FEM Correlation and Shock Analysis of a VNC MEMS Mirror Segment

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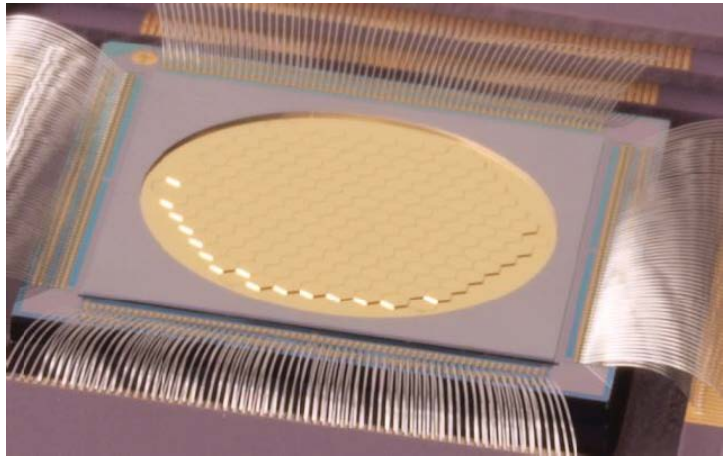
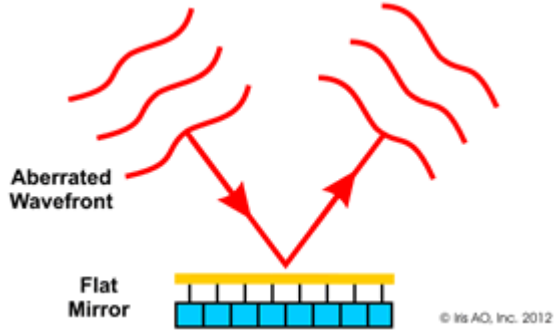
NEWTON Engineering & Product Development

Introduction

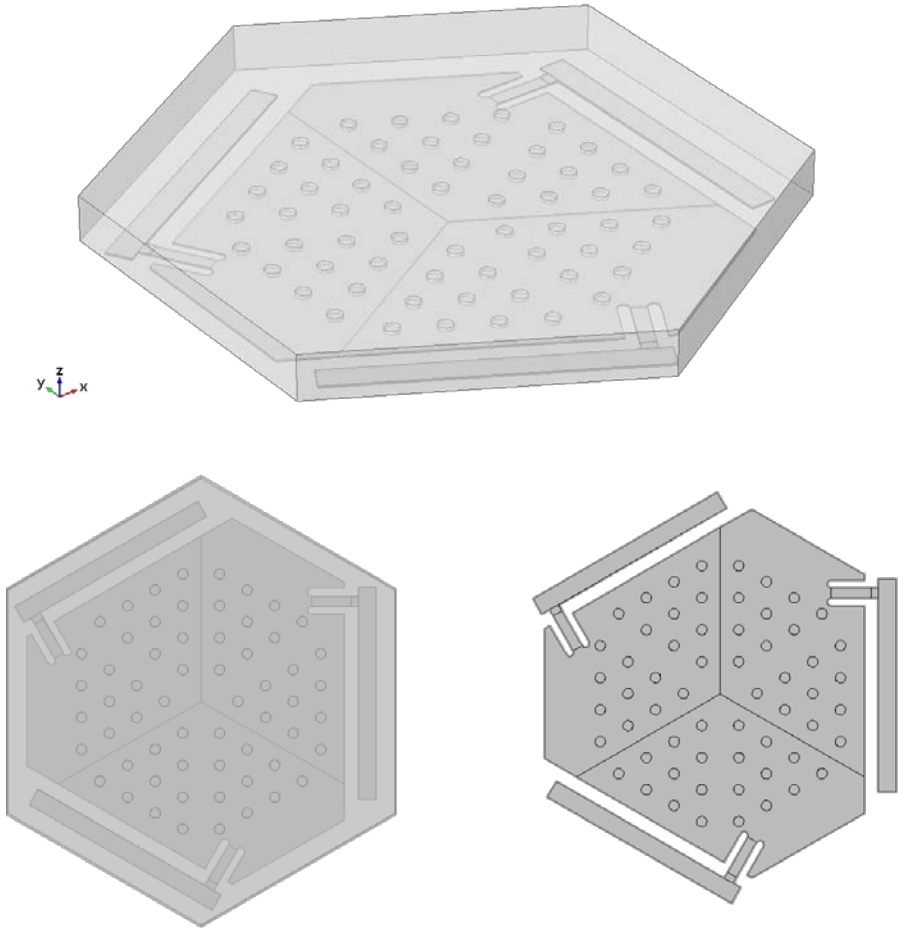
- Segmented MEMS Mirror used for corrective optics
  - Correct wavefront error
  - Octagon segments
- New, developing technology
  - Never used in spaceflight before
- Mechanical Analysis to:
  - Understand limitations of design
  - Provide input to increase reliability
  - Demonstrate space worthiness





Geometry

- Mirror Segment “glued” to platform
- Platform made of several material layers
  - Three flexure beams
  - Different pre-stresses on each material layer

