Performance Evaluation of a Parallel Cantilever Biaxial Micropositioning Stage

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Intelligent Systems and Precision Engineering Divisions
Manufacturing Engineering Laboratory
National Institute of Standards and Technology

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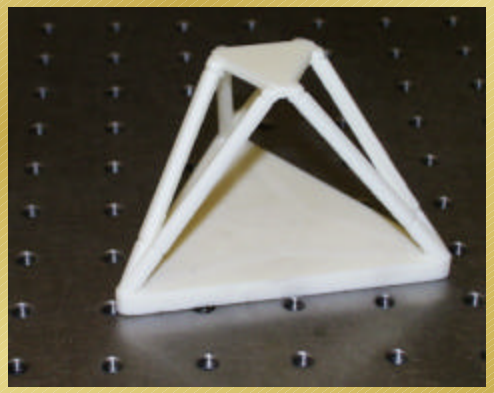
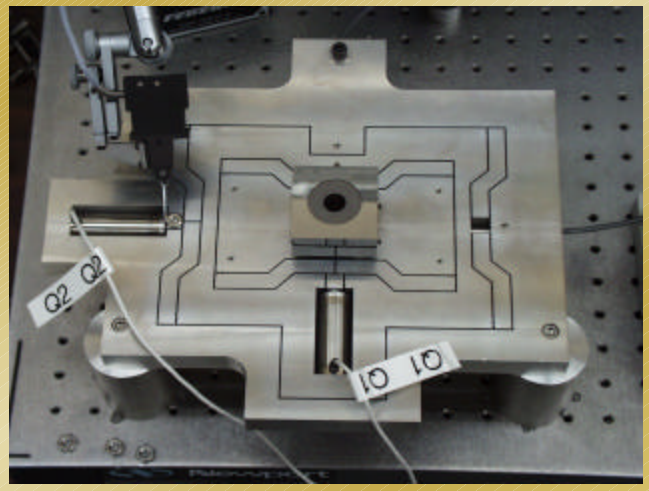


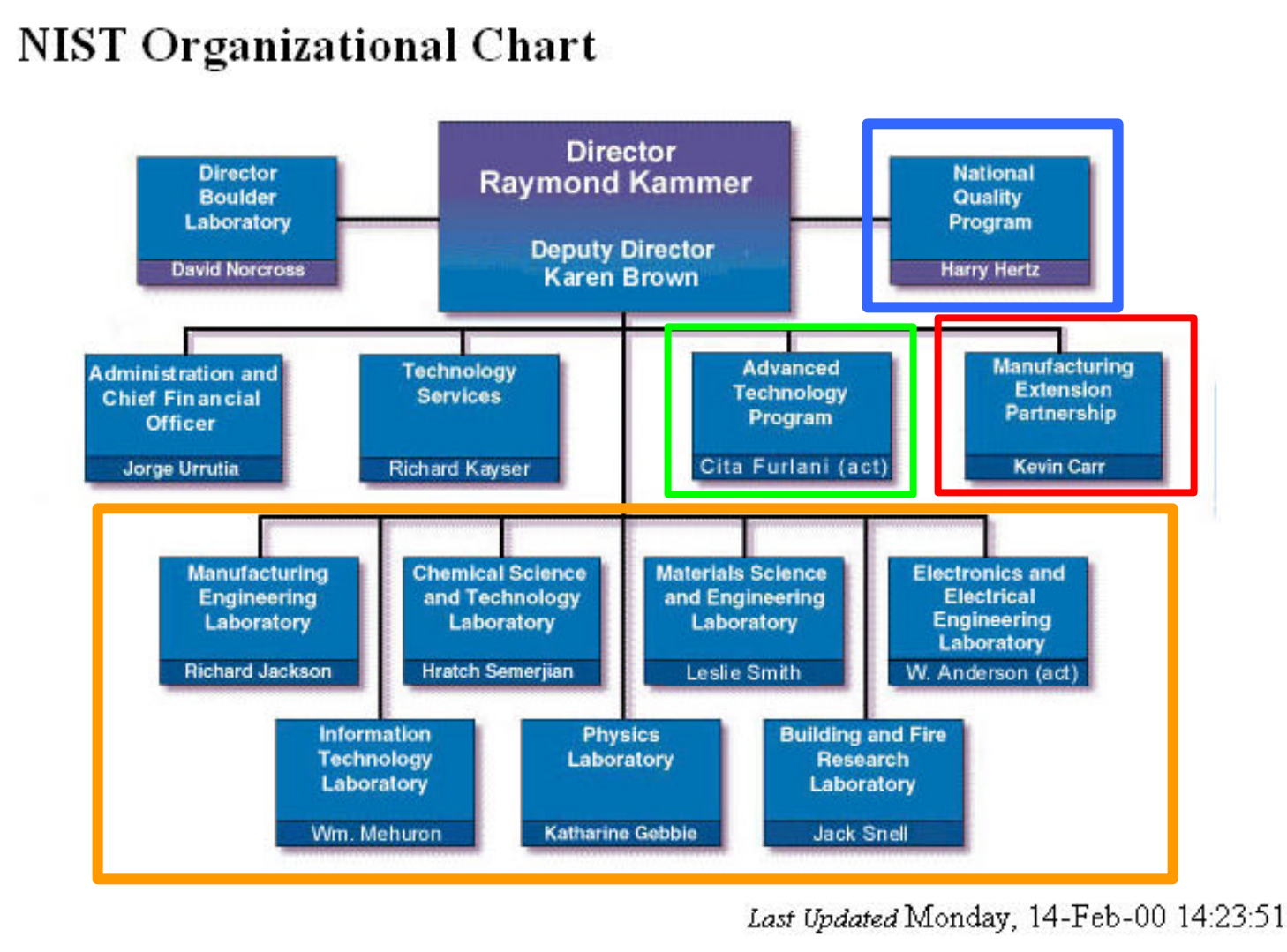
Outline



- Project Background, Research Objectives
- System Overview
- Planar Micro-Positioners: Models, Performance Testing, and Calibration
- Future Work, 3D Space Micro-Positioners
- Summary

Project Background and Research Objectives

National Institute of Standards and Technology



Precision Optoelectronics Assembly Consortium

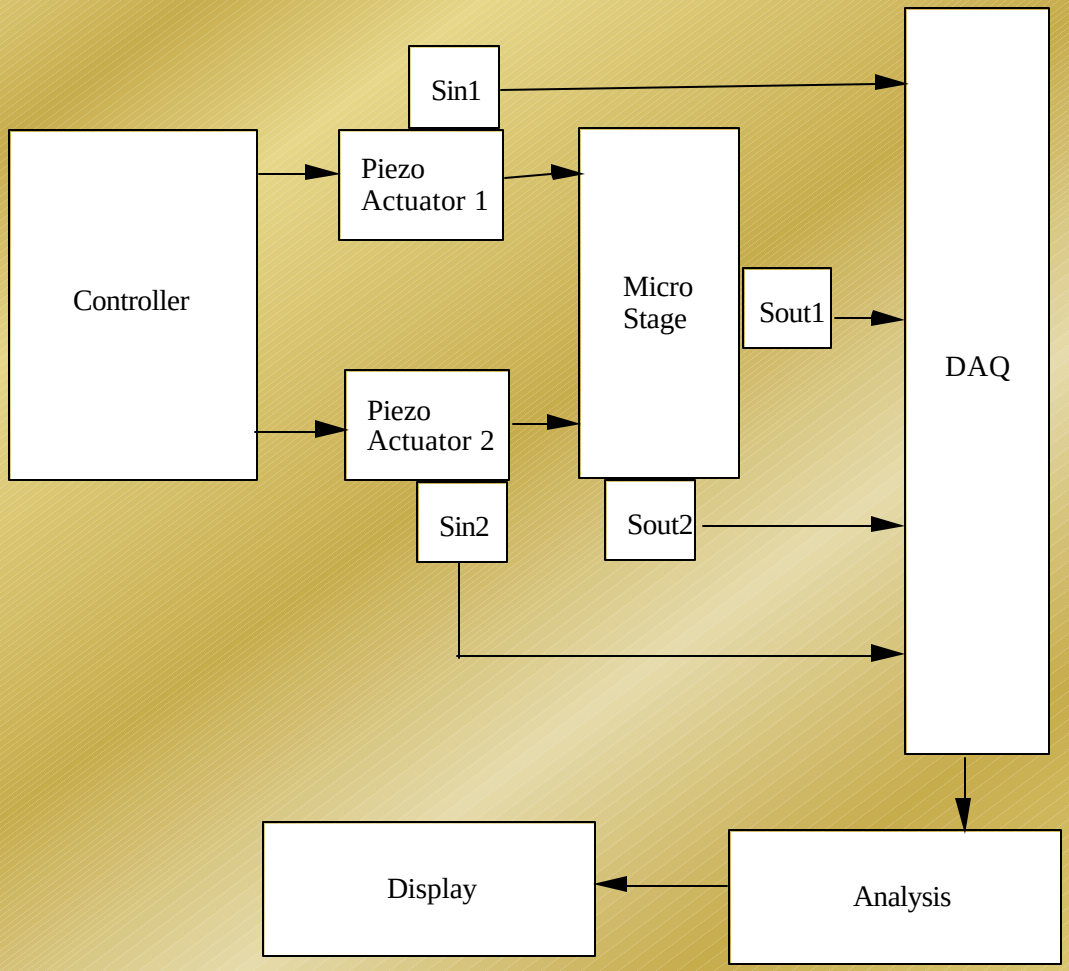
Adept Facility, September ‘99, Final POAC Meeting

NCMS, Adept Technology, Inc. , Boeing Co. , Corning, Inc. , Focused Research, Inc. , SRI International , NJIT, NIST/MEL, NIST ATP present for final meeting.

Objective: Performance Testing and Calibration of Micro-Positioners for Meso-Manufacturing

- Develop performance tests, including quick and simple tests, in order to improve the reliability of micro-positioners.
- Develop calibration procedures in order to improve the accuracy of operation of micro-positioners.
- Measure the performance of various micro-positioner configurations, couplings and calibration fixtures.

