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KAUST

Platform Isolation Using Out-of-plane Compliant Mechanism

by Arpys Arevalo

PhD Candidate in Electrical Engineering

Computer, Electrical and Mathematical Sciences and Engineering (CEMSE)

King Abdullah University of Science and Technology

EMPIRe Laboratory

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Introduction

In this work we present the simulation of a platform that is isolated using micro-scale large displacement compliant mechanism called the Tsang suspension [1]. The Tsang suspension consist of a flat micro-plate anchored down by two springs on either side, which can rotate out-of-plane and maintain its vertical assembly by simple single-axis actuation.

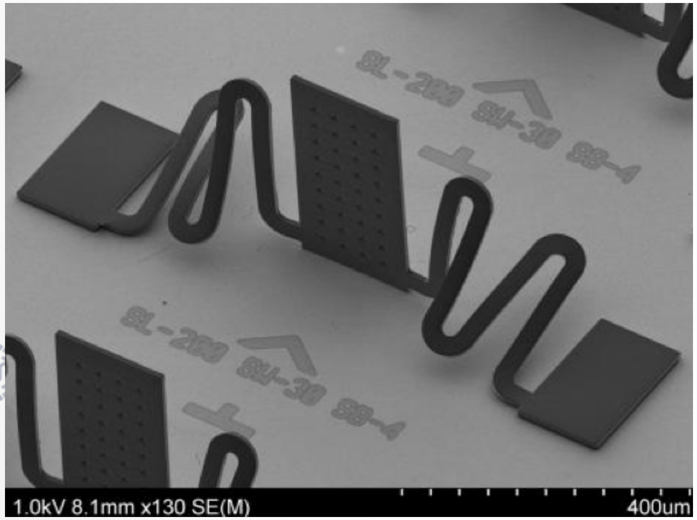


Fig. 1 SEM image of fabricated and assembled SU-8 Tsang Suspension.

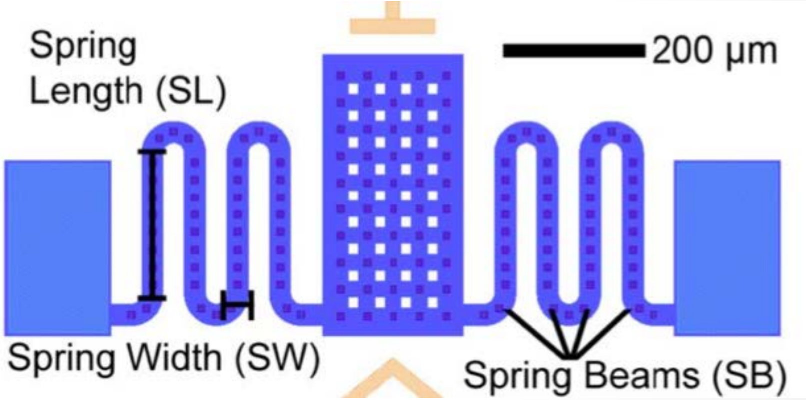
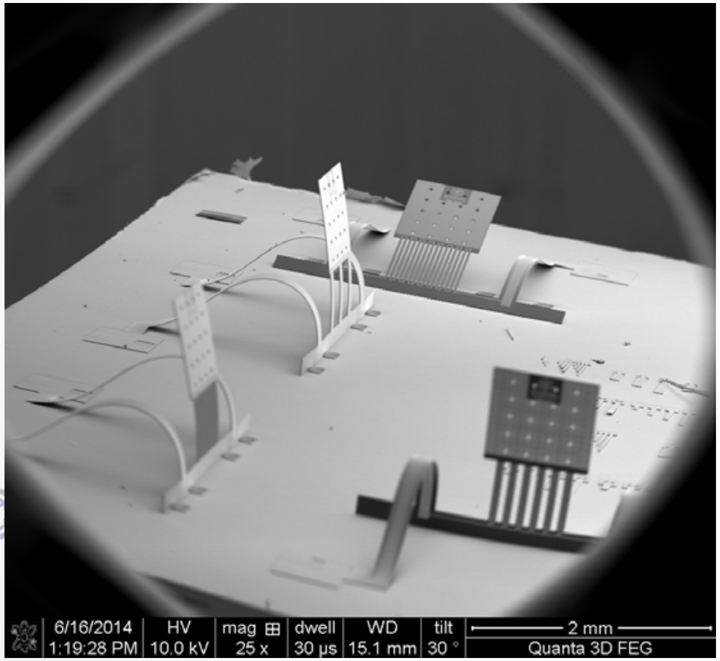


Figure 2: Illustration of a Tsang suspension layout with Spring Length (SL) = 200µm, Spring Width (SW) = 30µm, Number of Spring Beams (SB) = 4.

