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UNIVERSITY OF LOUISVILLE
NEXT GEN SYSTEMS

Experimental and Simulation Studies on Electrothermal Actuators

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University of Louisville

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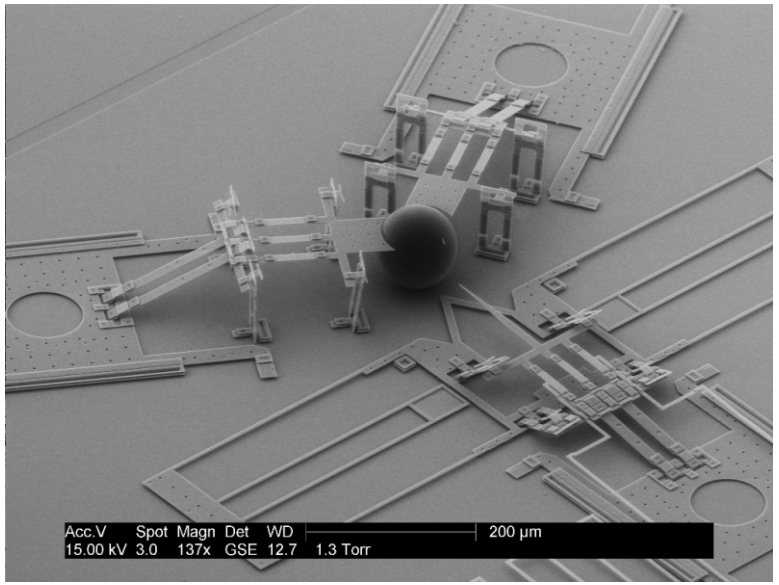
Introduction

Microrobotics

- Robotics on the micron scale
- Utilizes MEMS, MicroAssembly technology
  - Silicon-on-Insulator (SOI) technology too
- Applications in medicine, nanotechnology, and micromanufacturing



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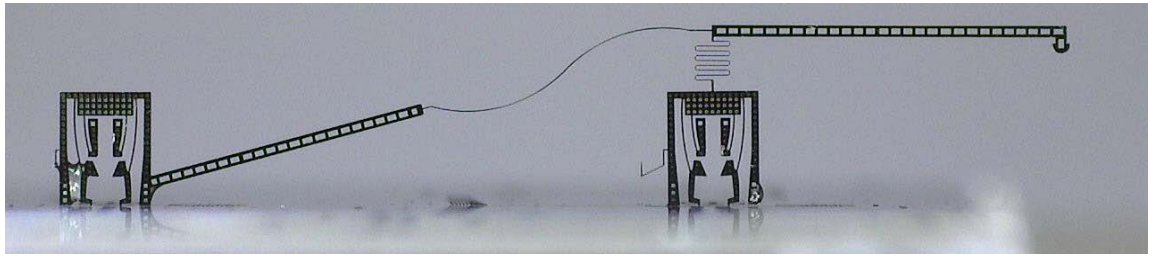
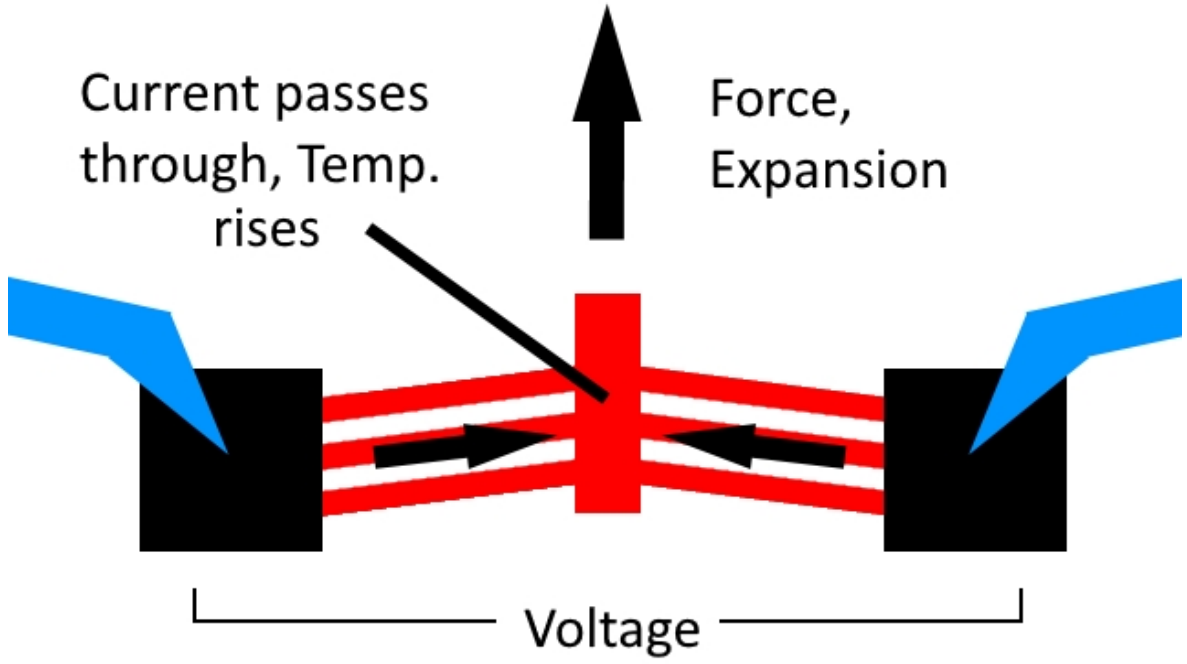


