iTRIS
Center for Information Technology
Research in the Interest of Society

BSAC

Natural Gas Pipeline Projects

PAC Kick-off Meeting
Monday November 28th 2011

Gas Technology Institute (GTI)

&

U.C. Berkeley

Agenda

- Introductions
- Project Overviews:
  - GTI : California Natural Gas Pipeline Assessment
  - UC Berkeley : Natural Gas Pipeline Sensors
- Logistics, etc.
- Adjourn

Introductions

- The California Energy Commission:
  - Fernando Pina
- UC Berkeley:
  - Prof. Paul K. Wright
  - Dr. Igor Paprotny
  - Prof. Richard M. White
  - Gaymond Yee
- GTI:
  - Jim Marean
  - Andy Hammerschmidt
- The Project Advisory Committee:
  - Dr. Robert E. (Bob) Nickell (AS&T) , Robert Fassett (PG&E), Jane Yura (PG&E), Mike Bermel (Sempra), Bret Lane (Sempra), Sunil Shori (CPUC), Jim Shetlar (SMUD)

the Energy to Lead

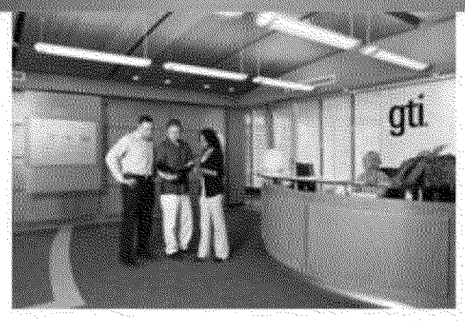
CALIFORNIA NATURAL GAS PIPELINE ASSESSMENT
CEC #500-10-050

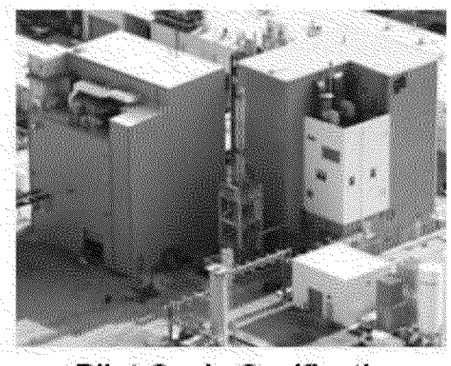
Introductory Joint PAC Meeting

November 28, 2011

GTI Overview

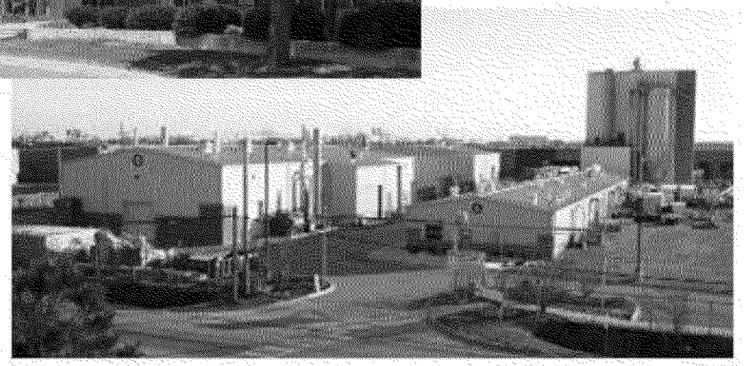
- Not-for-profit research, with 70-year history
- Facilities
  - 18-acre laboratory near Chicago
  - 200,000 ft^2, 28 specialized labs
  - Other sites in DC, Oklahoma, California, Massachusetts, Texas, Alabama, Pennsylvania
- Staff of 250
- Market opportunities are creating substantial growth
- 1200 patents; 750 products





Pilot-Scale Gasification Campus–Flex-Fuel Test Facility and Advanced Gasification Test Facility

