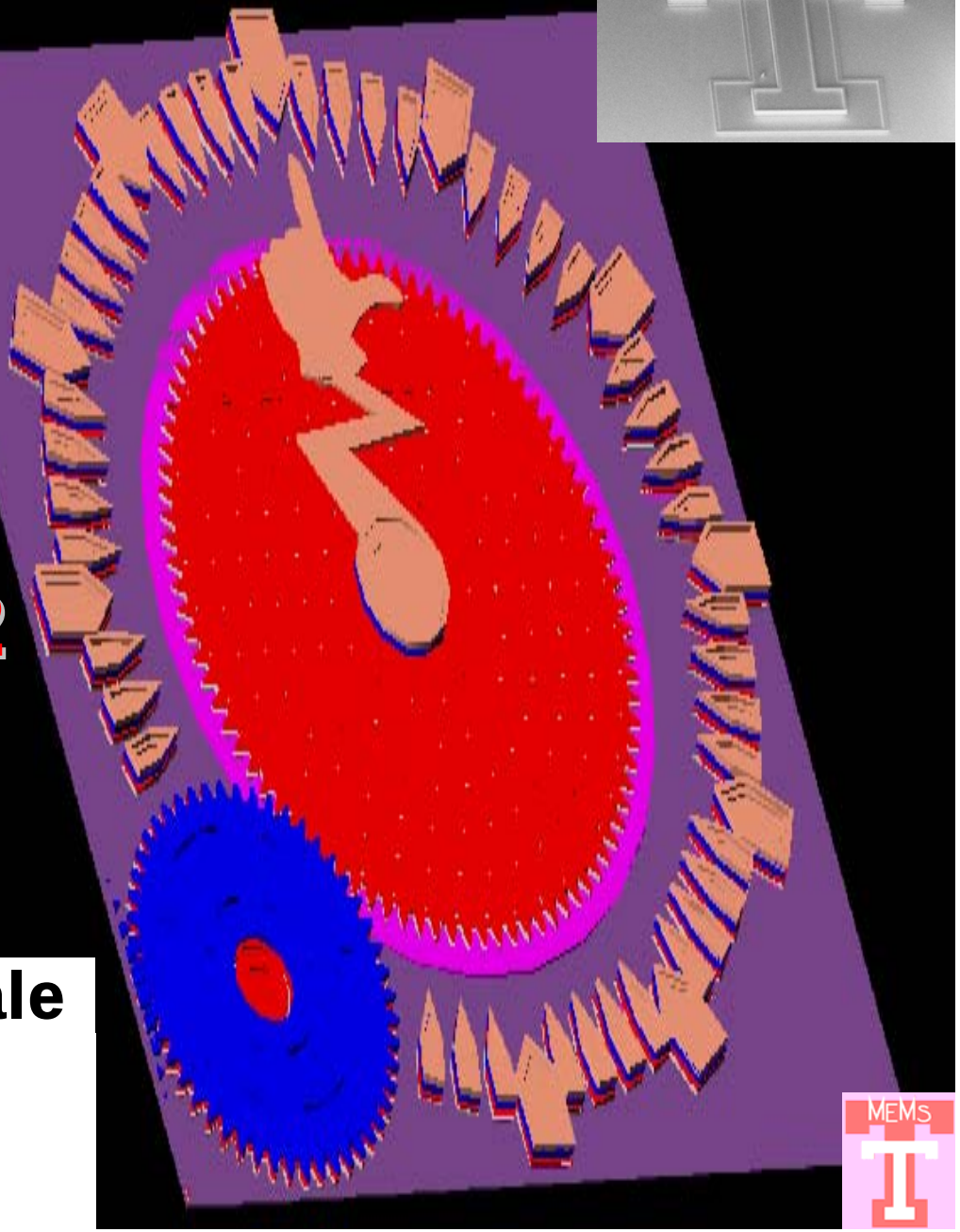
smallTime

The 18 mm^2 Classroom



T. Dallas, J. Berg, & R. Gale

TEXAS TECH UNIVERSITY™

NANO TECH CENTER

Thesis & Outline

- **Implementation and initial outcomes regarding the incorporation of Sandia's SUMMiT V MEMS design, visualization, and fabrication into the MEMS curriculum at Texas Tech University.**

1. **TTU MEMS Curriculum**
2. **SUMMiT V & University Alliance Program**
3. **Results – Spring 2005**
4. **Conclusions**

Nano Tech Center

MEMS

MEMS @ TTU

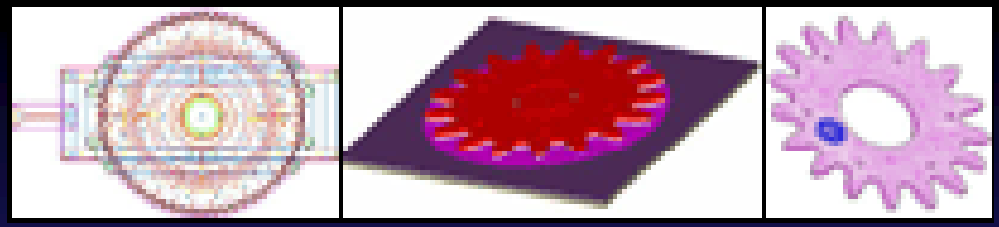
- **NSF Combined Research and Curriculum Development Grant (Fall 2000)**
  - **Lab based Classes in EE/ME/Phys**
    - **Humidity Sensor**
    - **Accelerometer**
    - **PDMS Microfluidics**
    - **DNA Sensor-on-a-Chip**
  - **Lecture and Simulation Based**
  - **Simulation Based**
  - **Design (SUMMiT V) & Simulation Based**
  - ***Design (SUMMiT V), Simulation, & Testing***

MEMS I
MEMS II
MEMS III

Nano Tech Center

MEMS

University Alliance Program



- Site license for up to 50 seats of SUMMiT™ design and visualization software for use in the lab or classroom by course participants
  - **Sandia Advanced MEMS Design Tools and access to Sandia's remote design rule checker**
  - **Sandia 2D-3D Visualizer Tools & 3D Geometry Modeler for SUMMiT™ design**
- Instructional materials from all of Sandia's MEMS Short Courses
  - **Sandia MEMS Introductory Short Course**
  - **Sandia MEMS Advanced Design Short Course**
  - **Sandia MEMS Reliability Short Course**
- Training and technical support for the university Superuser
  - **Sandia MEMS Introductory Short Course**
  - **Sandia MEMS Advanced Design Short Course**
- UA members will receive released parts.

$5000

Nano Tech Center

source: http://www.sandia.gov/mstc/education/alliance/

MEMS

MEMS II/III Spring 2005

?? Pertinent Questions ??

- What should we build?
- What can we build?
- What can we design and/or simulate in the time allotted (~3 months)?
- What will the students get out of all of this?

Henry Ford & SUMMiT V

"*Any customer can have a car painted any color that he wants so long as it is black*." – H. Ford

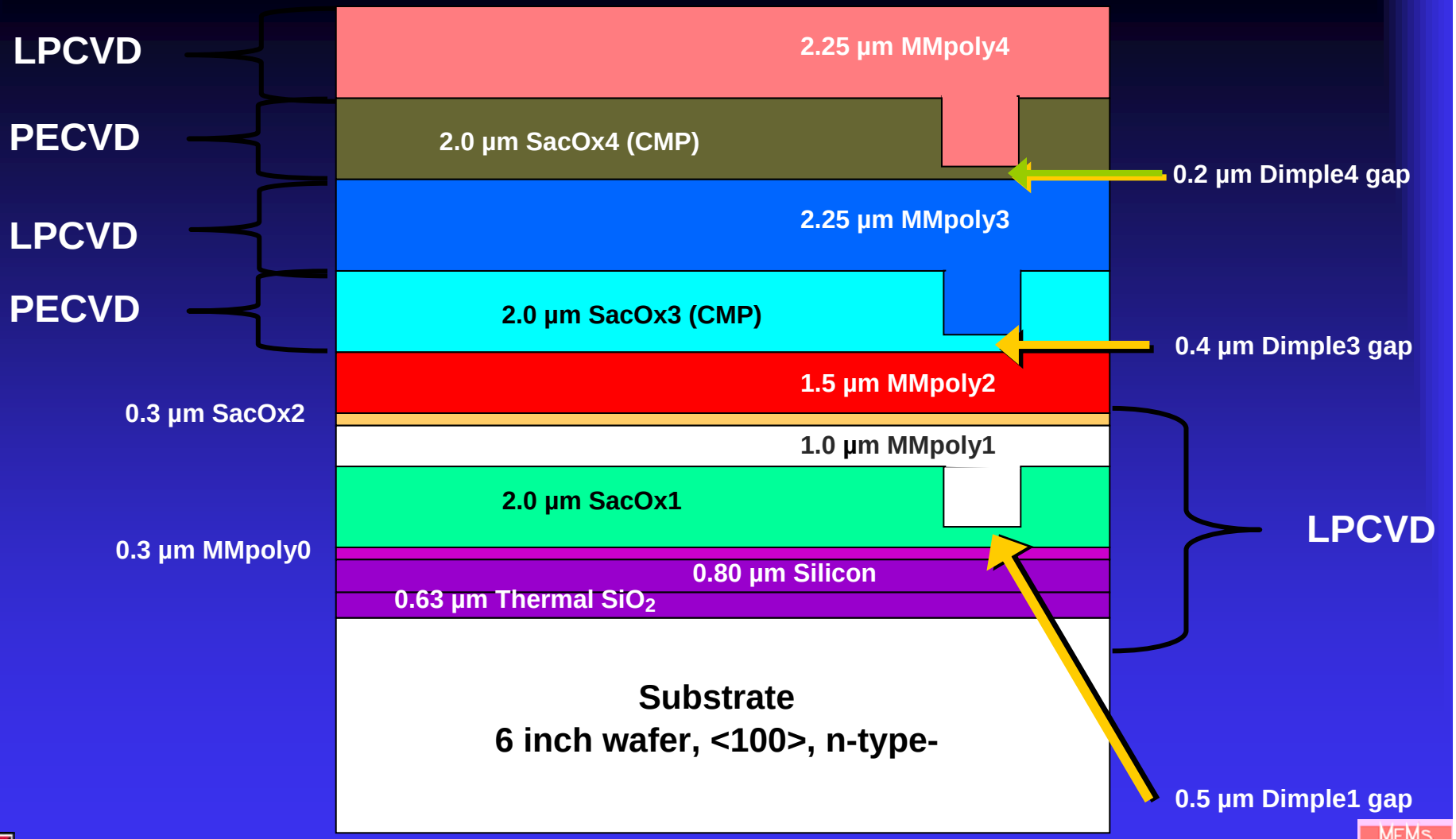
"You can use any material you want as long as it is polysilicon." - Sandia

