Microelectromechanical Systems: Optical Switches

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MEMS Research Lab

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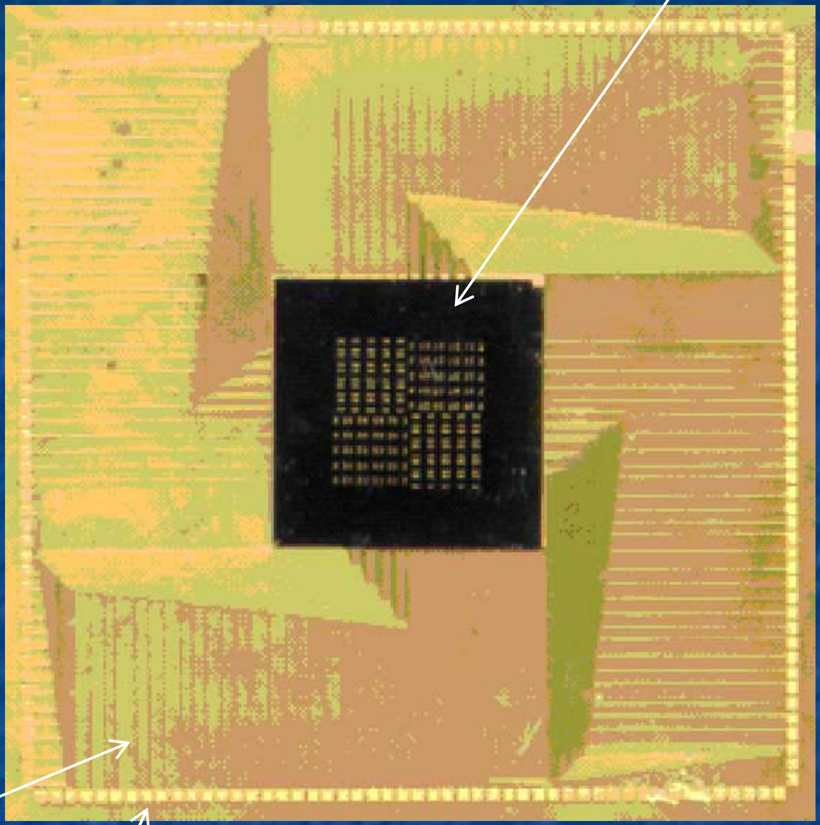
Overview

- Motivation
- Background
  - Device Explanation
- Testing
- Collected Data
- Current Results
- Conclusions
- Future Work
- Acknowledgements
- Questions



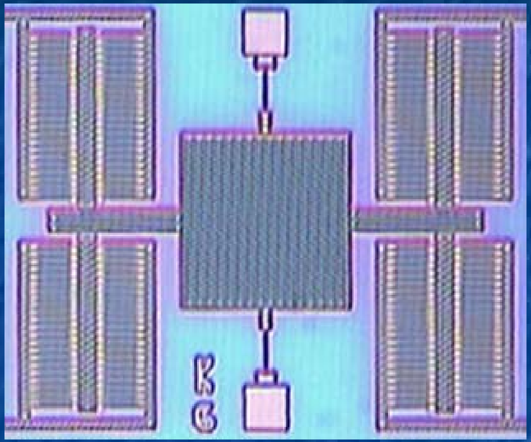
MEMS Device. Masa Rao, Marco Aimi

Motivation

- Research to improve the performance, reliability, and efficiency of Optical MEMS.
- <u>Applications</u>
  - Telecommunications
  - Digital Projectors (increase brightness, higher fidelity)
  - Military Applications

Background

- Project Constraints:
  - Angular mirror displacement
  - period of oscillation
  - voltages
- Optical MEMS vs. current technology
  - Costly (power consumption), reduces quality of signal, longer switching times