Offices & Labs



Energy & Environmental Technology Center

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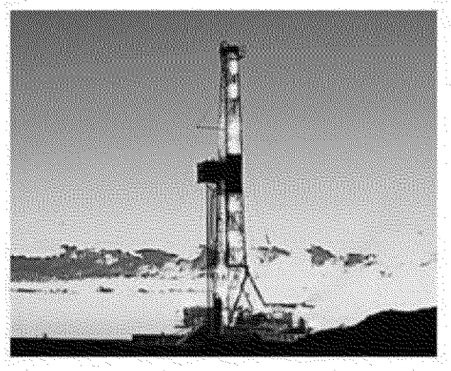
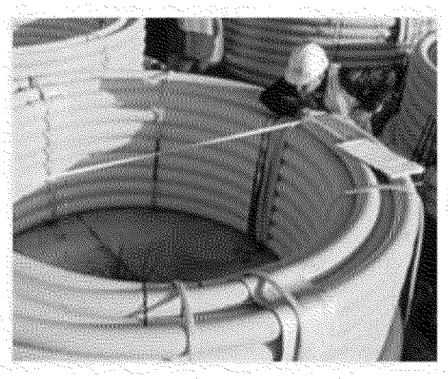
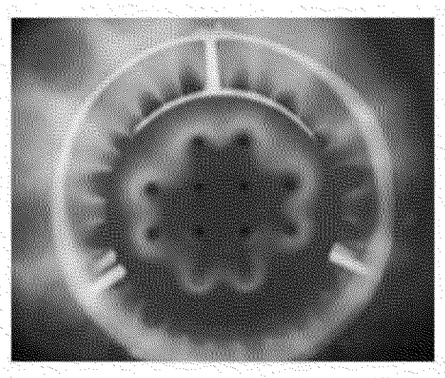
Addressing Key Energy Industry Issues Across the Value Chain

SUPPLY → **DELIVERY** → **END USE**

- Expanding the supply of affordable energy
- Ensuring a safe and reliable energy delivery infrastructure
- Promoting the efficient use of energy resources







Reducing carbon emissions to the environment

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Redacted

Redacted

Statement of Work

- Baseline Technology Assessment for Pipeline Integrity and Monitoring Technology in the State of California
- Assessment of Currently Available Pipeline Integrity Assessment and Monitoring Technology
- Evaluate Emerging Pipeline Integrity Assessment and Monitoring Technology
  - Place special emphasis on the development of a strategy to integrate the use of the AMI communications backbone, currently being installed or enhanced in California. This will optimize the value of the AMI system and the performance of the pipeline monitoring and safety technologies identified or developed for implementation.
- Implementation Plan to Introduce New Pipeline Integrity Assessment and Monitoring Technologies to the California Pipeline Network
- Technology Transfer - to make the knowledge gained, experimental results and lessons learned available to key decision-makers.
- Production Readiness Plan - to determine the steps that will lead to the manufacturing of the technologies developed in this project or to the commercialization of the project's results.

Contact Information

- Andy Hammerschmidt – Project Manager
  - Office 847/768-0686
  - Redacted
  -
- Jim Marean – Principle Investigator
  - Redacted
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CITRIS
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BSAC

Natural Gas Pipeline Sensors

U.C. Berkeley

Monday November 28th 2011

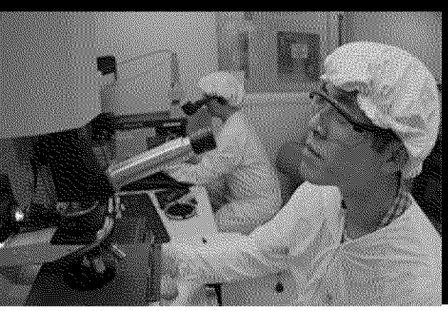
Prof. Paul Wright (ME/CITRIS), Prof. Dick White (EECS/BSAC/CITRIS)
Dr. Igor Paprotny (EECS/BSAC/CITRIS), Gaymond Yee (CIEE)

CITRIS

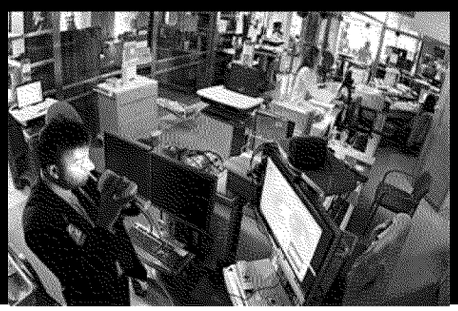
Center for Information Technology
Research in the Interest of Society

An unrelenting commitment to INNOVATION..