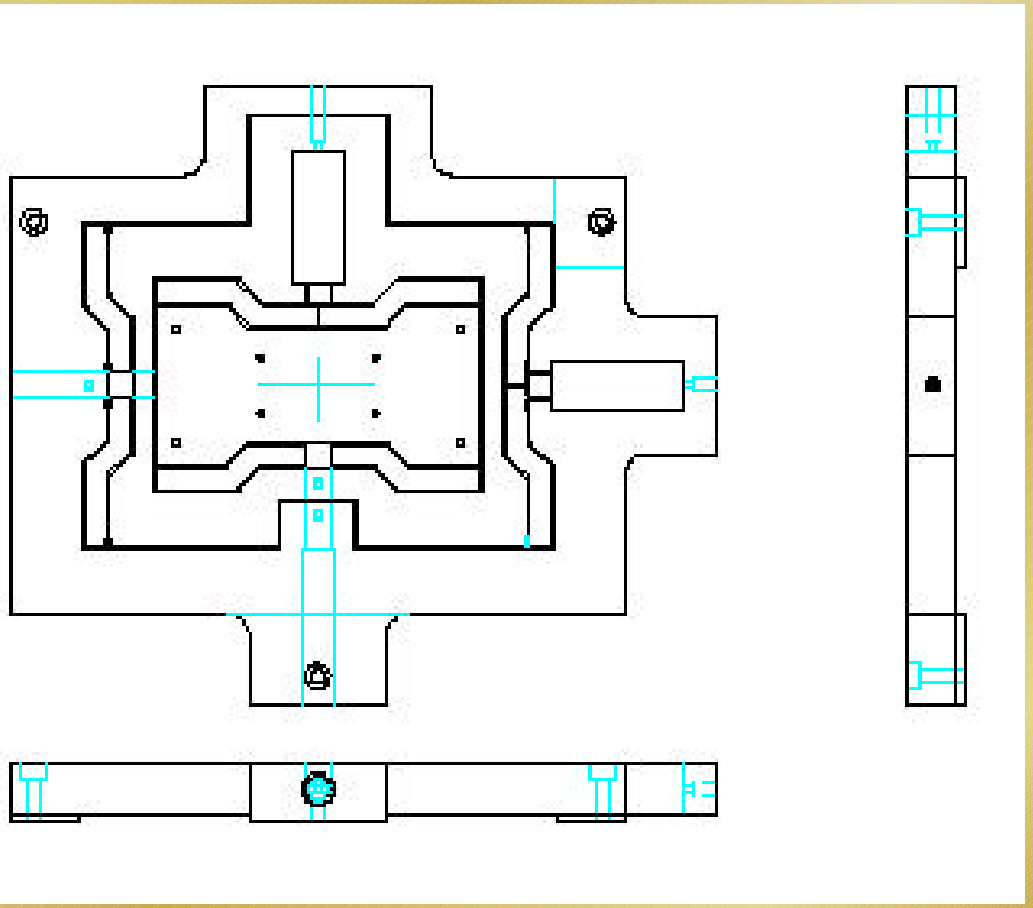
Block Diagram of Testing Setup

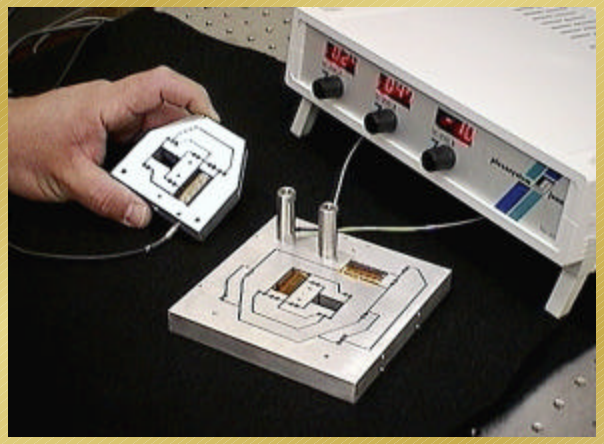


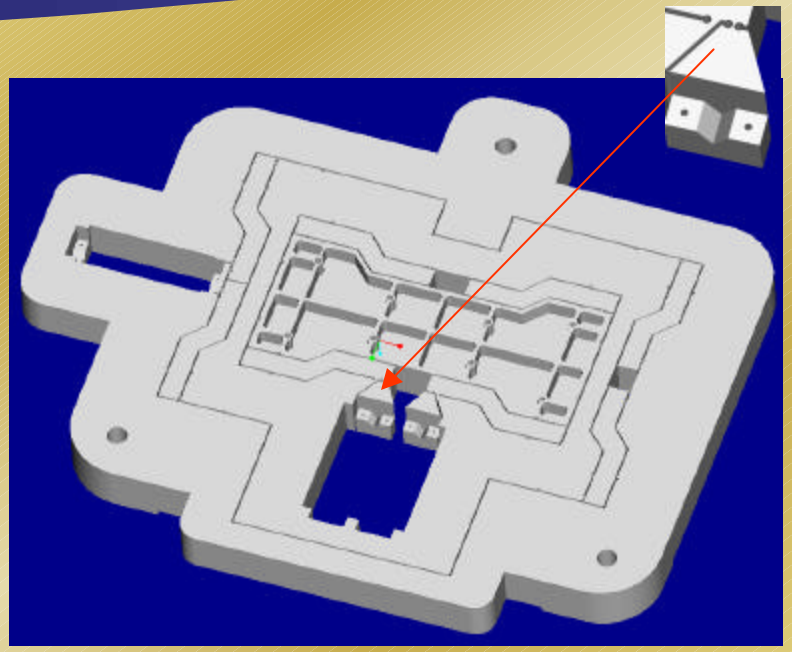
Design Objectives

1. **Improve linearity of the stage structure.**
2. **Minimize off axis motion (cross talk).**
3. **Increase the range of motion of the stage.**
4. **Keep the resonant frequency above a desired level.**

System Overview



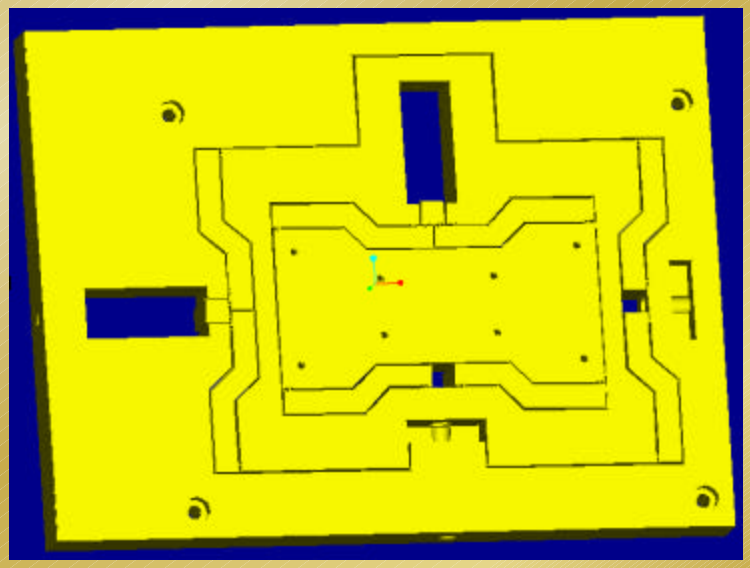




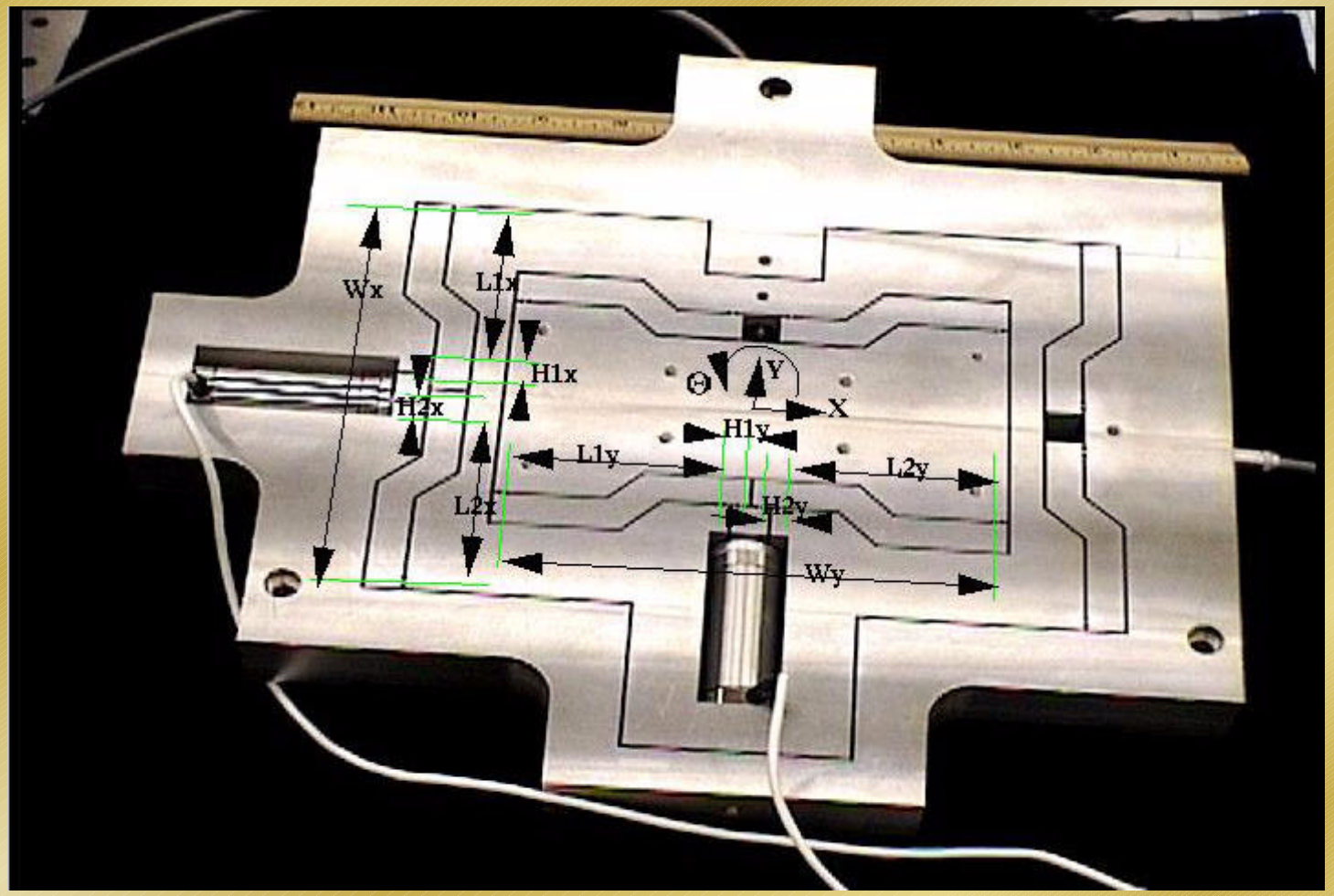
Wye Creek Instruments

Fred Scire, NIST

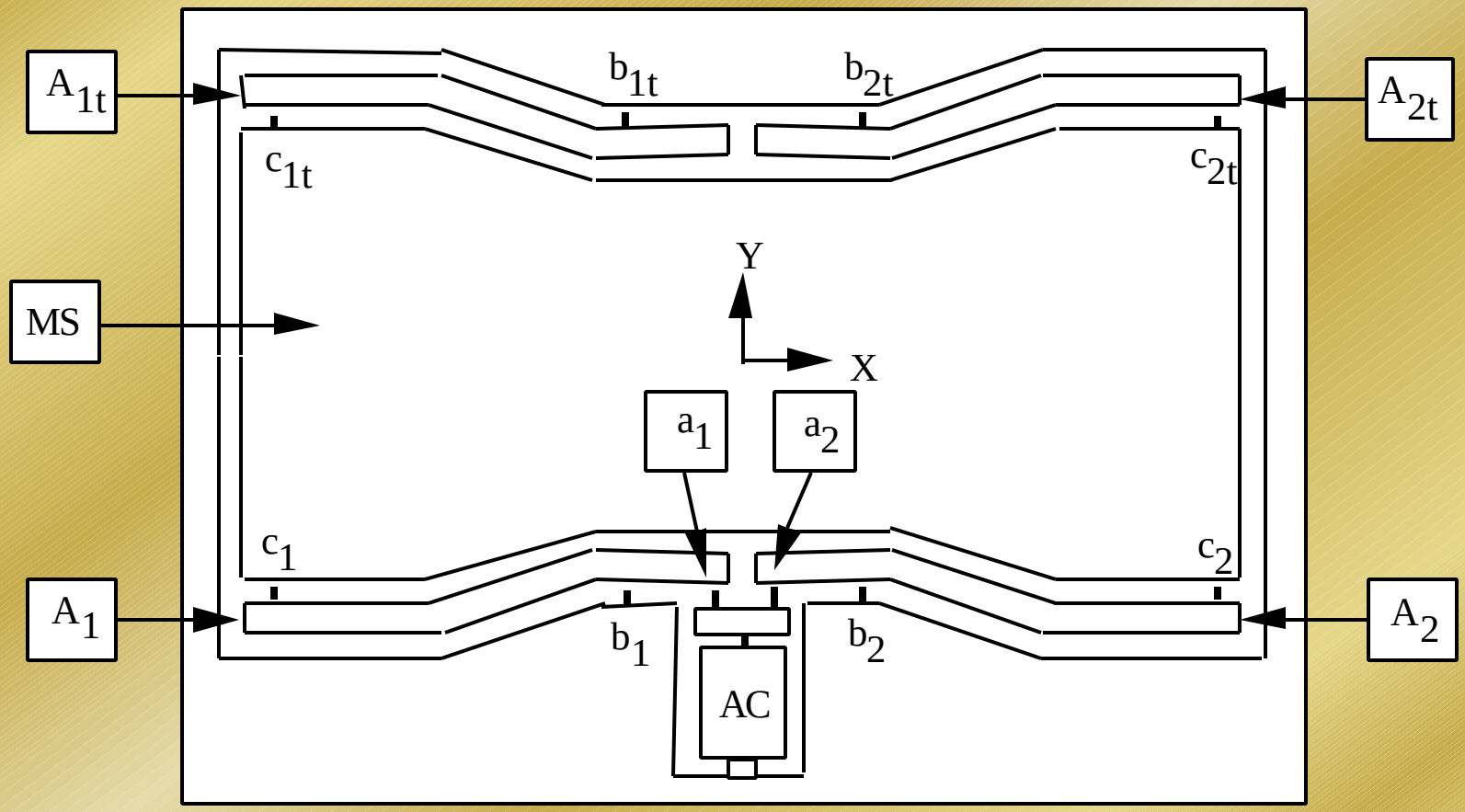
Patented “PiezoFlex”

