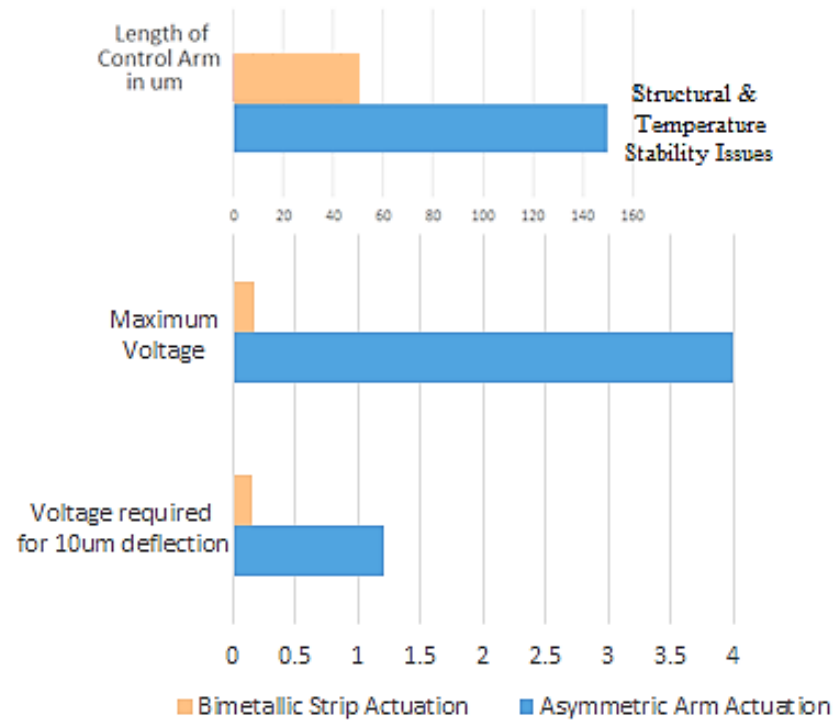
Fabrication



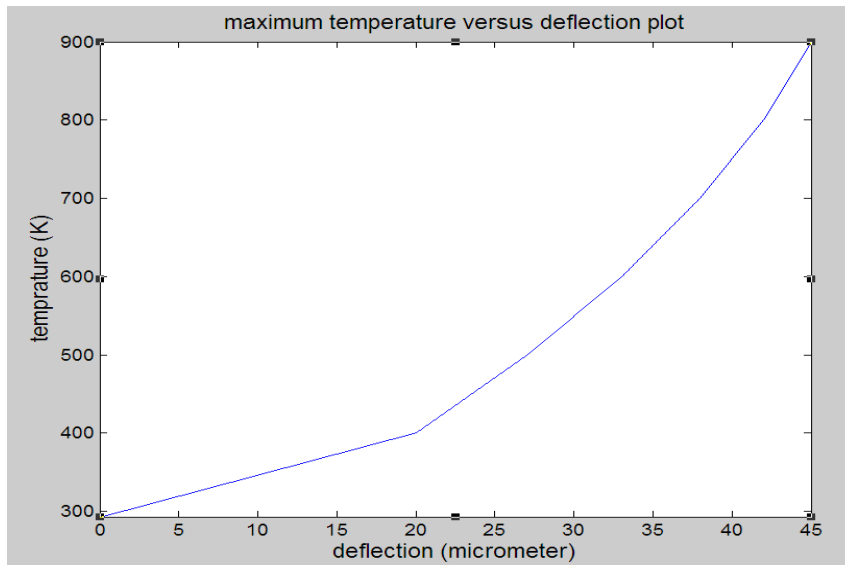
Design



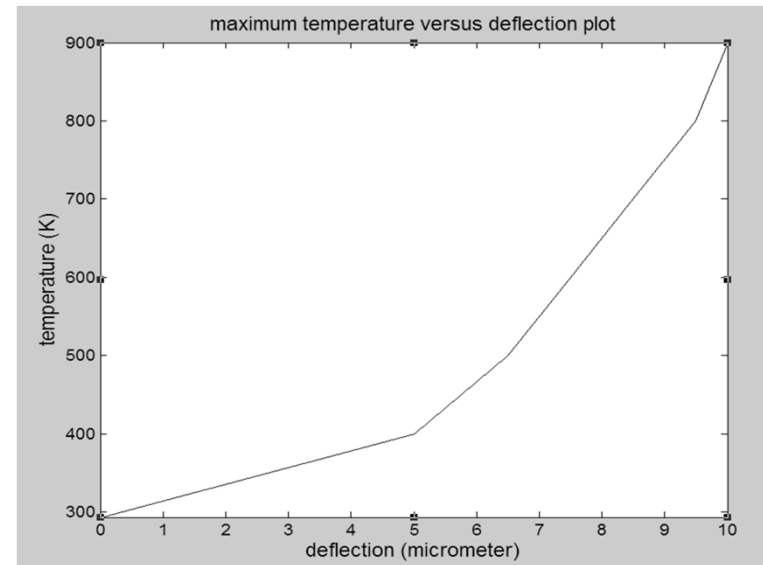
A Comparison



Results




Asymmetric Arm Actuator



Bimetallic Strip Actuator

Conclusion

- A stable actuation mechanism follows from the design of the proposed bilayer thermal actuator.
 - The capacitance can be controlled up to a tenth of its value.
 - The advantages are easier fabrication, a more compact control structure, lower actuation voltage and finer tuning.
 - The disadvantage is that the design bears a reduced tuning ratio.
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