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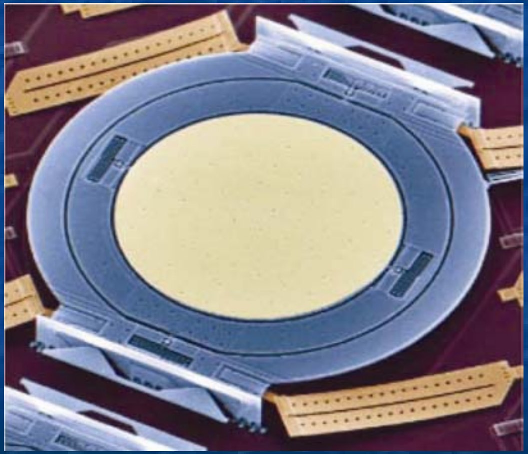
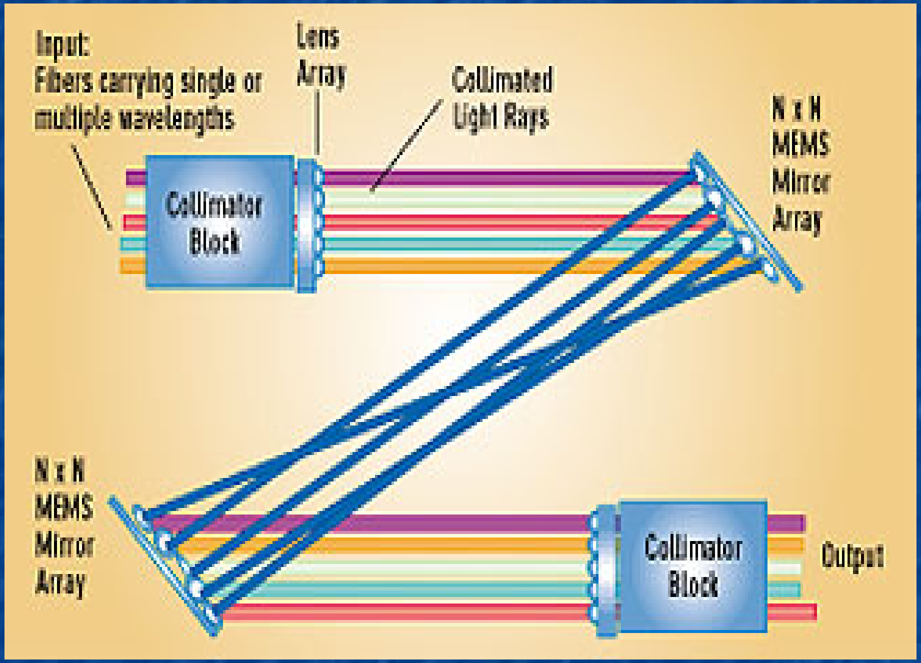
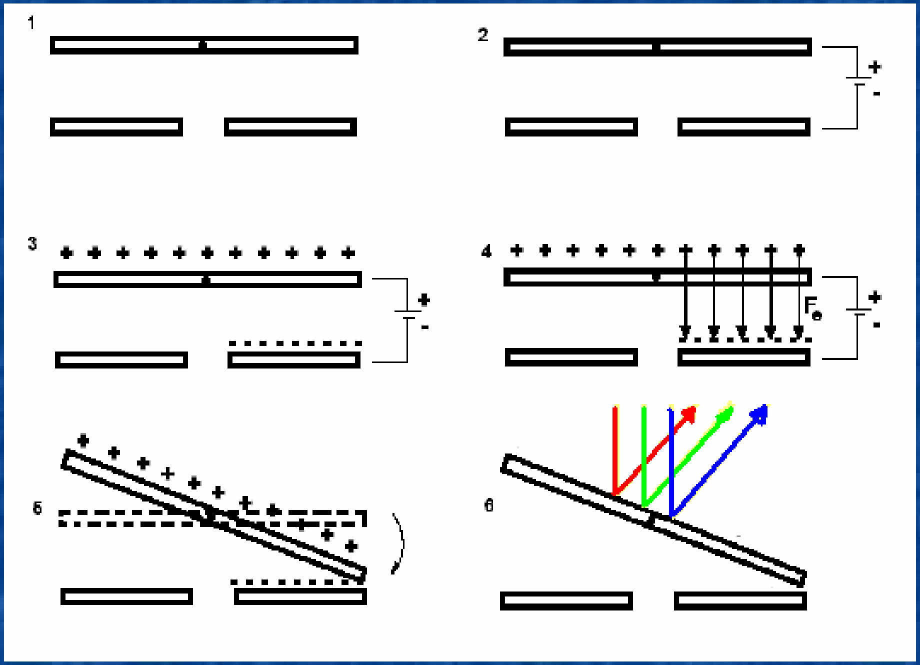