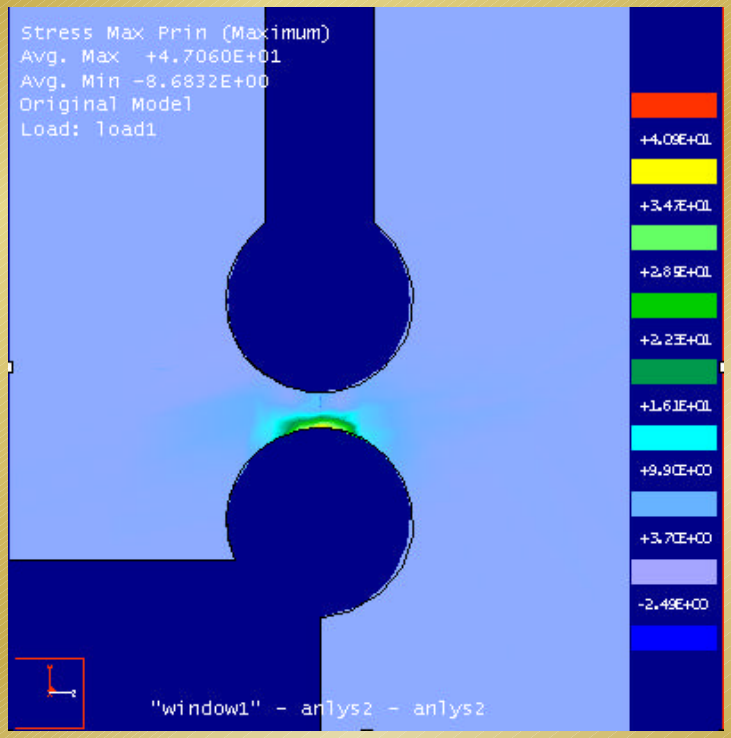


Parallel Cantilever Geometry



Schematic of Y axis





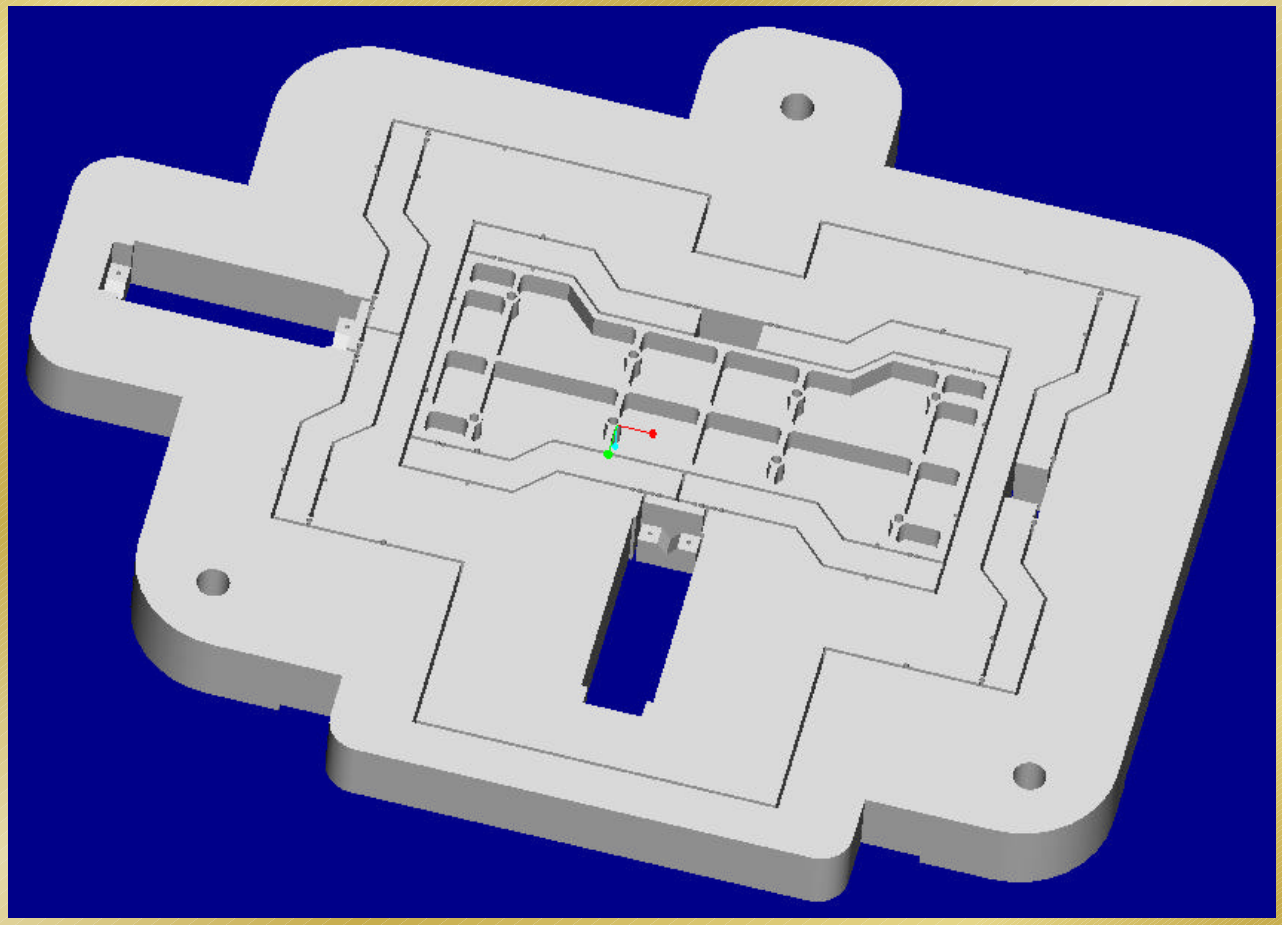
Flexure Analysis

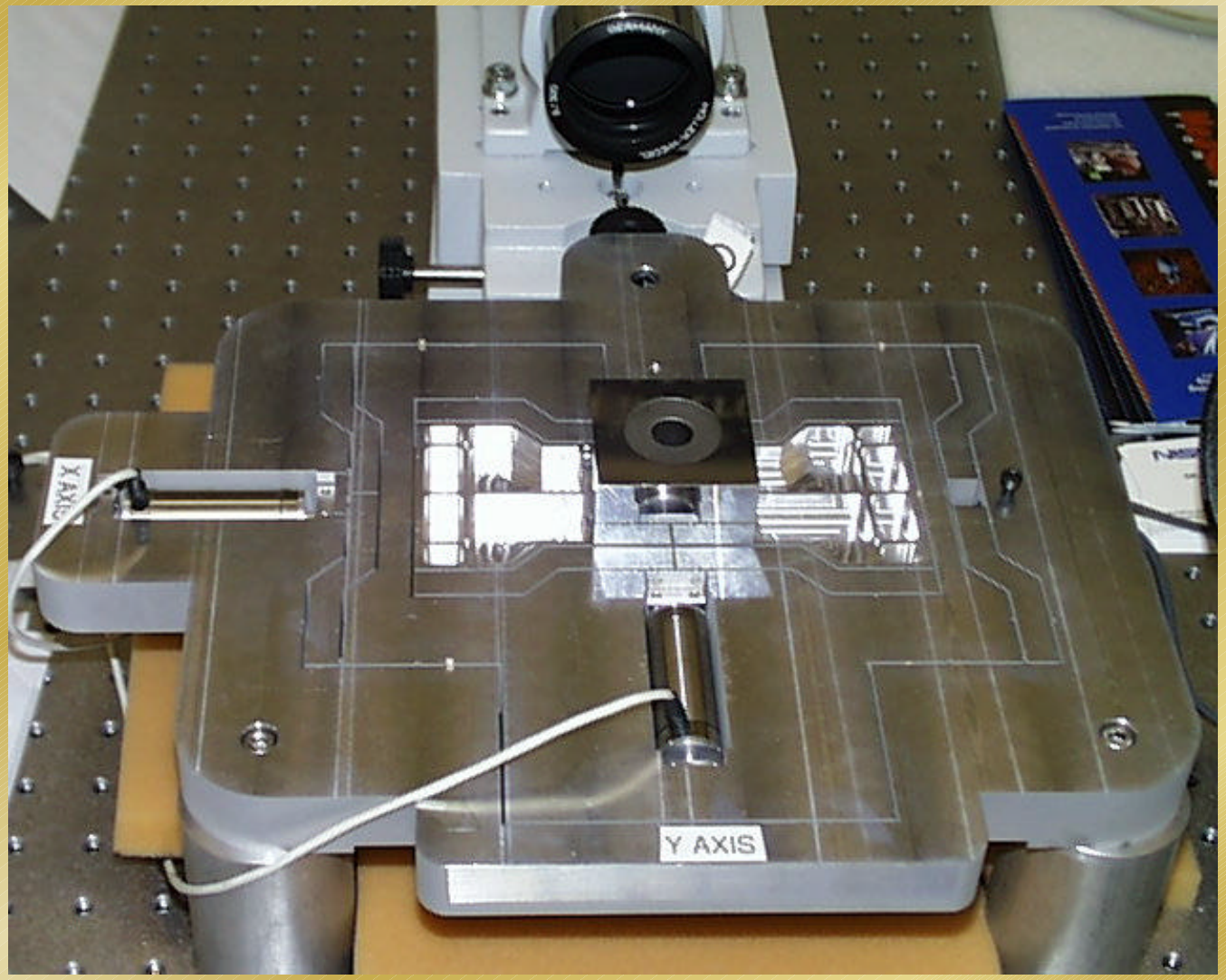
1.7mm holes

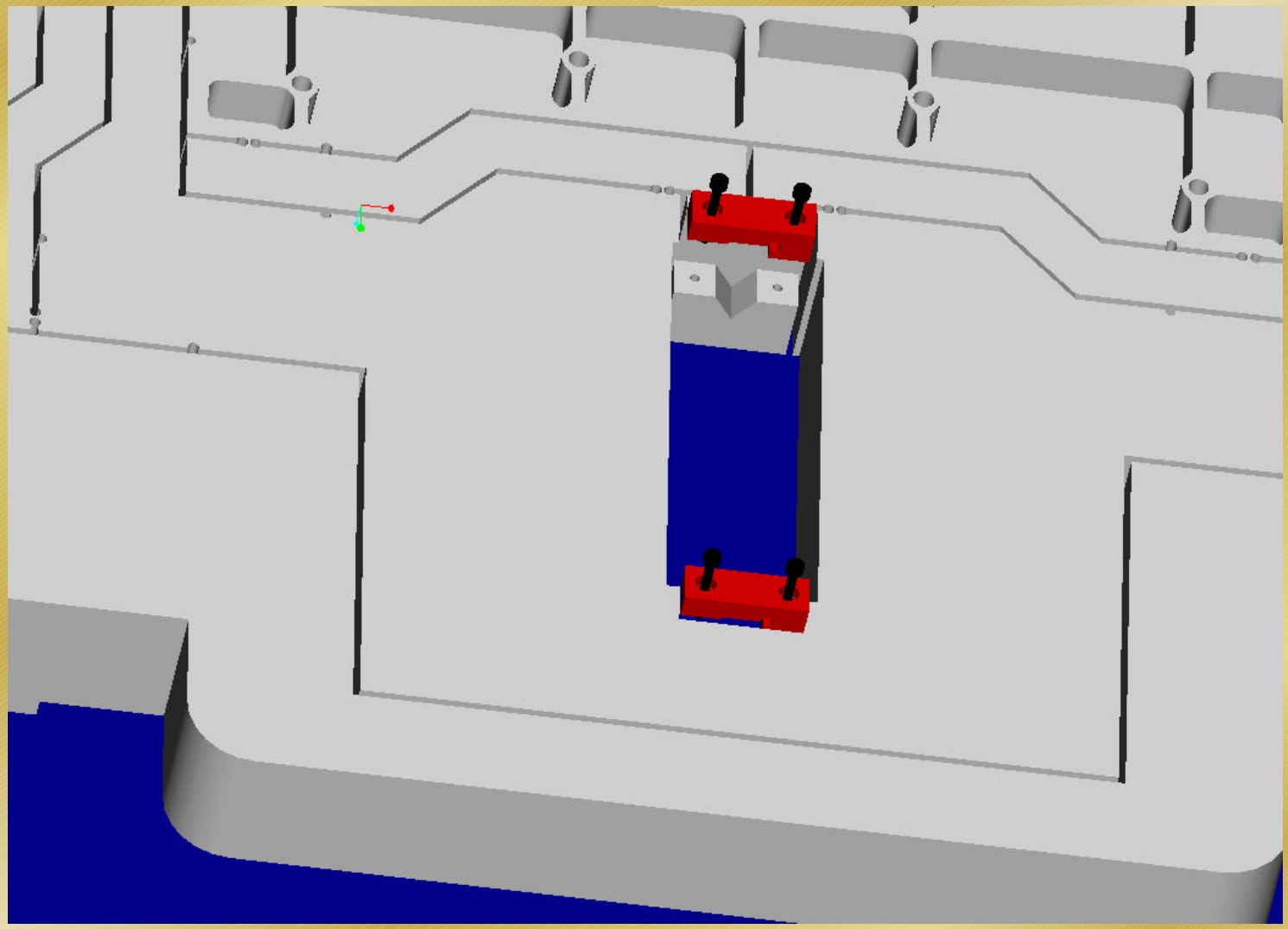
.3 mm web thickness

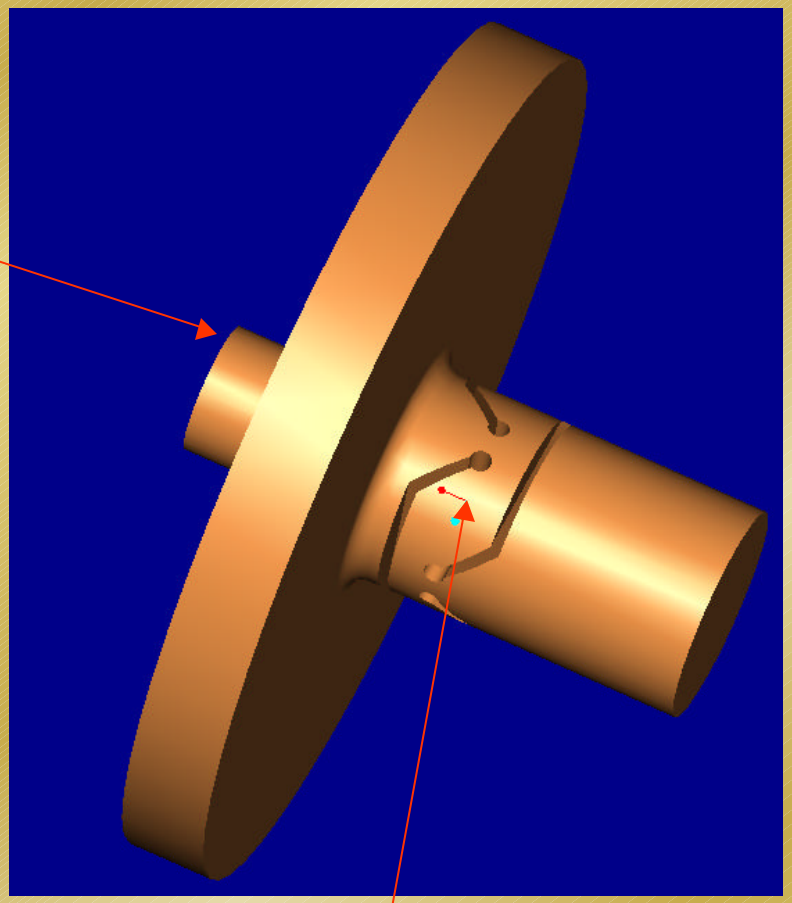
The flexure only experiences a stress of about **47 MPa** illustrated by the fringe pattern for a deflection of 15 micrometers. For **6061-T6 Aluminum**, the maximum yield strength is **255 MPa.** Since we are below this value, the flexure should not yield. BeCu and other materials maybe used to improve performance.