Introduction

- The world of Micro Electro Mechanical Systems (MEMS) is flat!
- Out-of-plane structures can help separate devices from the substrate, to provide good electrical and thermal isolation.



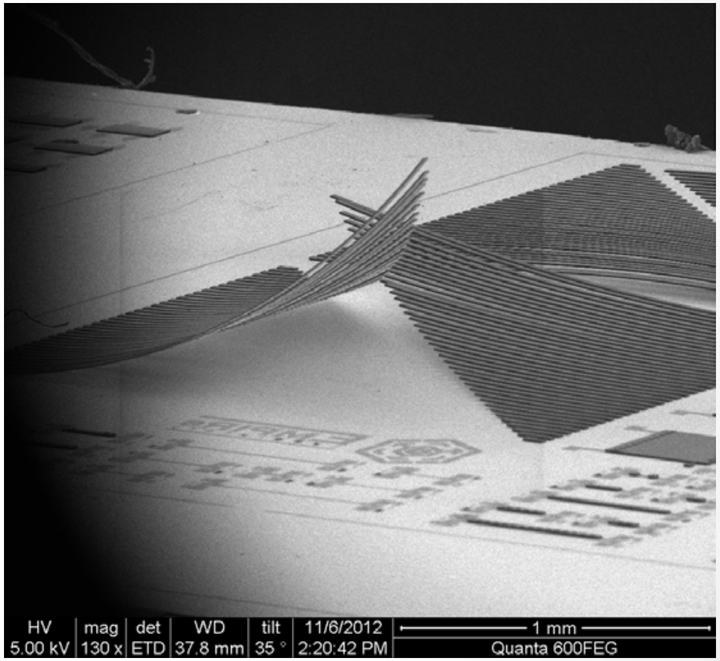
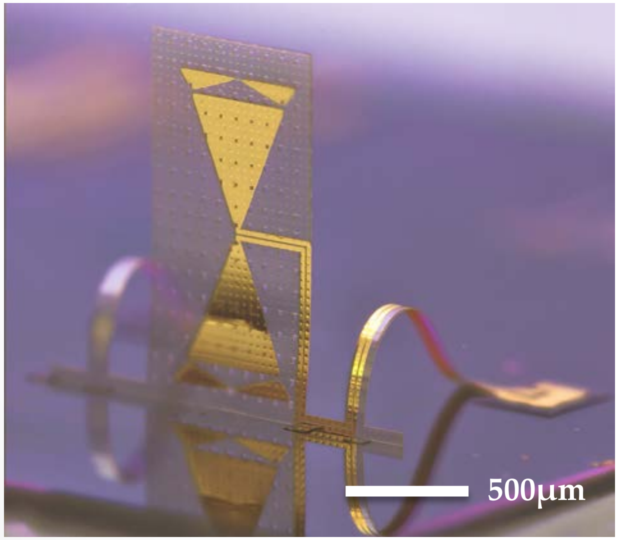


Figure 3 Left: BCP thermal actuated micro mirrors. Right: Bending effect test on chip.

Introduction

Tsang structures can be used in applications such as micro-mirrors [3], free-space optics [4-6] and RF systems [2, 7], amongst others. Several Tsang suspension can be attached to a common plate for electrical and thermal isolation of sensors [9,10].