Lucent Technologies

How Device Works





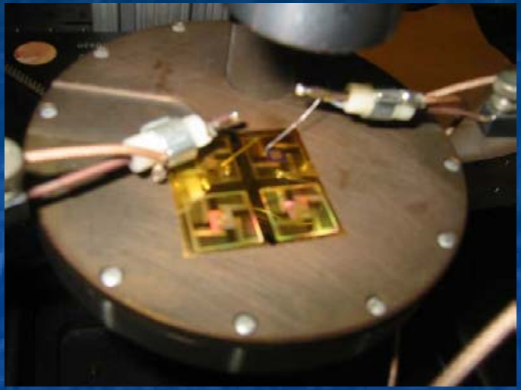
Optical Switching

Mirror Actuation

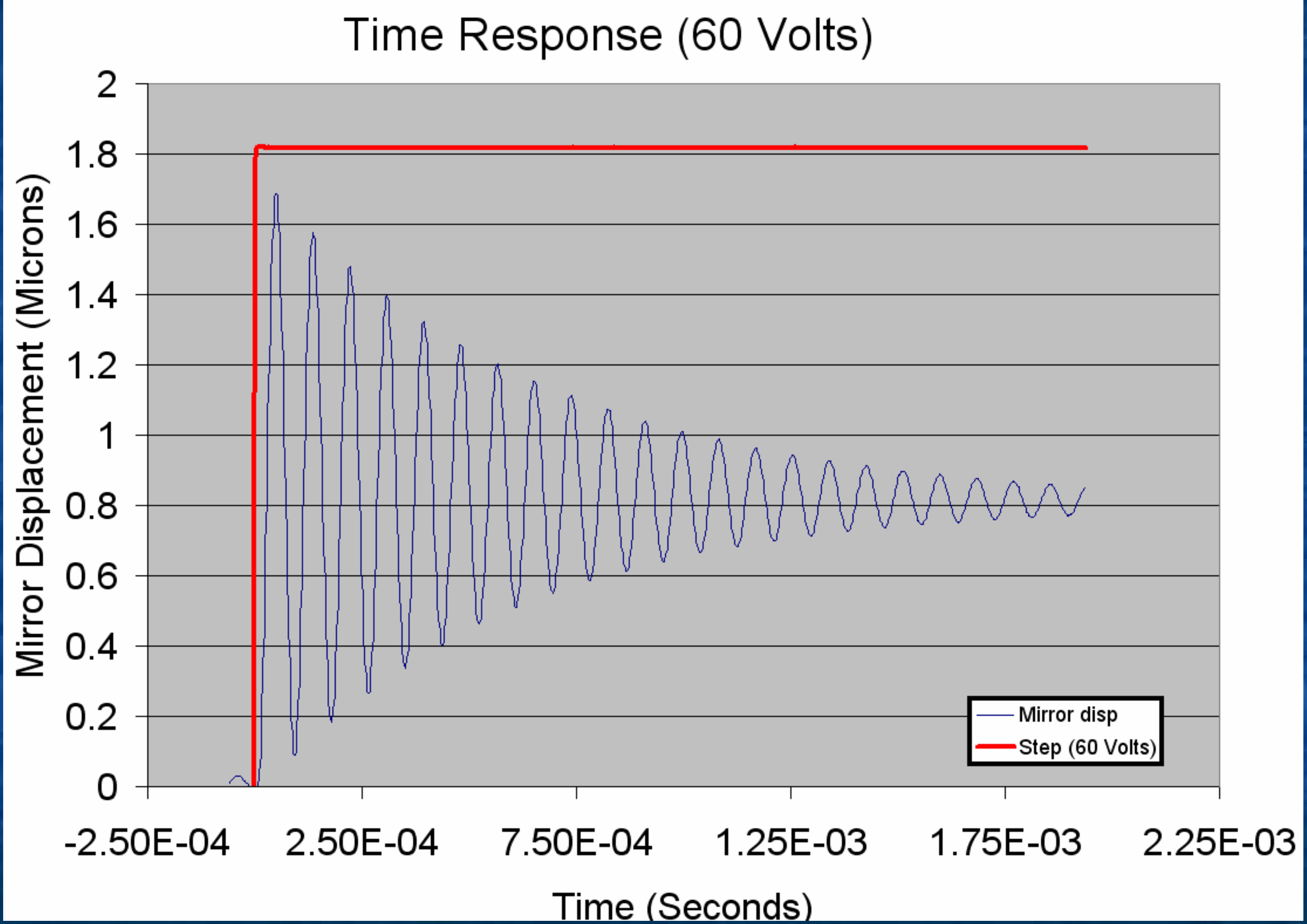
Image provided by:
www.analog.com

Testing

- Will incorporate the use of:
  - Optical microscope fitted with laser-vibrometer
  - Wyko optical profilometer
  - ANSYS 5.7 Analysis
- Collecting data:
  - Voltage vs. displacement
  - Time response
  - Resonance frequencies
  - Damping effects