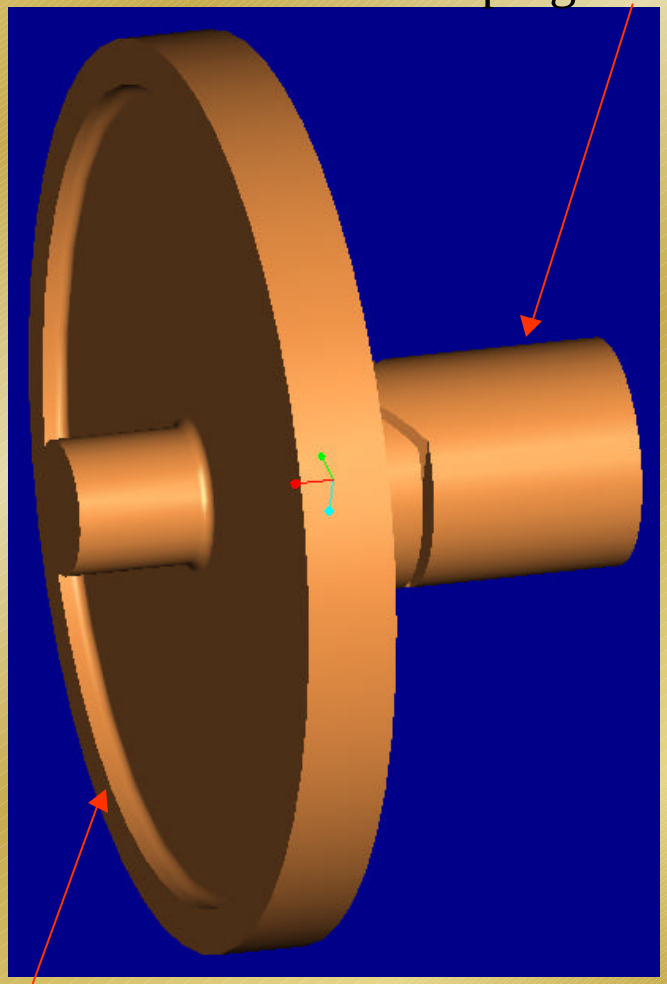
X-Y Microstage Revision




X AXIS
Y AXIS

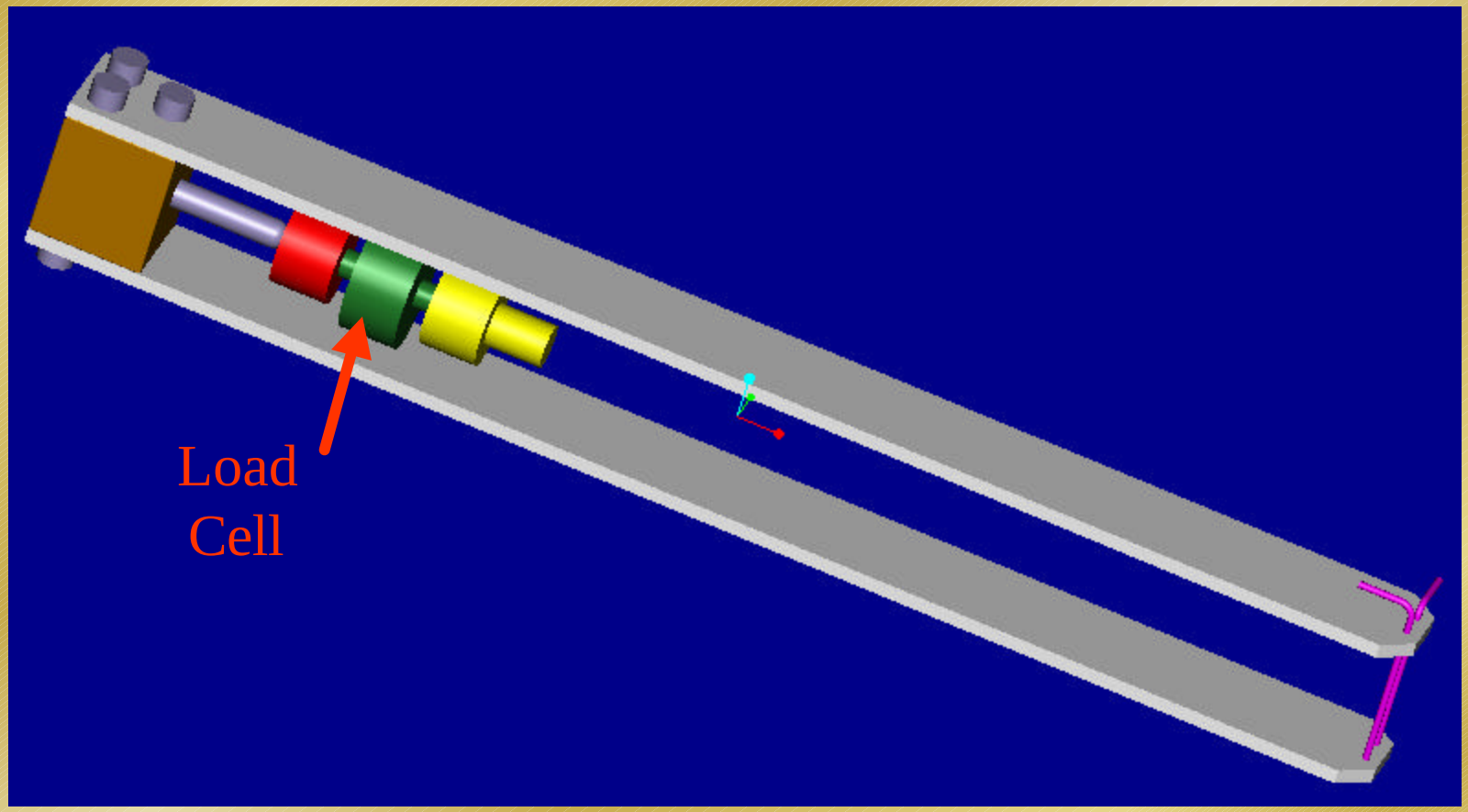






Optimized Coupler for PZTs on X-Y Stage

Pre-Load Mechanism for PZT Assembly



Used for establishing proper Preload on PZT's and determining stage stiffness

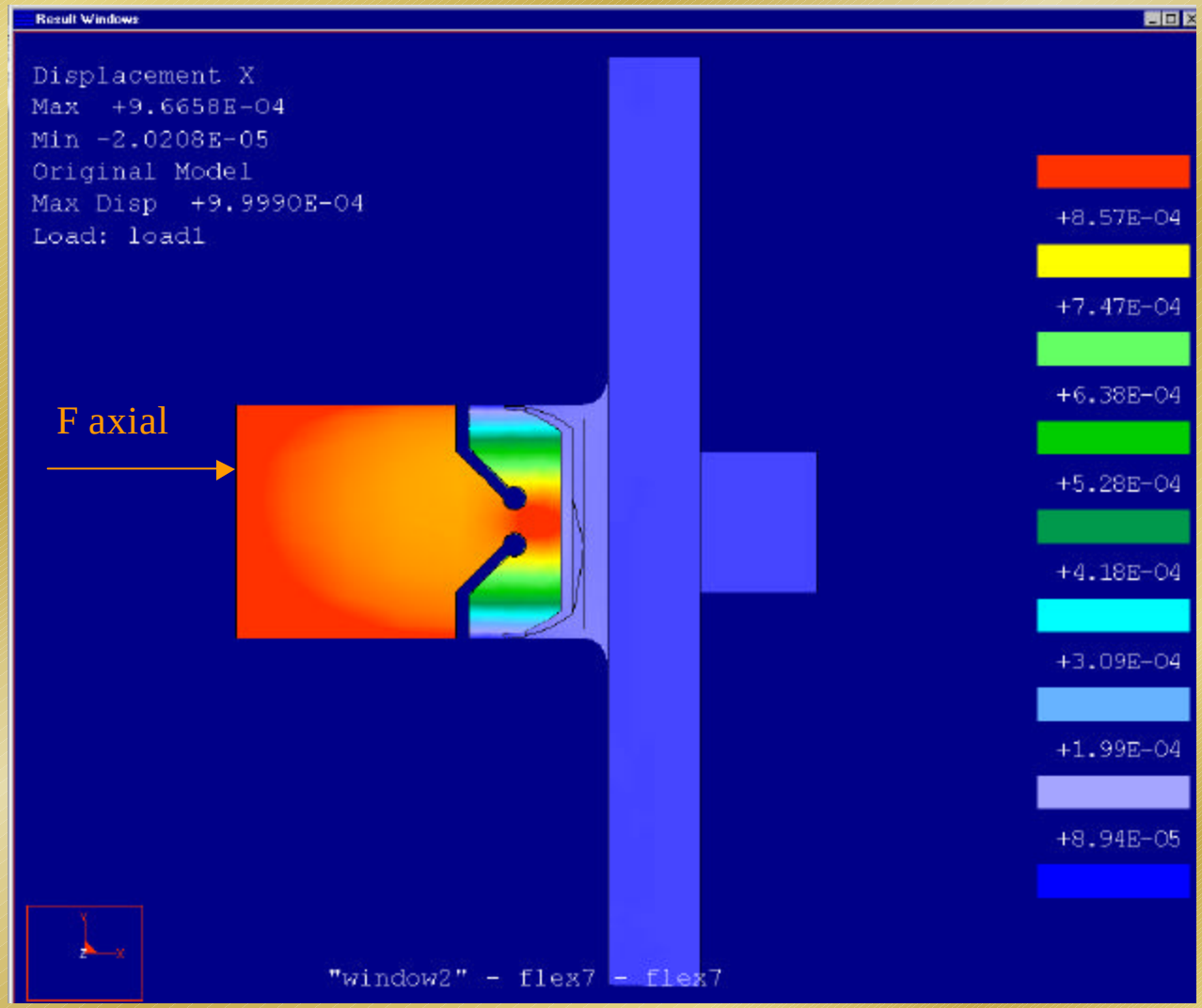
Axial Flexure Displacement

F axial ~ 22.24N

Displacement

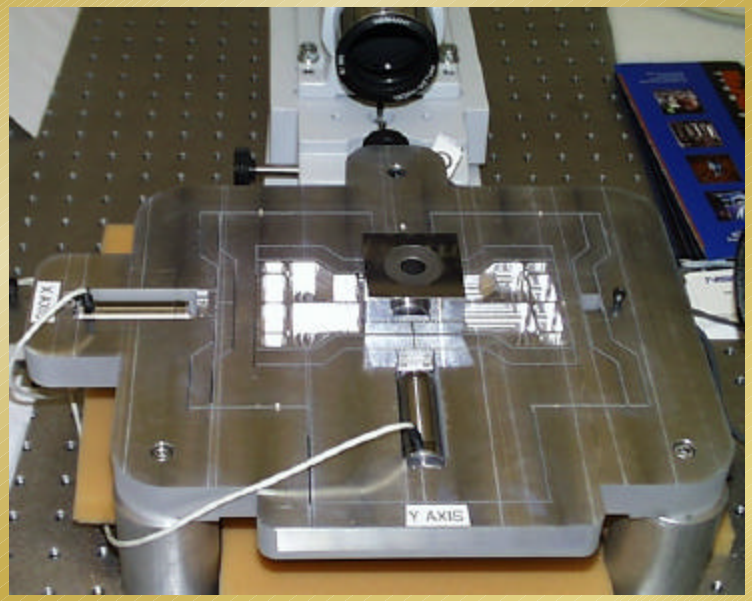
~ 0.00097

or 1 micrometer



Coupler Re-design Conclusion

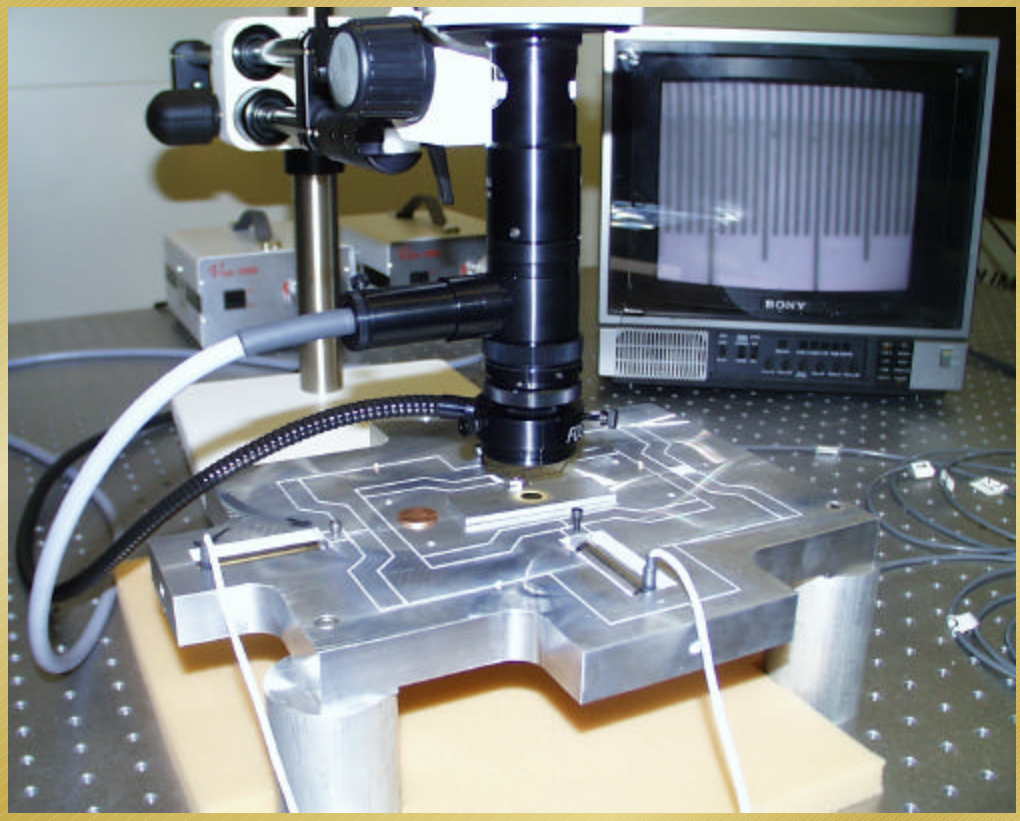
- Old Stage - glued, fixed PZT stacks - .6 arcsec yaw errors