"You can use any polySi thickness you want as long as poly1 is 1.0 microns, Poly2 is 1.5 microns, etc." - Sandia

Nano Tech Center

MEMS

SUMMiT V Process



Nano Tech Center

MEMS

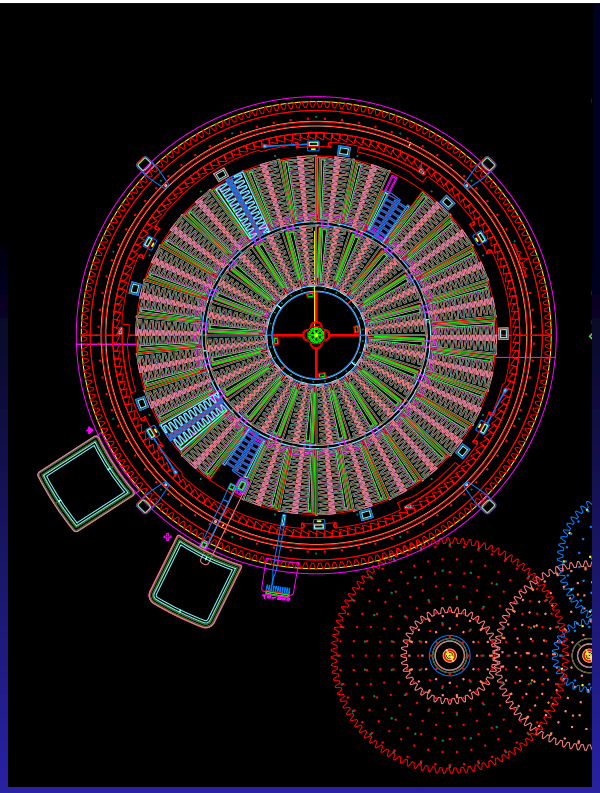
A starting place: Prior Art

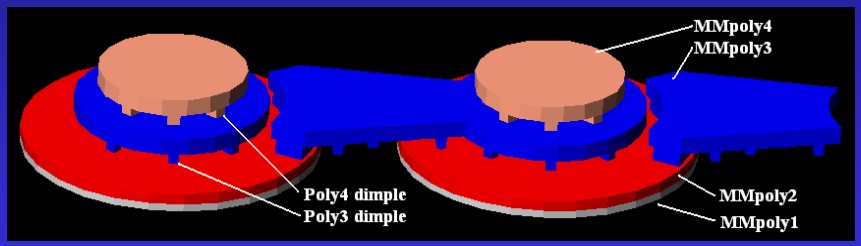
Students were initially responsible for …

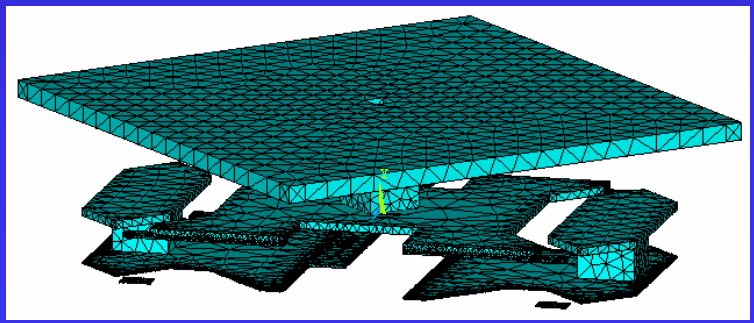
- **Literature search to see what has been published using SUMMiT V.**
- **Other polysilicon devices.**
- **New ideas.**

The Tools

- AutoCAD
- Sandia plug-ins
  - Design Tools
  - Standard Parts Library
  - 2D Visualizer
  - 3D Visualizer
  - Design Rule Checker
- ANSYS





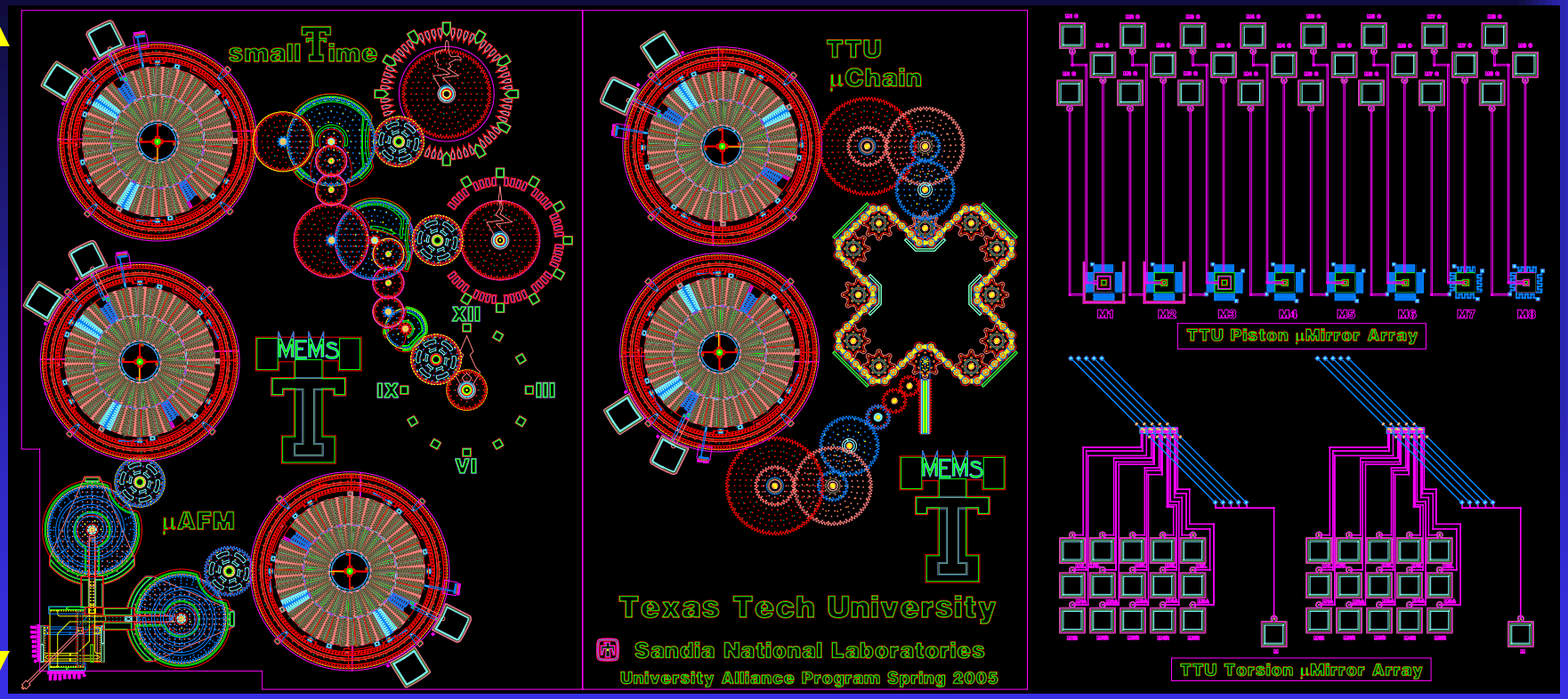


Nano Tech Center

MEMS

TTU 18 mm² Module Design Spring 2005

6.34 mm



2.82 mm

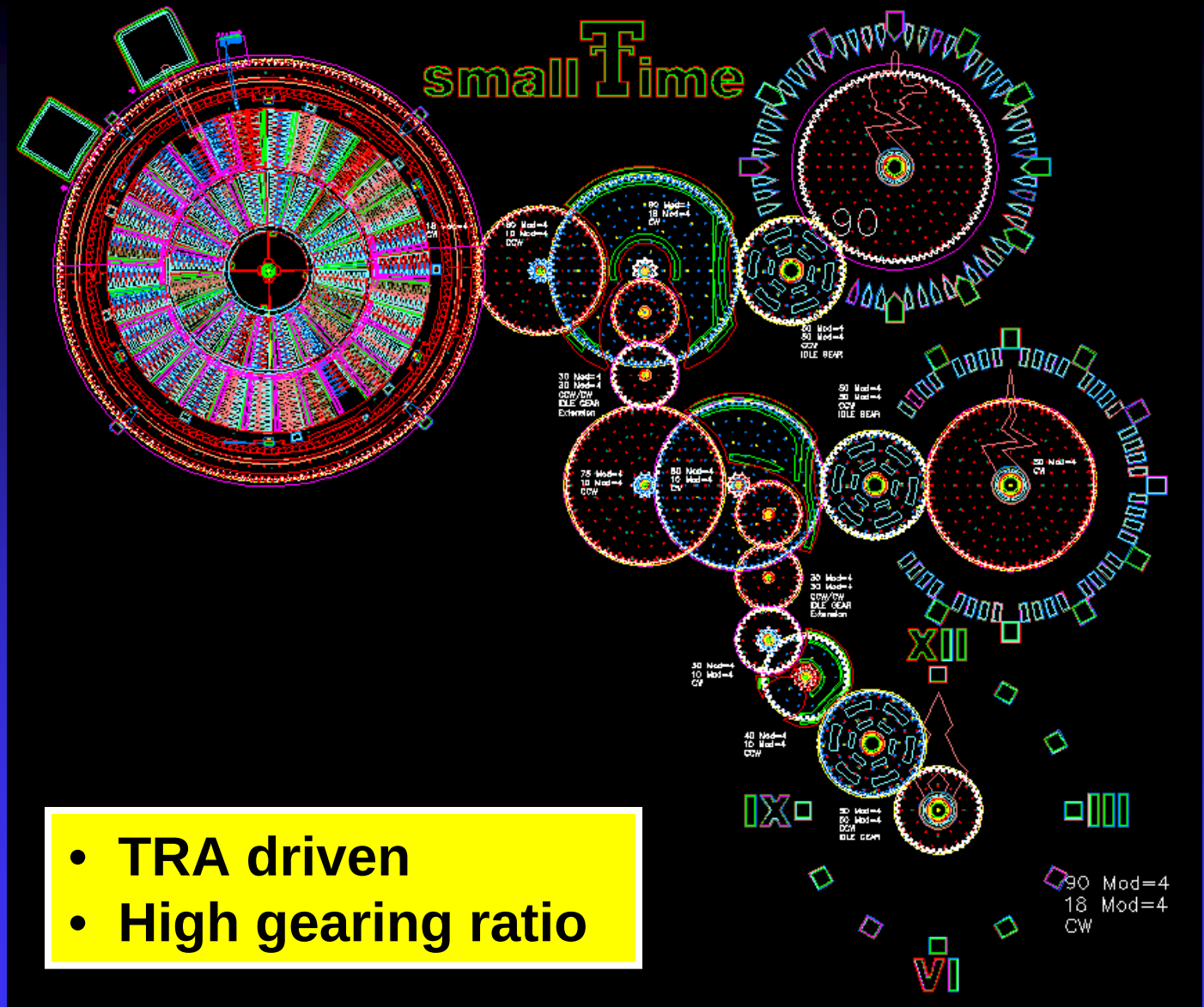
Nano Tech Center

MEMS

Non-simulated Designs

- smallTime (microClock)
  - First student design
- microChain
  - Modified and enhanced version of previous work by Sandia
- microAFM
  - Prototype XY stage
  - Pseudo AFM cantilever arm and tip

