ROCHESTER INSTITUTE OF TECHNOLOGY
MICROELECTRONIC ENGINEERING

Research Portfolio

Dr. Lynn Fuller, Dr. Ivan Puchades and Students on Team Galt

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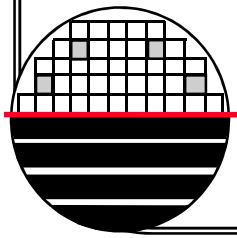

DR. LYNN FULLER

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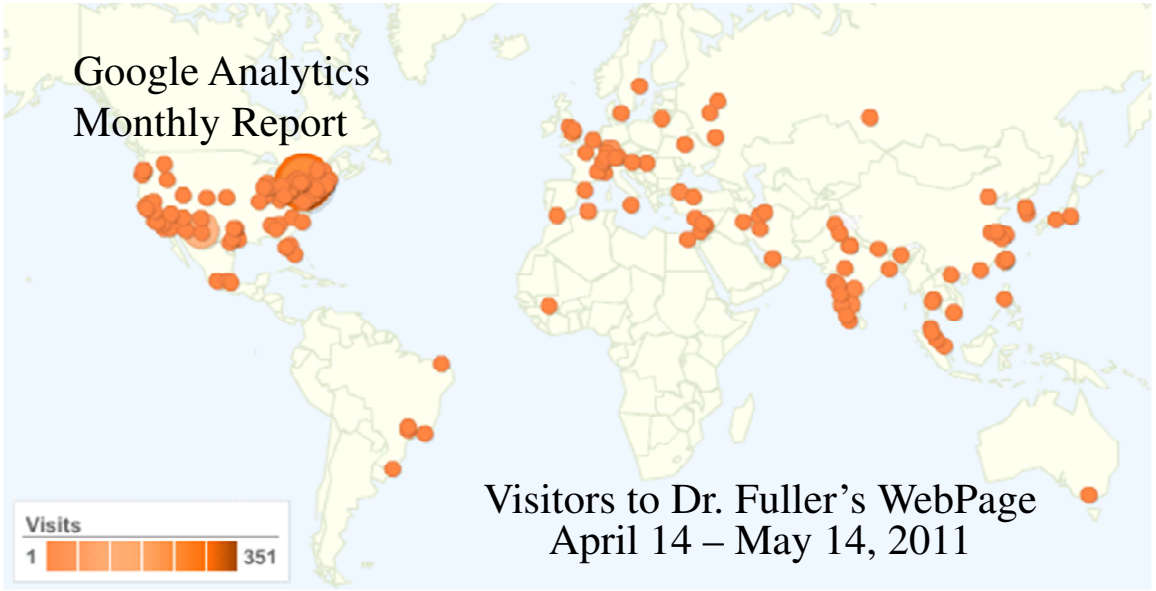
Webpage: http://people.rit.edu/lffeee

Professor
IEEE Fellow
Eisenhart Outstanding Teacher
KGCOE Outstanding Alumnus
Electrical Engineering
Microelectronic Engineering
Microsystems Engineering



1,310 visits came from 226 cities

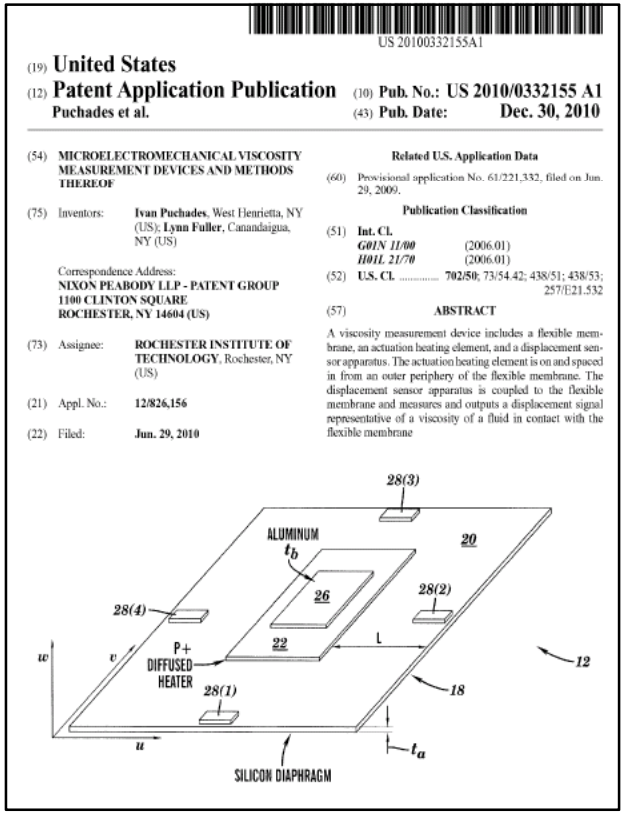
DR. IVAN PUCHADES

Research Assistant Professor
IEEE Member
Dr. Renan Turkman Scholar
MS Electrical Engineering
BS Microelectronic Engineering
PhD Microsystems Engineering