- Old Stage - coupler installed on one side - .3-.4 arcsec yaw errors
- New Stage - couplers on both sides of PZT - .04-.12 arcsec yaw errors



Planar Micro-Positioners: Models, Performance Testing, and Calibration

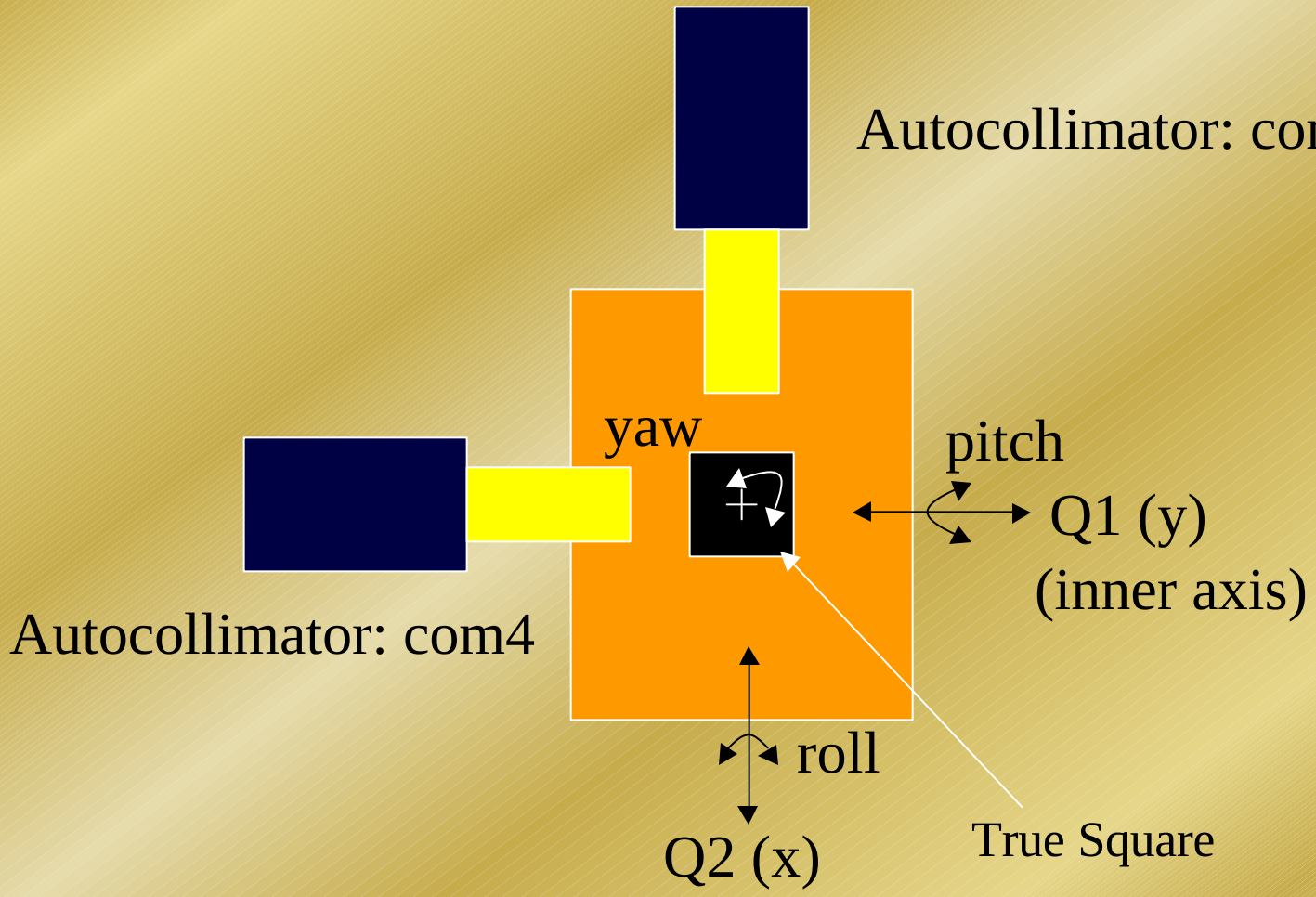
Stage Motion Performance Tests

- X-Y Axes Cross Talk
- Angular Error Measurements
- Stage Linearity
- Mechanical Coupling Transmission Ratio
- Stage Calibration

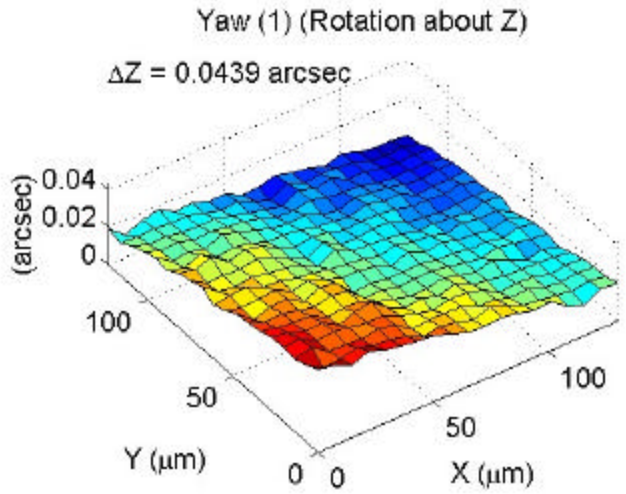


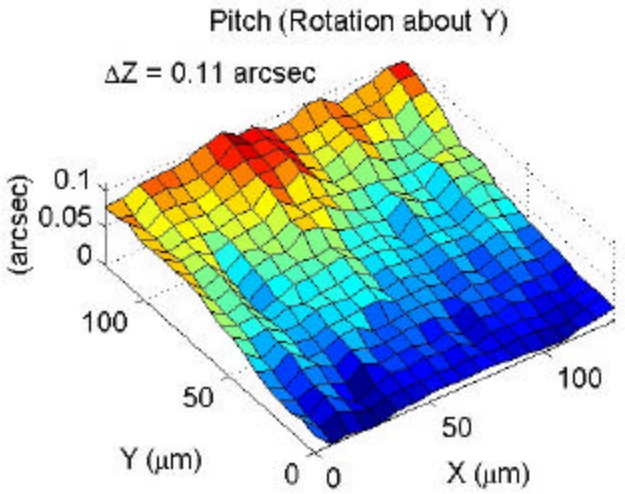
(for example: mathematical models - identify parameters of kinematic model - leads to better control performance.)