Photo credit: Ruoshi Zhang/U of L

Introduction

- Electrothermal Chevron Actuators
  - Power microrobots
  - Convert electric current to work by Joule effect
    - Electric Current > Heat > Expansion
- This project deals with chevron-powered grippers
  - Design
  - Fabrication
  - Simulation
  - Testing



Electrothermal Chevron Actuators
Credit: John Ronkainen

Design

- Three microgrippers designed in Tanner L-Edit
  - Designated A, B, and C
  - All use electrothermal chevrons

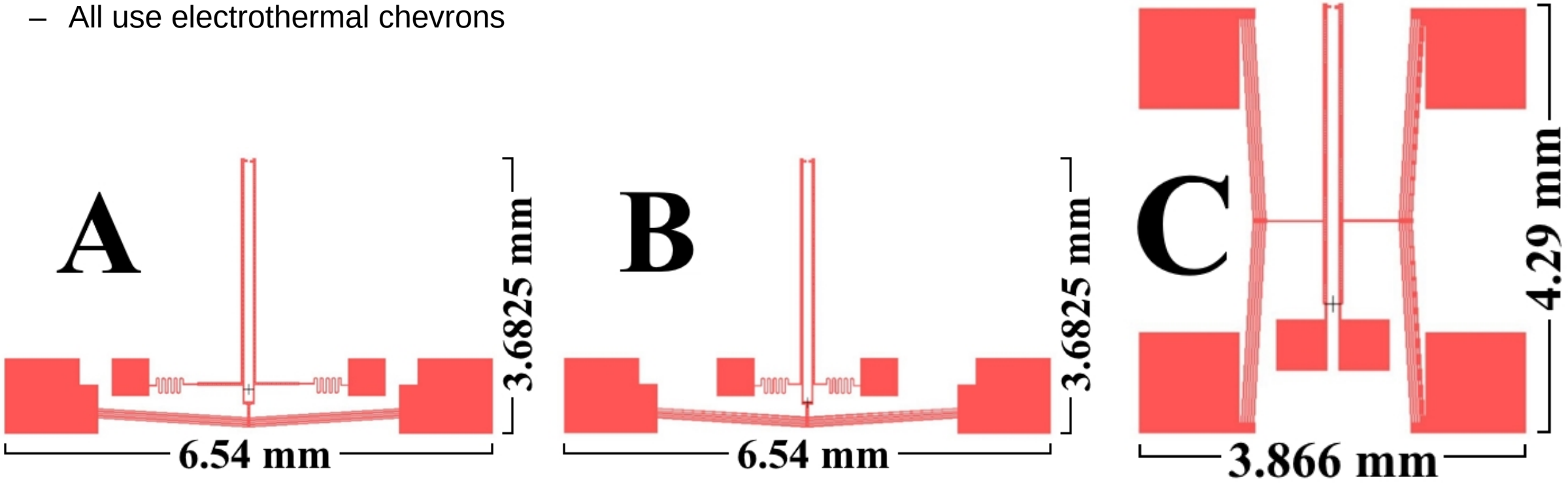
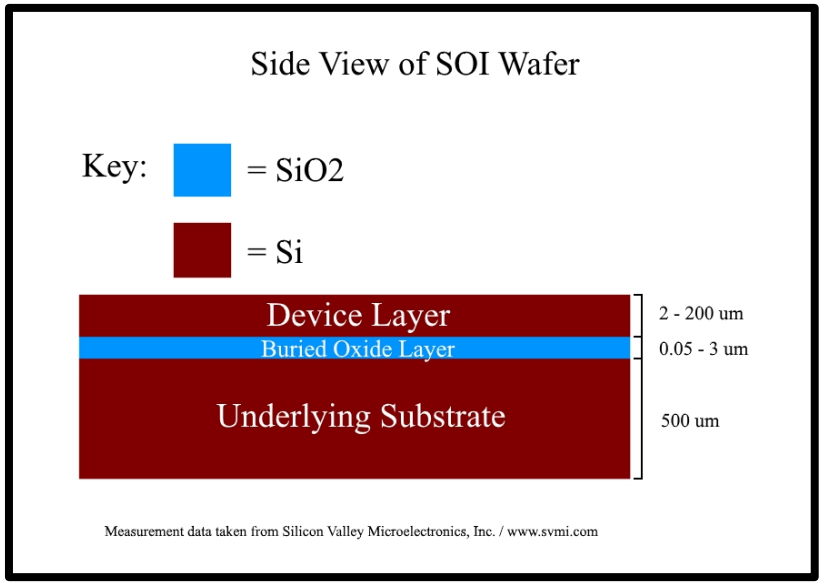
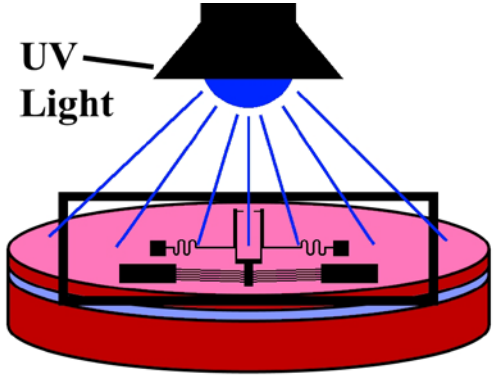


Image credits: John Ronkainen

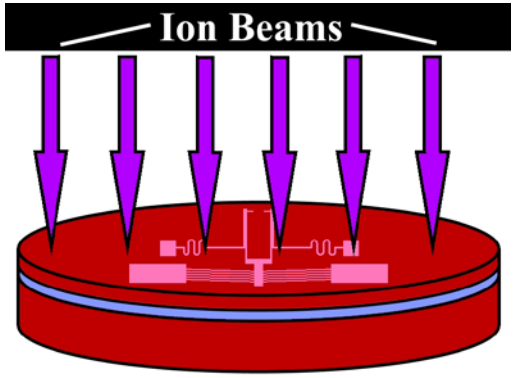
Fabrication

- Fabricated via Silicon-on-Insulator process
  - Photolithography
  - Deep Reactive Ion Etching
  - HF Acid Release