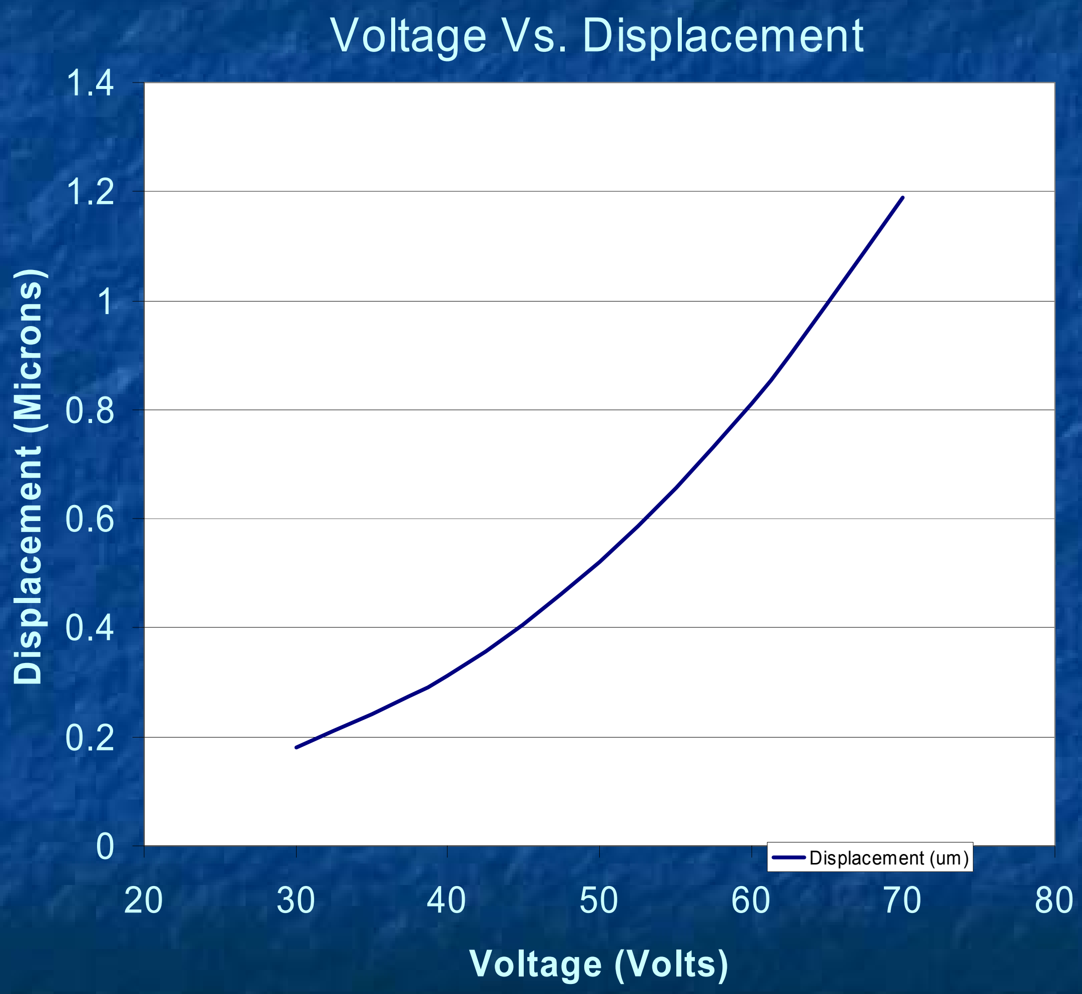


Current Data



Current Data

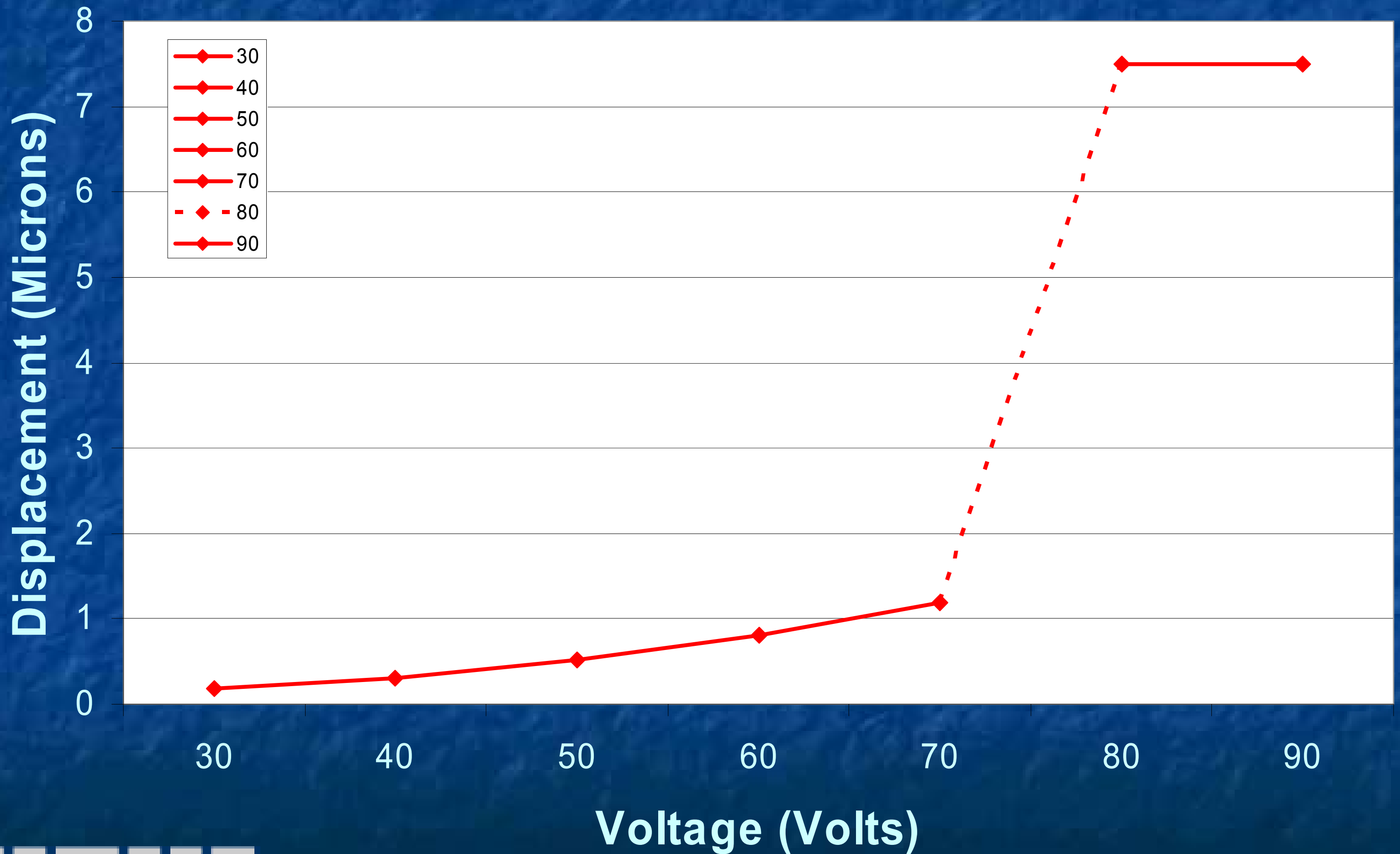
$$F_e \propto \frac{1}{r^2}$$



Current Data

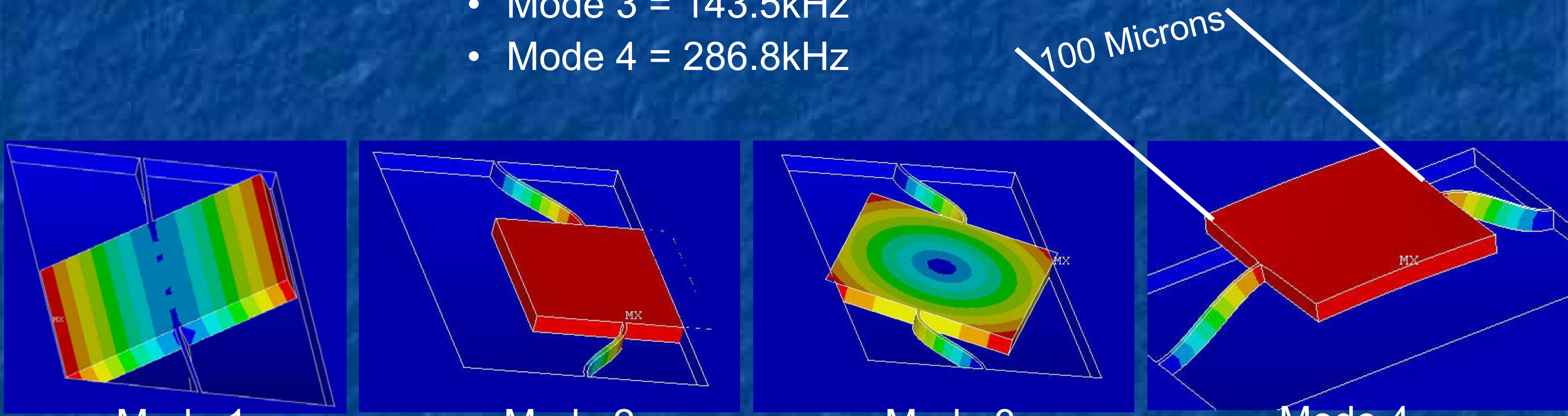
Voltage Vs. Displacement

$$F_e \propto \frac{1}{r^2}$$



Current Data

- ANSYS 5.7 Analysis
  - Solved for resonance frequencies, 1st 4 modes
    - Mode 1 = 52.9kHz
    - Mode 2 = 72.0kHz
    - Mode 3 = 143.5kHz
    - Mode 4 = 286.8kHz



