MEMS Current and Voltage Sensors

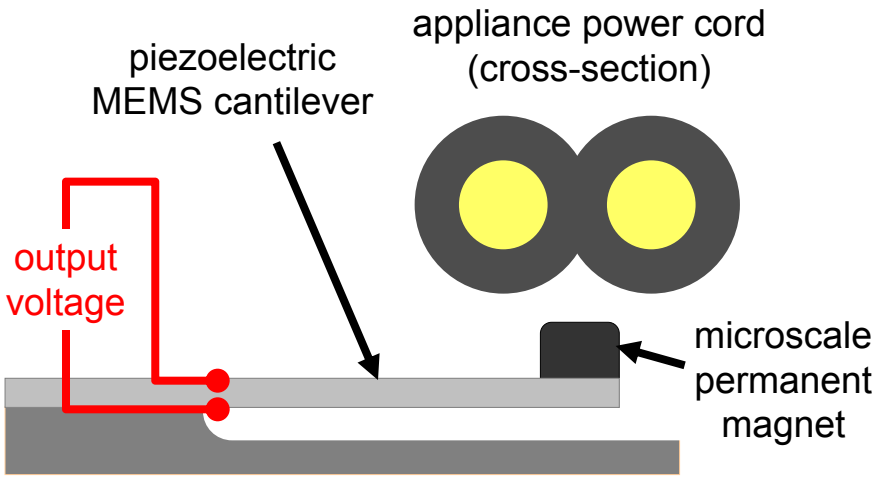
We have developed sensors that are:

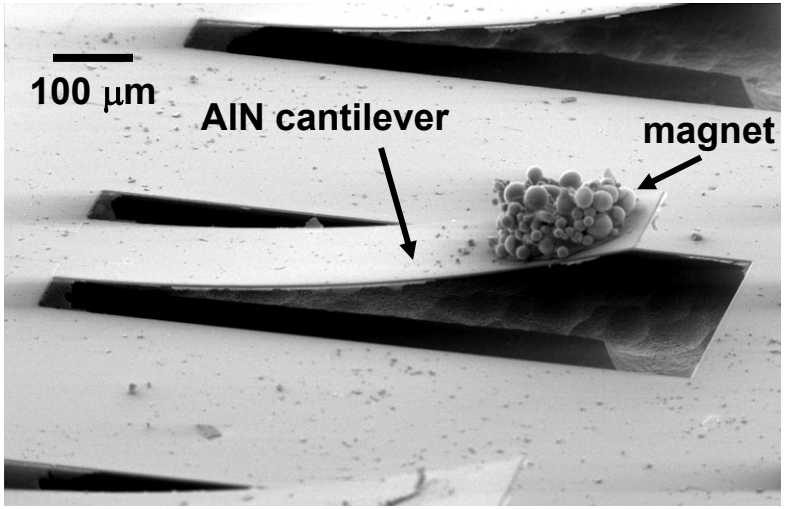
- Passive
- Proximity-based
- Integratable

Eli S. Leland, Christopher Sherman, Peter Minor, Dr. Igor Paprotny, Prof. Richard M. White, Prof. Paul K. Wright

