Center of Integrated Nanomechanical Systems
NSEC Grant # 0832819

PIs: Alex Zettl, Ron Fearing, Tsu-Jae King Liu, Roya Maboudian, Peidong Yang

COINS Application Drivers

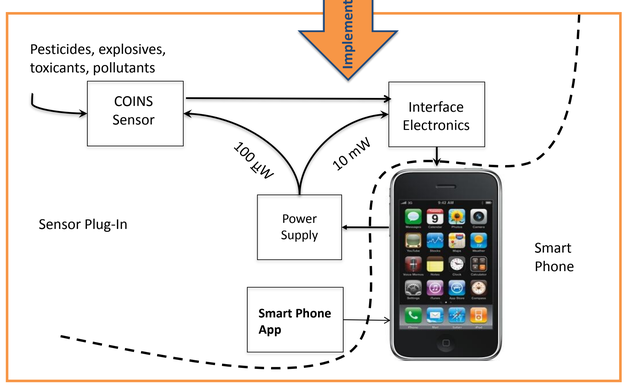
Personal Monitoring


Exhaust from power plant smokestack

ppbRAE 3000 State-of-the-art personal environmental monitor.

- Current personal environmental monitors are still expensive ($7k), power hungry, and run for 10 hours at a time
- COINS goal: better air-quality detection
  - Should be portable, sensitive, low-cost, low-power
  - Something that people can use easily, interfaces with cell phones

Implementation



COINS Application Drivers

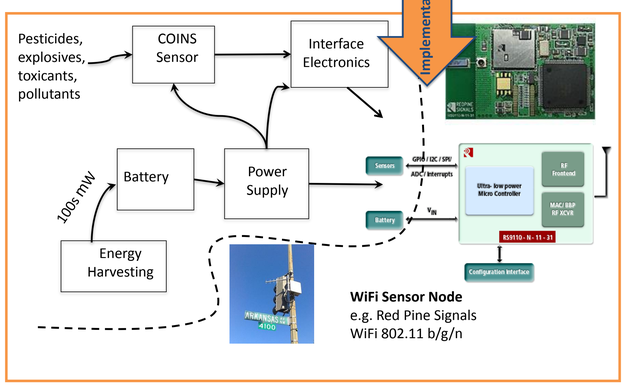
Community Monitoring


San Bruno Gas Explosion


Crop Duster Applying Pesticide

- Low-power, low-cost chemical sensors will enable wireless sensor networks to provide real-time feedback of environmental conditions to:
  - Detect and locate leaks of explosive gas and other harmful pollutants
  - Monitor pesticide drift in air and pesticide build-up in ground and drinking water
- COINS goal: explore novel low-power, low-cost, selective nanomaterials-enabled chemical sensors for detection of explosives and toxicants

Implementation



COINS Application Drivers

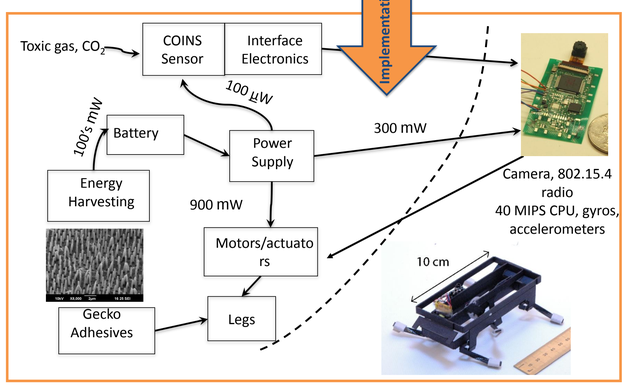
Mobile Monitoring


Rapidly Deployable Chemical Detection System, 2006


Rescuers search for survivors after earthquake in Haiti, 2010

- In addition to being expensive and power hungry, current chemical detections systems require humans for mobility.
- After disaster, collapsed buildings are dangerous for rescue teams making it difficult to locate people safely.
- COINS goal: create efficient tools for search, rescue and disaster prevention services.
  - Should be mobile, communicate wirelessly and able to maneuver in confined spaces.

