SACL

Piezoelectric Devices for Stanford's Stretchable Network

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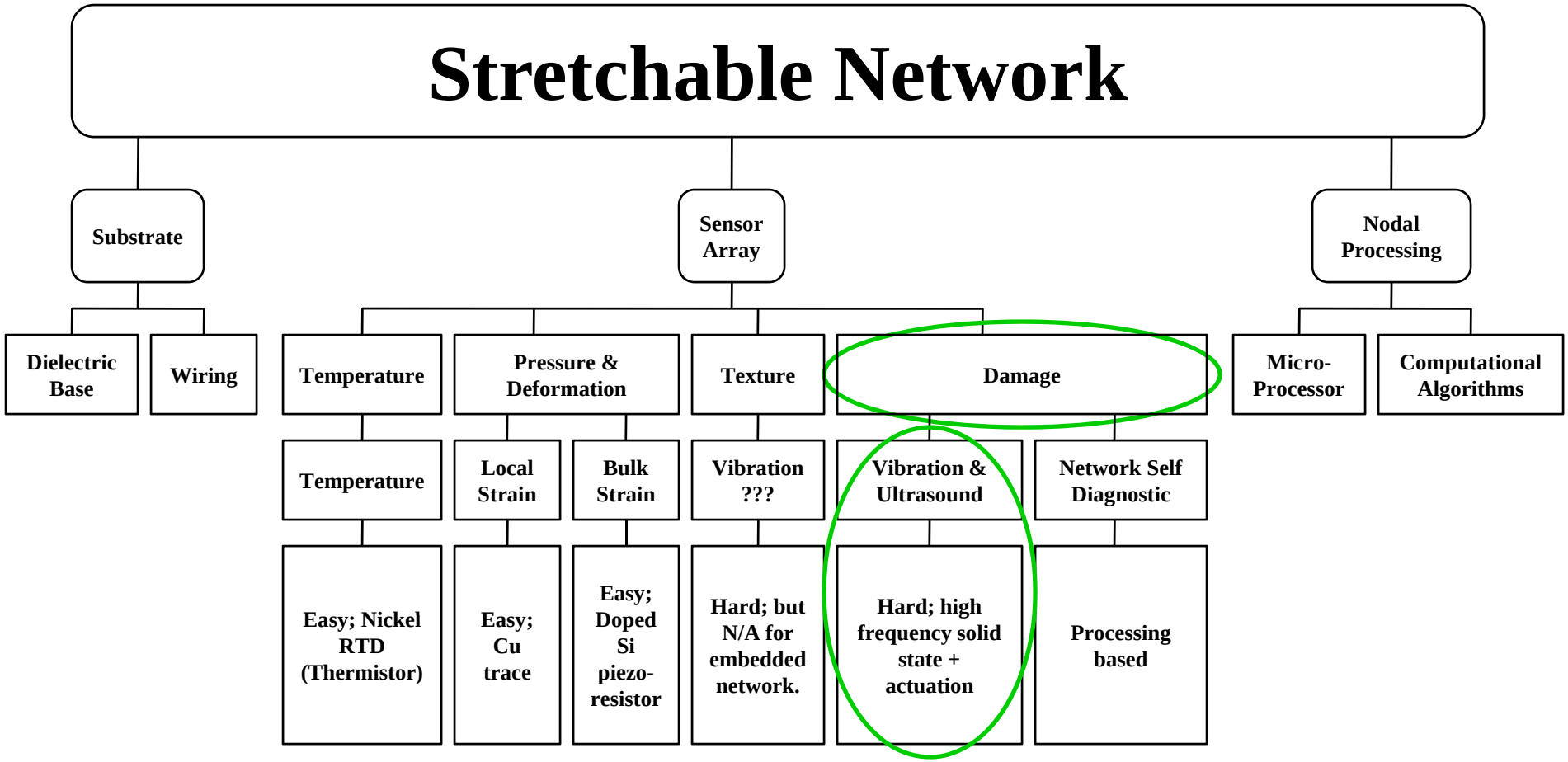
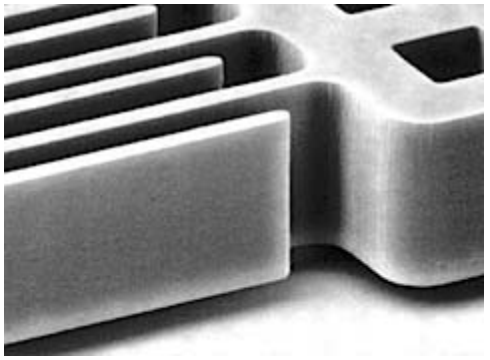
Parts of the Stretchable Network