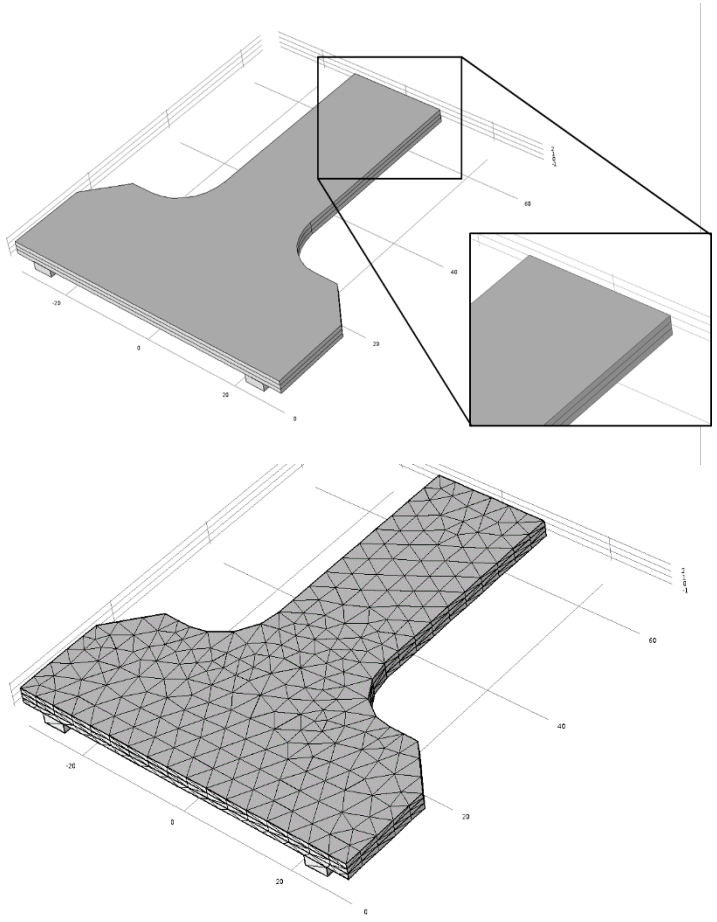


Process

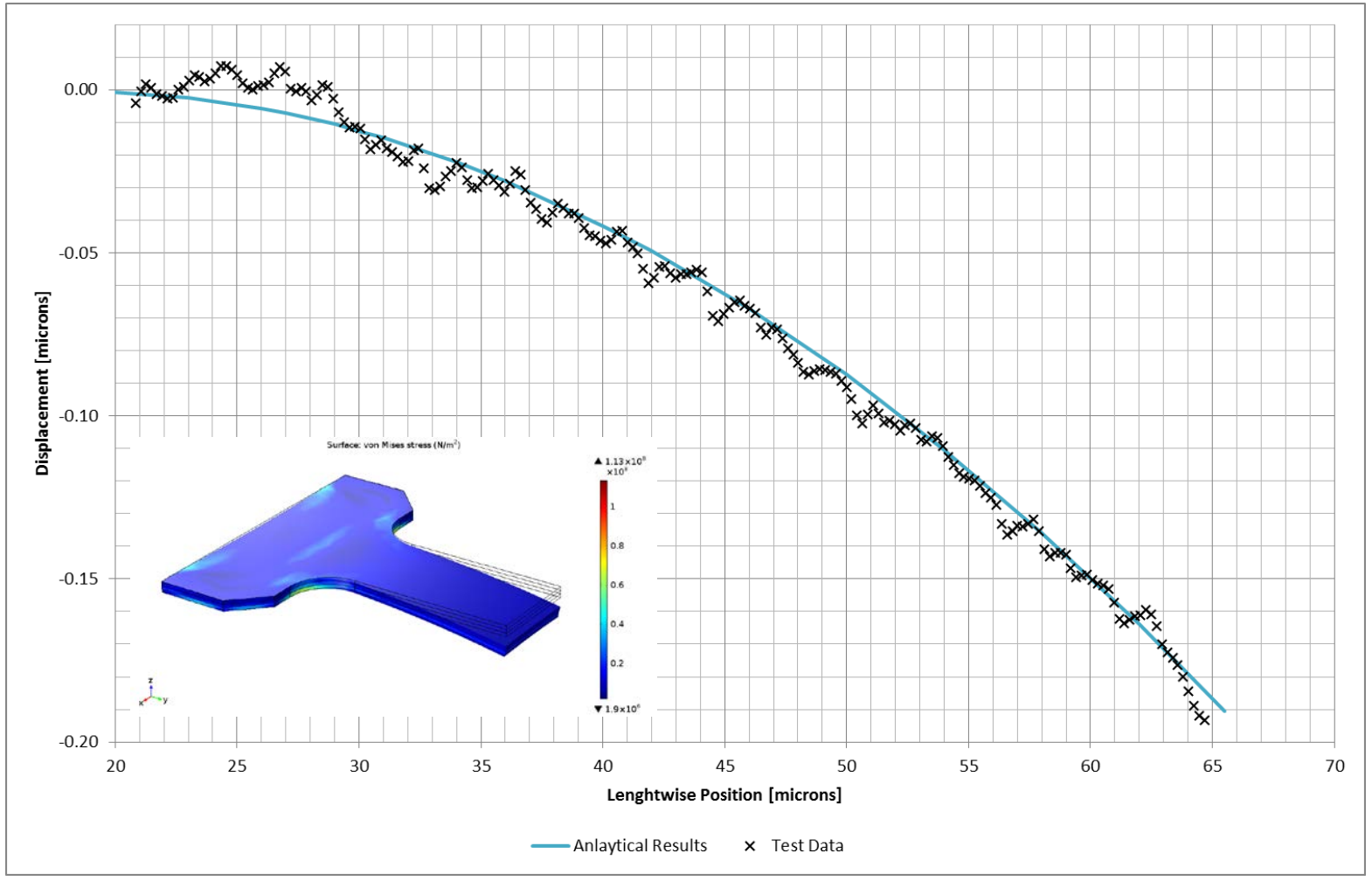
- Incremental model correlation
  - Single layer cantilever Beam
  - Multi-layer cantilever beam
  - Platform
  - Static Loading
  - Sine vibration
- Perform Shock Analysis
  - Synthesize time history
  - Apply load