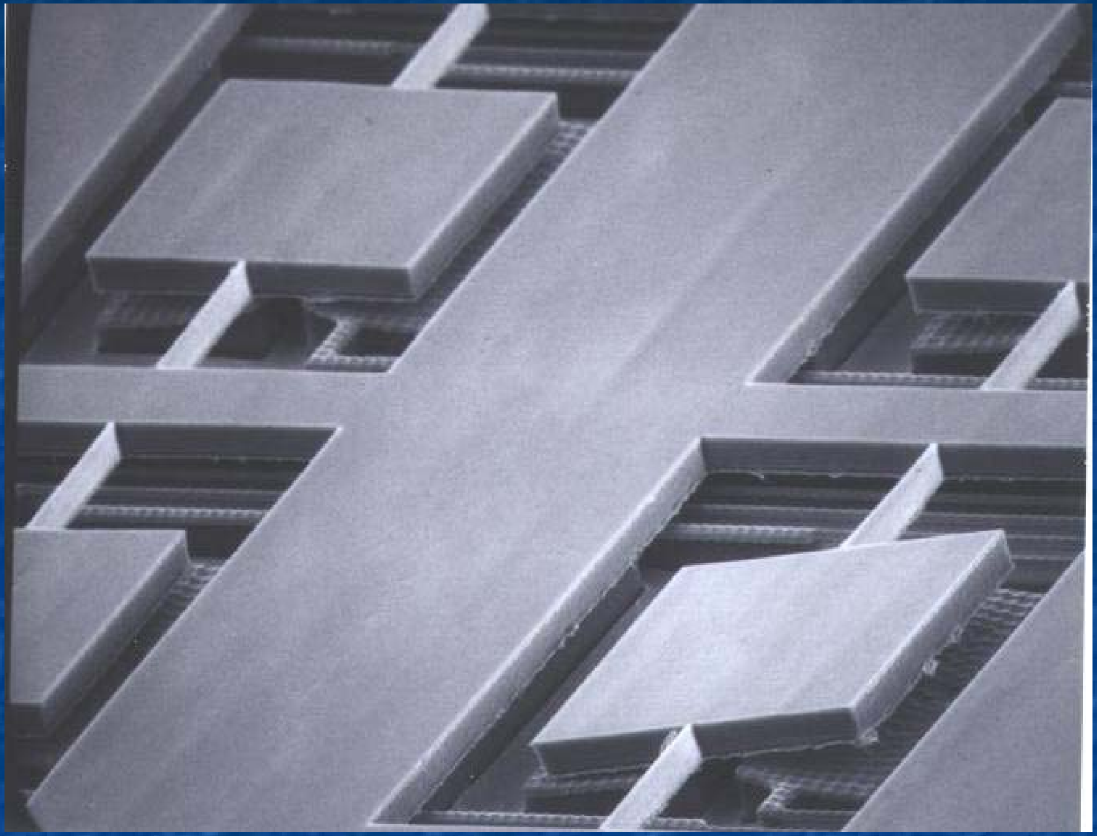
Mode 1 — out of plane torsion

Mode 2 — in plane bending

Mode 3 — in plane rotation

Mode 4 — out of plane bending

Current Results



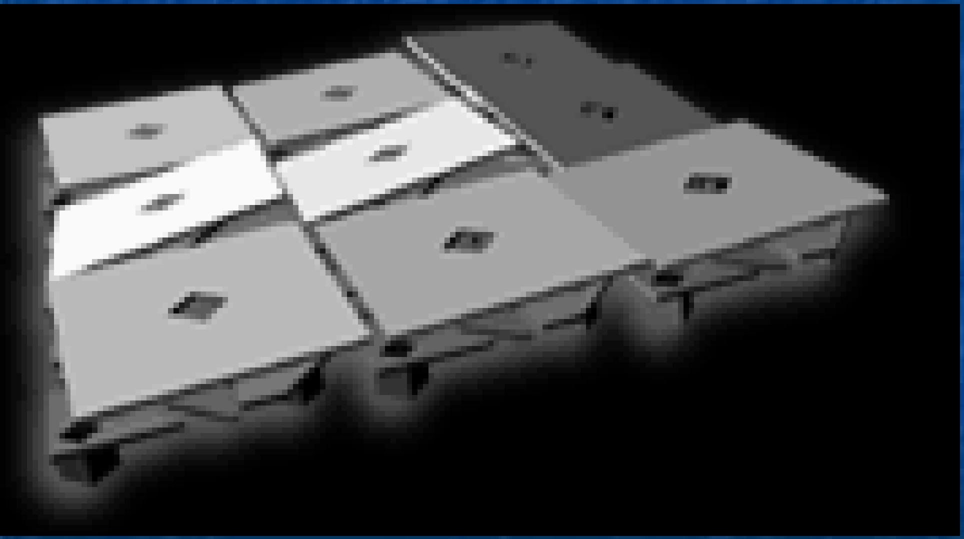
- The device works!
- Acquired max displacement at 75 Volts
- 8 degree angular displacement achieved