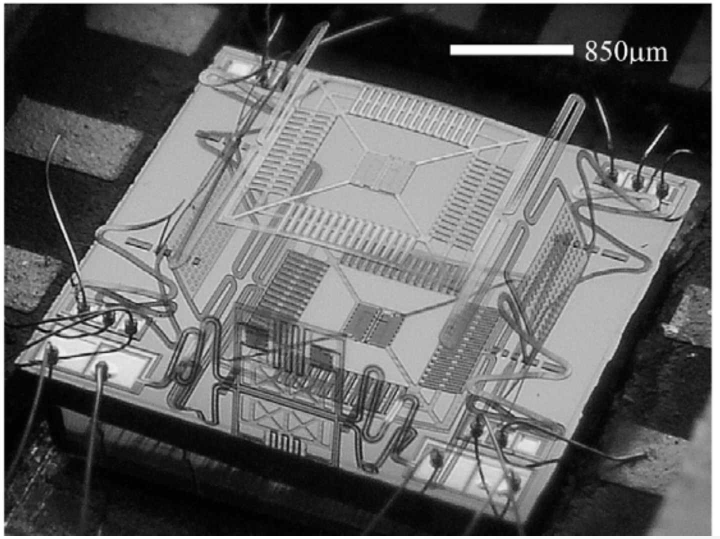


Figure 4 Left: Out-of-Plane Dual Band (60 and 77 GHz) Antenna on Buckle Cantilever, using Polyimide and Gold for the metal layer [L. Marnat, **A. Arevalo** et al., IEEE TAP, 2013]. Right: Several Tsang suspensions (Silicon and Polyimide) hold an elevated platform with a 2 axis thermal accelerometer [3] .

Use of COMSOL

- One of the challenges of Micro Electromechanical Systems (MEMS) is the direct measurement of their mechanical properties, due to the fact that the device's dimensions are small, typically <1mm.
- We deal with a large displacement compliant mechanism with torsion.
- Complex to model analytically.
- Common solution is to use nonlinear finite element modeling.

Simulation Design

- The first design parameters investigated were: the spring length (SL), the spring width (SW), and the number of spring beams (SB).