....solving problems in society that people think cannot be solved



UC Berkeley



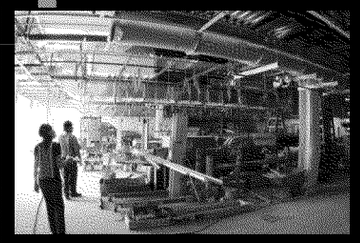
UC Davis

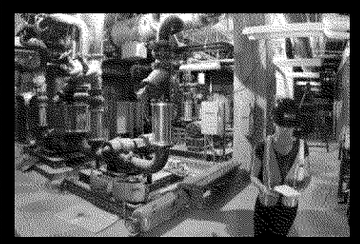
UC Santa Cruz

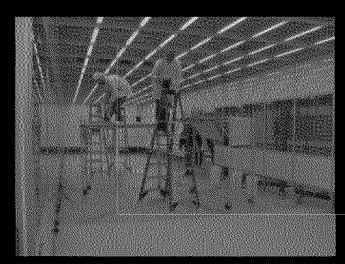
UC Merced

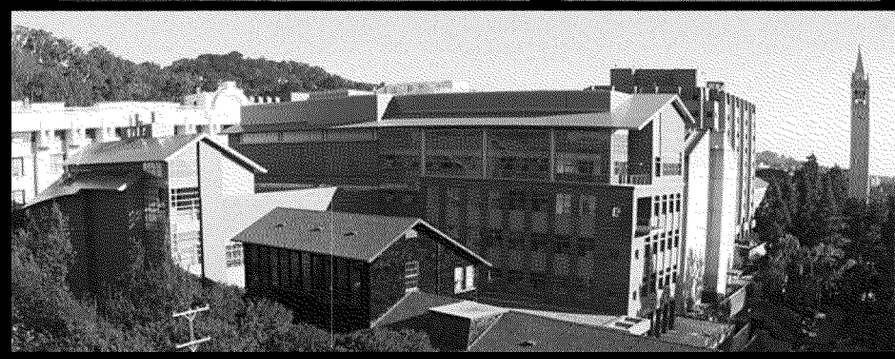
We have the most innovative building on campus

- *Technology for Societal Impact means:*
- *Not "technology-push"*
- *Professors from the Business School, Law School, Public Policy, Political Science, and the Lawrence Berkeley Laboratory also have offices in our Headquarters building*









Berkeley Sensor & Actuator Center

National Science Foundation
Industry/University Cooperative Research Center
on MEMS/NEMS (Since 1986)

- Largest of 37 NSF I/UCRC's, only one with MEMS/NEMS
- Access to 150 Researchers, 120 Projects

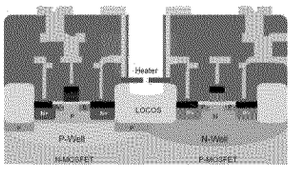
- Use of Berkeley MicroLab at a Discount
- Patent Advantages for Members

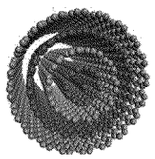
- Sponsored (Contracted) BSAC Research Projects
  (access to BSAC Faculty & Graduate Student Recruiting/ Internships)

- Semiannual 3-Day Research Reviews @ Berkeley March/September PLUS
  Annual meetings in Japan & Europe

- Visiting Industrial Fellow Program
  (Send Researchers to Campus for Extended Period)

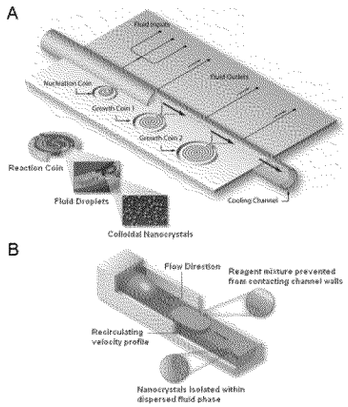
BSAC Research Areas



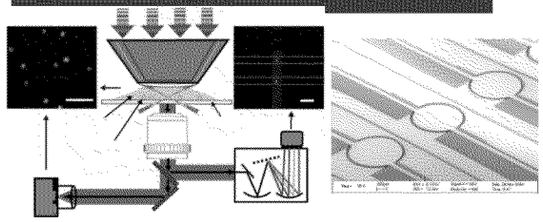


•NanoStructures Materials Process & Devices 15 Projects

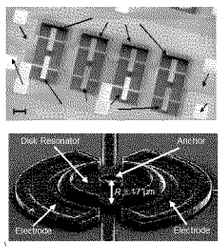
• Microfluidics
8 projects

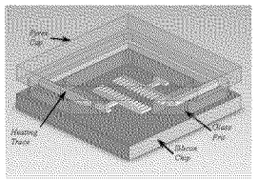


•NanoPlasmonics, Microphotonics, & Imaging 20 projects



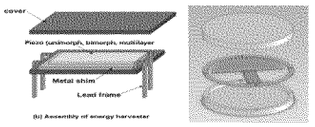
•Wireless & RF Components & Systems
19 projects