smallTime

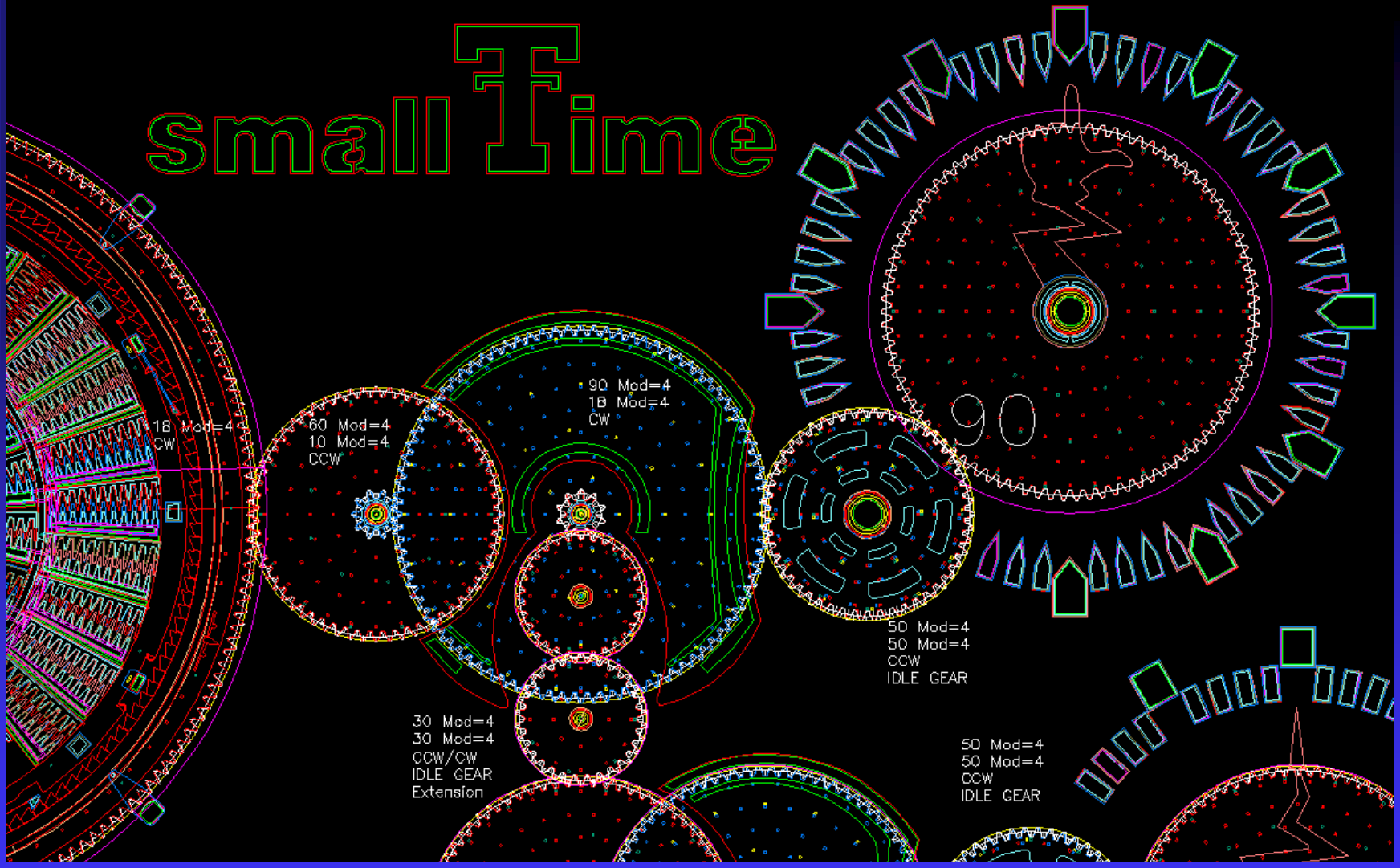


- **TRA driven**
- **High gearing ratio**

Nano Tech Center

MEMS

smallTime

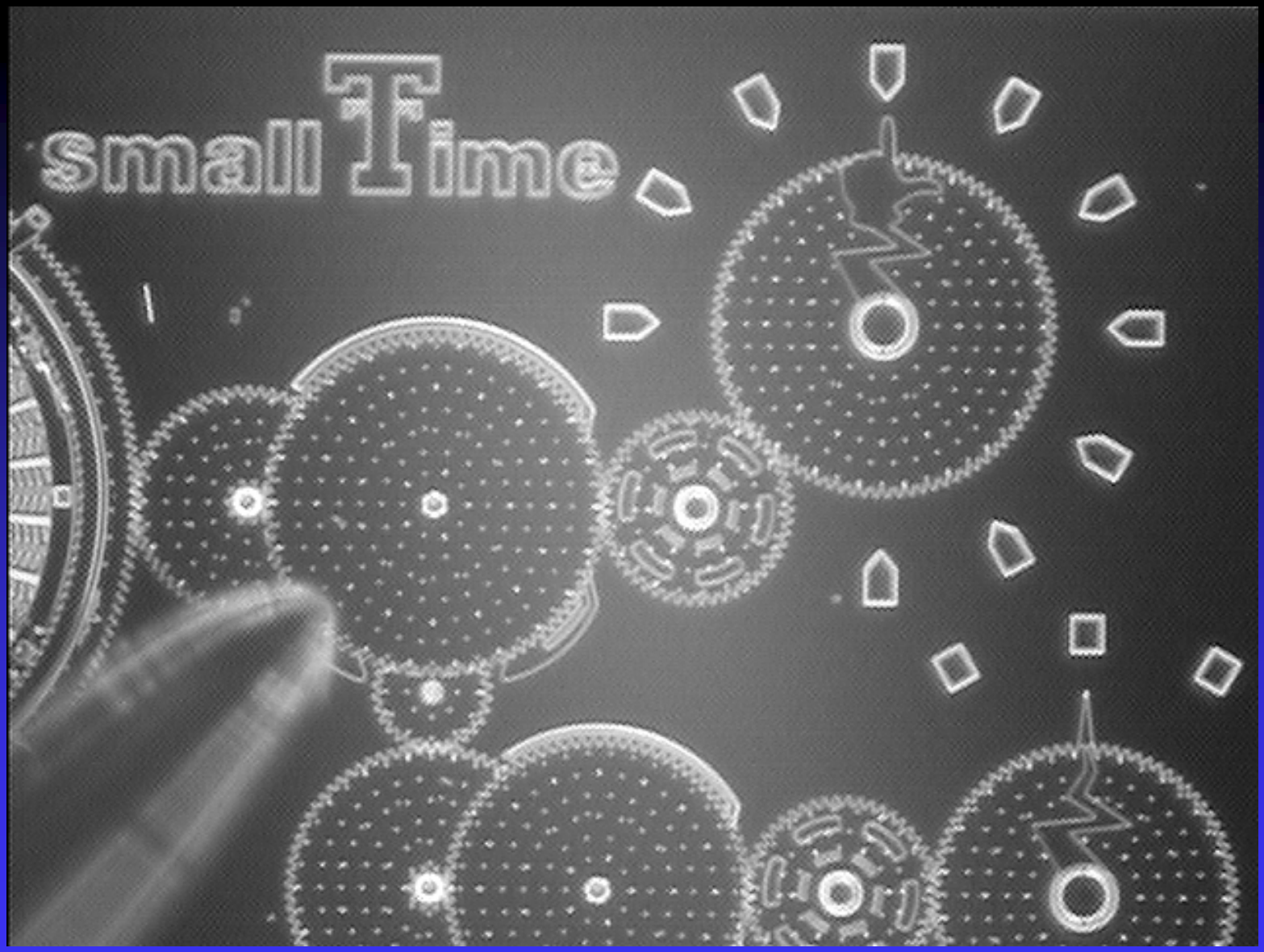


Nano Tech Center

Phillip Beverly – Session 4: Thursday 1:20pm

MEMS

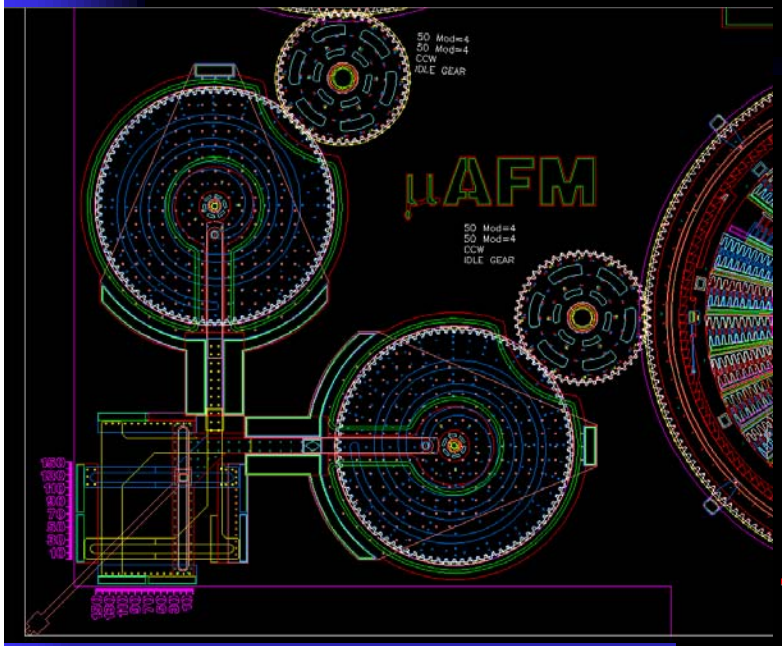
smallTime

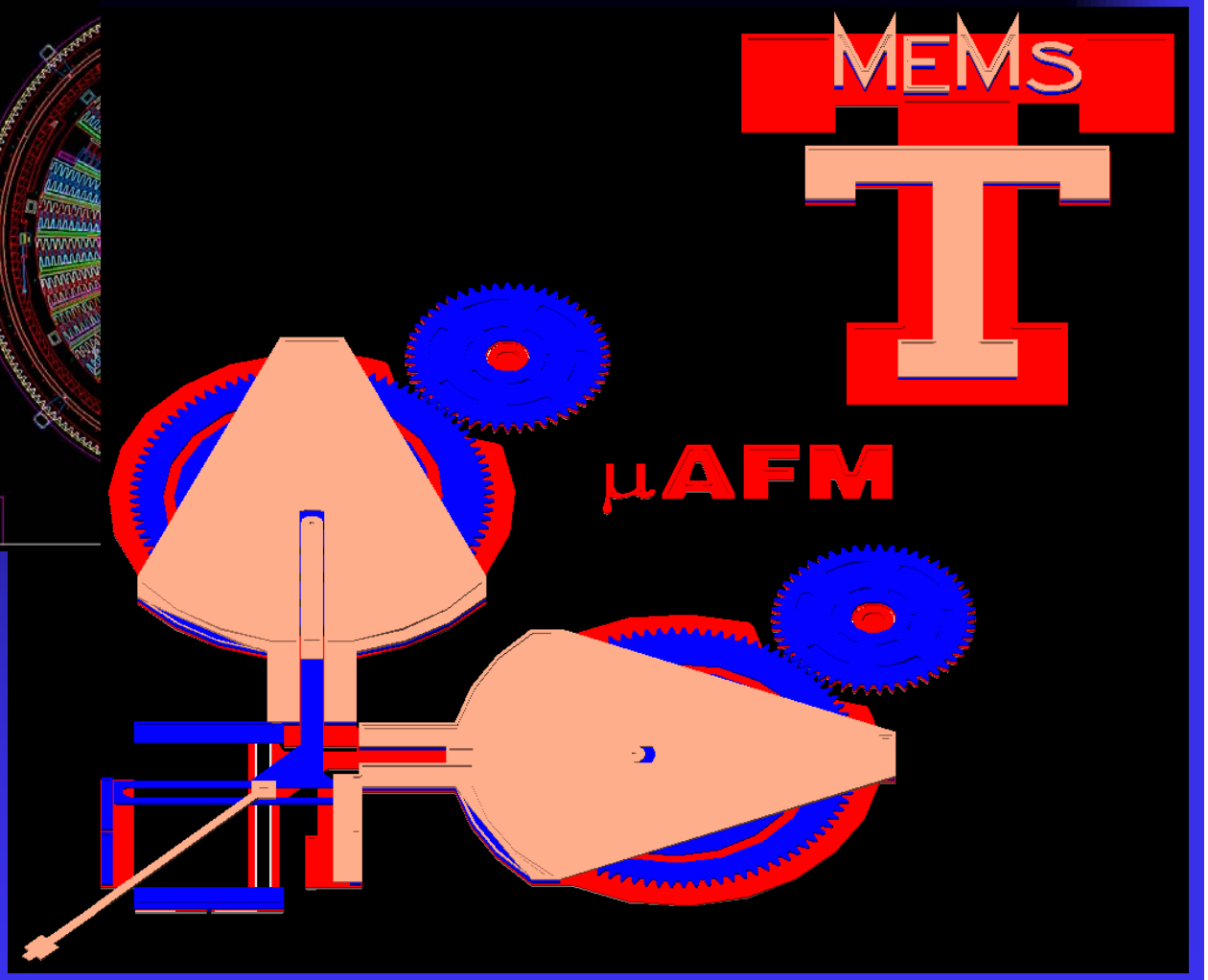


Nano Tech Center