Industry Experience:
National Semiconductor, Maine
Freescale Semiconductor, Phoenix
Impact Technologies, LLC, Rochester
University of Barcelona

At RIT Teaches: MEMS
Microelectronics, Circuits
Lectures and Labs
Team Galt Research

From: Barcelona, Spain



US 20100332155A1

(19) **United States**
(12) **Patent Application Publication**
Puchades et al.
(10) **Pub. No.: US 2010/0332155 A1**
(43) **Pub. Date: Dec. 30, 2010**

(54) **MICROELECTROMECHANICAL VISCOSITY MEASUREMENT DEVICES AND METHODS THEREOF**

(75) Inventors: **Ivan Puchades**, West Henrietta, NY (US); **Lynn Fuller**, Canandaigua, NY (US)

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(73) Assignee: **ROCHESTER INSTITUTE OF TECHNOLOGY**, Rochester, NY (US)

(21) Appl. No.: **12/826,156**

(22) Filed: **Jun. 29, 2010**

Related U.S. Application Data

(60) Provisional application No. 61/221,332, filed on Jun. 29, 2009.

Publication Classification

(51) **Int. Cl.**
G01N 11/00 (2006.01)
H01L 21/70 (2006.01)

(52) **U.S. Cl.** **702/50**; 73/54.42; 438/51; 438/53; 257/E21.532

(57) **ABSTRACT**

A viscosity measurement device includes a flexible membrane, an actuation heating element, and a displacement sensor apparatus. The actuation heating element is on and spaced in from an outer periphery of the flexible membrane. The displacement sensor apparatus is coupled to the flexible membrane and measures and outputs a displacement signal representative of a viscosity of a fluid in contact with the flexible membrane

TEAM GALT

Tal, Lynn, Ellen Sedlack, Christian, Artur, Ivan, Renat

Heidi, Murat

B.S., M.S., Ph.D., students from EE, ME, MicroE, CE, Materials Science

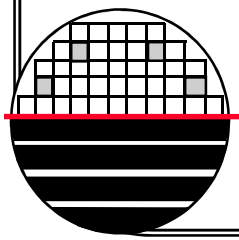
SMFL Semiconductor and Microsystems Fabrication Lab

15,000+ sq. ft. Clean room
Complete Equipment Set
for CMOS and MEMS

TEAM'S FUNDED RESEARCH

Eastman Kodak Co. – Ink Jet Head with 30 rows and 47 columns
Bausch and Lomb, Inc. – Wireless Pressure Sensors for Glaucoma
Impact Technology, LLC – Multisensor MEMS Oil Quality Sensor
NYSERDA – Multisensor MEMS Oil Quality Sensor
DOD Army – Multisensor MEMS Drinking Water Quality Sensor (Dr WatSen)
DOD Navy – MEMS Multi-Sensor (PRISM)
DOD Air Force – Aircraft Wireless Brake & Tire Monitor (BATMON)
DOD DARPA - Blast Dosimeter, $998K (Co-PI with Dr. Borkholder)
DOD Army - MEMS Inertial Guidance System (Co-PI with Dr. Crassidis)
U of R Medical Center - Energy Harvesting and Motion Sensing Pacemaker Leads
NIH/U of Hawaii – ISFET Biosensors
BP – Beta Voltaic Energy Harvesting
RIT – MEMS Viscosity Sensor

3 months to 2 years, $10K to $1,000K each



RESEARCH AREAS

MEMS Sensors
MEMS Multisensor Chips
Chemical Sensors

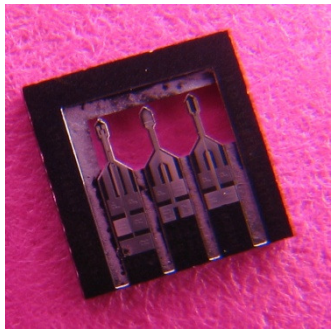
Microcontrollers in Microsystems
Wireless Microsystems