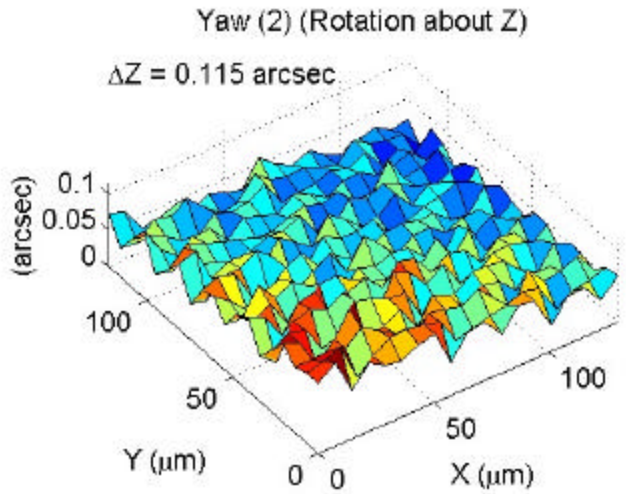
Measurement Setup

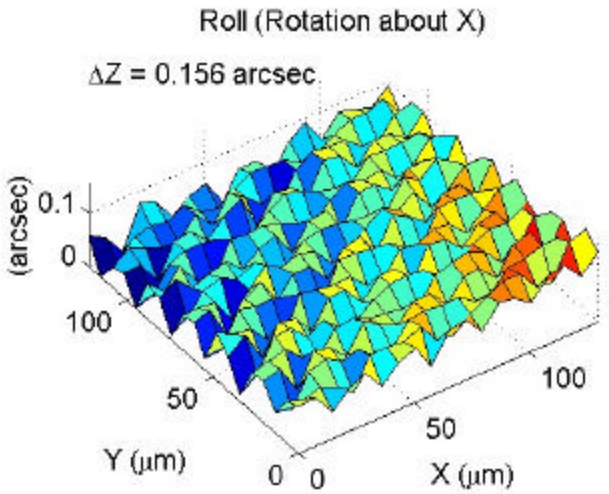


Experimental Set-up for Rotational Error Testing





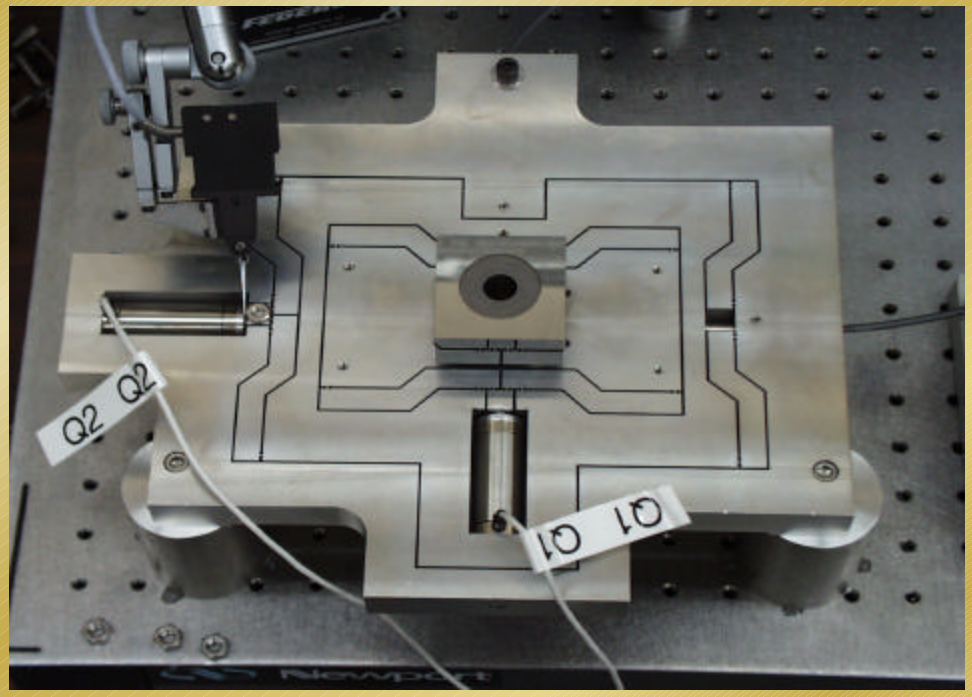




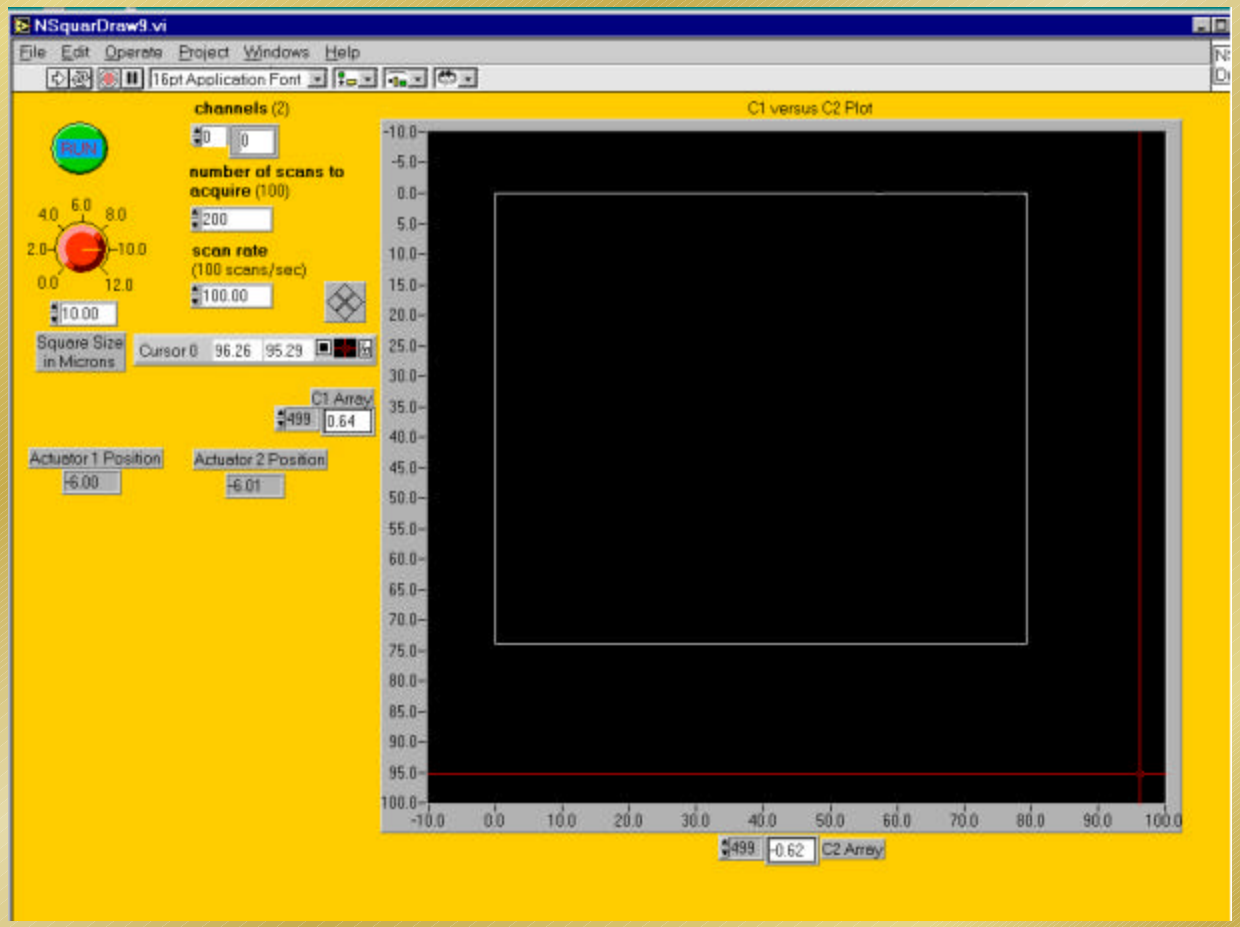
Range of Stage is 130 X 130 micrometers

Axis Crosstalk

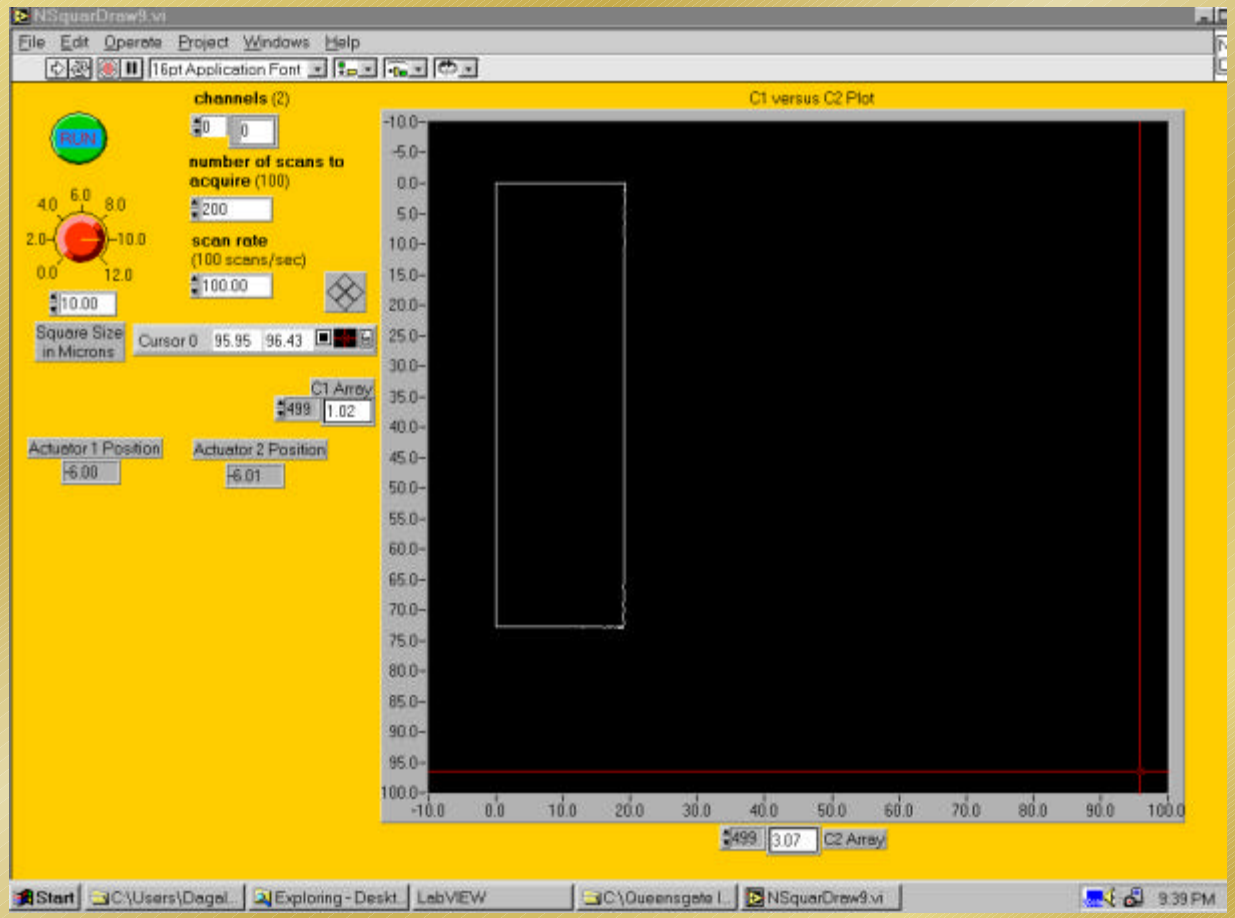
- Static checks indicate crosstalk to be approximately one part in 4000 (25 nm over 100 micrometers) -- on old stage design.