MEMS

µAFM



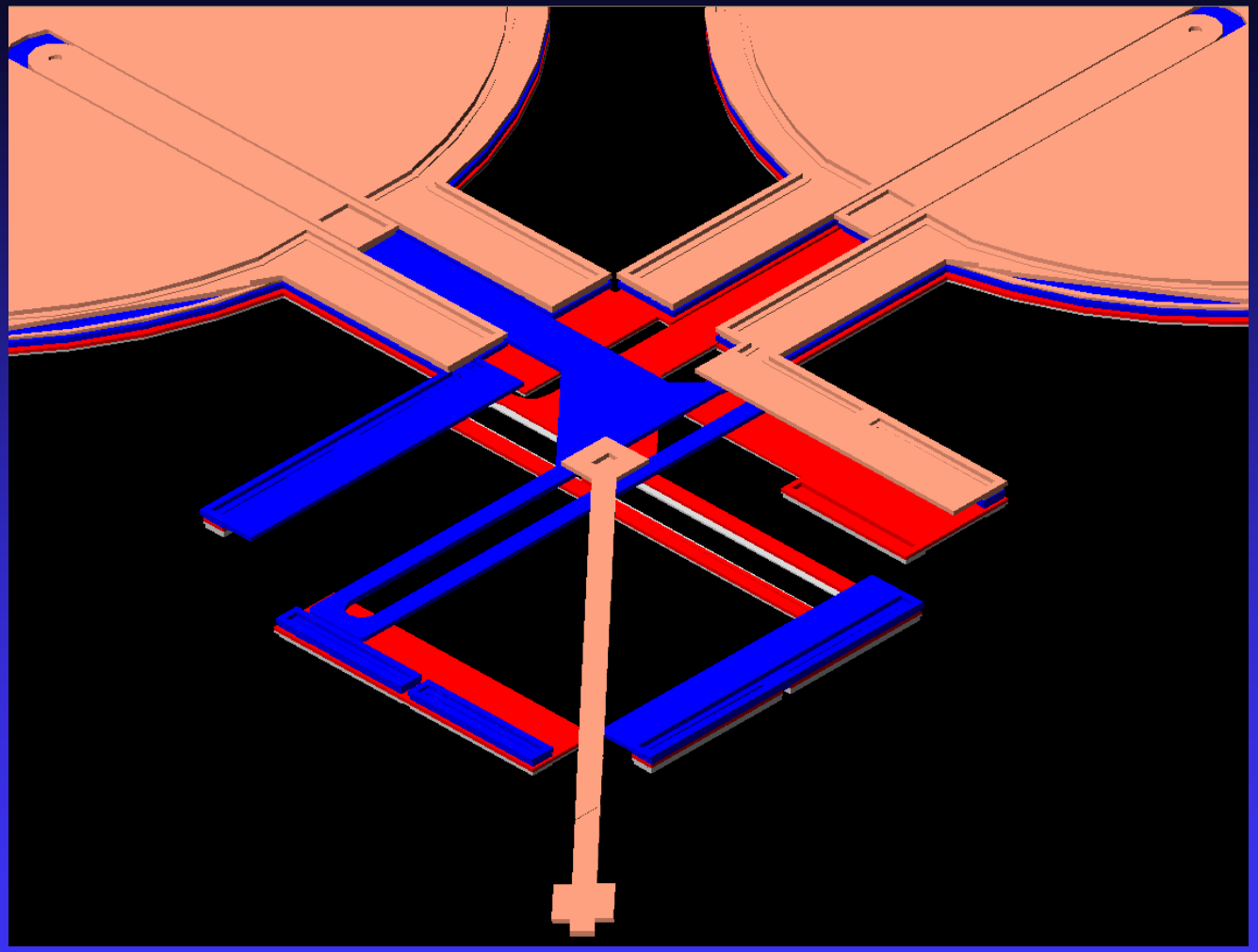


Nano Tech Center

Phillip Beverly – Session 4: Thursday 1:20pm

MEMs

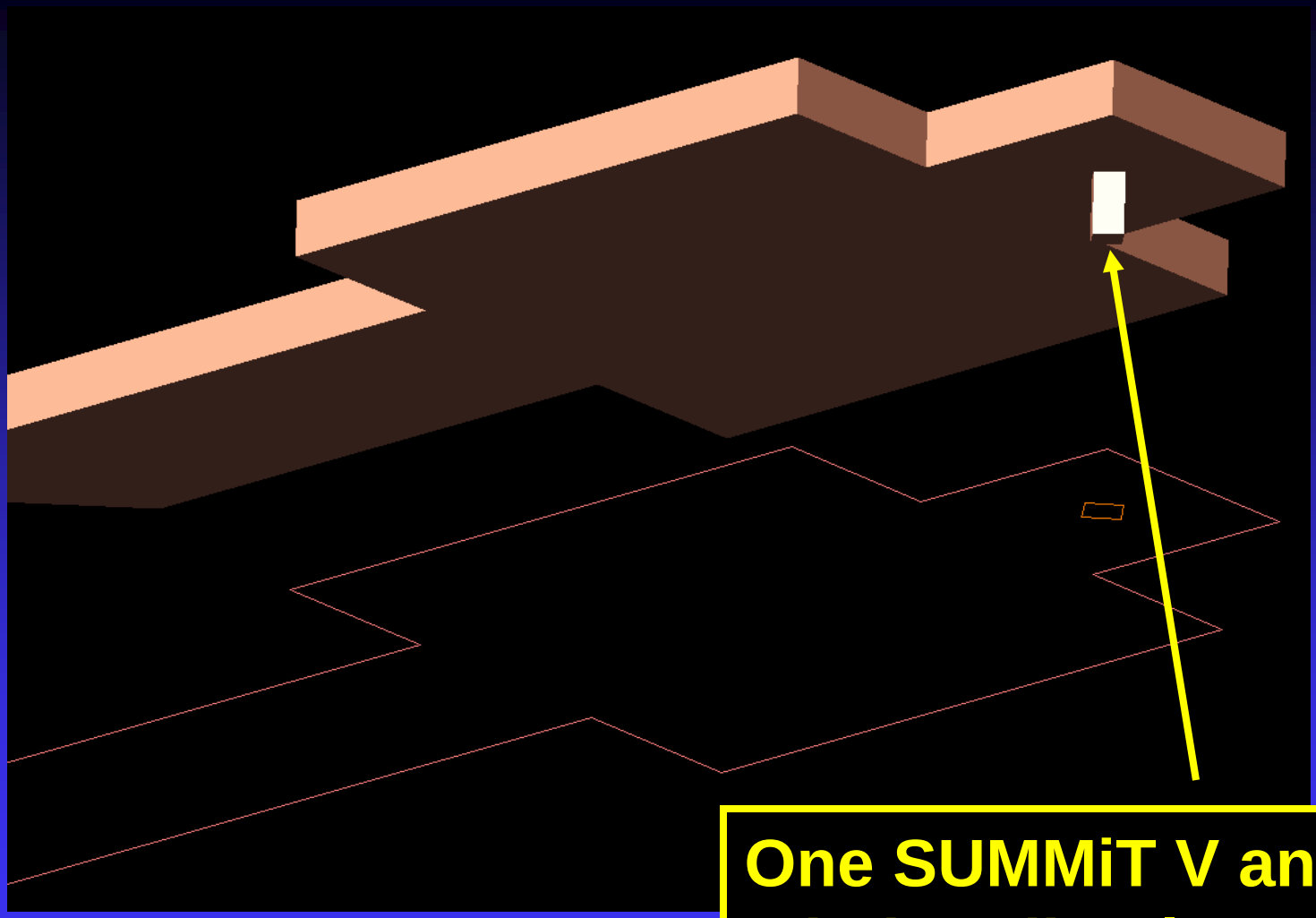
µAFM-Tip Assembly



Nano Tech Center

MEMS

µAFM-Tip

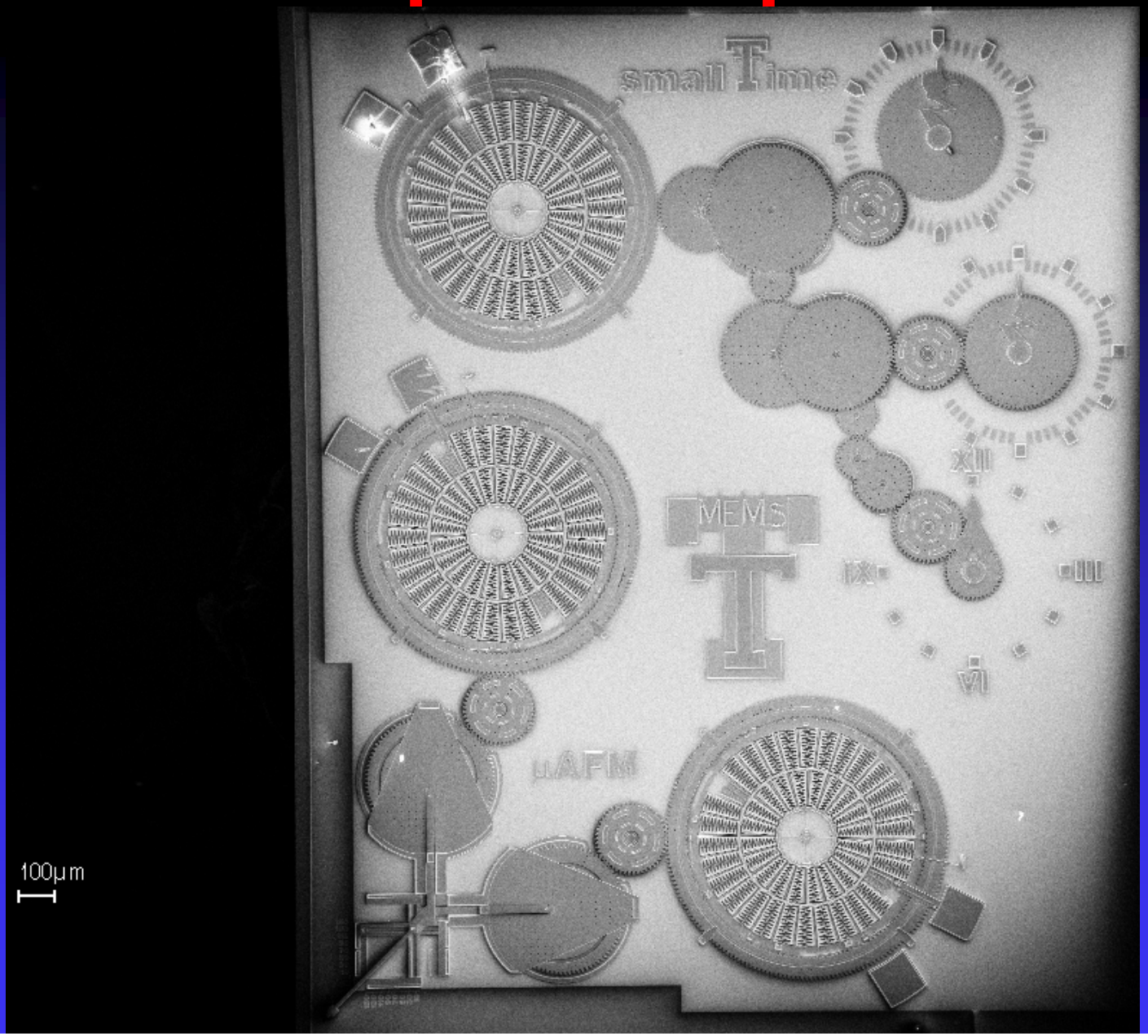


One SUMMiT V anti-stiction dimple

Nano Tech Center

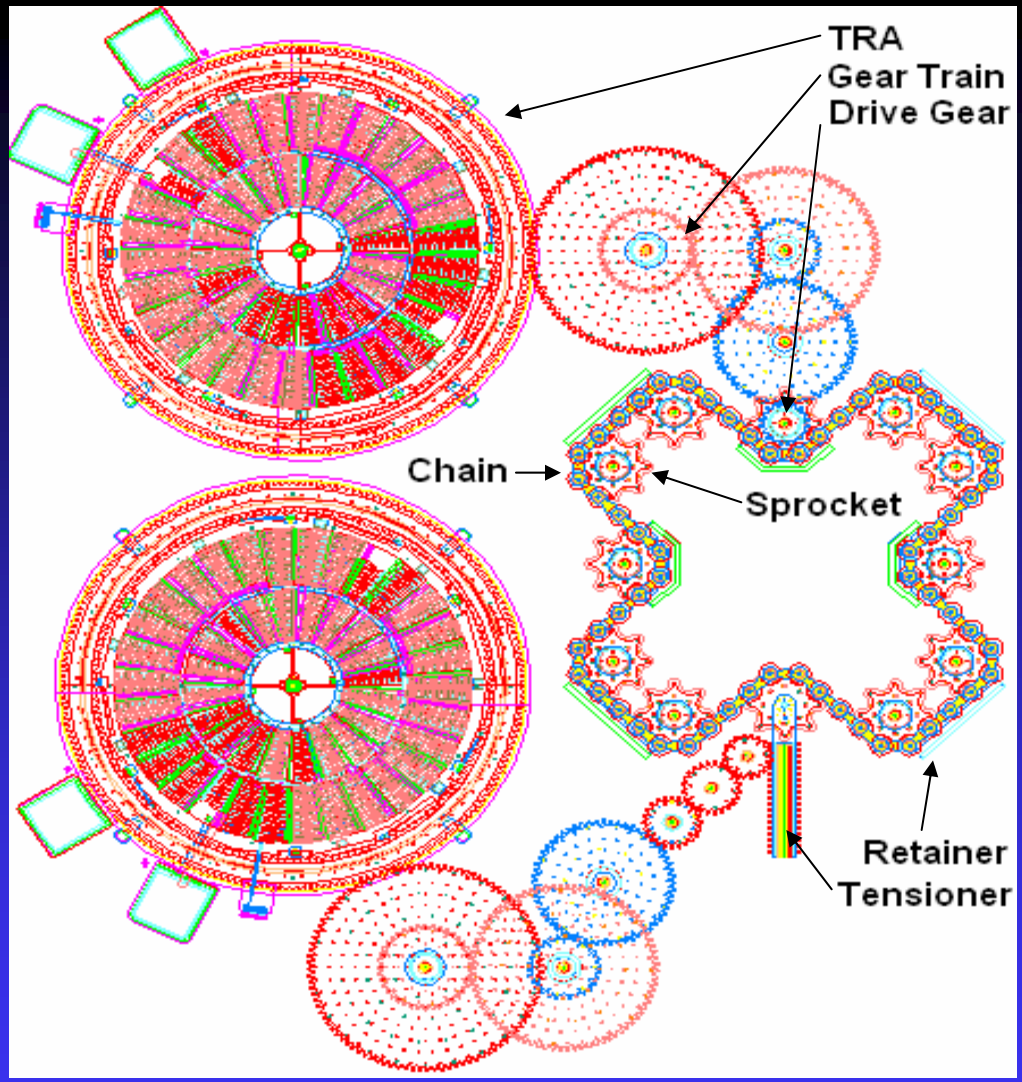