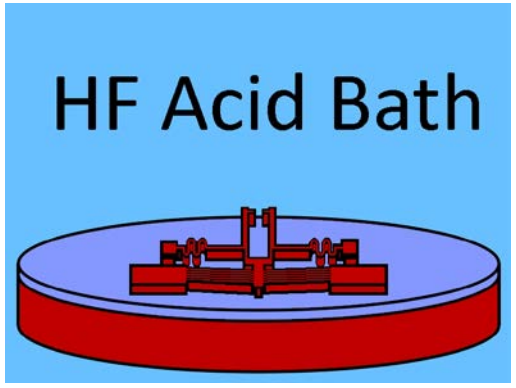




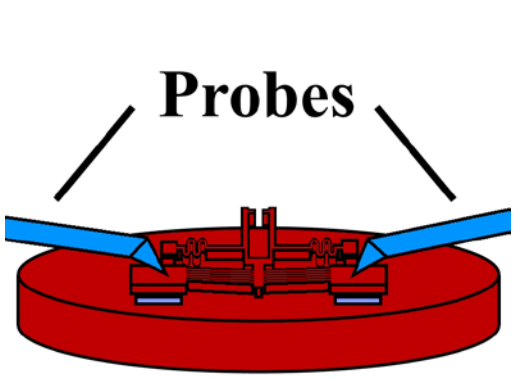
Photolithography



DRIE



HF Acid Release

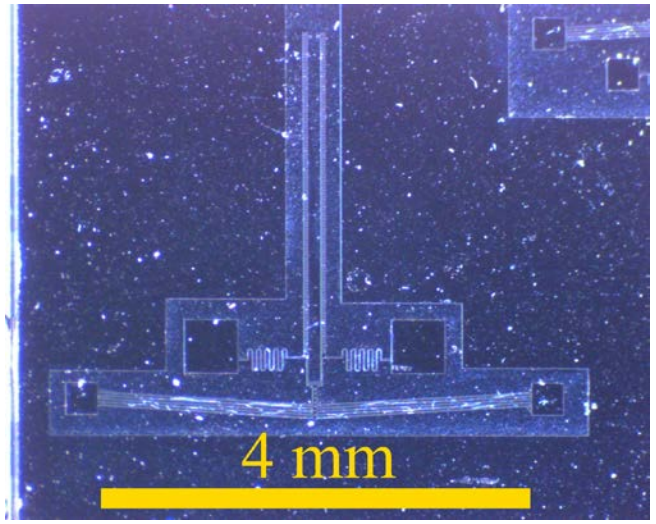


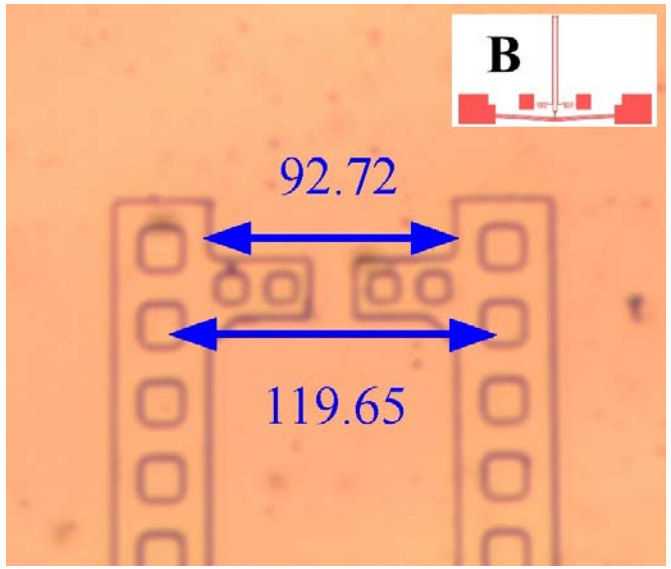
Finished Fabrication

Image credits: John Ronkainen

Experimental Results

- Testing:
  - Placed probes on contact pads
  - Applied DC voltages
    - 20 V to 33.6 V
  - Displacements measured by optical metrology
    - Displacement is ½ change in tip gap





