Bat-inspired Hair Sensor

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Concept
- Biomimetic hair sensors
  - Polymer fiber fabricated with integrated circuit transducers
  - Directional readout via capacitive coupling to electrodes at base
  - Robust physical design, easily manufacturable
- Sensors distributed on bat wing

System Design
- Ultimate goal is to understand the role of multimodal sensing in natural flight
- Initially use COTS readout and refine to reduce footprint and improve resolution

COTS:
- Surface mount ROIC 5 x 6 mm
- Overall size 9 x 10 mm on wrist
- Min resolution 4 fF

Custom:
- Custom ROIC < 2 x 2 mm, Hair on top
- Place sensors on finger knuckles, too
- Min resolution <100 aF

Sensor Structural Design
- Directional sensing possible using multiple electrodes
- High sensitivity due to diaphragm
- Silicon disc provides capacitance amplification
- Simple and robust mechanical structure

Hair Fabrication Process
- Standard microfabrication in a 3-step process (Top half, Bottom half, and Assembly)
  - Optical fiber based UV lithography
  - Easy to mimic tapered structure of bat hair due to beam divergence of optical fiber

Capacitive Sensing
- Two stage conversion:
  - Coarse conversion performs capacitive offset compensation (MSB)
  - Fine conversion converts residue (LSB)

I2C readout:
- Only 4 wires: Power, Ground, Serial Data, Serial Clock
- Interface already implemented and will be adapted for custom design

Contributions
- Designed, simulated, and prototyped physical structure
- Concept for instrumented animal studies
  - Pair flex PCB with microcontroller and battery backpack
- Custom readout design implemented and chip currently being tested