MEMS

SEM of µAFM & µClock



Nano Tech Center

µChain

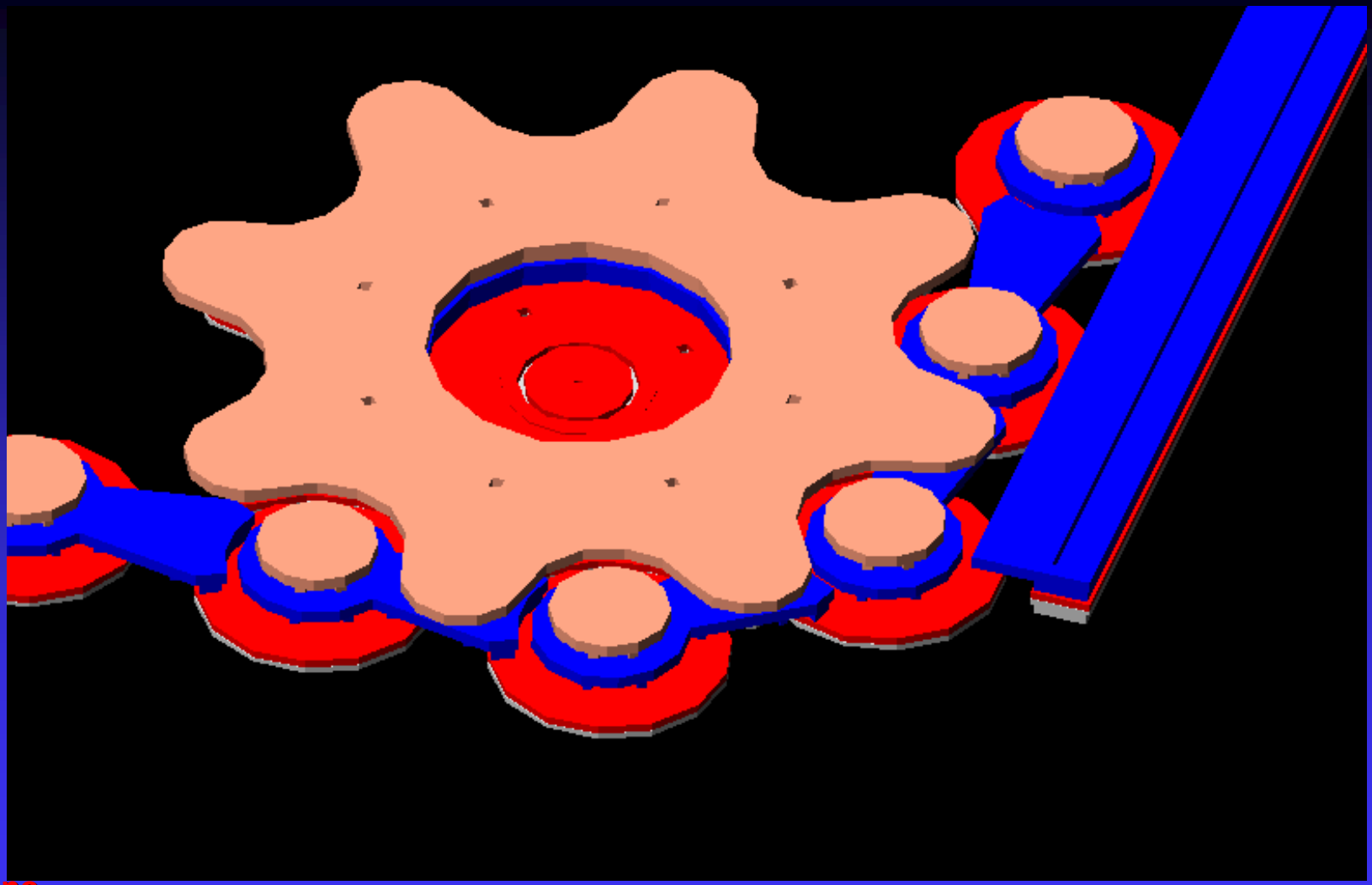


Nano Tech Center

Shad Holt – Session 1 (Wiggins Room): Wednesday 12:00pm

MEMS

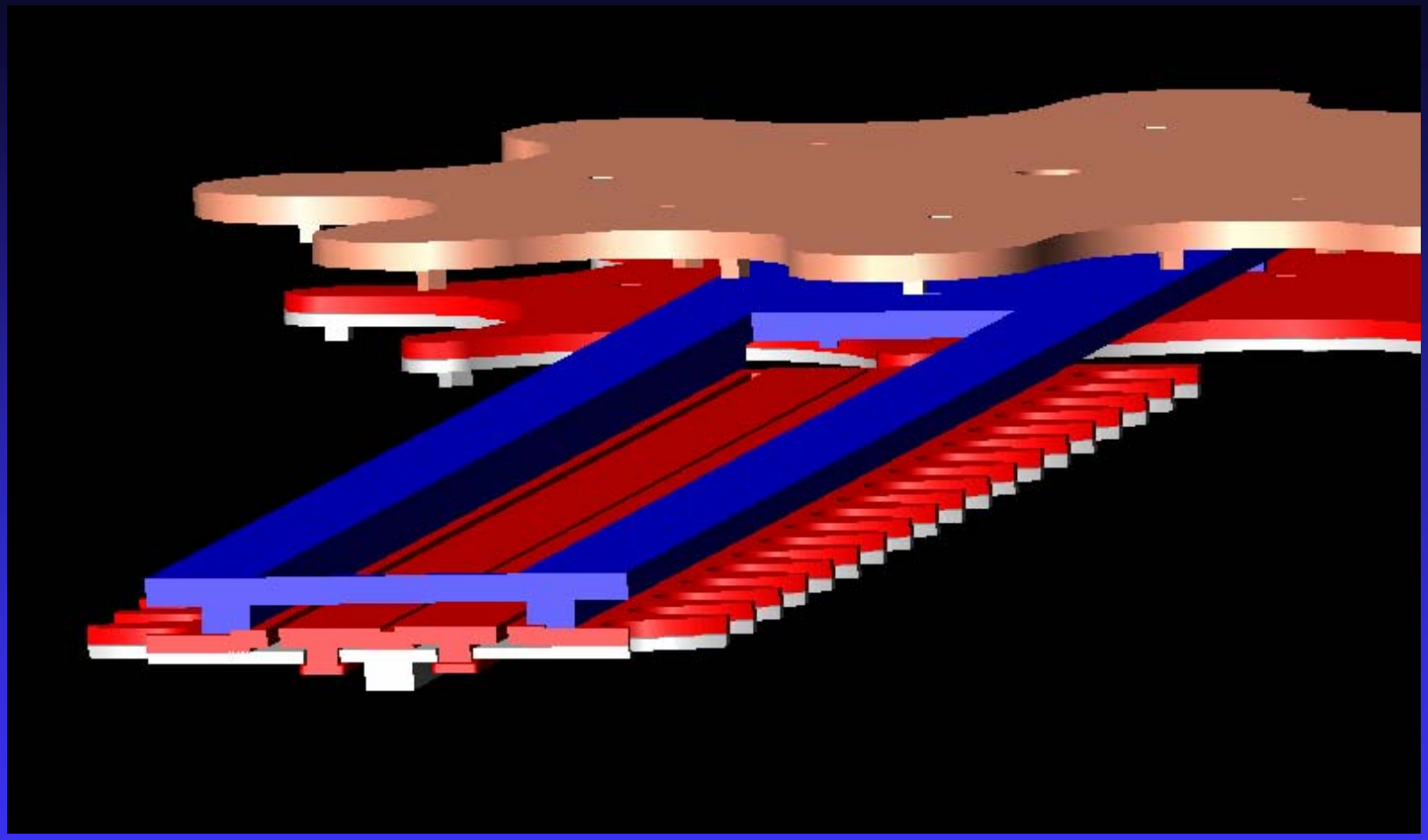
Chain, Sprocket and Guide



Nano
Tech
Center

MEMS

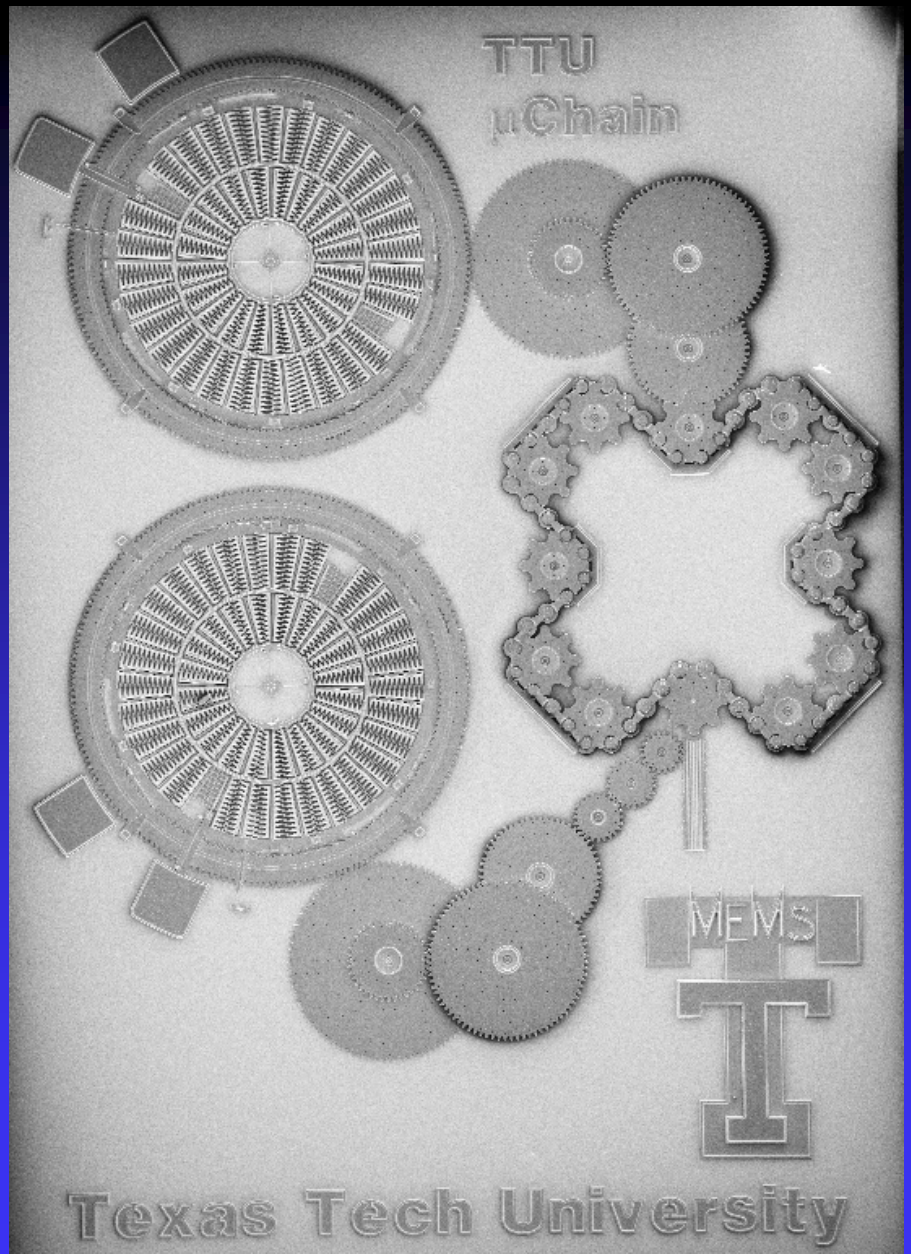
Chain Tensioner



Nano
Tech
Center