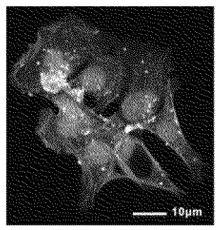


•Packaging, Processes & Materials *14 projects*

•uPower & Energy
10 projects



•Sensors & Actuators
18 projects



•BioMEMS
18 projects

California Institute for Energy and Environment (CIEE)
URL: http://uc-ciee.org

- **Administered by the University of California at Berkeley**
- **Independent and serves all of the University of California**
- **Mission: Support public-interest energy and environmental research in California**
  - Planning
  - Project and contract administration
  - Technical coordination
- **Main Office: 2087 Addison Street, Second Floor in Downtown Berkeley, CA**
- **Sacramento Office: 901 P Street, Suite 142A, Sacramento, CA**
- **My Contact Info:**
  - Gaymond Yee
  - Email: Gaymond.Yee@uc-ciee.org
  - Phone: Redacted

PUBLIC INTEREST ENERGY RESEARCH
"Research Powers the Future"

U.C. Berkeley – Nat. Gas Sensors

Paul K. Wright,

Professor, ME Department, U.C. Berkeley, Director, Center for Information Technology Research in the Interest of Society (CITRIS), U.C. Berkeley.

Paul K. Wright's degrees are in metallurgy and materials science, and his research is in the broad field of mechanical/electrical design, rapid-prototyping and manufacturing. In this work on gas-line diagnostics, collaborating with students and colleagues, he will prototype the MEMS sensor packages and participate in the modeling of the welded pipes. In his National Academy of Engineering citation, he is credited for the invention of the first open-architecture controller for machine tools and manufacturing systems; and for the invention of the "CyberCut/CyberBuild" system for Internet-based CAD/CAM systems. His more recent work, with this same group of colleagues on the gas-line project, has been on energy scavenging for microelectronics and building-to-grid systems including demand response.

U.C. Berkeley – Nat. Gas Sensors

Richard M. White,

Professor Emeritus, EECS Department, U.C. Berkeley,and Founding Co-Director, Berkeley Sensor & Actuator Center

After graduating from Harvard with the Ph. D. in Applied Physics, I worked at the General Electric Microwave Laboratory in Palo Alto, CA, doing research and development on high-power microwave vacuum tubes and filters. After five years, I moved to U. C. Berkeley where I have engaged in teaching and in research on microfabricated solid-state sensors, and on ultrasonic devices and phenomena, including surface acoustic wave filters and the generation of ultrasonic waves by transient surface heating. My most recent research topics include sensors and diagnostic techniques for electric power delivery systems and on miniature particulate matter monitors for airborne particulate matter such as diesel exhaust particles.

U.C. Berkeley – Nat. Gas Sensors

Igor Paprotny,

Research Scientist, EECS Department, U.C. Berkeley, CITRIS, BSAC, i4 Energy Center.

Dr. Igor Paprotny is a Research Scientist at the Center for Information Technology Research in the Interest of Society (CITRIS), Berkeley Sensor & Actuator Center (BSAC), and i4 Energy Center at U.C. Berkeley, where he is involved in applying MEMS technologies to develop distributed microsensors for electric power system sensing, microfluidics for environmental monitoring, and microrobotics. He holds a PhD in Computer Science (MEMS) from Dartmouth College, BS and MS degrees in Industrial Engineering from Arizona State University, and a degree in Mechatronics from the NKI College of Engineering in Oslo, Norway. Prior to his graduate career, he accumulated over 3 years of professional experience in the semiconductor industry where he was involved in designing automated material handling systems. His research areas include MEMS sensors for power systems and environmental sensing, energy harvesting, and MEMS microrobotics.