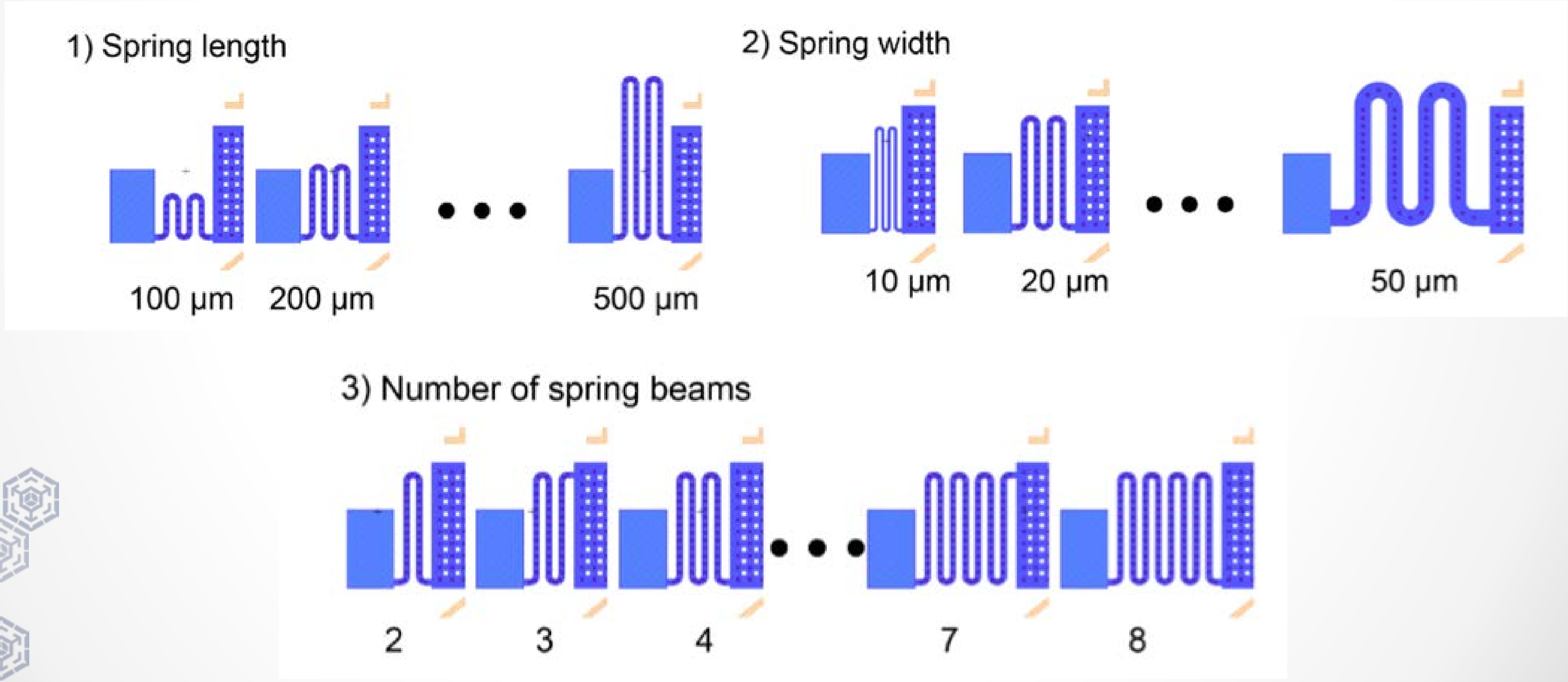


Figure 5 Representation of the parameters that were varied.

Simulation Design

- Design parameters used in COMSOL

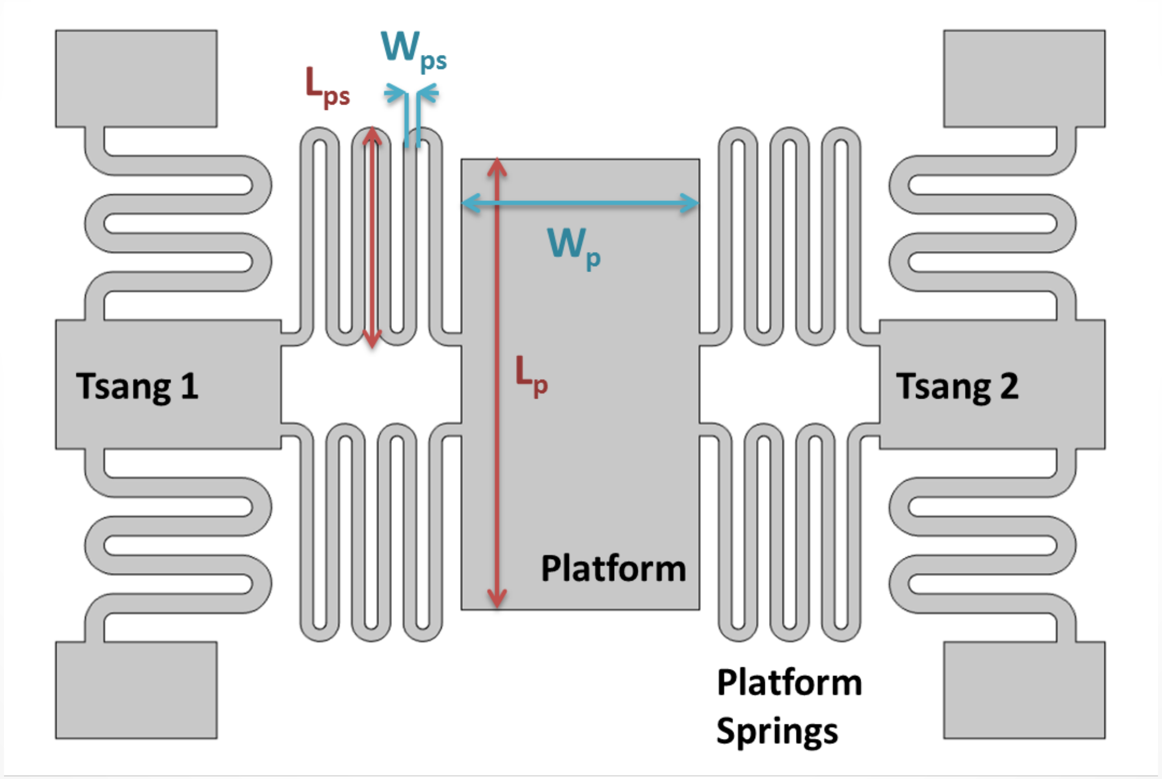


Figure 6 Platform configuration design

Simulation Results

- Scanning Electron Microscopy (SEM) was use to capture the top-view of the assembled structures.
- The simulation had good agreement with the experimental assembly.