Single Layer Cantilever Beam

- Simplified flexure beam
- Single material layer
  - Stress gradient
  - Modeled as three sublayers

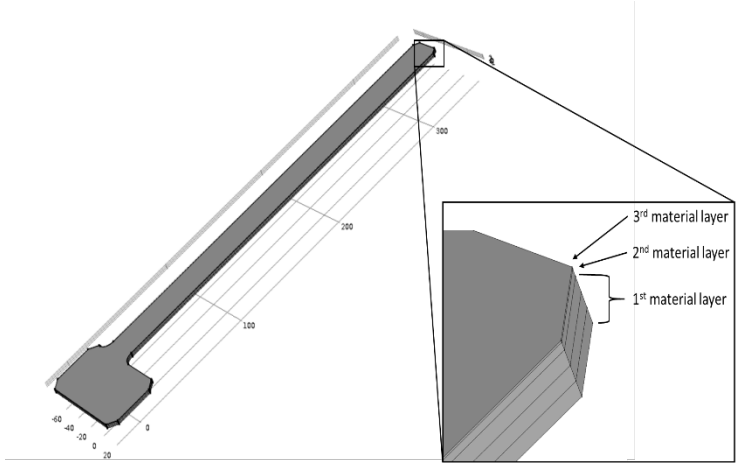


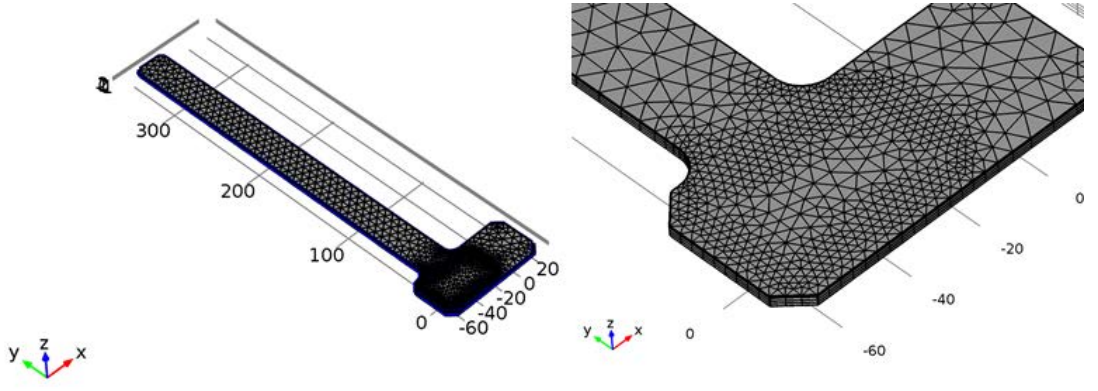
Single Layer Cantilever Beam Results



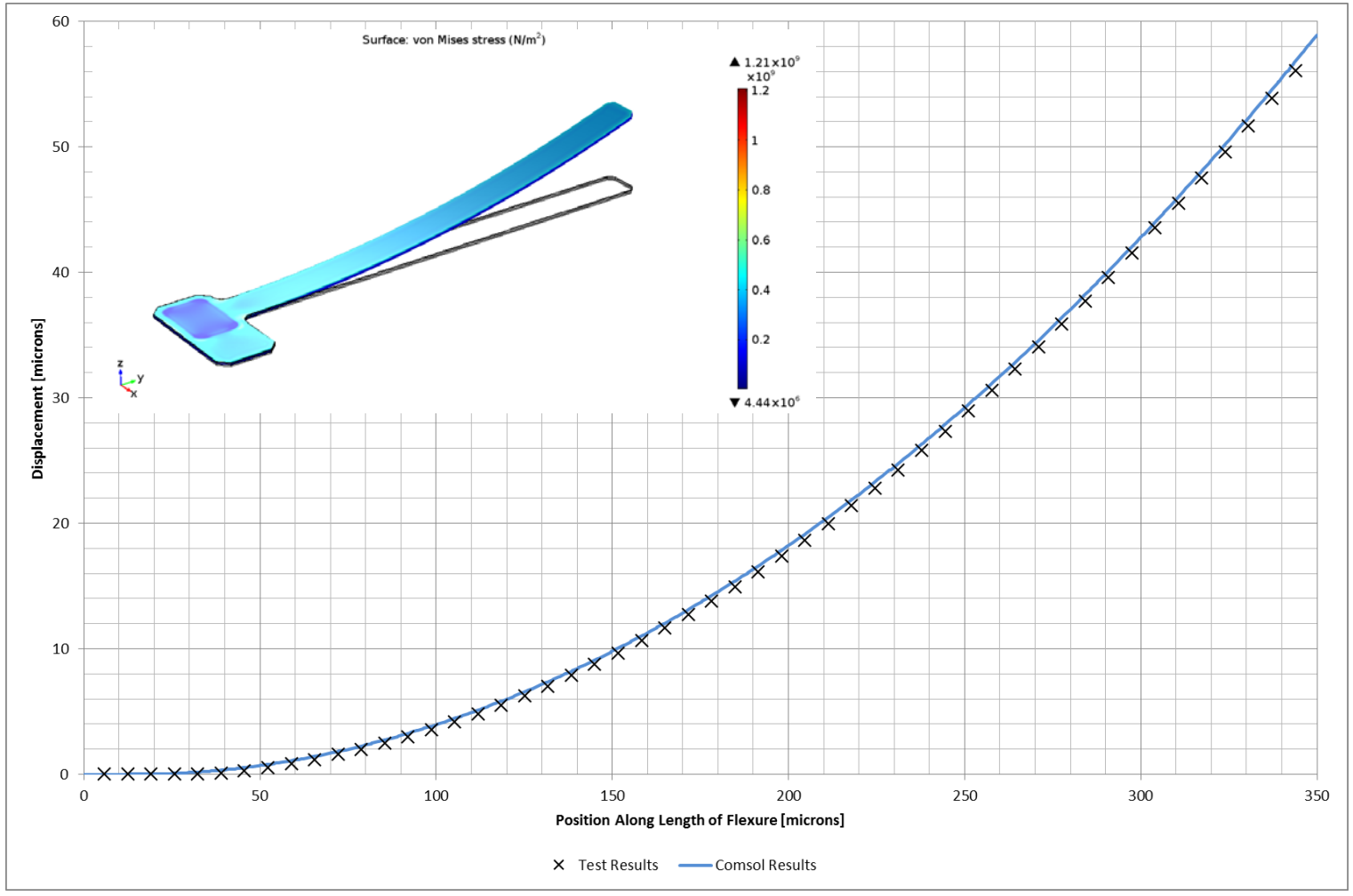
Multi-Layer Cantilever Beam

- Simplified flexure beam
- Multiple material layers
  - Different pre-stresses
  - Stress gradients modeled with sub-layers as in previous analysis