Baseline Control Trajectory

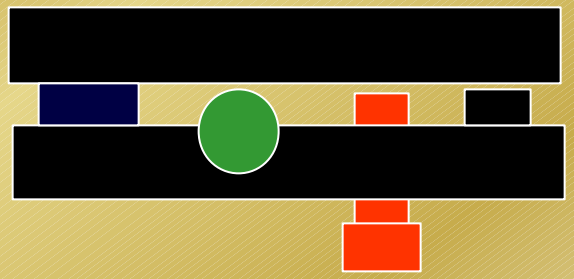


Defective Coupling Control Trajectory

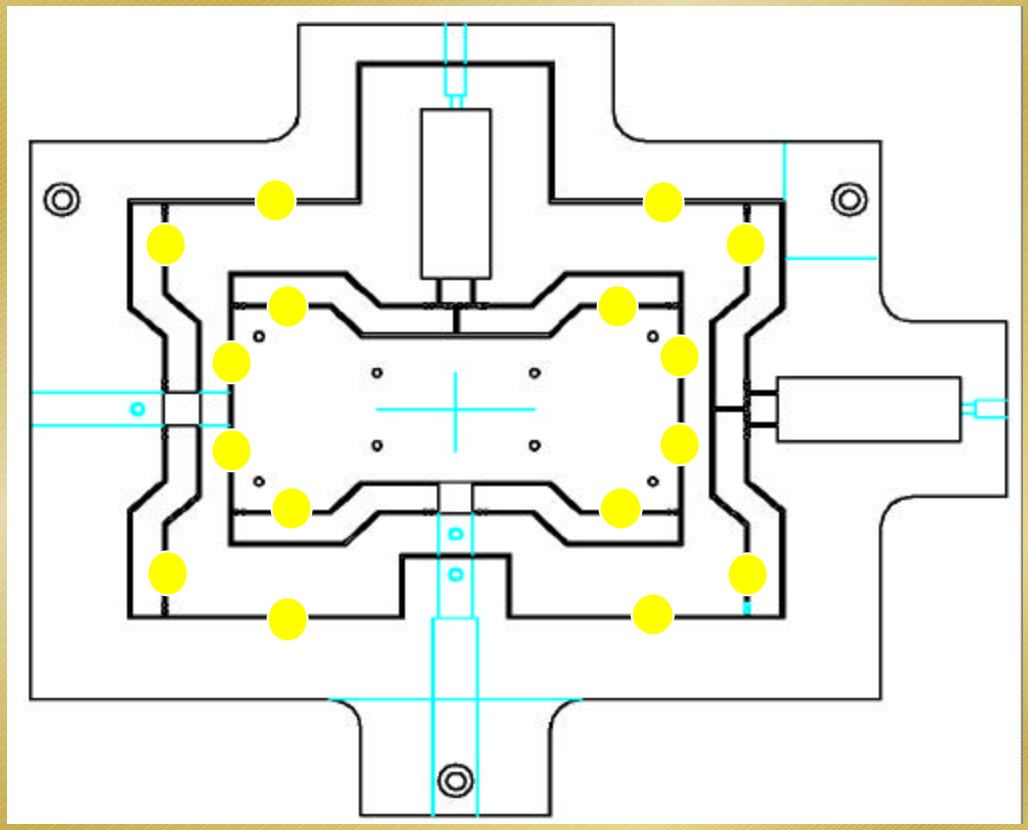


Future Work including 3-D Space Micro-Positioner Designs

Safety Stops



- Elastomer
- Plastic or Steel Rod
- Stop Screw
- Designed/Machined Stop



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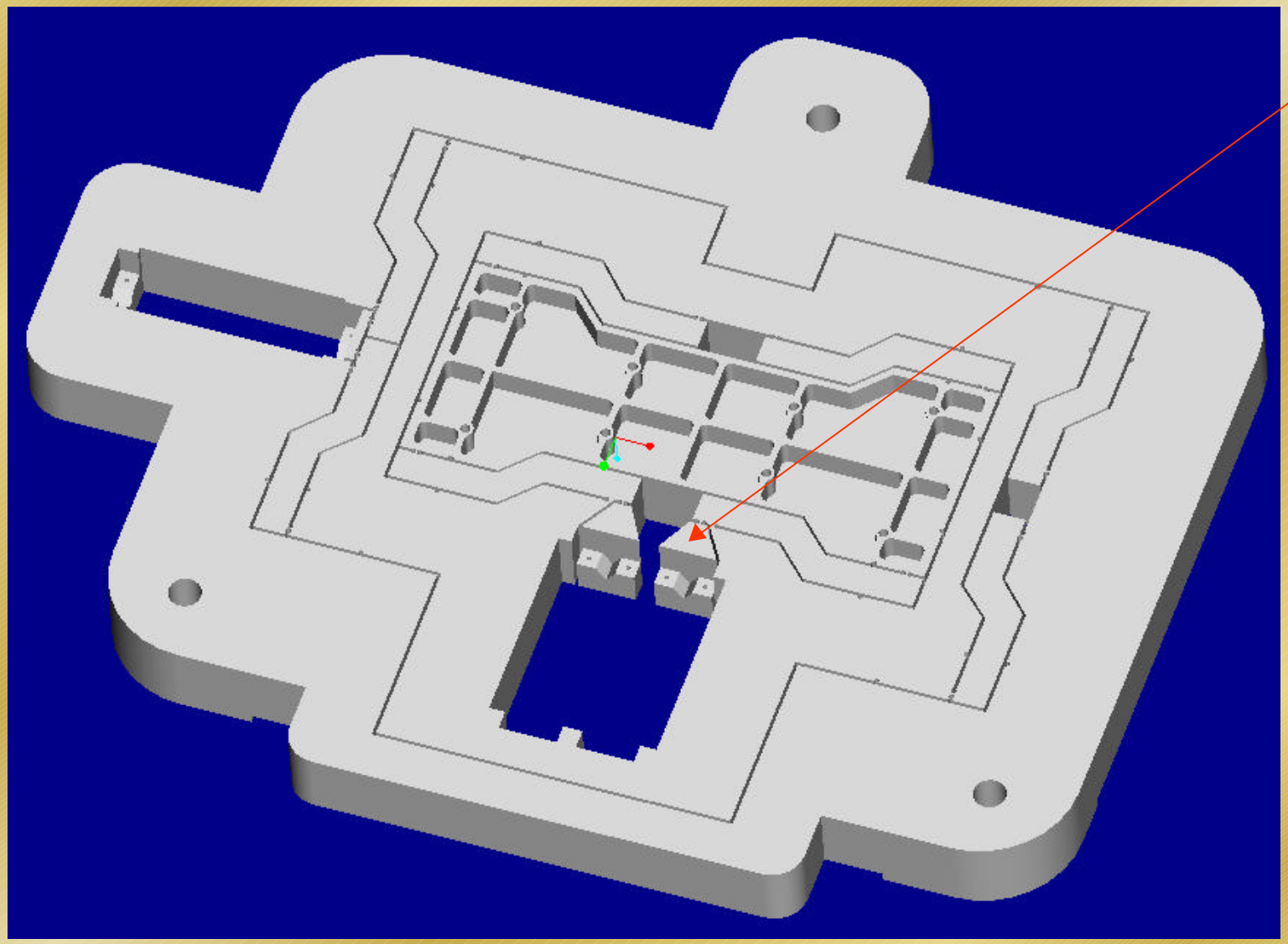