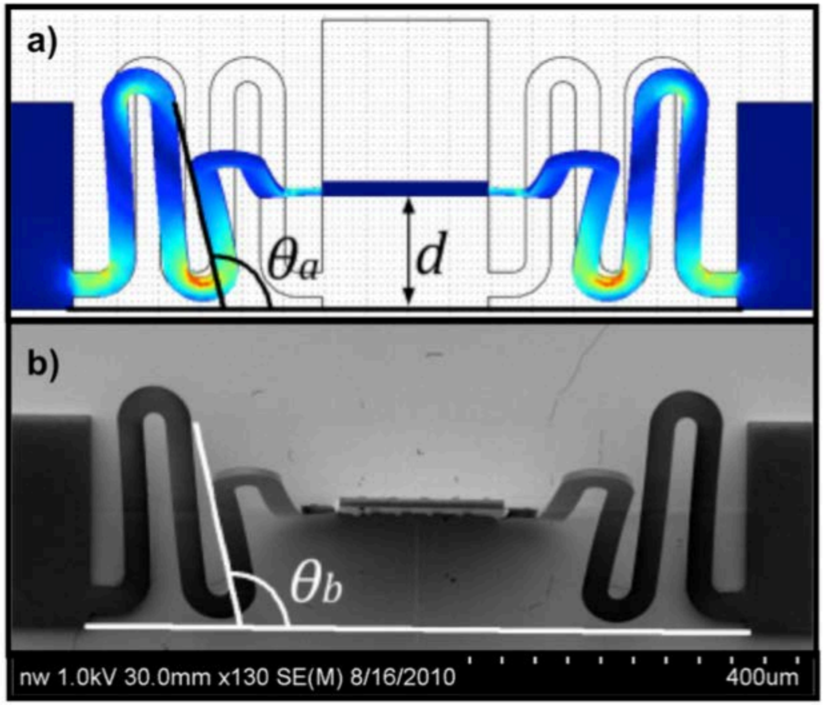


Figure 7: Top view of simulation and SEM image. An example comparison angle, “theta-a” and “theta-b”. And displacement to vertical “d” are shown.

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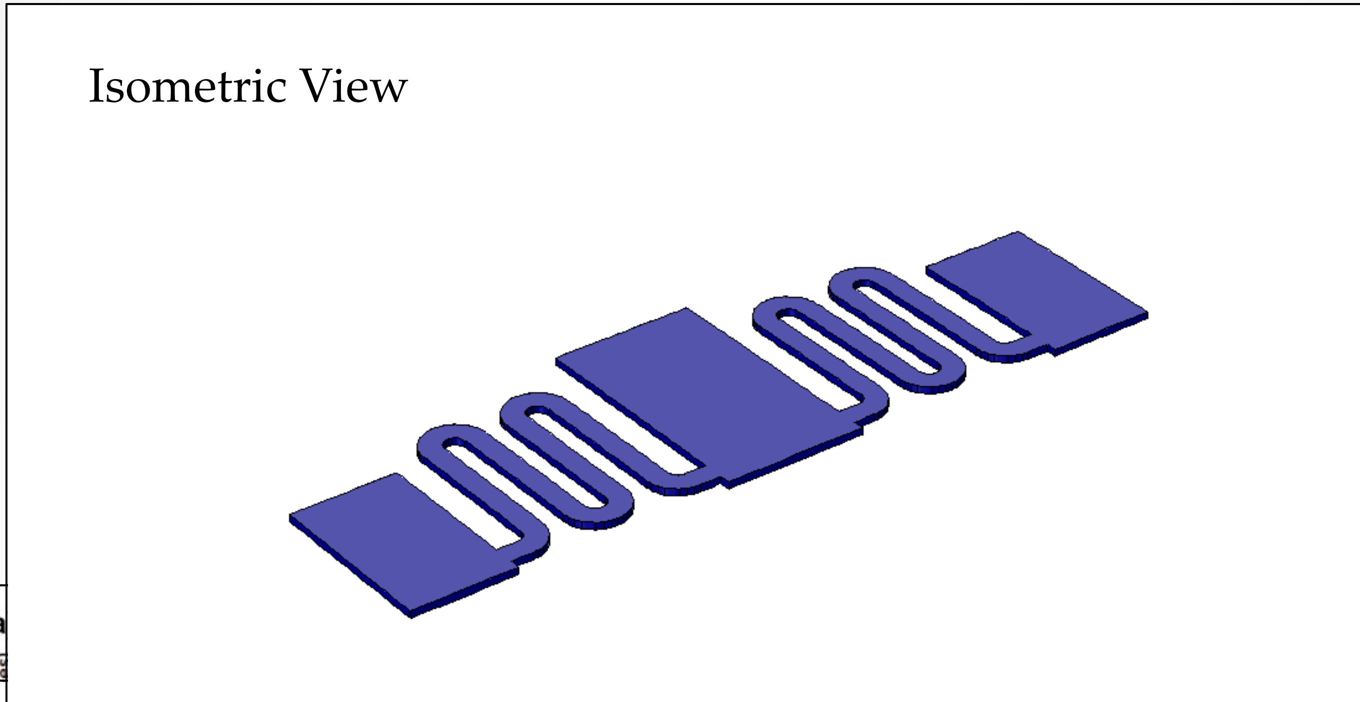