U.C. Berkeley – Nat. Gas Sensors

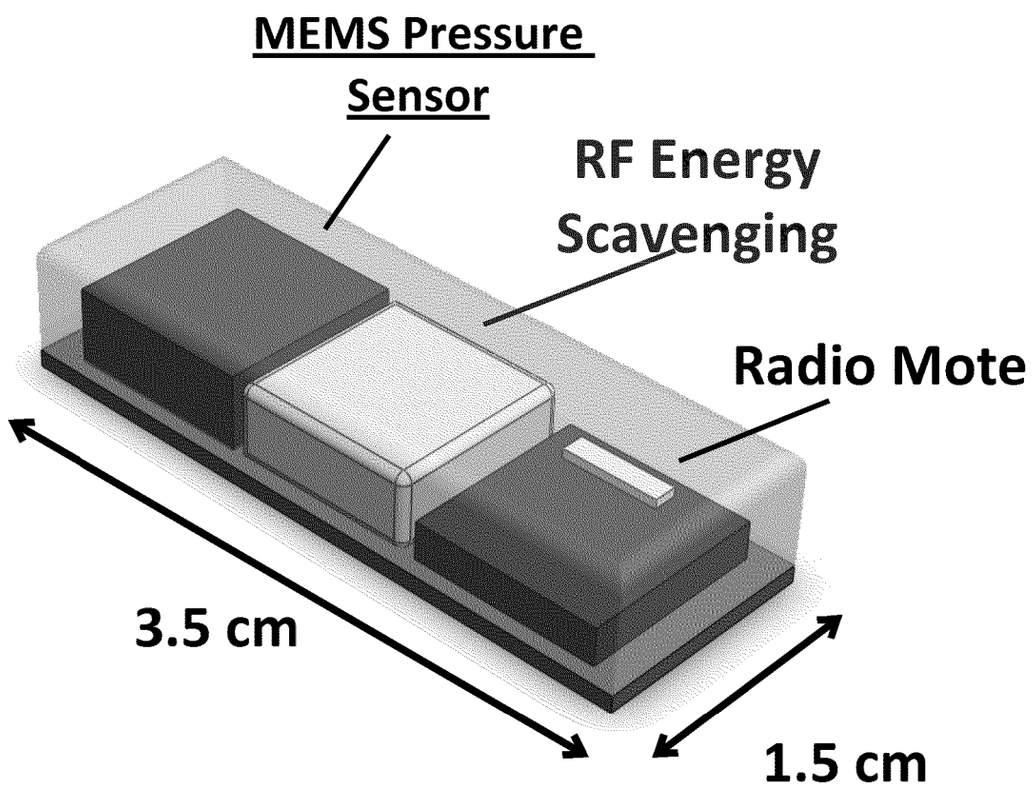
Gaymond Yee,

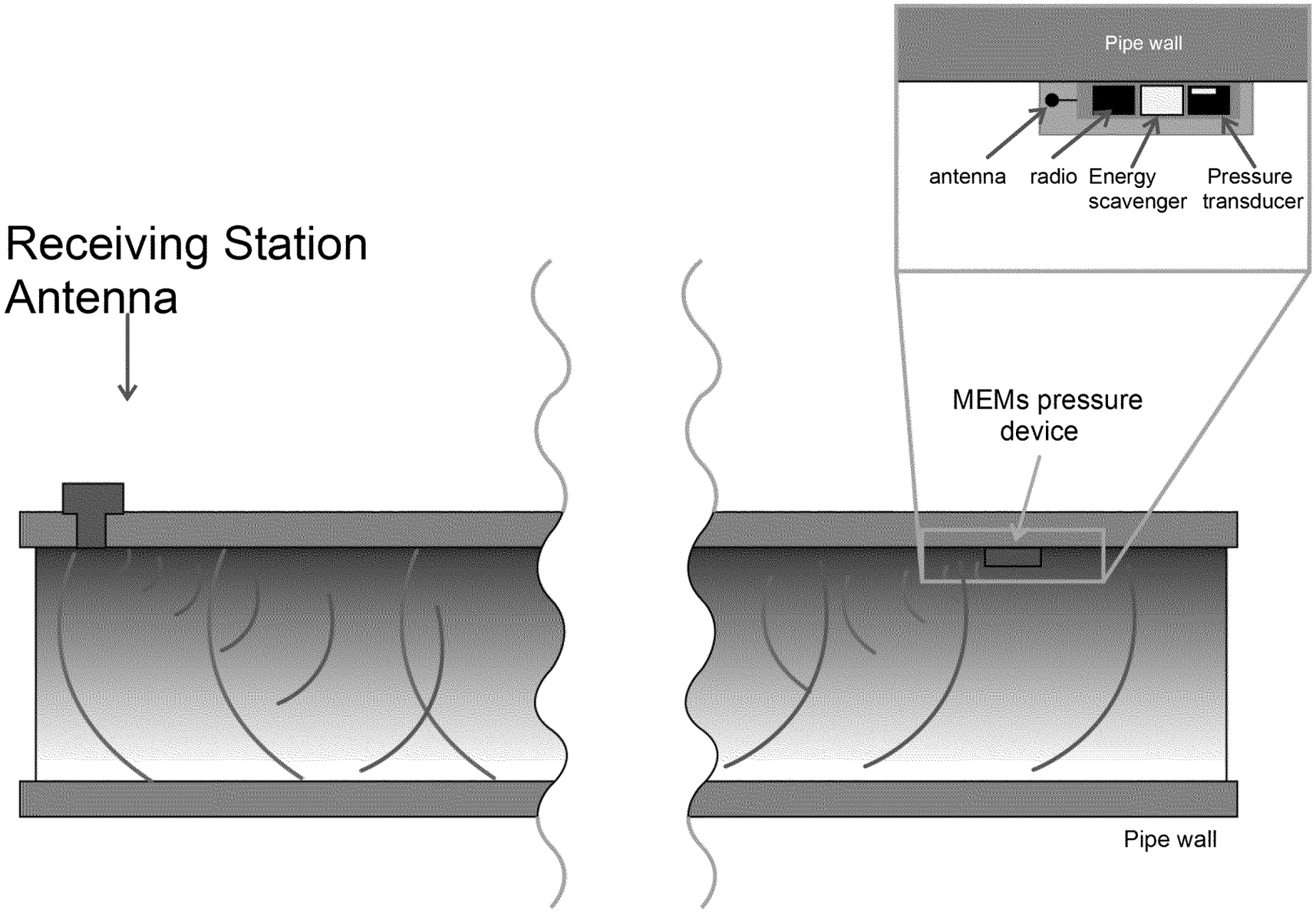
Research Coordinator, California Institute for Energy and Efficiency (CIEE), Technical Director of the i4Energy Center