Energy Harvesting

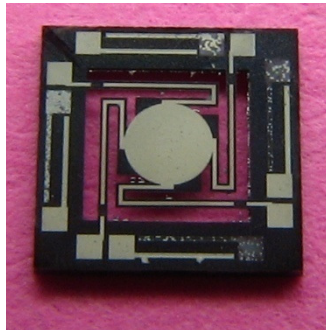
Bio MEMS

CMOS Circuit Design
CMOS Fabrication

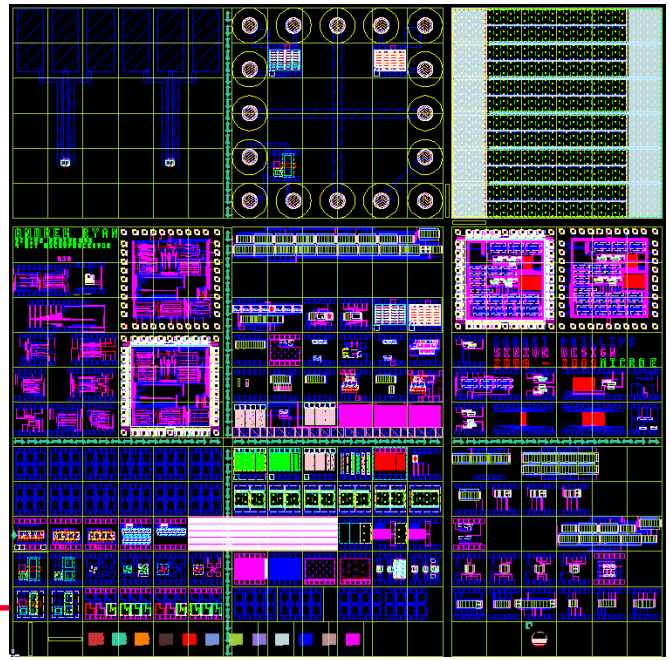
Packaging



BioProbes



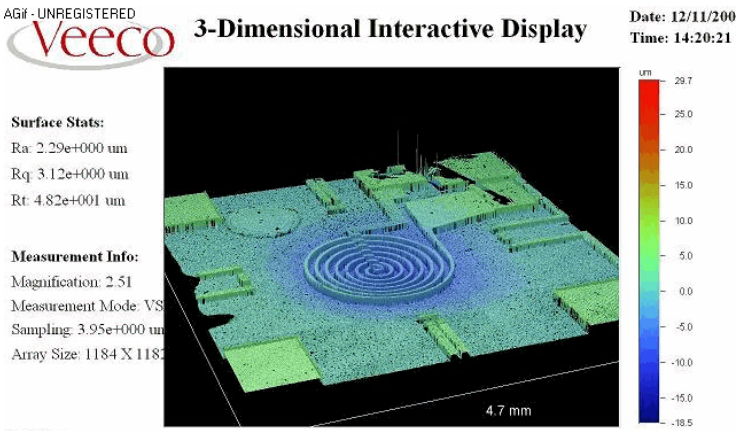
Energy Harvester



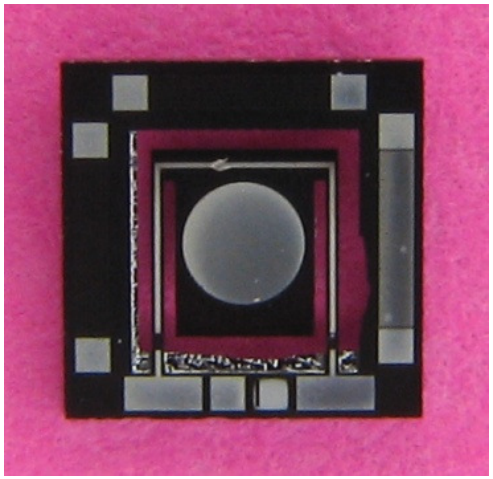
CMOS

MEMS SENSORS / MULTI SENSORS

Temperature
Viscosity
Acceleration
Humidity
pH
CHEMFETs
Chem Resistors
Liquid Level
Pressure
Strain
Light
Gas Flow
Electrochemical Spectroscopic Impedance