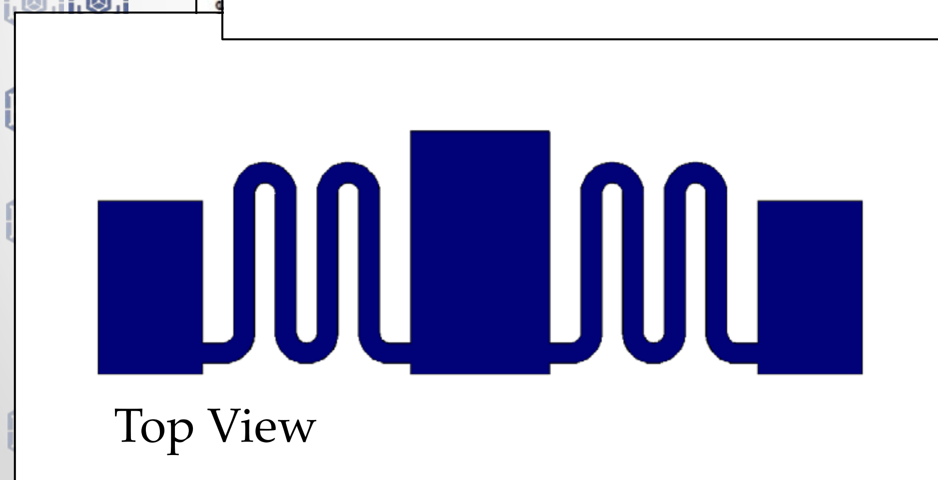

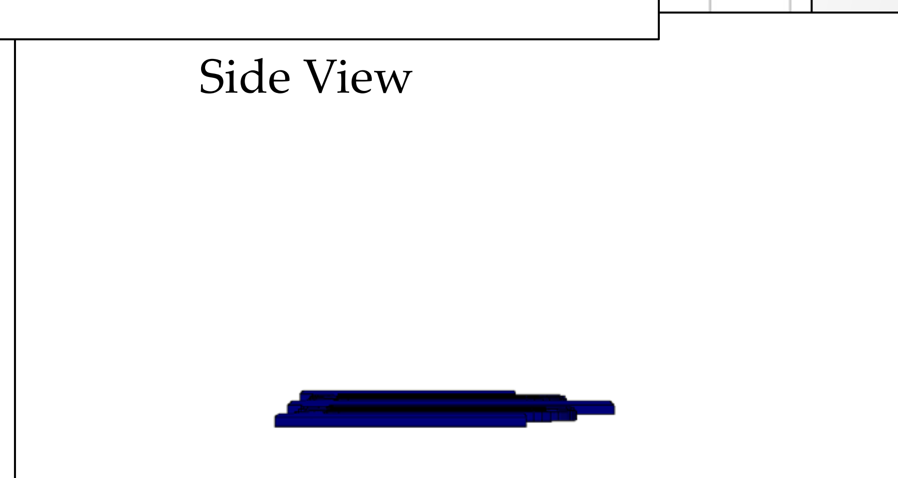

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