MEMS

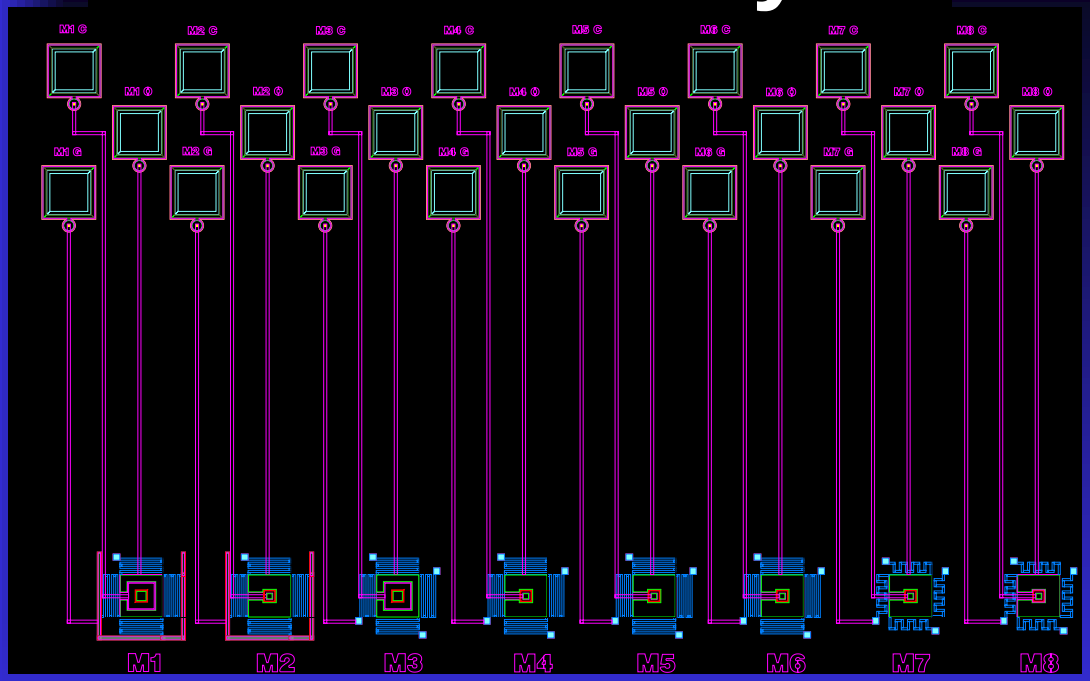
SEM of µChain



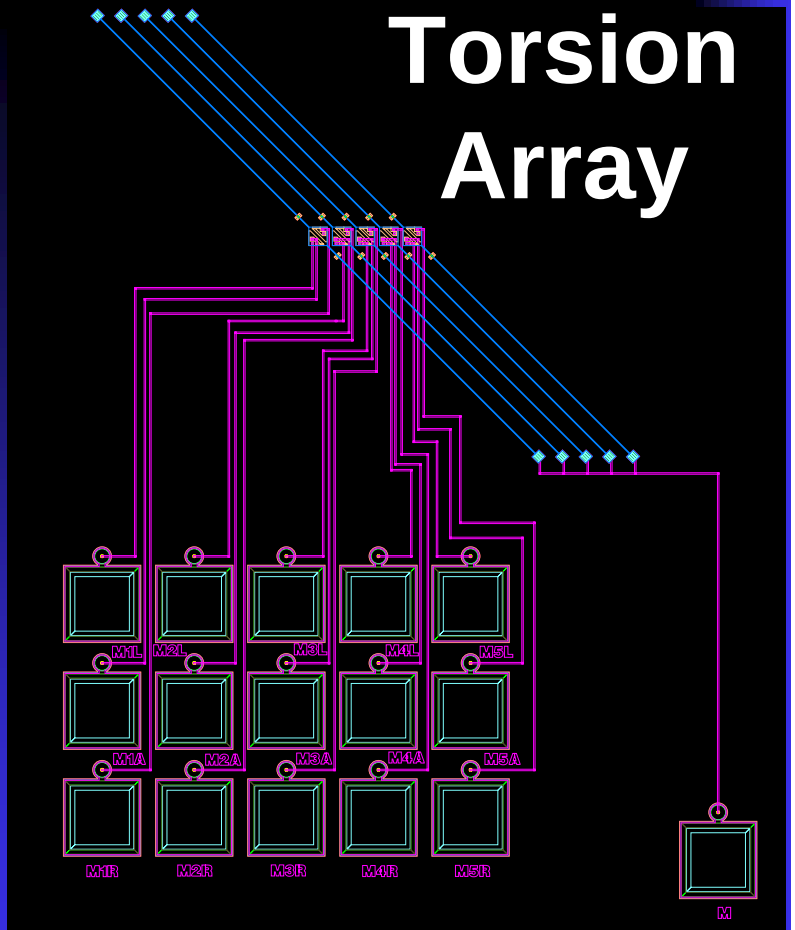
Nano
Tech
Center

Simulated Designs: µMirrors

Piston Array



Torsion Array



Analog control beyond snap down voltage?

Nano Tech Center

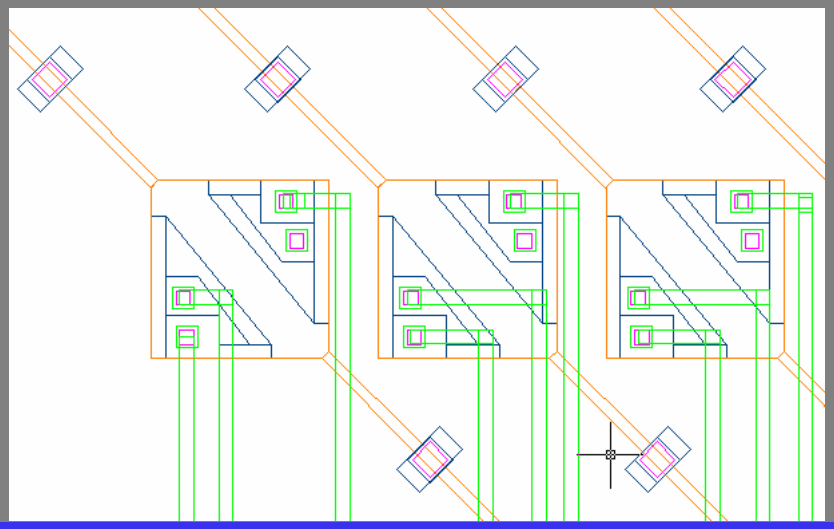
B. Kawade – Session 1 (Wiggins Room): Wednesday 11:40pm