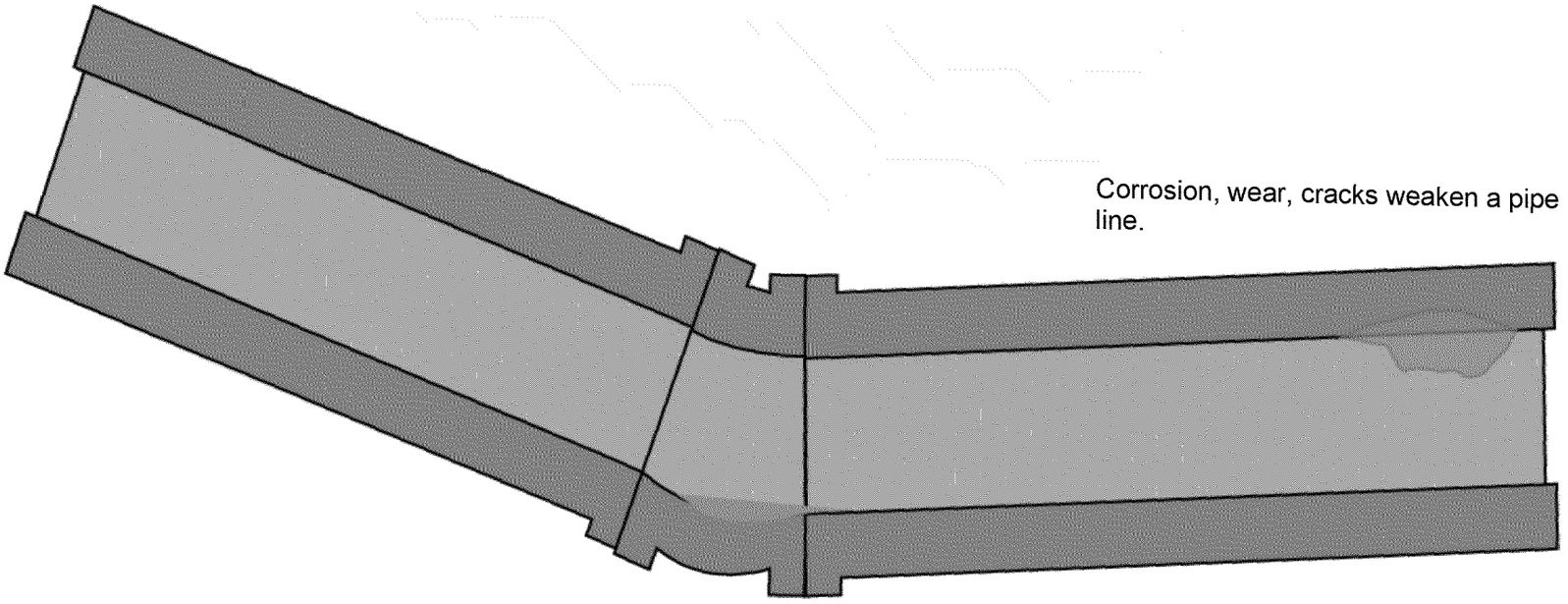
Gaymond Yee is a Research Coordinator at CIEE where he manages the Enabling Technologies Development Project for the California Energy Commission's PIER Program. He also serves as the Technical Director of the i4Energy Center. As project manager of the Enabling Technologies Development Project, Gaymond coordinates multi-disciplinary and collaborative research teams from universities, national laboratories, and private industries to develop the next generation of hardware and software building blocks for future smart grid applications. Prior to CIEE, Gaymond has over 12 years experience in research and in implementation of successful energy-related projects. These projects include commercial energy management systems, residential energy information systems, electricity curtailment programs utilizing programmable communicating thermostats, and wireless smart meters. He has a Bachelor of Science Degree in Mechanical and Nuclear Engineering, and a Master of Engineering Degree in Mechanical Engineering from UC Berkeley.