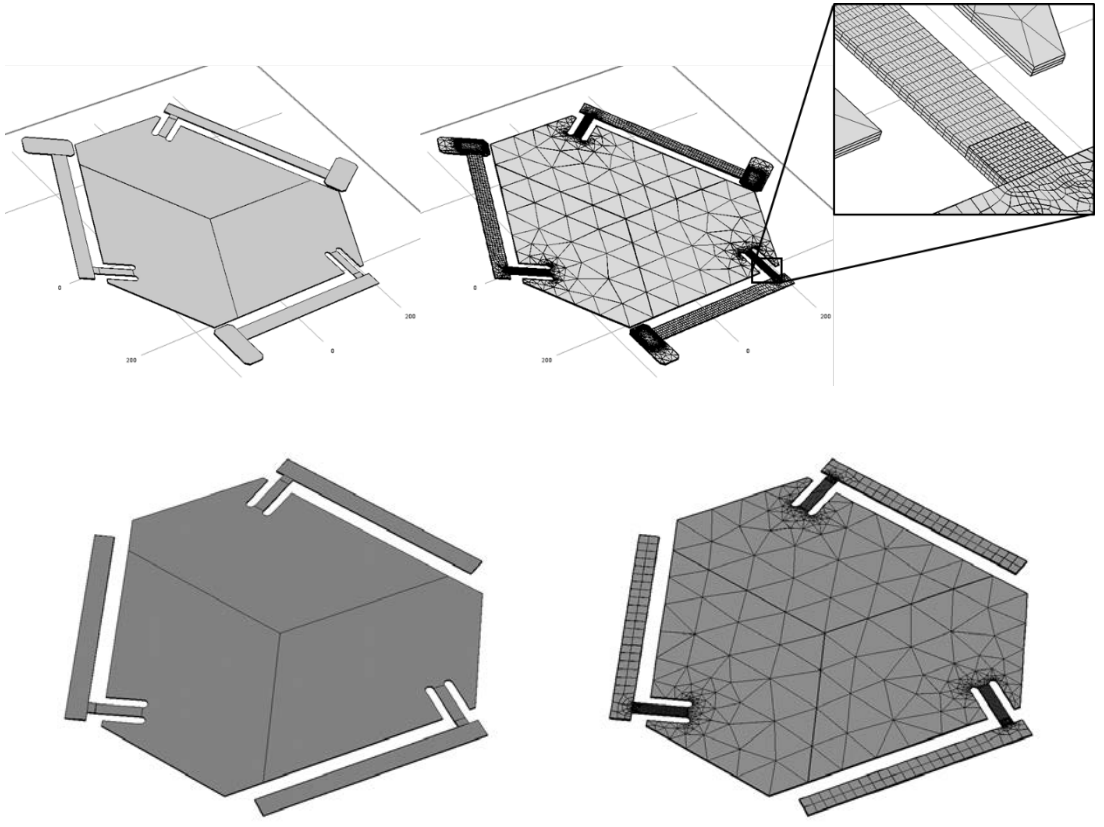


Single Layer Cantilever Beam Results

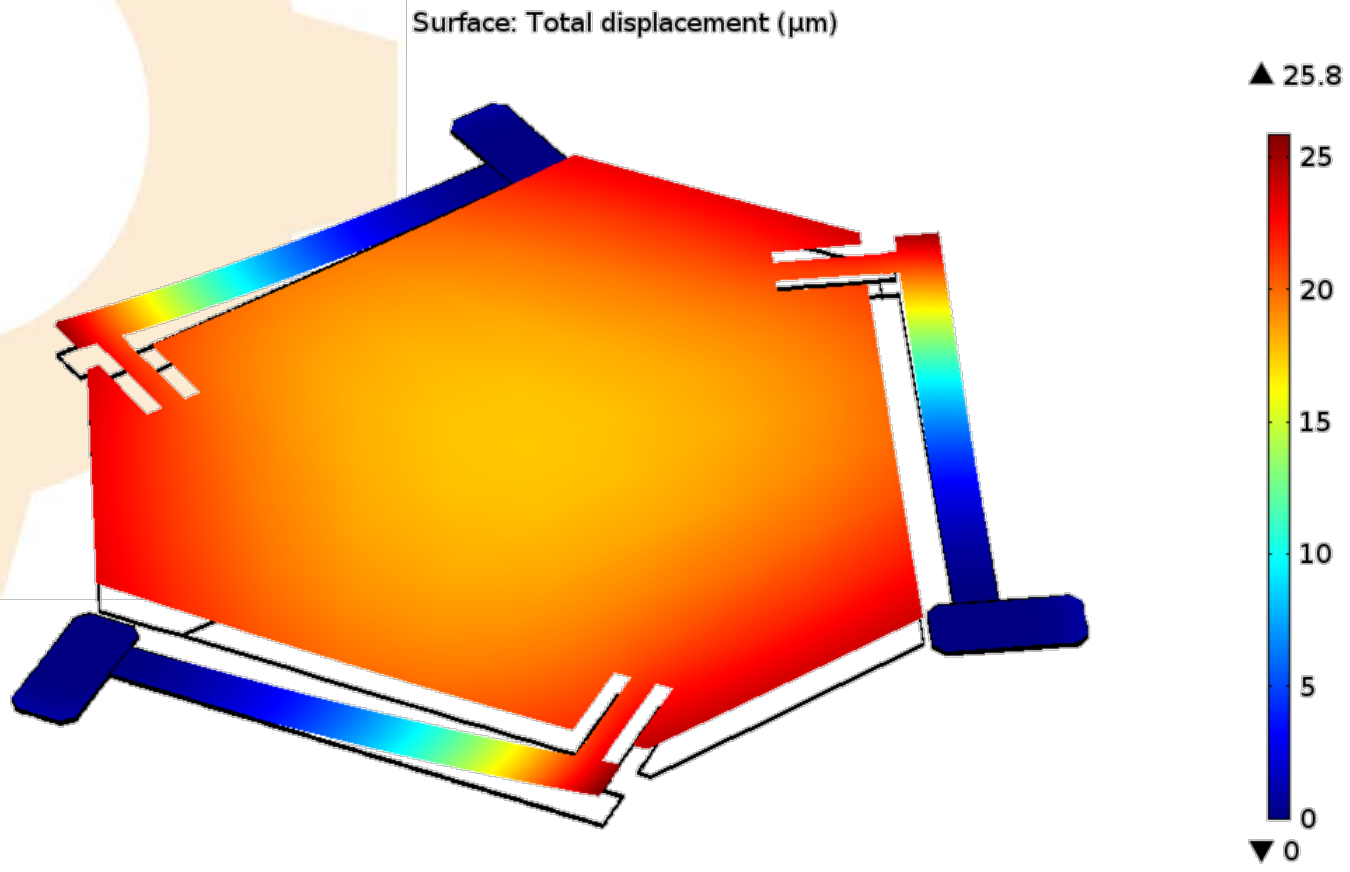


Platform

- Full Platform
- Multiple material layers
- Study effects of removing geometric details
- Mesh refinement study