Implementation



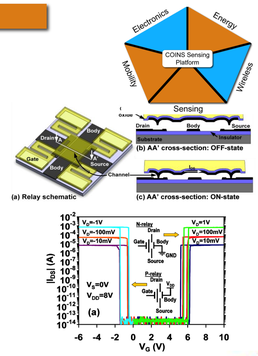
Electronics Example

NEM relays for ultra-low-power circuits

Tsu-Jae King Liu and Roya Maboudian

Challenge: Ultra-low-power electronics for computation and communication, to enable self-sustaining sensors.

Solution: Create a ultra-low-power nano-electromechanical (NEM) relay that offers ideal switching performance:
- zero standby power
- abrupt switching
- high on-state conductance



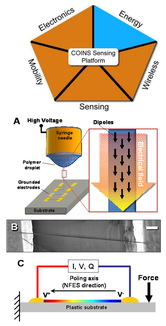
Energy Example

Polymer Piezoelectric Nanogenerator

Liwei Lin

Challenge: Scavenge energy from environment using lightweight, compliant materials

Solution: Direct-write piezoelectric polymer nanogenerator
- Polyvinylidene fluoride (PVDF) can be written directly onto flexible substrate
- High efficiency
- Can also be used as a nanoactuator



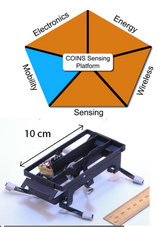
Mobility Example

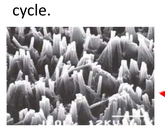
Robotic Work Highlight

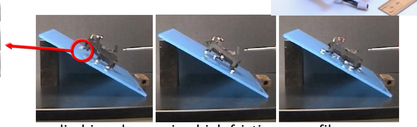
Roya Maboudian and Ron Fearing

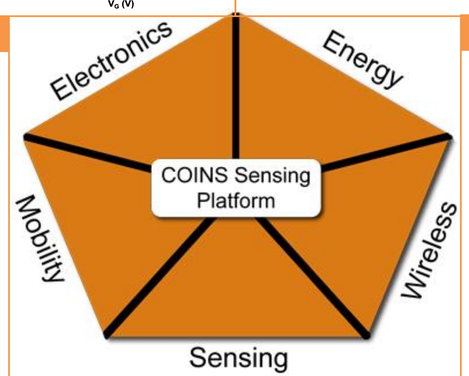
Challenge: Create a mobile platform, capable of carrying COINS sensors, which dynamically engages nanofibrillar adhesives.

Solution: DASH platform (mass 15 grams) with 60 ms leg cycle.




800 nm diam. LDPE nanofibers


climbing slope using high friction nanofibers



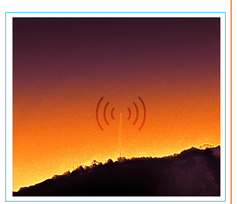
Wireless Example

The Carbon Nanotube Radio

Alex Zettl

Challenge: Development of functional, integrated components for COINS platform.

Solution: Create fully functional, fully integrated radio receiver, orders-of-magnitude smaller than any previous radio, from a single carbon nanotube. The single nanotube serves, at once, as all major components of a radio: antenna, tuner, amplifier, and demodulator.



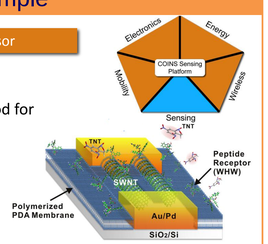
Sensing Example

Integrated Selective Coated Carbon Nanotube FET Sensor

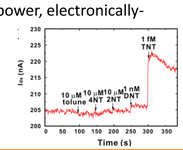
Arun Majumdar and Seung-Wuk Lee

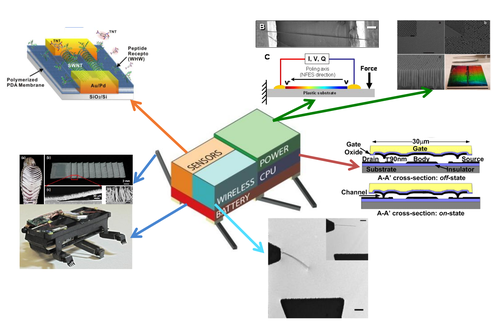
Challenge: Field deployable measurement method for detection of specific targets