Statement of Work – UC Berkeley

1. Benchmark Existing Diagnostic Approaches
2. Design Gas Pipeline Sensors / Packages
    1. Gas pressure sensor that monitors the pipeline for over-pressure conditions.
    2. Laser-based sensor to detect defects in pipeline welds from the inside.
    3. Water accumulation and corrosion sensor
3. Fabricate and Demonstrate Gas Pipeline Sensor Prototypes
4. Lab-test Prototypes
5. Field-test Prototypes
6. Analyze Data from Field Tests

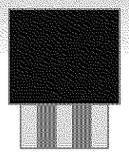

MEMS Pressure Sensor
RF Energy Scavenging
Radio Mote
3.5 cm
1.5 cm


Pipe wall
antenna
radio
Energy scavenger
Pressure transducer
Receiving Station Antenna
MEMs pressure device
Pipe wall

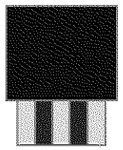


Corrosion, wear, cracks weaken a pipe line.

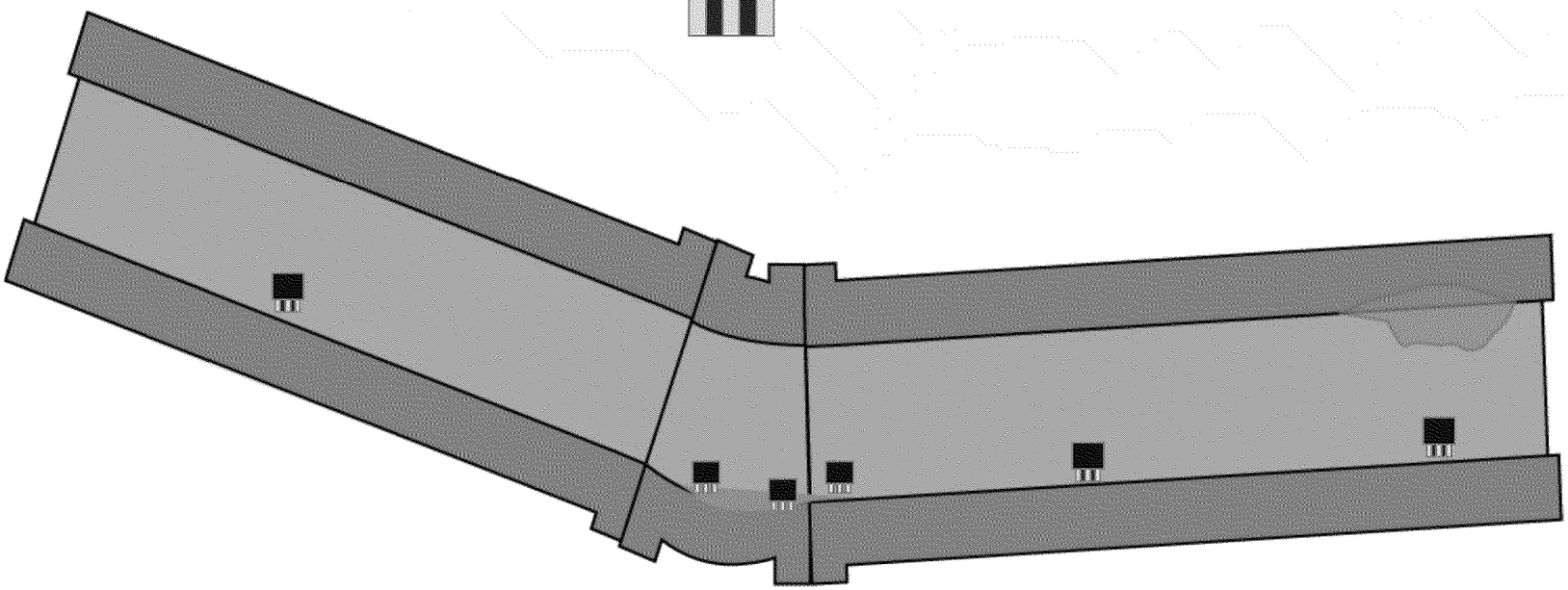
Water (condensation) can collect in “low points” of a pipeline.