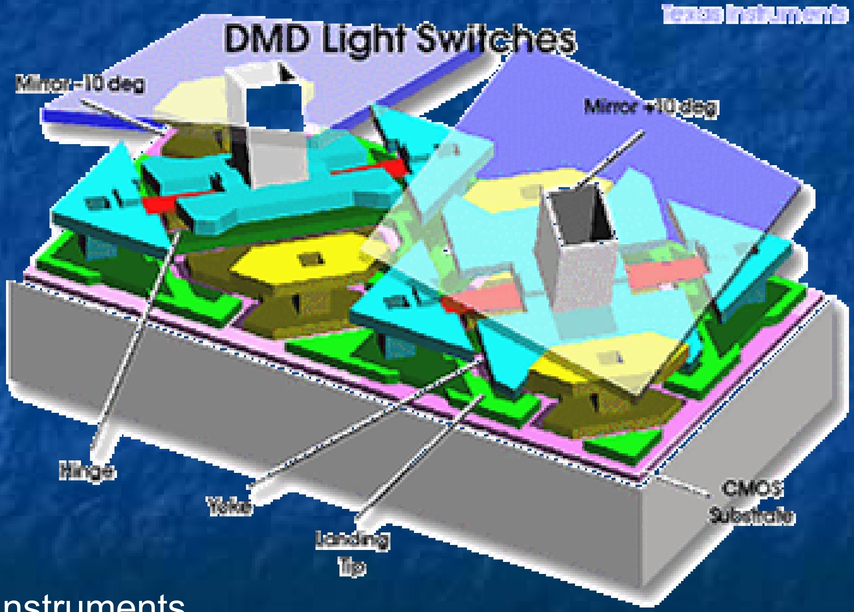
Conclusions

- Device has achieved many of the project goals
- Current setbacks
  - Misalignment (Bonding Issues)
  - Removal of gold on back surface of mirrors (prevent sticking, a.k.a. stiction)
  - Damping?
- Solutions
  - Bonding techniques, design new vacuum chuck, better equipment
  - Filling gaps between mirrors

Future Work

- Multi-Dimensional Tilting Mirrors
- Larger Arrays
- Smaller, Faster, Stronger, More Reliable





- Images Provided by Texas Instruments

Acknowledgements

Thanks to:

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MacDonald MEMS Group

Santa Barbara City College

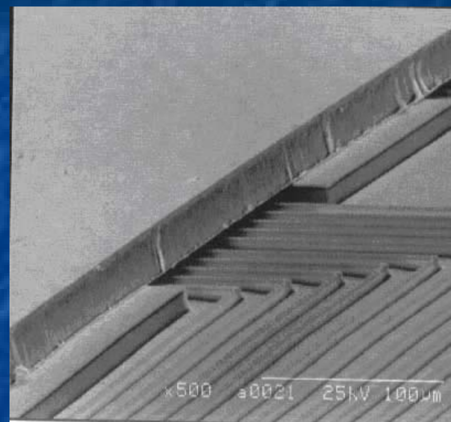
University of California Santa Barbara

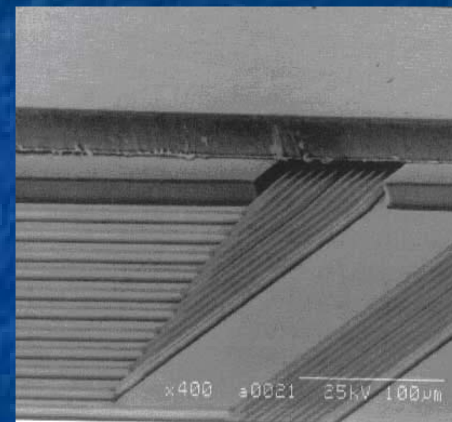
And to everyone else who has helped me along the way

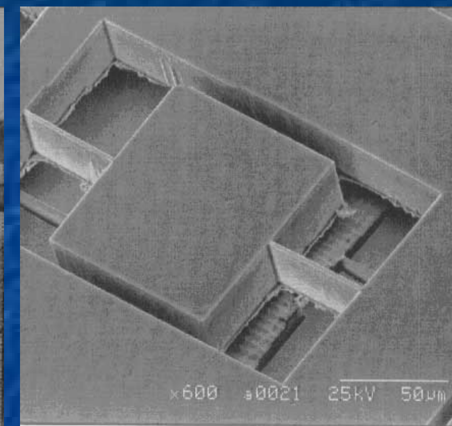
Questions?