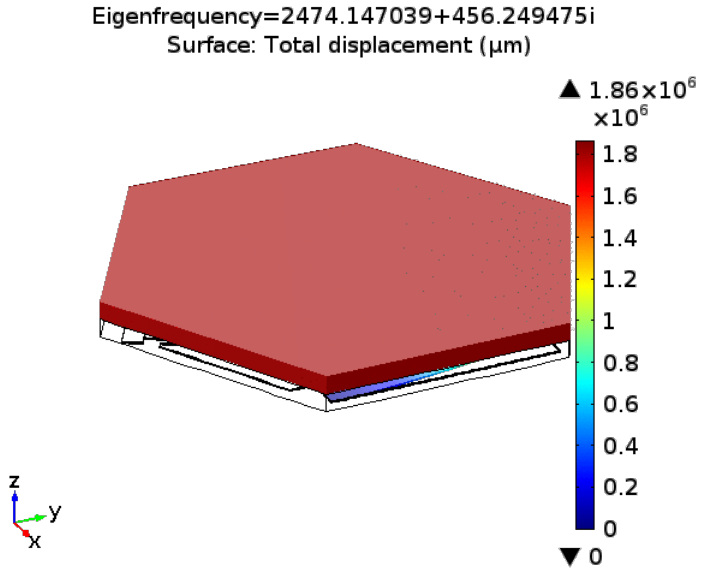
Platform Results

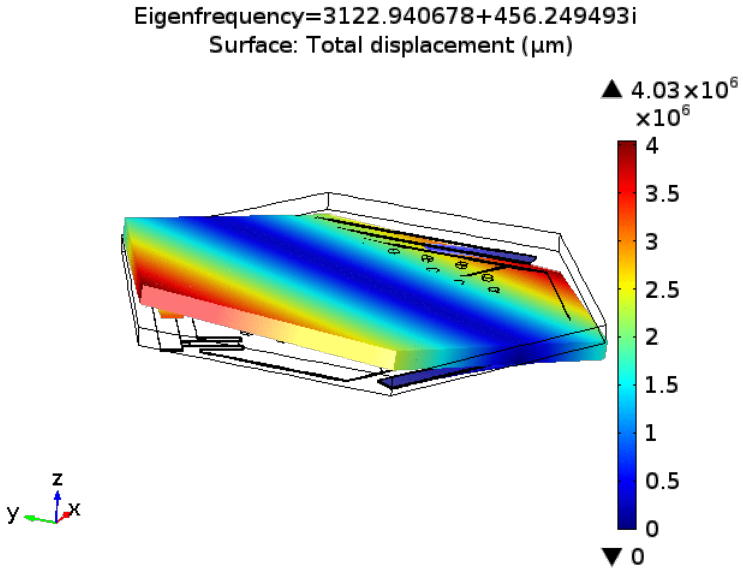


	Location [um]		Displacement [um]	
Point ID	**X**	**y**	**As-Measured**	**Analysis**
1	261	158	25.87	24.31
2	-266	147	24.95	24.15
3	5.9	-305	26.05	24.83

Dynamics

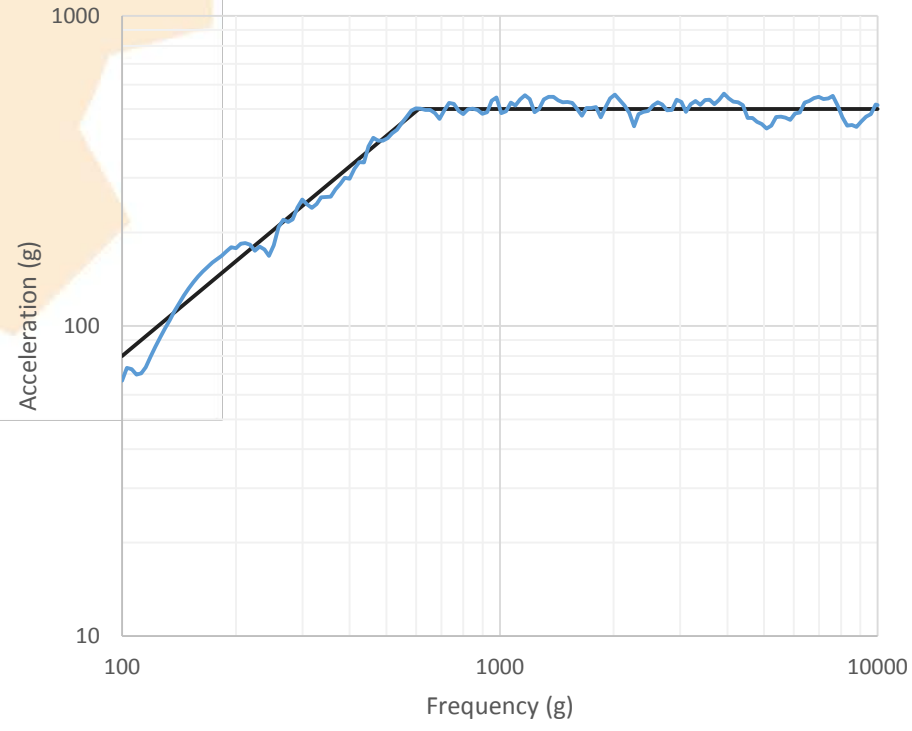
- Verify stiffness and damping
  - Fn = 2470 Hz
  - Q = 2 at first mode