Jordan Berg – Session 2 (Wiggins Room): Wednesday 1:50pm

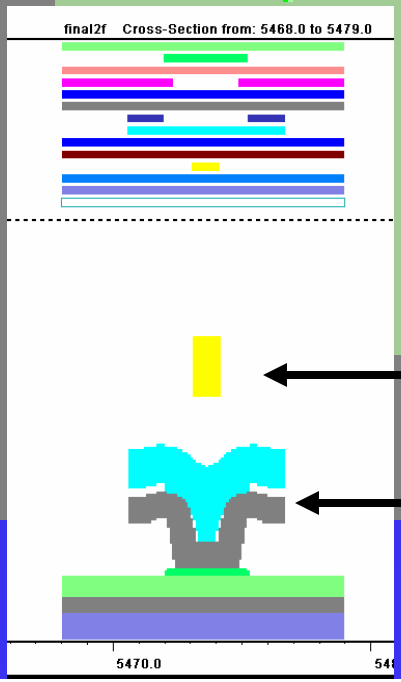
MEMS

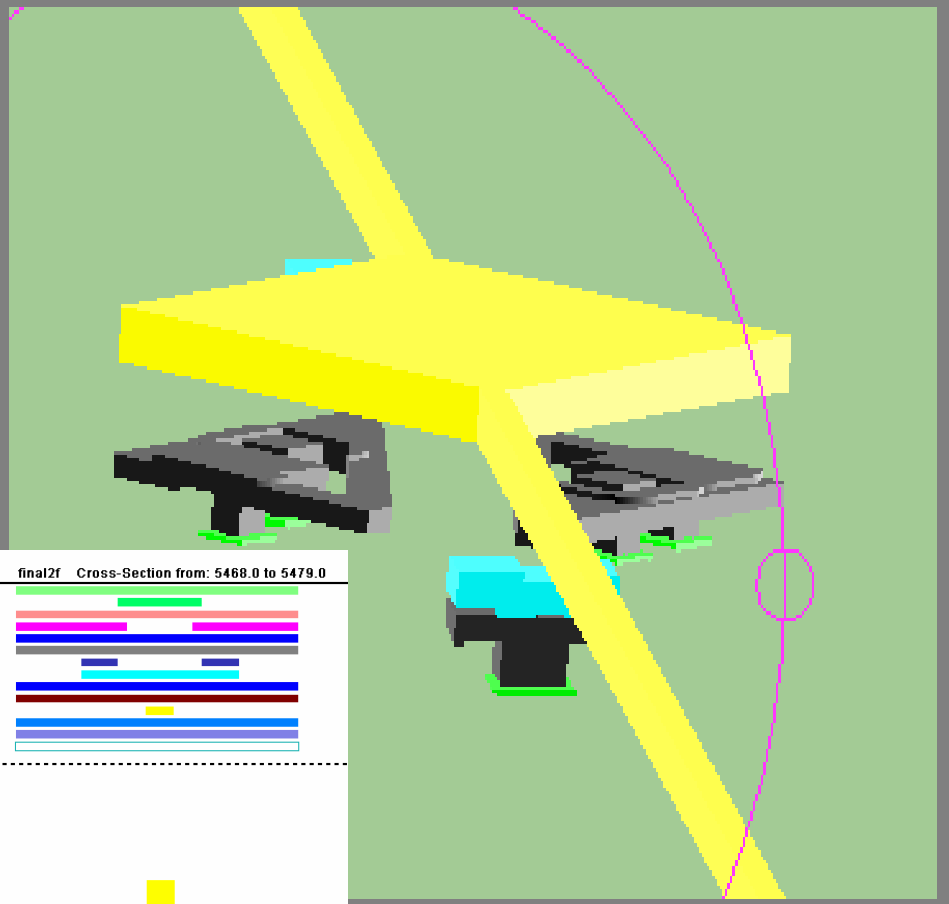
Torsion µMicromirror Array

Mirror dimensions:
- **Pitch: 32 µm**
- **Size: 25 µm x 25 µm @ poly3**
- **Spring length: 400 µm**

Performance
- **Analog translation: 0.36 µm**
- **Analog rotation: 8°**
- **Voltage: 50 V**