Solution: Combine peptide receptors with carbon nanotube FET
- Peptide receptors enable high selectivity
- Carbon nanotube FETs provide high sensitivity with a low-power, electronically-simple read-out



Peptide Receptor-PDA functionalized SWNT FET





Education & Outreach

Undergraduate Accomplishments

Summer Research Programs

- UC Berkeley's REU program continues to strengthen as nearly every objective of our 2010 program showed improvement (based on assessment by an outside evaluator).
- UC Merced, which began with 3 interns in their first year, continues to grow in both numbers and diversity. Year 6 included 13 students of which 53% were underrepresented minorities.

To date, 2 patents & 1 start up were the result of a COINS undergraduate research project that was a collaboration between a UC Merced & UC Berkeley faculty member.

New Programs

Caltech
- Summer 2011 will provide a UC Merced student with a research opportunity at Caltech

Stanford
- Summer 2011 introduces two RET positions at Stanford

UC Berkeley
- Spring 2011 will begin with an NSE research experience for UCB sophomores and community college transfers

With the introduction of an REU position at Caltech and RET at Stanford, COINS will now have an education program at each partner institution.

Diversity

Challenge: Increase the diversity of COINS at all levels

We have incorporated diversity recruitment into all of our activities and have a strong, comprehensive plan to increase the numbers of underrepresented populations.

Accomplishments:
- Faculty diversity has increased to 29% female in Year 6. In addition, females comprise 43% of the COINS leadership team.
- Undergraduate minority participation reached a record 44% in Year 6.

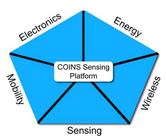
Societal Implications

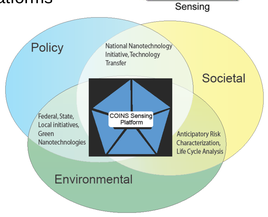
Maximizing Benefits, Minimizing Risks

Mark Philbrick, Margaret Taylor, Chris Vulpe, Ben Gilbert and Peidong Yang

Challenge: Identify and mitigate potential risks associated with the COINS detection platforms

Solution:
- Look at potential applications using a scenario-based life-cycle approach
- Determine nanowire risks: assess the potential for environmental release, behavior in environmental media and toxicity to living organisms





University of California, Berkeley (Lead Institution)

Paul Alivisatos (Chem, MSE)
Daryl Chrzan (MSE)
Michael Crommie (Physics)
Ronald Fearing (EECS)
Ben Gilbert (LBNL)
Amy Herr (BioE)
Ali Javey (EECS)
Tsu-Jae King Liu (EECS)
Luke Lee (BioE)
Liwei Lin (ME)
Seung-Wuk Lee (BioE)
Roya Maboudian (ChemE)
Kris Pister (EECS)
Ramamoorthy Ramesh (MSE, Physics)
Sayeef Salahuddin (EECS)
Rachel Segalman (ChemE)
Ting Xu (MSE)
Margaret Taylor (Public Policy)
Chris Vulpe (Nutritional Science & Toxicology)
Feng Wang (Physics)
Junqiao Wu (MSE)
Peidong Yang (Chem)
Alex Zettl (Physics)

California Institute of Technology

Keith Schwab (Applied Physics)
Michael Roukes (Physics, Applied Physics, Bioengineering)

Stanford University

Beth Pruitt (Mechanical Engineering)
Tom Kenny (Mechanical Engineering)
Roger Howe (Electrical Engineering)

University of California, Merced

Lilian Davila (School of Engineering)
Valerie Leppert (School of Engineering)
Jennifer Lu (School of Engineering)
Lin Tian (School of Natural Sciences)

11 Represented Departments: Applied Physics, Bioengineering, Chemical Engineering, Chemistry, Environmental Science, Policy & Management, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, Nutritional Science & Toxicology, Physics

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