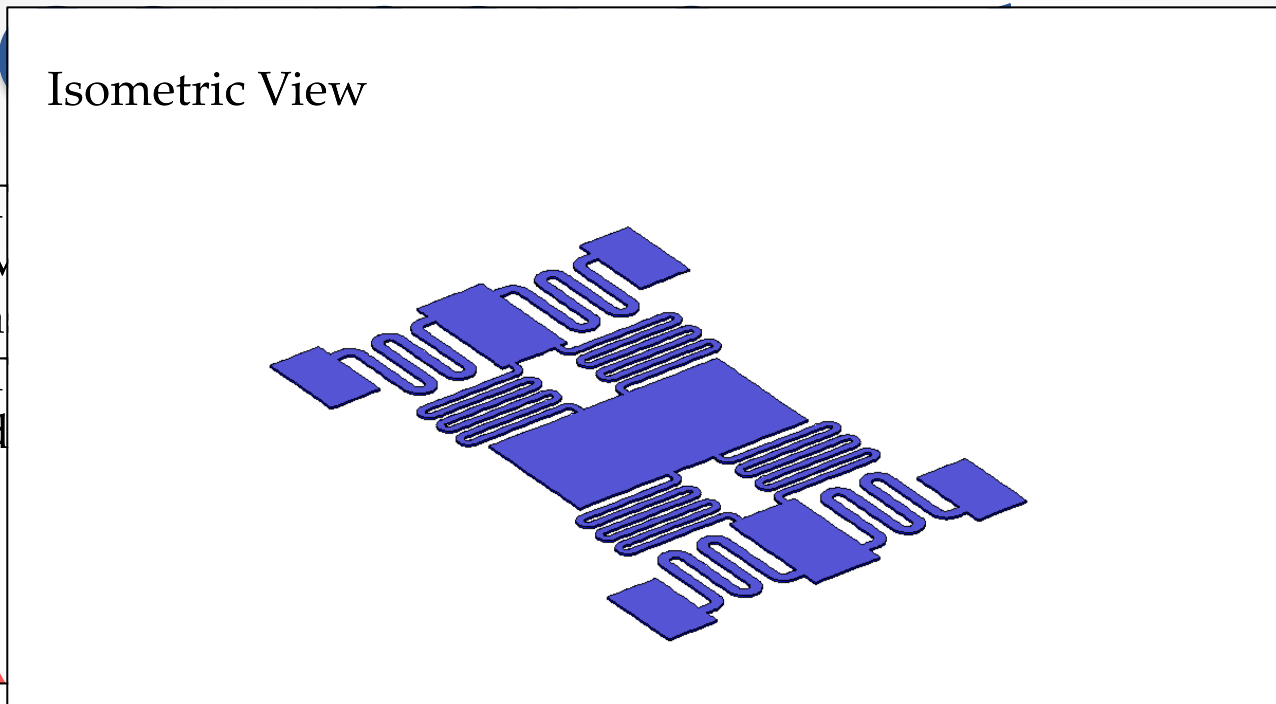
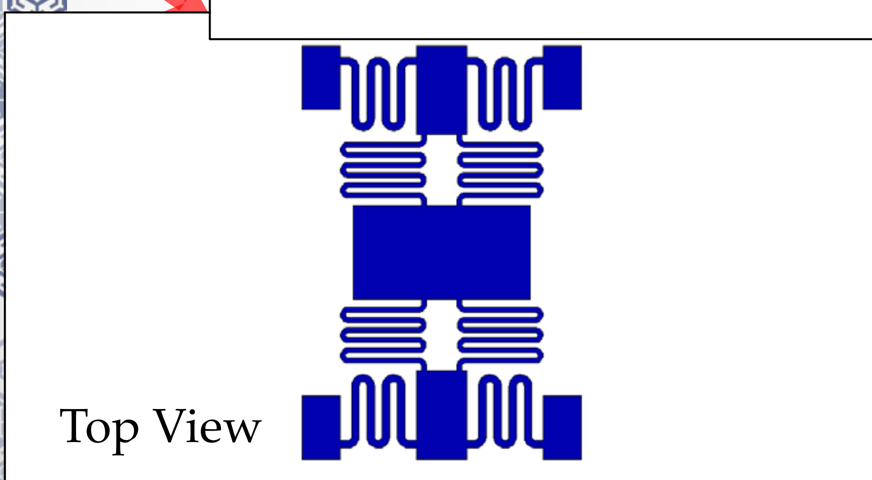
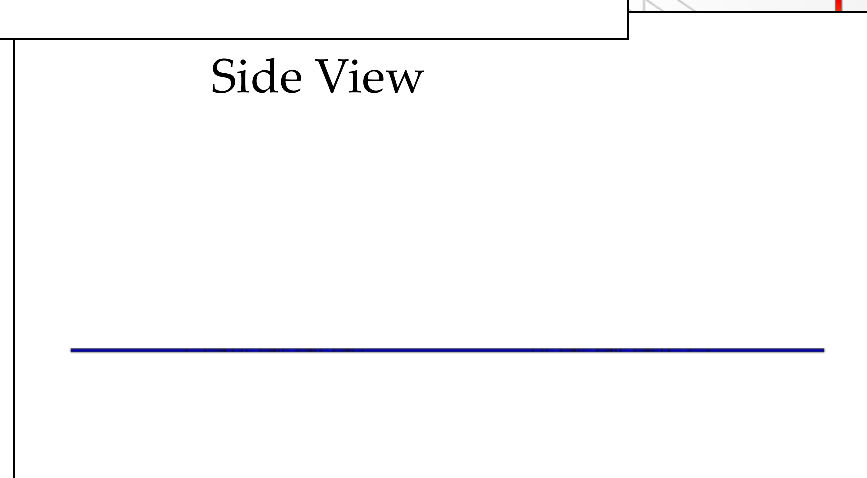
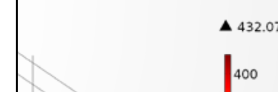