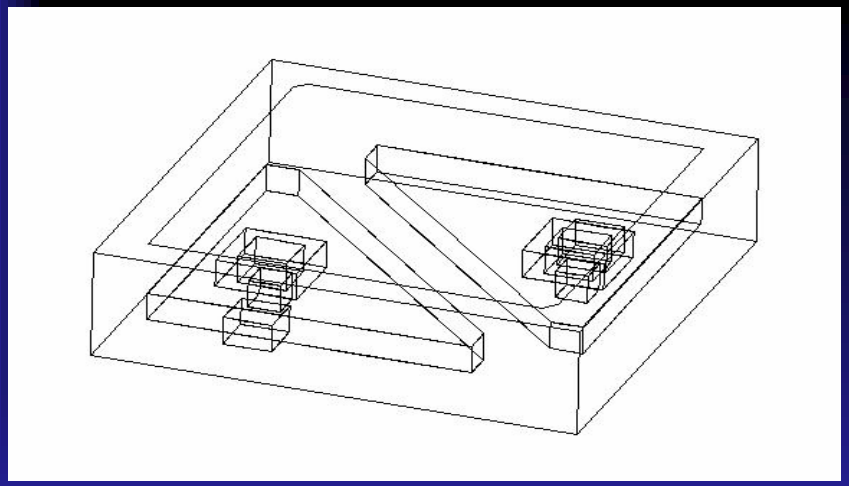




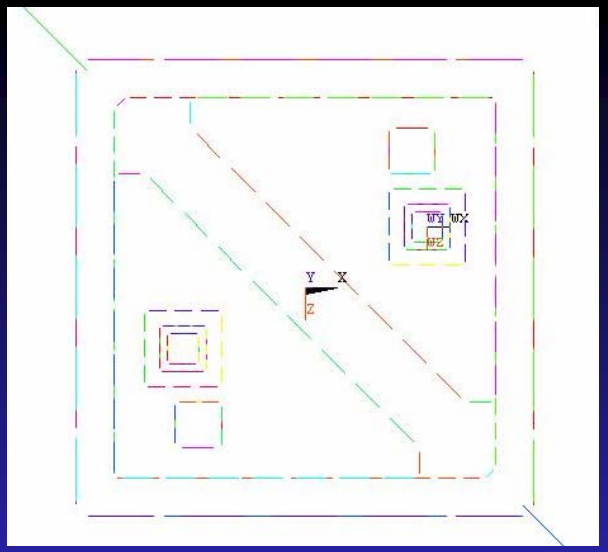
Nano Tech Center

MEMS

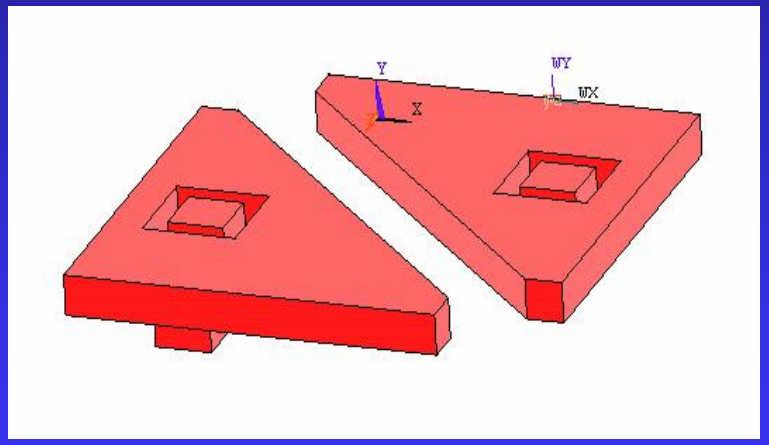
ANSYS Modeling of Mirror



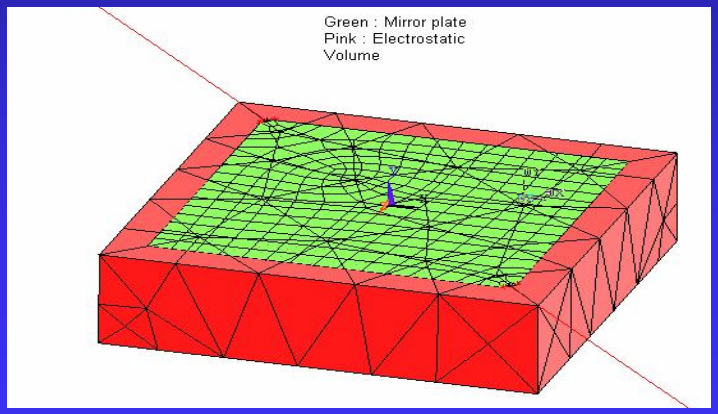
Line Model



Top View



Drive And Auxiliary Electrodes

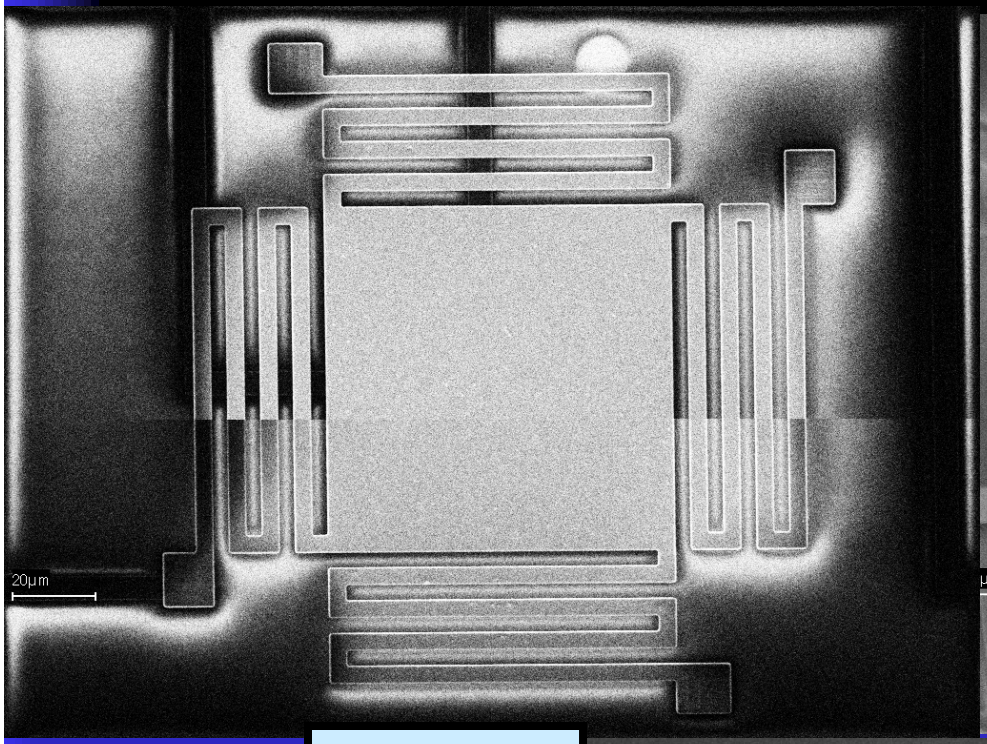


Meshed Model

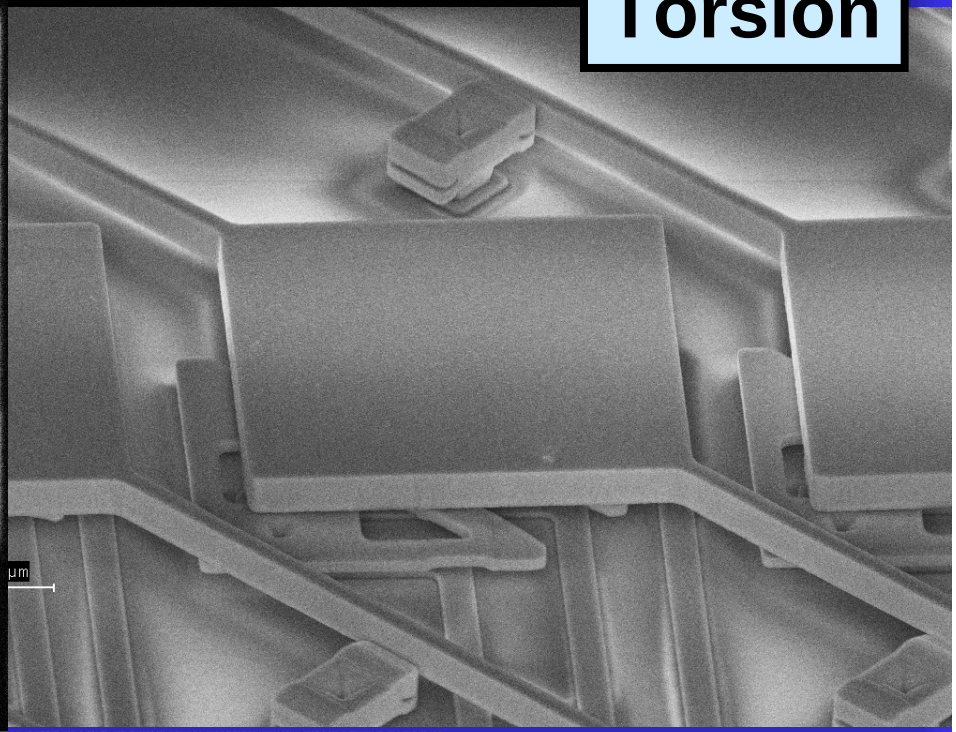
Nano Tech Center

MEMS

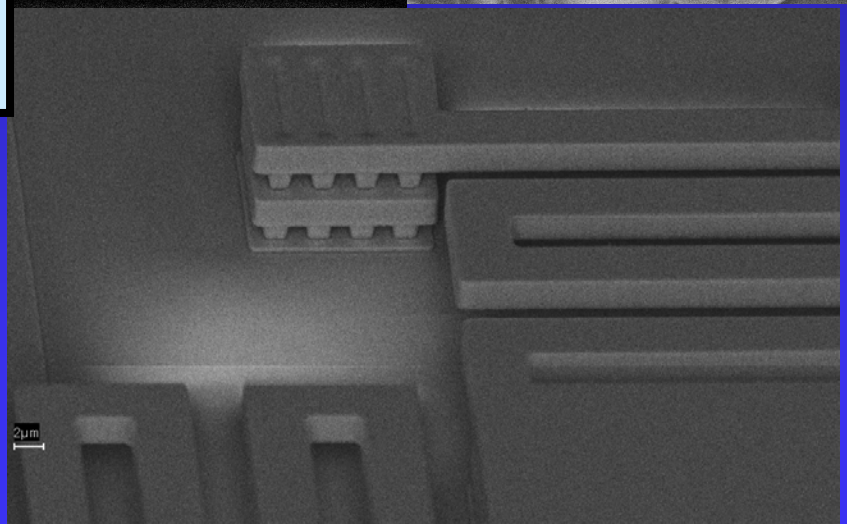
SEM of Mirrors



Torsion



Piston



Nano Tech Center

MEMS

Outcomes

- Students learned a lot about MEMS design, simulation, and processing
- Won design competition
  - more importantly: design was fabricated and we now are in the process of testing the devices.
- Devices will benefit research – journal articles
- Start of recurring process for MEMS class activities
- Generated interest in next class of students

Nano Tech Center

MEMS

Conclusions

- Students motivated by contest
- Students motivated by tie-in to own research
- Students discover difficulty in design
- Fabricated devices will allow testing/characterization by subsequent classes
- “Curriculum” can be tailored to each students needs and interests.

Nano Tech Center

MEMS

Acknowledgements

- **MEMS II/III Students – Spring 2005**
  - **Phillip Beverly, Shad Holt, Meetul Goyal, Erika Washington, Balasaheb Kawade, Vinayak Raja, Ananth Krishnan, Yeong-Jer Chen, Ranjith Podival, Shashikant Shrimali**
  - **Lu Tian and Jongsin Yun (Imaging and Electronics)**
- **TTU TLTC Grant**
- **NSF ECS #0326218**
- **Sandia MESA Group**

Nano Tech Center

MEMS