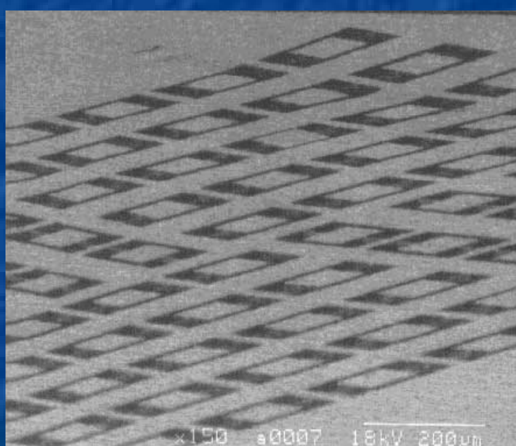
- Purpose?
- Data?
- Equipment?
- More Images?

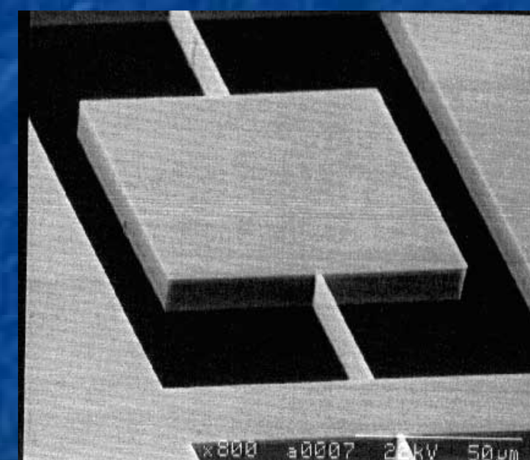
Research Photos





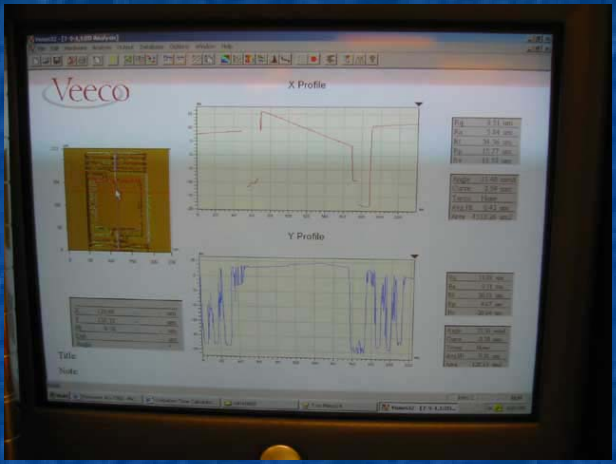


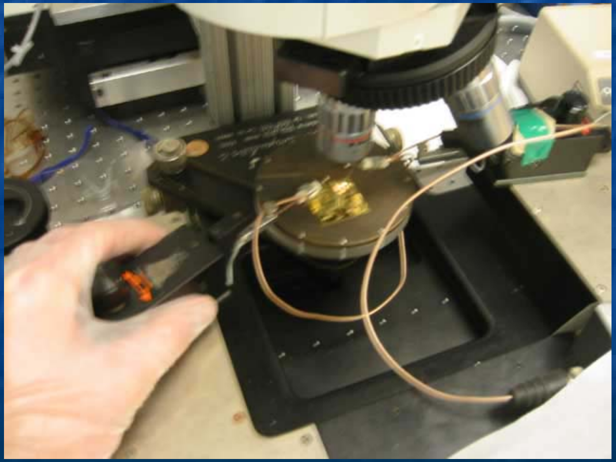




Marco Aimi, Masa Rao

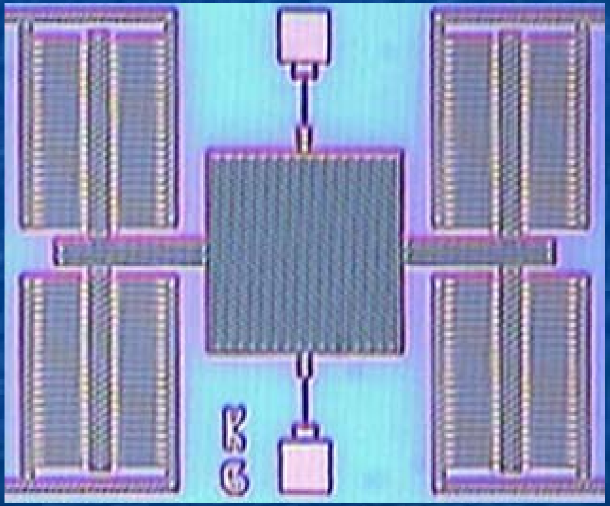
Testing Equipment





Background

- Need a MEMS device to deflect light (information via fiber optics)
- Project has specific constraints/ goals:
  - Actuation voltages <100V
  - Period of oscillation: 50 microsecs
  - Mirror deflection angle: 10 degrees
- Project evolution:
  - Comb-drive actuated mirrors
  - Flat capacitive plates
  - Angled capacitive plates



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