Pt and Al2O3 equipped sensors can detect the presence of water
These sensors would be strategically placed in low points in the pipeline.

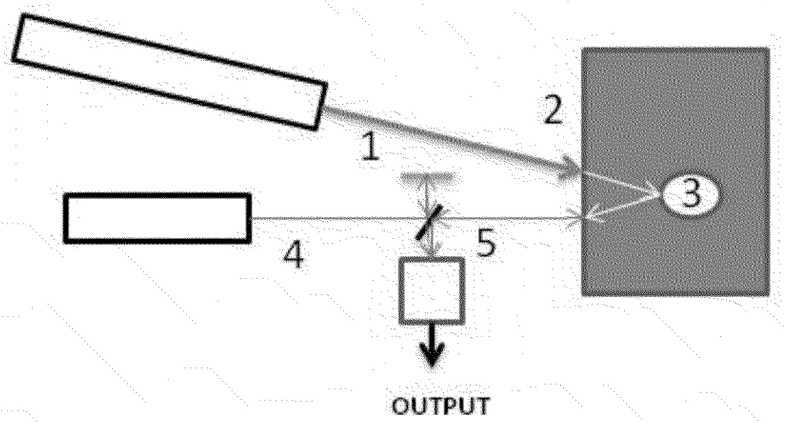


Fe and Al2O3 equipped sensors can help detect corrosion and wo
be placed randomly throughout the length of the pipeline.



LASER ULTRAS0NIC DETECTION OF PIPELINE PROPERTIES

1. Ultrasonic waves can be used to determine (from the velocity of the waves) the strength of materials such as steel and the presence of standing liquids, and (from wave reflections) the porosity of pipe welds, the presence of stress corrosion cracks, and the thickness of pipe walls.
2. Non-contacting ultrasonic transducers are of particular value for measurements in contoured objects such as pipes. With laser ultrasonics one can make both non-contacting optical ultrasonic sources and receivers that could be carried on pipeline "pigs".
3. Source: A high-power pulsed laser (1) shining on a pipe wall (2) causes the local temperature to rise, creating thermal stresses that generate ultrasonic waves. The waves interact with boundaries of voids (3) and cracks in the metal, producing reflected waves that return to the source area. Receiver: A low-power laser beam (4) incident at that location is reflected to an interferometric optical receiver (5) that permits the induced surface motion to be measured. (Other non-contacting receivers can also be used.) The surfaces of interest can be scanned rapidly.



See Scruby and Drain, "Laser Ultrasonics: Techniques and Applications", Adam Hilger, 1990

Contact Information

Professor Paul K. Wright
office: (510) 643-2200
email: pwright@citris-uc.org

Professor Richard M. White
office: (510) 642-0540
email: rwhite@eecs.berkeley.edu

Dr. Igor Paprotny
office: (510) 643-9825
cell: (802) 683-9081
email: igorpapa@eecs.berkeley.edu

Gaymond Yee
office: (510) 459-6063
email: gaymond.yee@uc-ciee.org

Logistics

- Two separate projects
  - Finish date for both: Q1 2013
- Set up PAC project meetings
- Any (other) items / questions ?

Thank you for agreeing to participate on the PAC meeting for our projects !