iTRIS
Center for Information Technology Research in the Interest of Society

Design concept: Piezoelectric cantilever and a permanent magnet

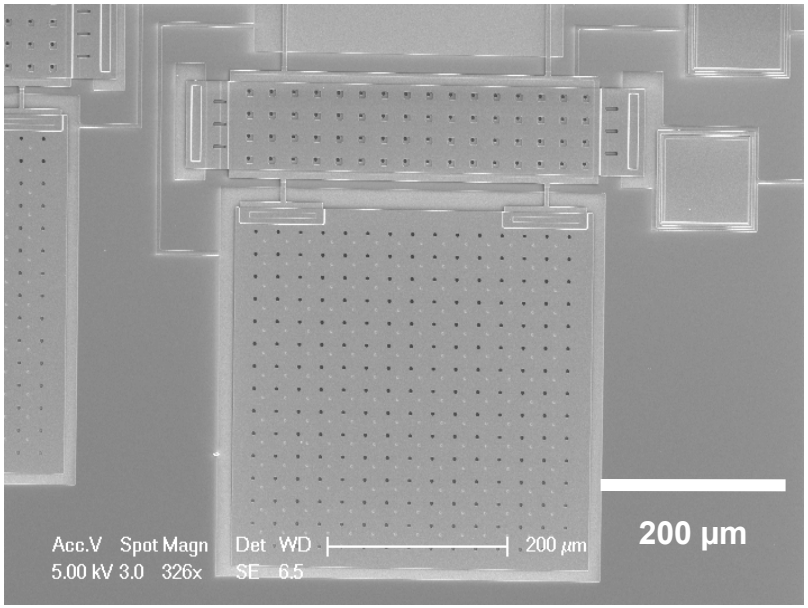




- Permanent magnet couples to the magnetic field surrounding AC current carriers, piezoelectric cantilever converts force on magnet to voltage signal
- Sensor device does not require power supply or physical encirclement of conductor
- Fabrication process is compatible with microelectronics fabrication

Voltage and power sensing

- Prof. White and Dr. Igor Paprotny have fabricated an integrated MEMS power sensor and are working on MEMS voltage sensors. Research continues on these devices



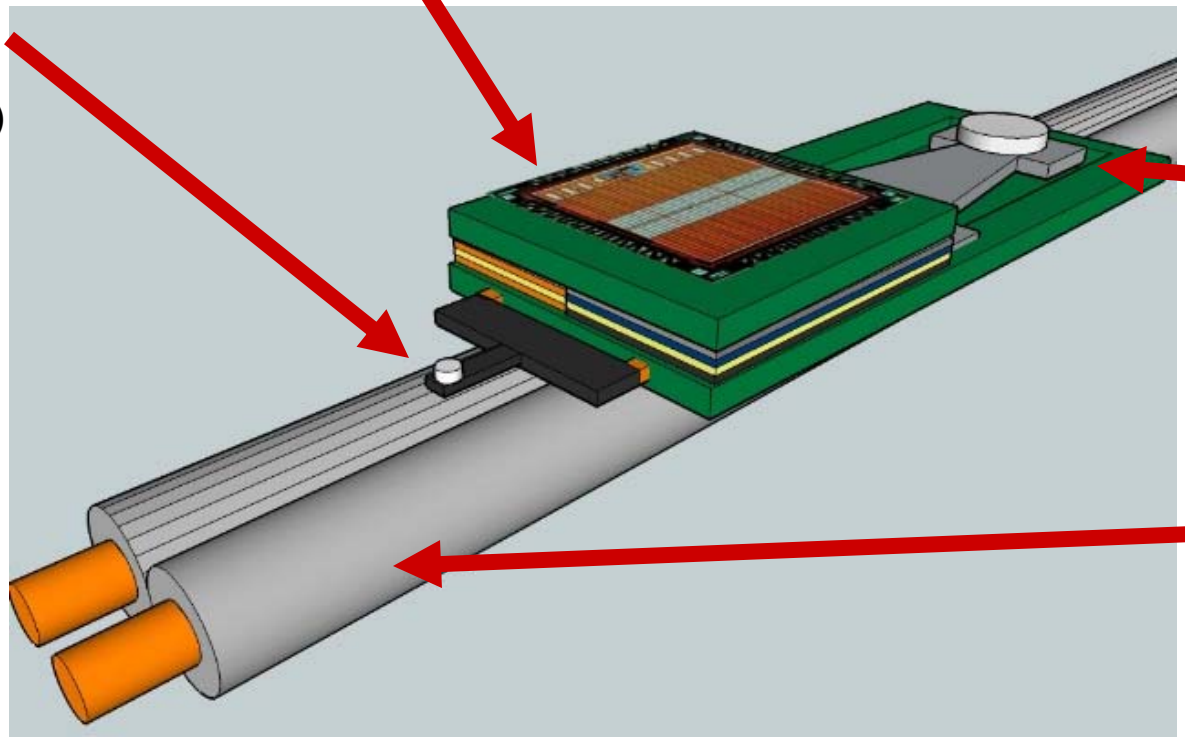
SEM of a fabricated MEMS passive proximity power sensor (testing ongoing)