Issues with Current Devices

- Micro Scale Devices
  - Sensing only, no actuation
  - Low Frequency
    - Typically <5kHz
  - Require air gaps
    - Comb or tuning fork design
    - Not appropriate for immersion in a polymers or embedding in composites
- Macro-Scale Devices
  - Not easily scaled to appropriate size



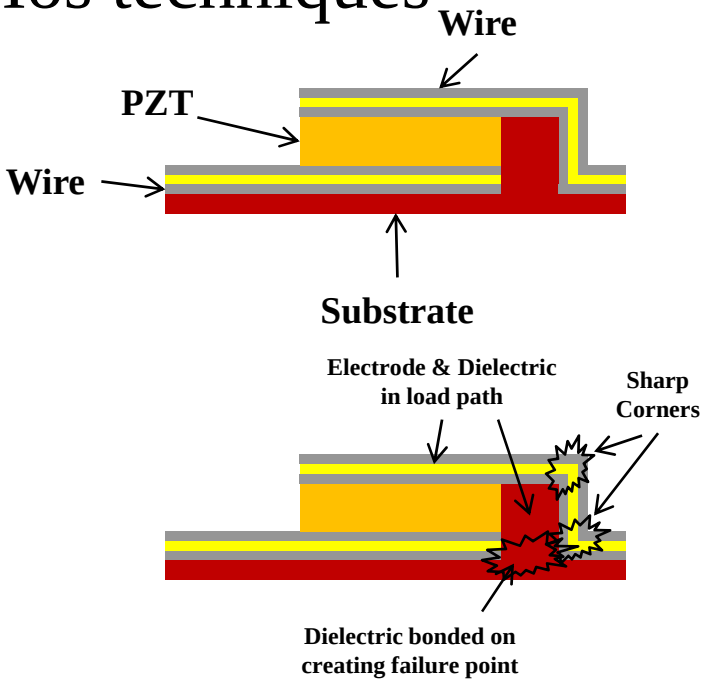
Close up of a comb MEMS accelerometer, note air gaps

Piezoelectric devices

- Piezoelectric based systems provide the most capable SHM systems at the Macro scale
  - Ultrasonic systems capable of detecting multiple damage forms
  - Actuation & sensing capability
  - Impact and other forms of detection
  - Miniaturization will enable greater capability through more precise quantification of damage.

Issues with "Traditional" PZTs

- Hard to manufacture using C-Mos techniques
  - Many layers(8 layers + 4 masks)
  - Application of individual PZTs
- Numerous failure points
  - Electrode may disbond
  - Wire breakage
    - Sharp corners
    - Wiring in load path
    - Possibility of numerous disbonds that could lead to breakage
- Indirect load path (through wiring and dielectric)



Solution:

- Develop piezoelectric transducers that are easily manufacturable on a small scale.
  - Manufacturable in sizes from 200µm (7.9mil) to 800µm (31.5mil) in diameter
  - Manufacturable in C-Mos foundry/clean room, to enable concurrent manufacture of other components.
- Design should include
  - Clean load path to surrounding structure
  - Reduced stress concentration & failure points

Current work

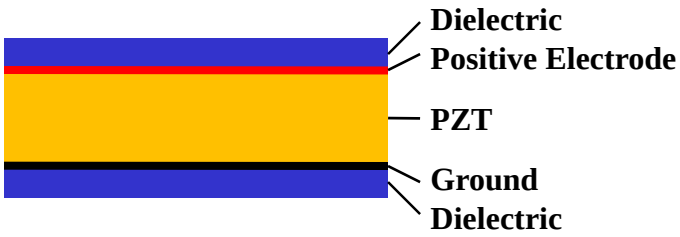
- 2 pronged approach
  - Macro-scale (Easier to characterize and compare results to existing technology)
    - Utilize scalable manufacturing techniques easily adapted to micro-scale production
    - Develop techniques that will work at the micro scale
  - Micro-Scale
    - Develop manufacturing techniques to produce robust actuator/sensors at of the appropriate size
    - Develop functional and robust Piezoelectric actuator/sensors at appropriate scale

Nathan Salowitz

- Education
  - B.S. – Engineering Mechanics
    University of Wisconsin
  - M.S. – Aeronautics & Astronautics
    Stanford University
- Experience
  - Structural Analyst
    Boeing
- Hobbies
  - Sailing
  - Snowboarding

Comparison

Traditional PZT



- Advantages
  - Standard polarization = easier bulk fabrication
- Disadvantages
  - Indirect load path
  - More layers
  - Significant step
    - Complicates nano-fabrication
    - Failure point

Planar Electroded PZT

- Advantages
  - Fewer layers =easier nano-fabrication
  - Direct load path
  - Potential gain in actuation
    - d_{33} direction
- Disadvantages
  - Non-standard polarization
  - Non-standard deformation