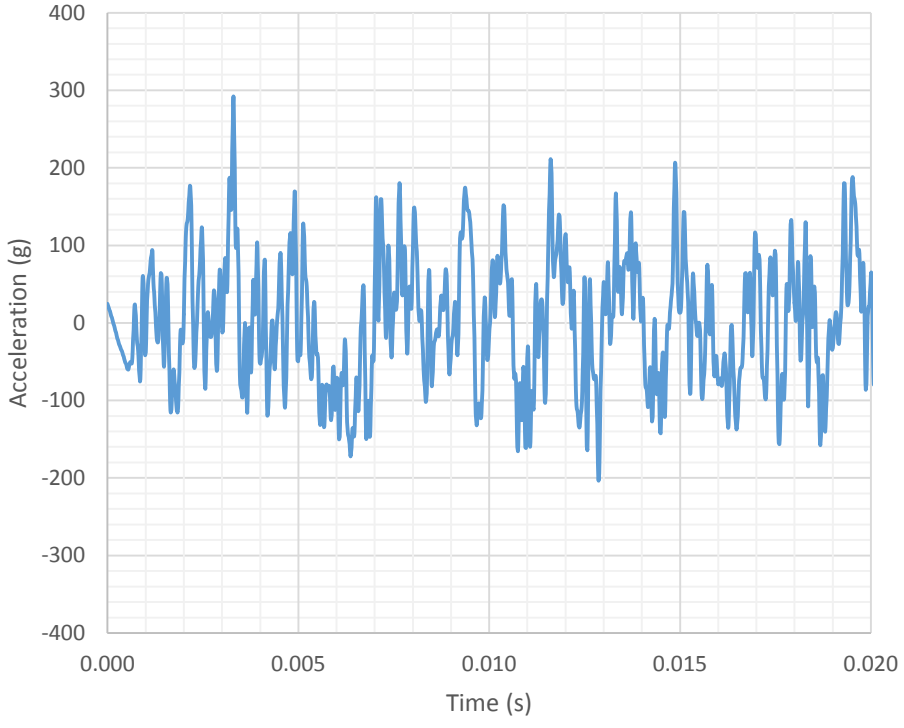




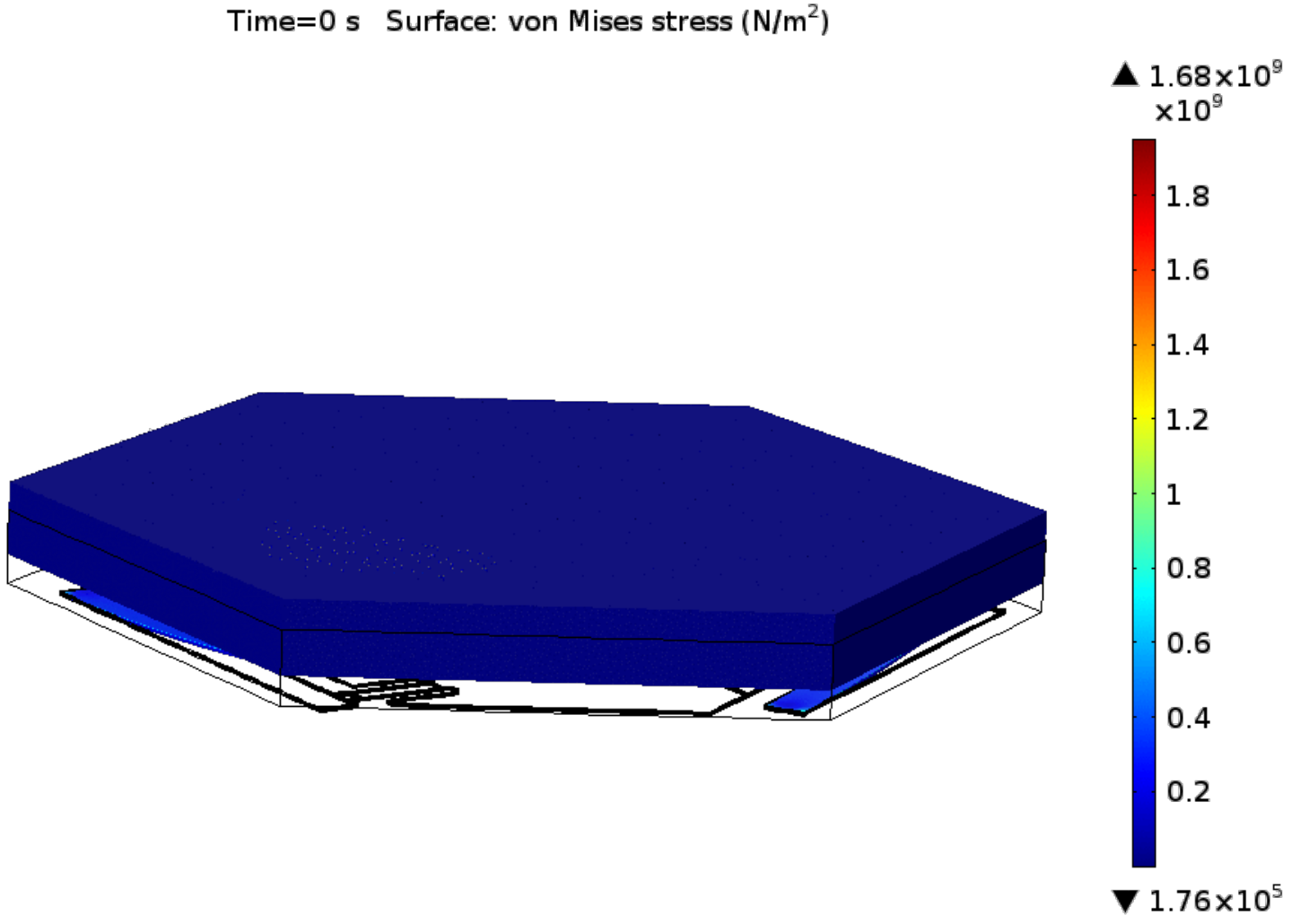
Shock Analysis

- Synthesized SRS

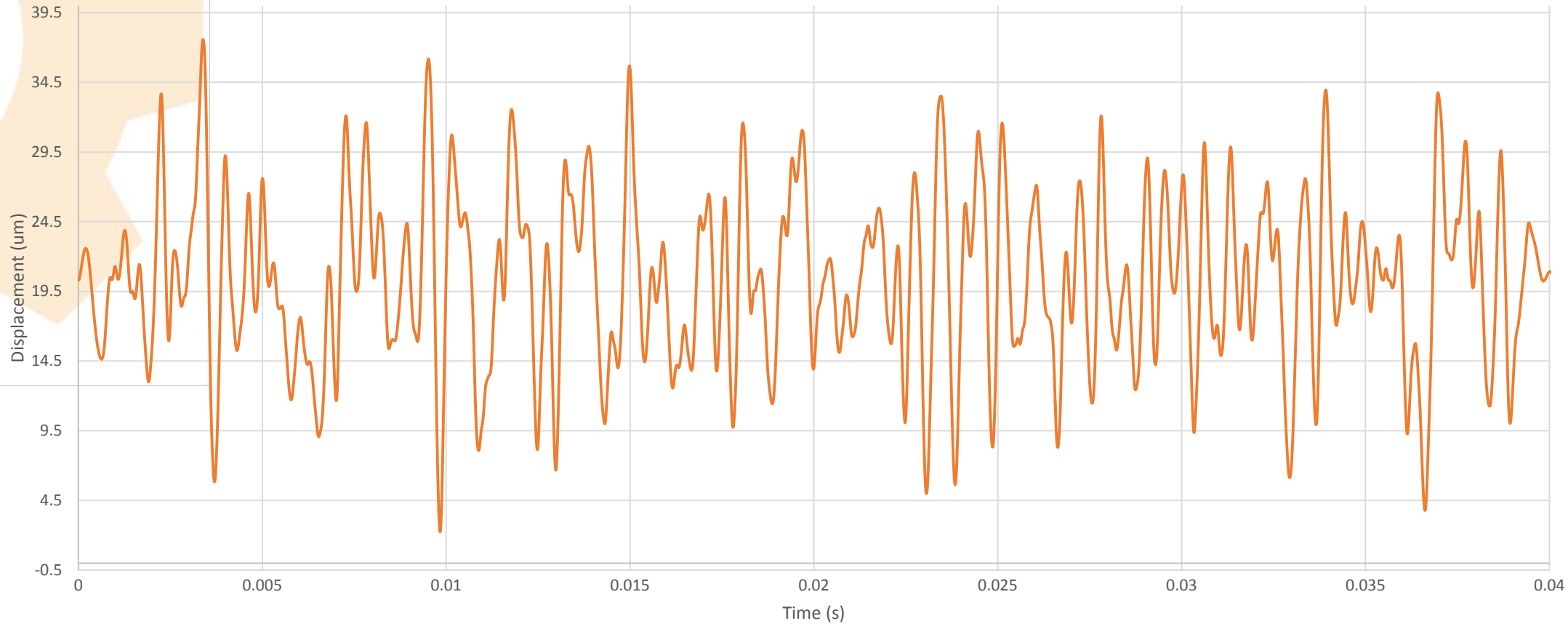




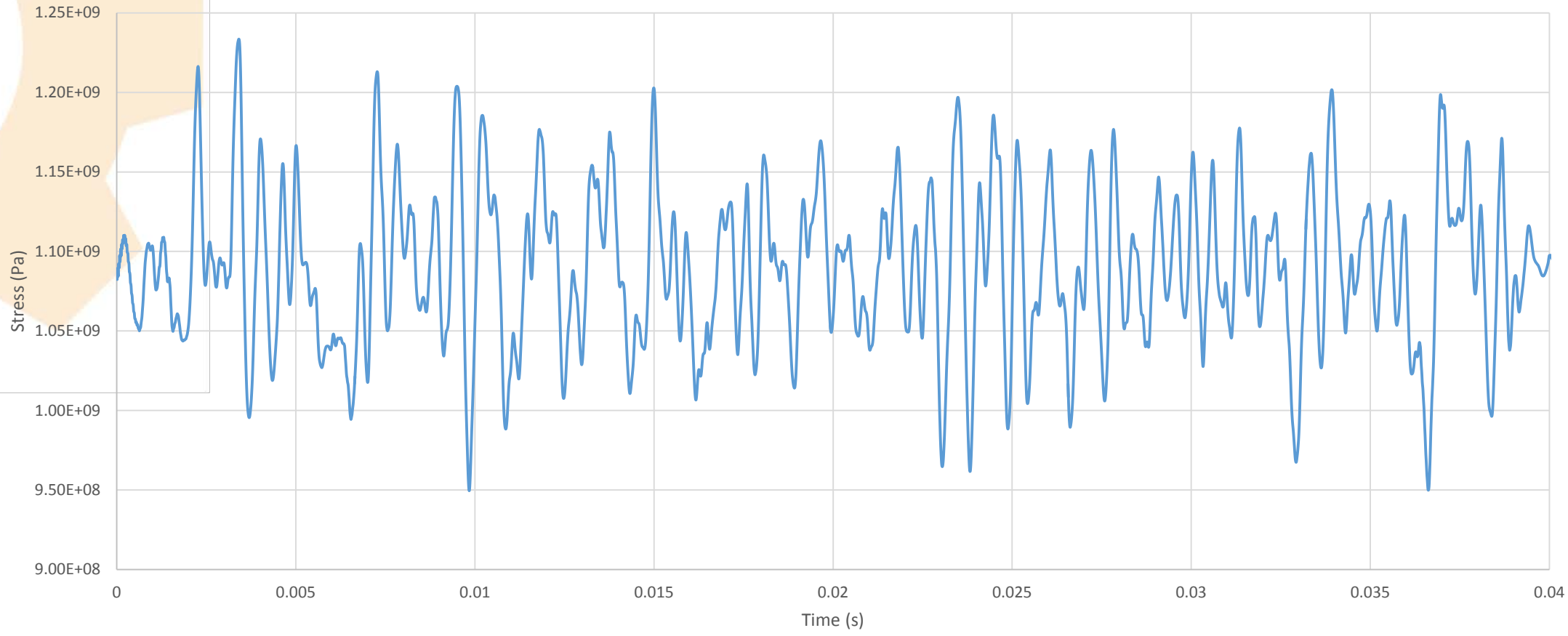
Shock Results



Shock Results - Displacement



Shock Results - Stresses



Conclusion

- COMSOL is being used to guide the design of a MEMS Mirror
  - Material and dynamic properties have been correlated
  - Model can be used to predict behavior in various spaceflight environments
- Future analysis and correlation will be performed as further tests are performed
  - Vibroacoustics
  - Random vibration