Concept sketch: Integrated current sensor node

MEMS AC current sensor (AlN cantilever with NdFeB magnet)

On-board printed energy storage, radio, computational circuitry

Energy-harvesting power source (PZT cantilever with larger NdFeB magnet



Dual-conductor electric power cord (AKA "zip-cord")

A self-contained, self-powered current sensor node can be constructed using two similar piezoelectric cantilever devices, one optimized for current measurement and the other for energy harvesting power generation. These devices combined with printed storage (battery/capacitor) and low-power computation and radio circuitry would comprise a complete sensor node.

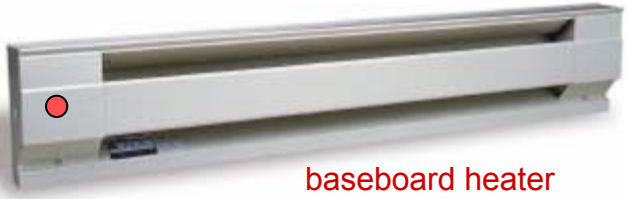
Application: Electricity end-use monitoring

Keep track of where all the electrons are going! Retrofit or build sensors in to...

power strip and appliance cord

electric range

air conditioner



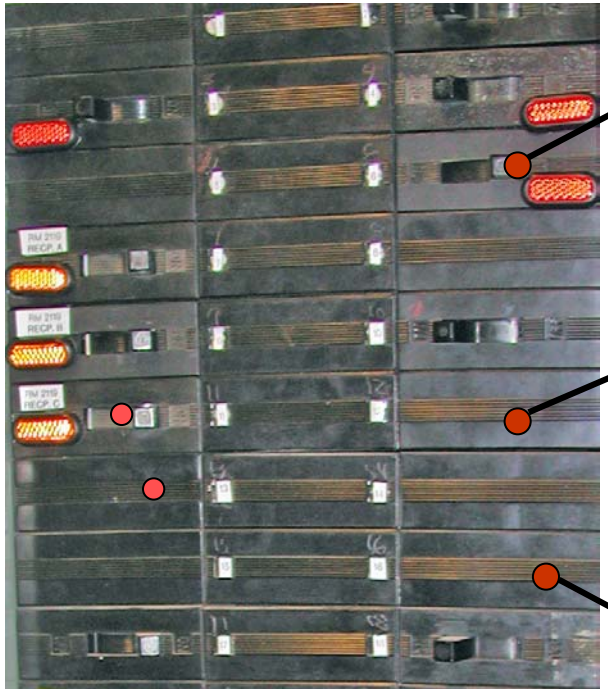
baseboard heater

- This new current sensor in combination with advances in wireless sensing platforms will enable "power-aware" homes and buildings that can track electricity use in real time with high resolution
- MEMS sensors can be retrofit to appliance cords or built in to appliances or cable housings
- Applications of these technologies include demand response and energy efficiency
- This application would target the OEM market (license technology to appliance makers or their suppliers)

Application: Sub-metering, circuit breakers

Build sensors in to circuit breaker housing or retrofit with "stick-on" sensors

circuit breaker



Radio inside closed breaker box transmits information to outside for interpretation

Machine shop

Instructional lab

Computer closet

- Circuit breaker industry is a $5B market, annually
- Circuit breaker box can be used as a central point for current monitoring
- Again, target circuit breaker OEMs
- Patent applied for

Application: Sub-metering, cable access points

480-volt 3-phase cables that supply the Berkeley Microfabrication Facility in Cory Hall