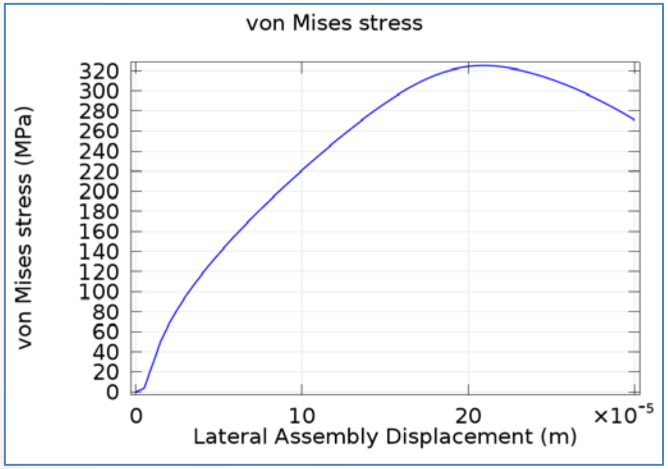






Simulation Results

Material	Final Platform Height (µm)	Von Misses Stress (MPa)	Tensile strength (MPa)
PI 2611	405	293	350
SU-8	404	71.8	73.3
Polysilicon	404	5748	1200



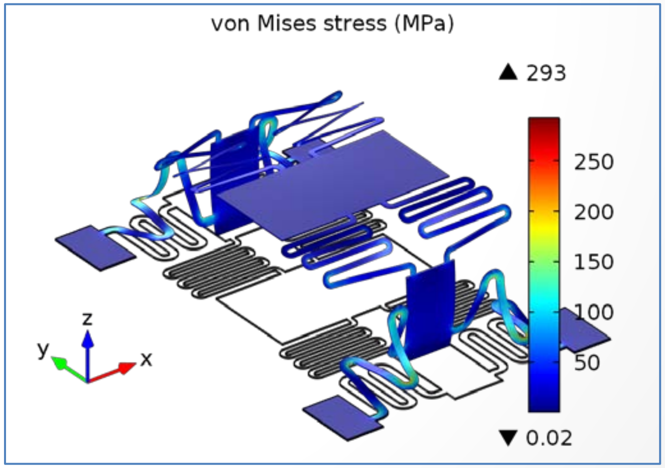


Figure 10 Left: Von Mises Stress vs Lateral Assembly Displacment graph. Right: Isometric View of the simulated assembly showing the von Mises Stress.

Conclusions

- We have used COMSOL to simulate the assembly of an out-of-plane compliant structure, which robustness and stability heavily depends on the dimensions and materials properties of the spring structures used.
- Polyimide and SU-8 are adequate materials for this design.
- Polysilicon structures are likely to fail with the proposed design, but design parameter variation can be evaluated.

Thank You!

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Questions?