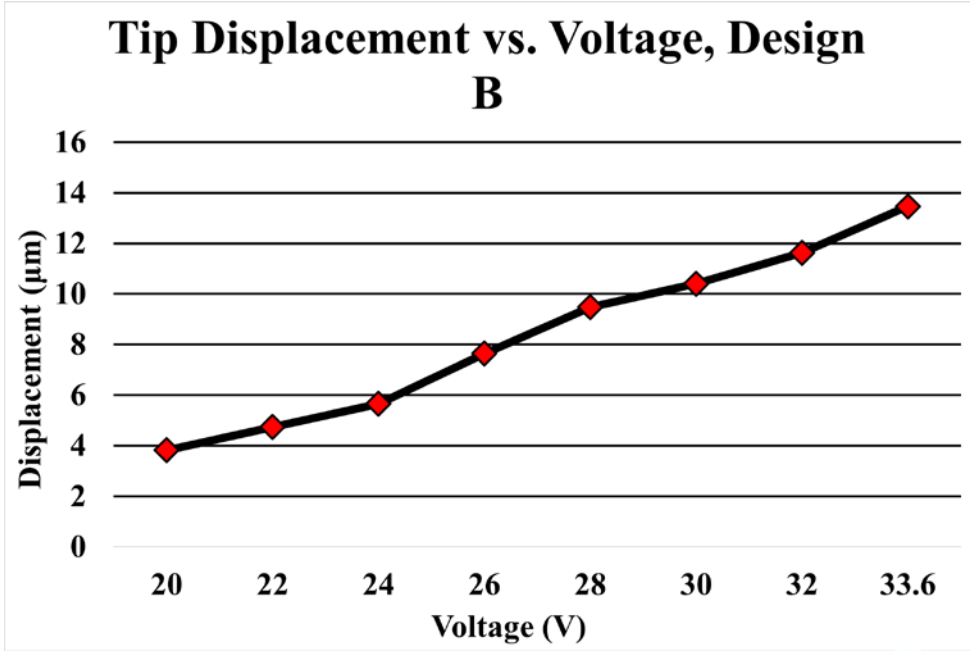
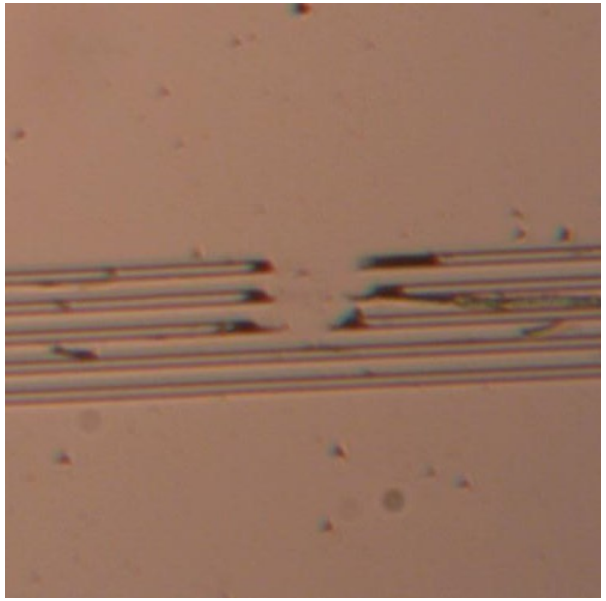


Image credits: John Ronkainen

Experimental Results

- Over-etching during fabrication
  - Prevented characterization of Designs A and C, more time is required to test these
  - Design C shows basic functionality