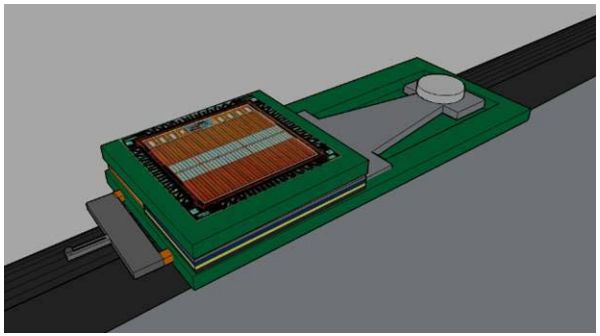
Current sensors on slack 480-volt 3-phase cables in Cory Hall

- Standalone sensors can be retrofit or integrated to cables at convenient access points in buildings

Application: Distribution-level monitoring

Foster-Miller, 1997

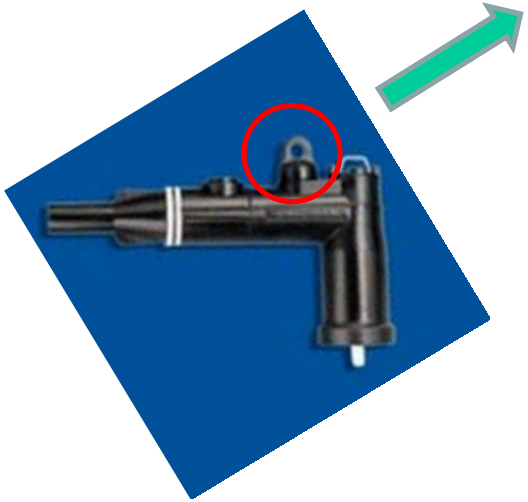
GridSense, Today

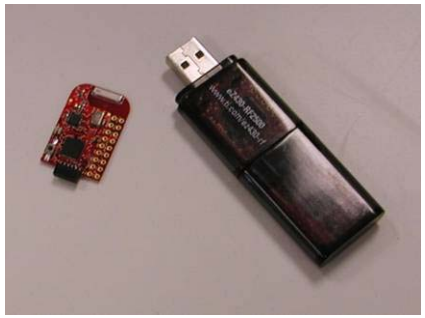


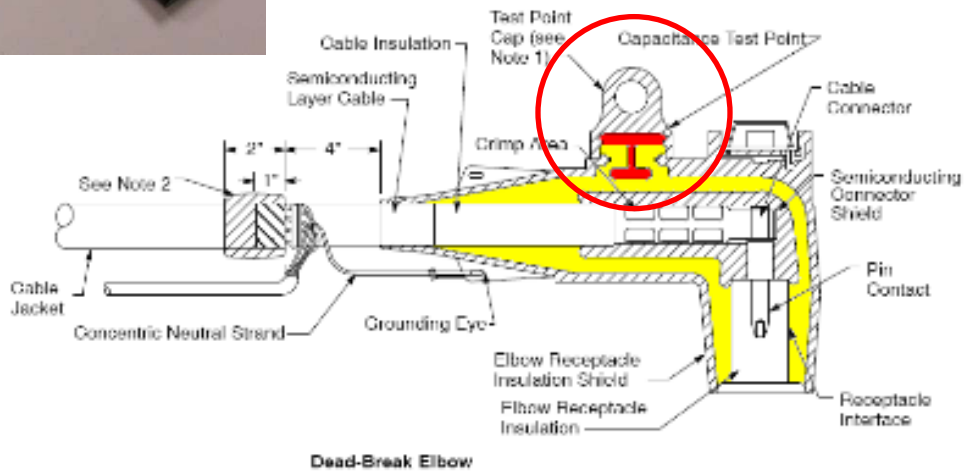
Berkeley MEMS, Tomorrow!

- Widespread distribution has eluded previous and present technologies because of cost ($10-12k per three phases)
- We think a price point of $1k per three phases installed is realistic
- Could eventually integrate sensor package into cable insulation, driving installation cost to zero
- This market would target the distribution infrastructure owner/operators and their OEM suppliers

Application: Current and voltage measurement in underground distribution cables







Dead-Break Elbow

- PG&E has 75,000 miles of underground distribution cable in its territory. At some point all of this cable will be monitored.
- 75,000 miles of cable = a lot of sensors

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Questions?

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