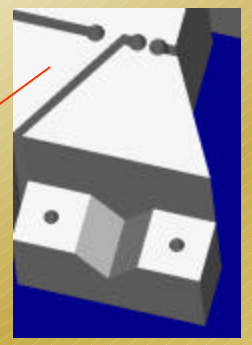

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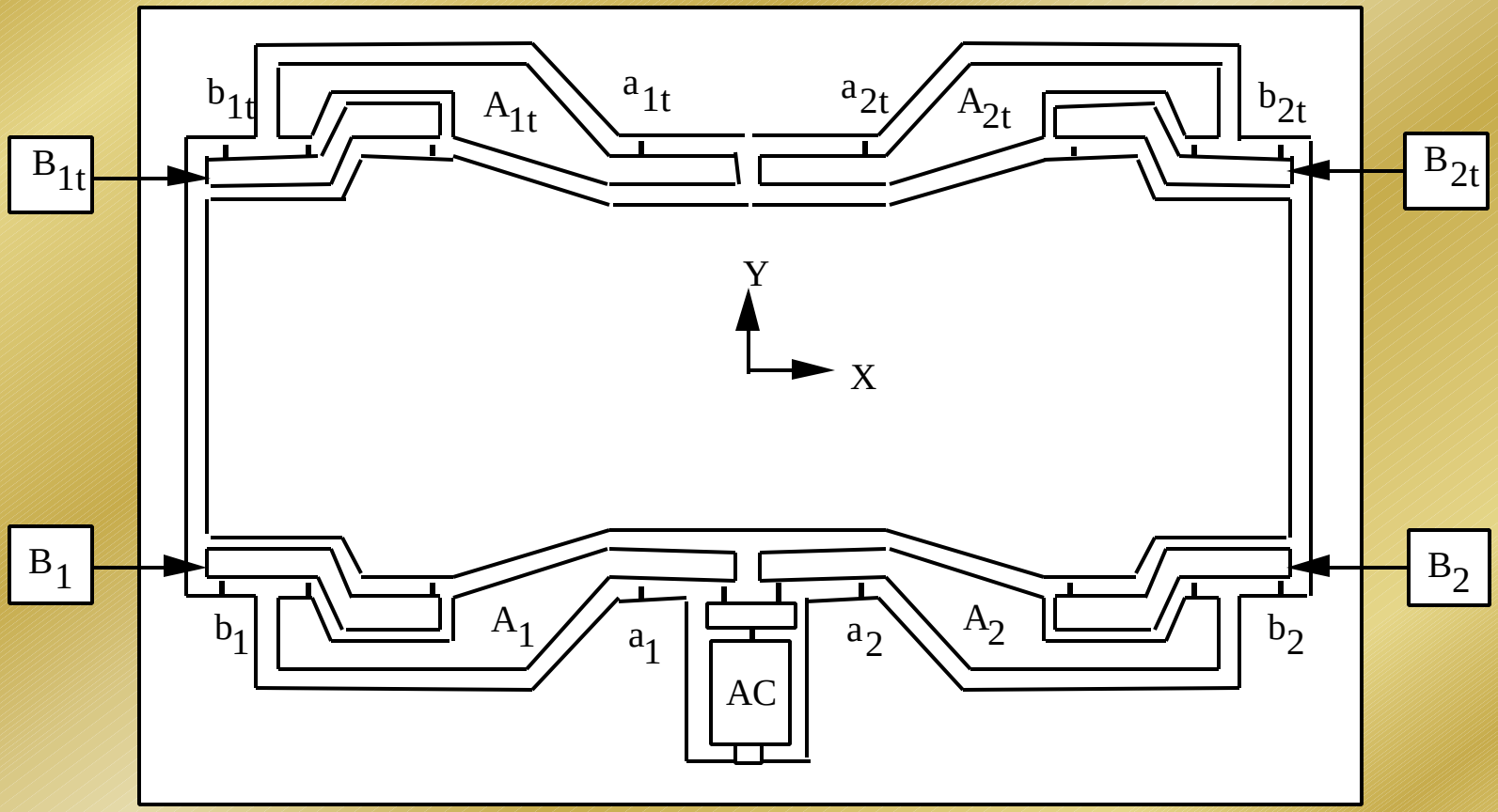
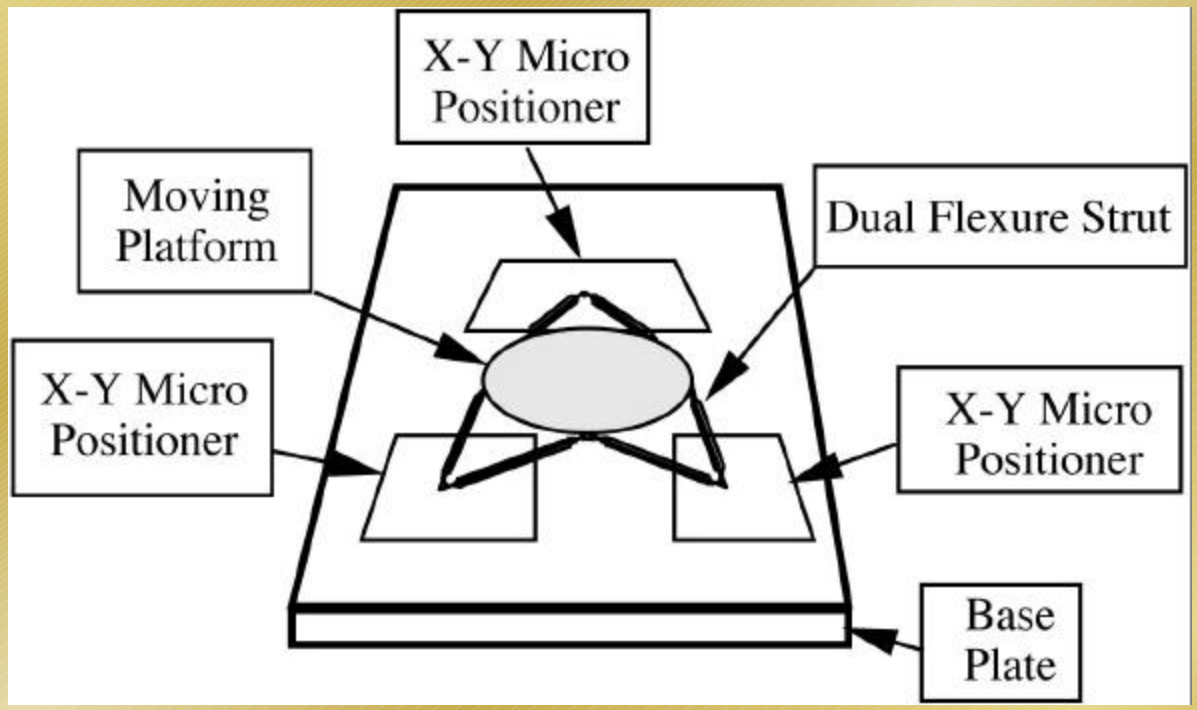
Reduce Size with Compound Cantilevers

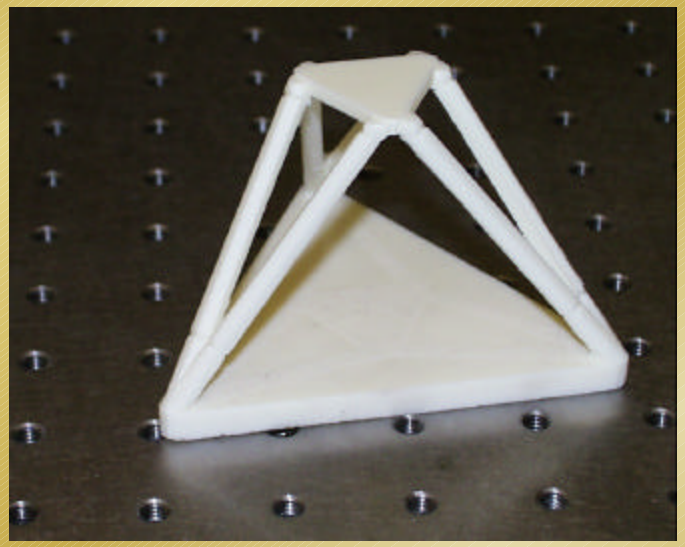


Only shows Y-axis

6-Degree of Freedom Tri Stage Micro-positioner



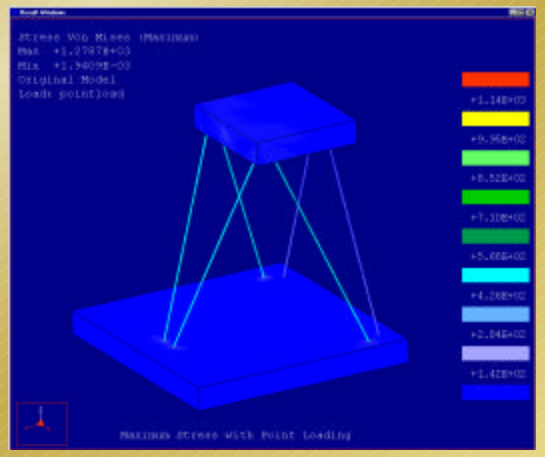
MicroDevices - Performance Measures

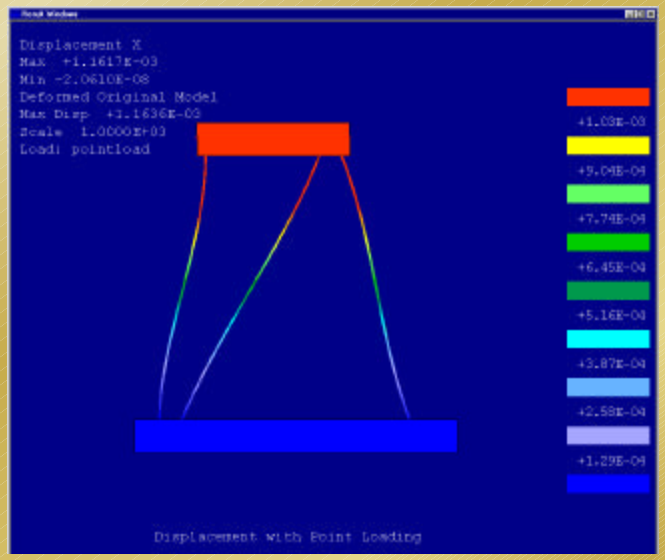


6 Degree of Freedom

Microstage Prototype

Advanced Performance Measures and Design Tools





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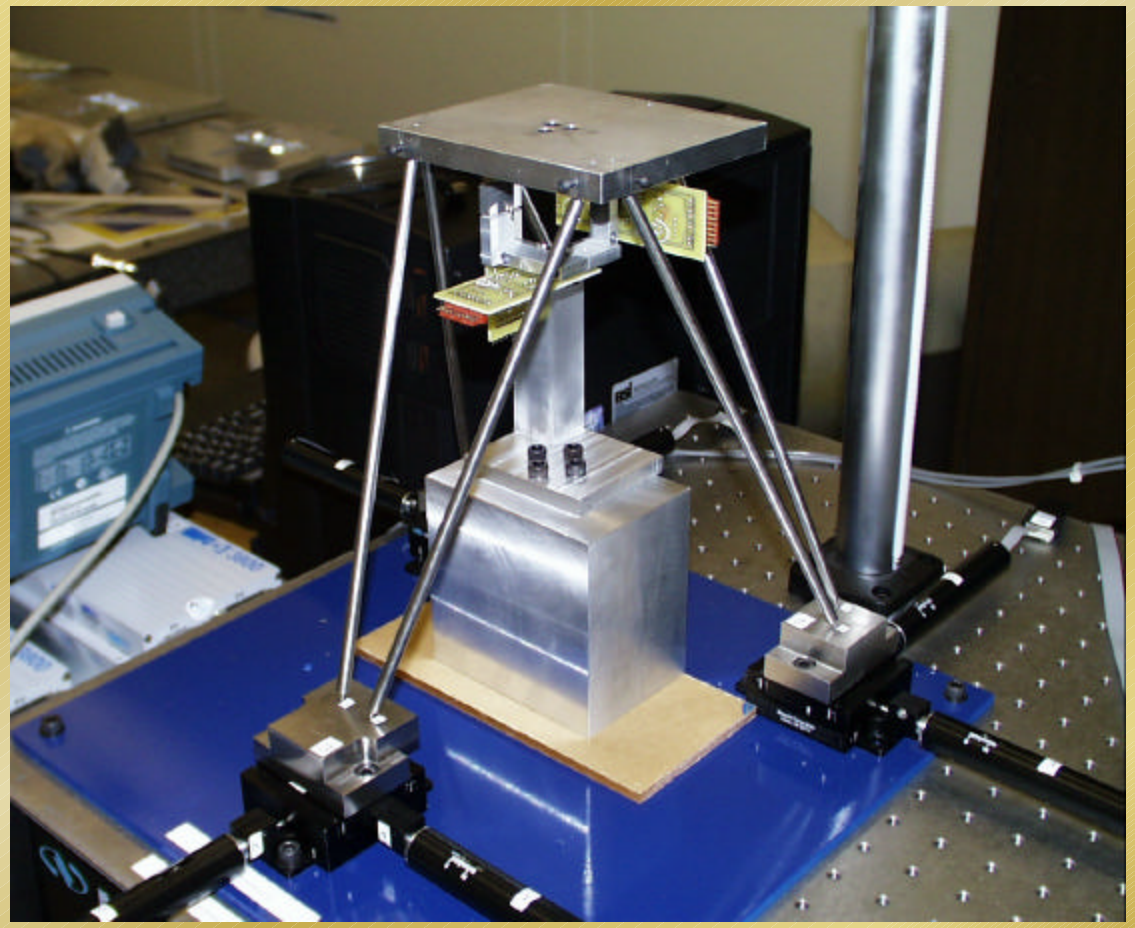

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Summary

Planar Stage Performance (unqualified)

- Angular Crosstalk Error

  0.04 to 0.2 arcseconds

- Translational Crosstalk Error

  1 part in 4000, 25nm over 100 micrometers

- Stage Range

  130 X 130 micrometers

- PZT/Coupler/Stage Transmission Ratio

  70 - 75 %

- Cantilever Gain 10 to 1
- Closed-Loop Resonant Frequency ~ 66 Hz on the new stage
- Material of Prototypes Aluminum 6061-T6

Summary (continued)

- Accuracy, Repeatability, Straightness
  - (ISO 230-2, ASME B5.54)
- Stage issues to be resolved - constraints, dynamics
- X-Y Micro-positioners performance measures and testing software
- Beginning to apply performance measures and testing to 6DOF micro-positioners

For more information:

- Information posted on our website:
  - Final Report on Micro-Meso Scale Manufacturing Exploratory Project and Workshop proceedings:
    - Manufacturing Technology for Integrated Nano- to Millimeter (In2m) Sized Systems, March 1999
    - Manufacturing Three-Dimensional Components and Devices at the Meso and Micro Scales, May 1999
  - Copy of these vu-graphs

http://www.isd.mel.nist.gov/meso_micro/

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