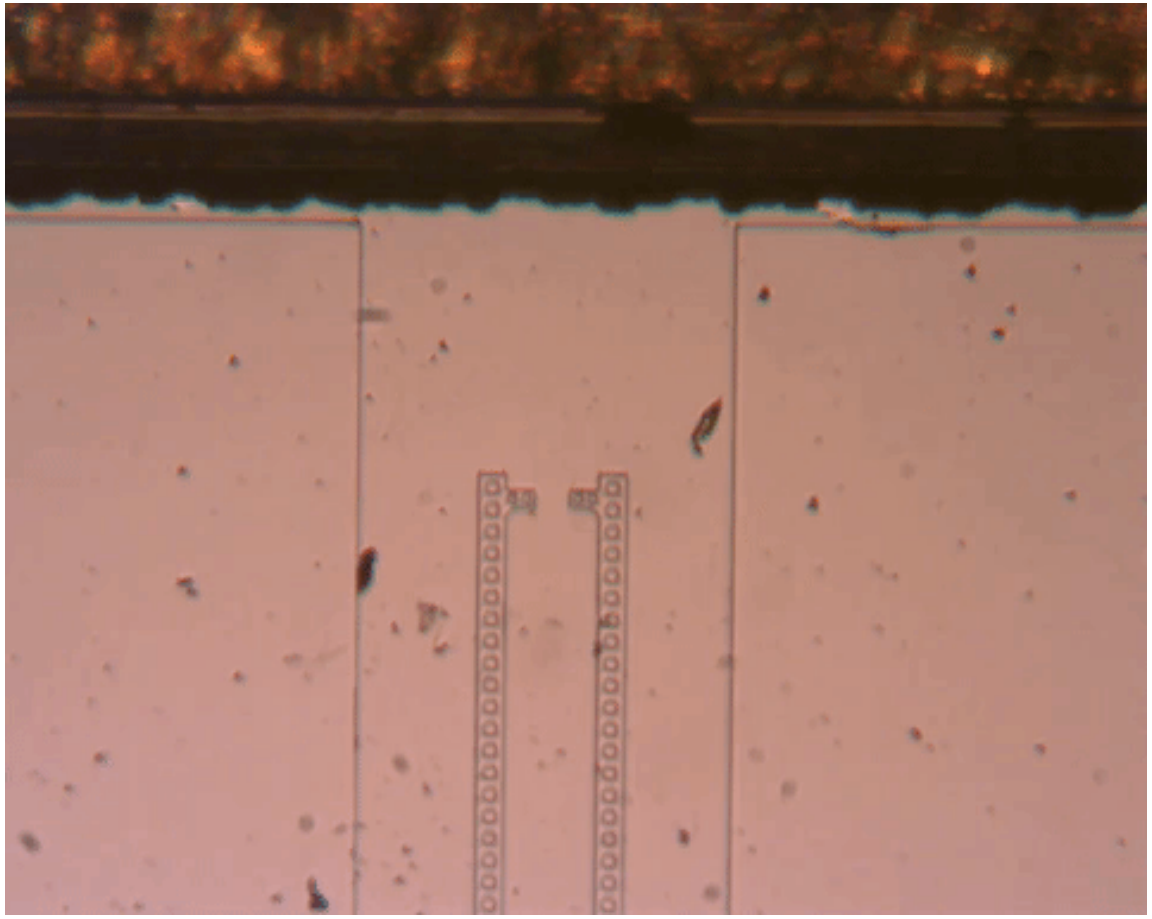
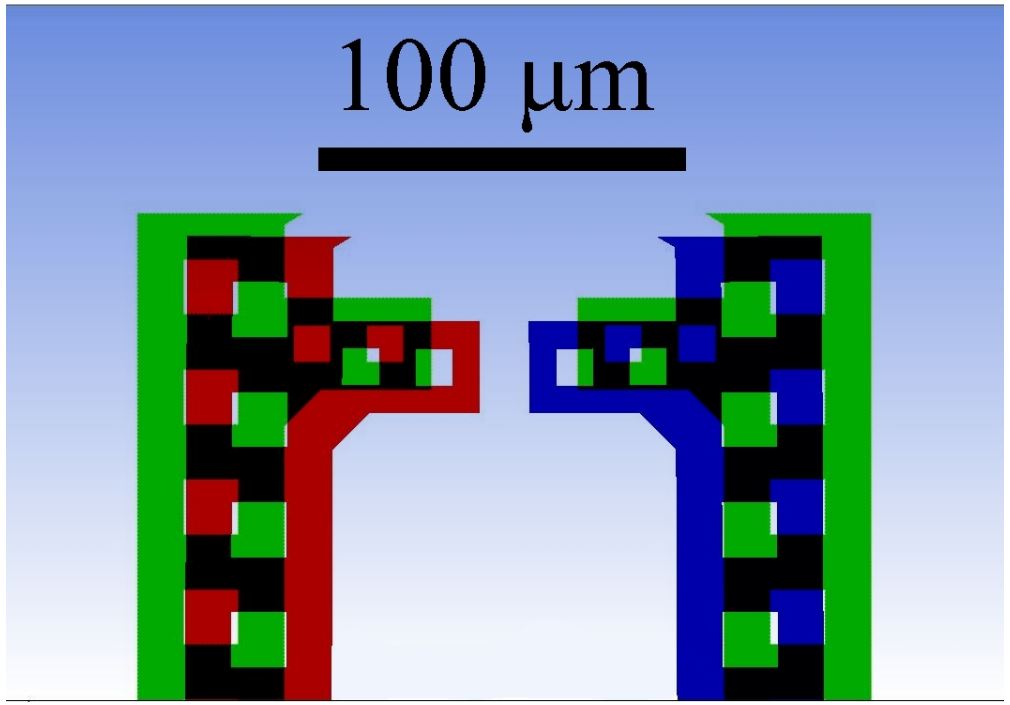
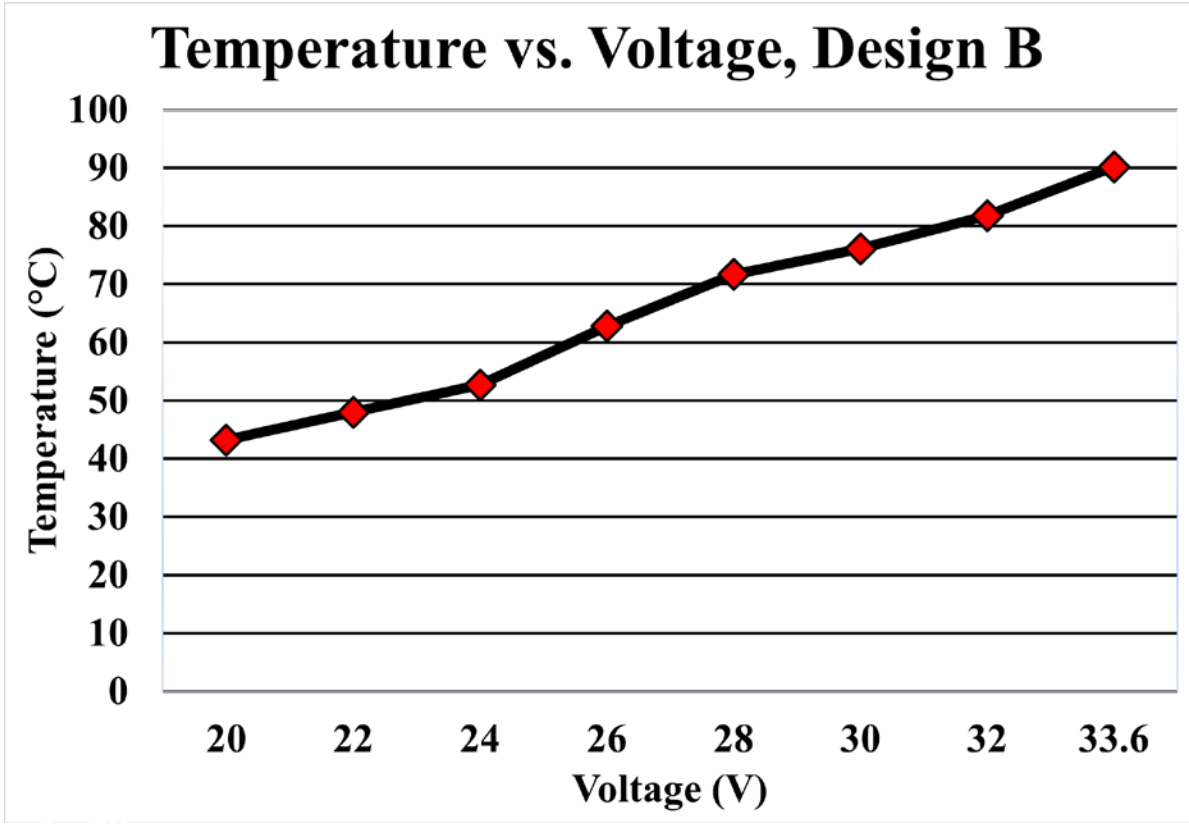


Image and video credits: John Ronkainen

Simulations

- L-Edit files converted to SolidWorks models, placed in ANSYS
  - Thermal conditions modeled
  - Displacements replicated, temperatures recorded





Conclusions/Future Work

- Future Work
  - Design: redesigning will decrease size, increase usability
  - Device Layer Thickness: 20 μm is very thin, 50 or 100 μm would be sturdier
  - Fabrication and Testing: more devices could be made and tested, larger sample size

- Microgrippers were designed and fabricated
  - Design B shown to work
    - Voltage: 20 – 33.6 V
    - Temperature: 43.2 – 90.2 °C
    - Displacements of 3.8 – 13.5 μm

Acknowledgements

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- The Next Generation Systems Group provided much-needed assistance in this project

Are there any questions?