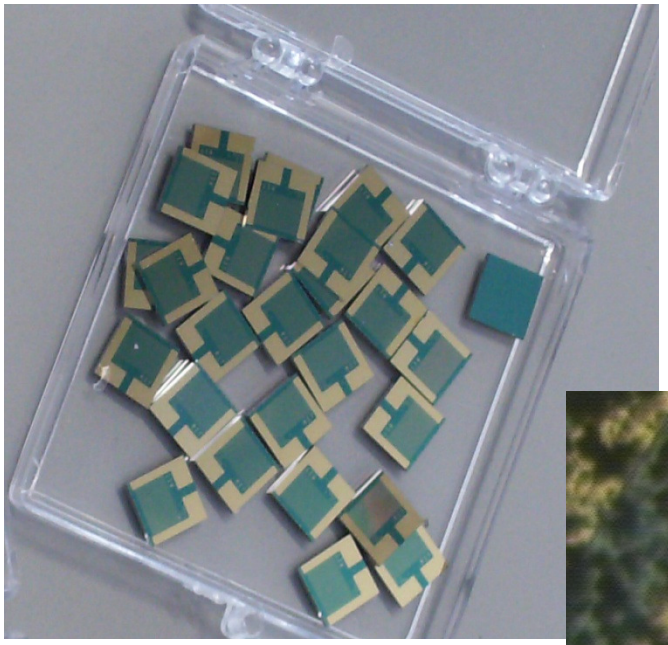


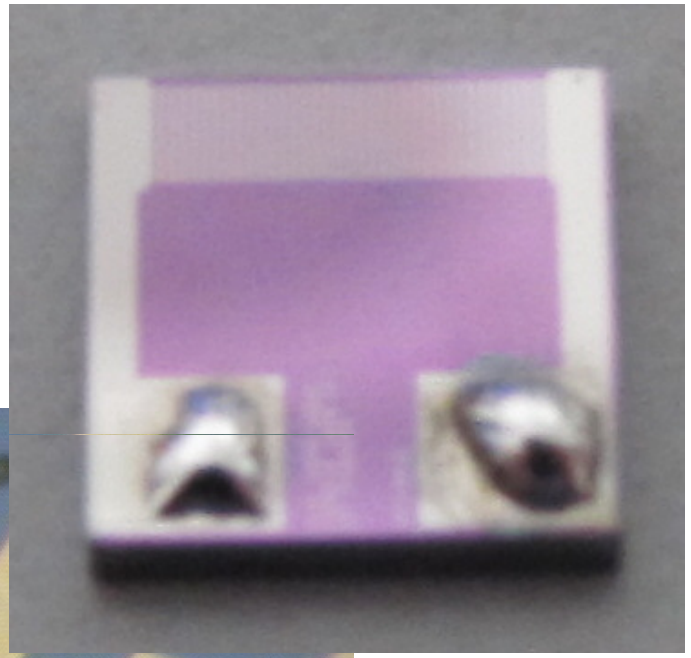
Viscocity Sensor

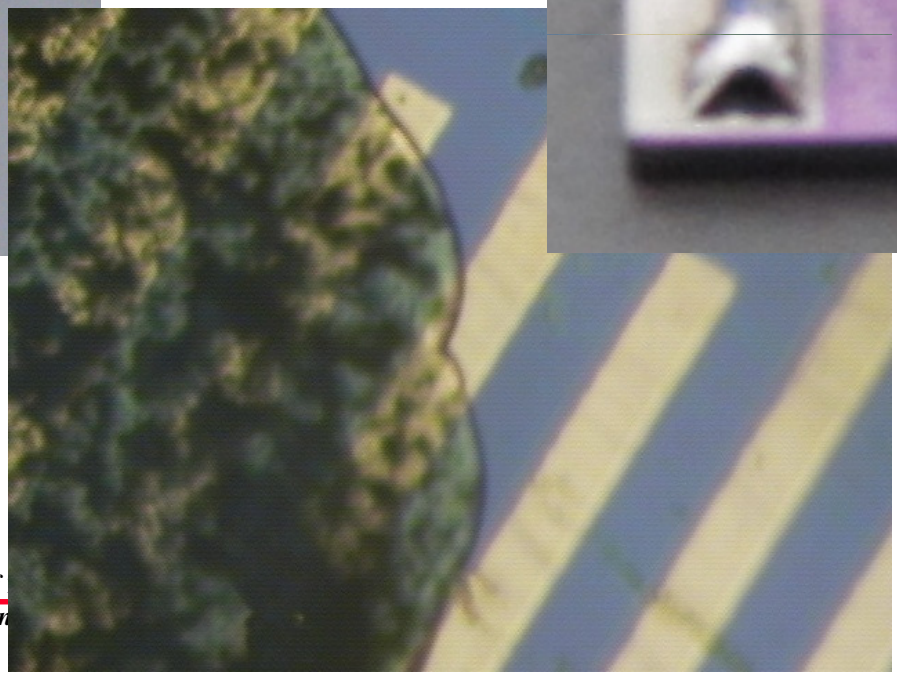


Accelerometer

CHEMICAL SENSORS

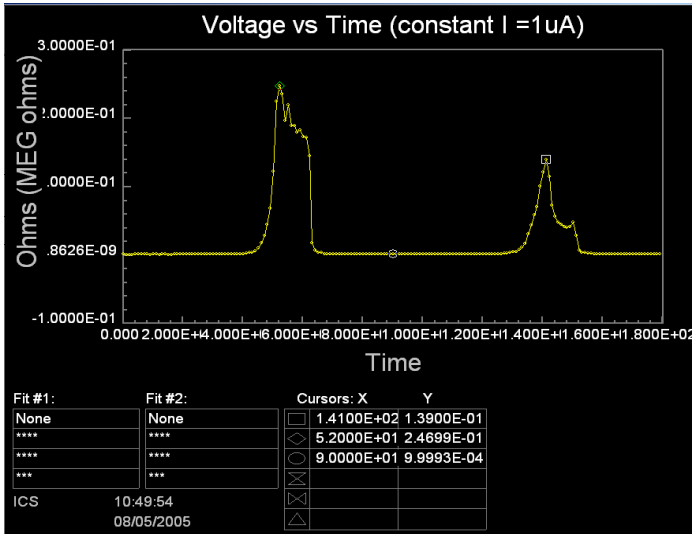




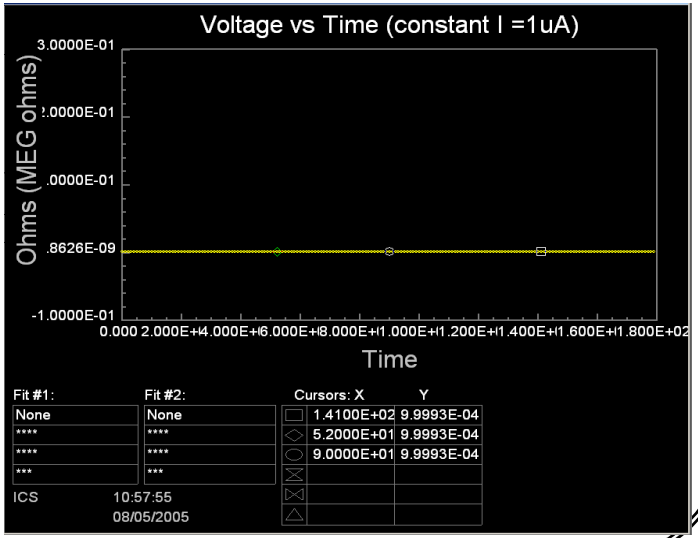


NAIL POLISH / CARBON BLACKRESPONSE TO ACETONE AND ISOPROPANOL

30s off, 30s on, 60s off, 30s on, 30s off
0.5 ml Acetone/ 125 ml bottle = 4000 ppm
Resistance goes from ~100 ohms (no vapor) to ~ 100,000 ohms (with vapor)



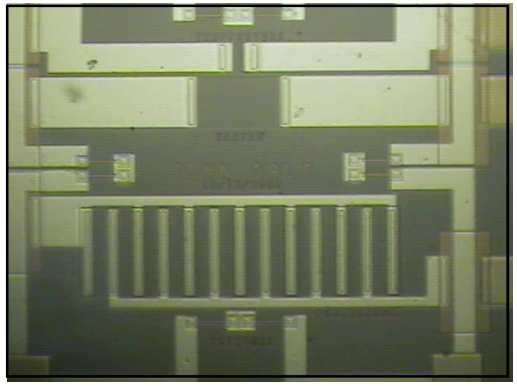
30s off, 30s on, 60s off, 30s on, 30s off
Isopropanol ~ 10,000 ppm
No Response



MEMS MULTI-SENSOR CHIP's

Cleanroom Bay Environment Sensor

Fabricated Multi Sensor Chips

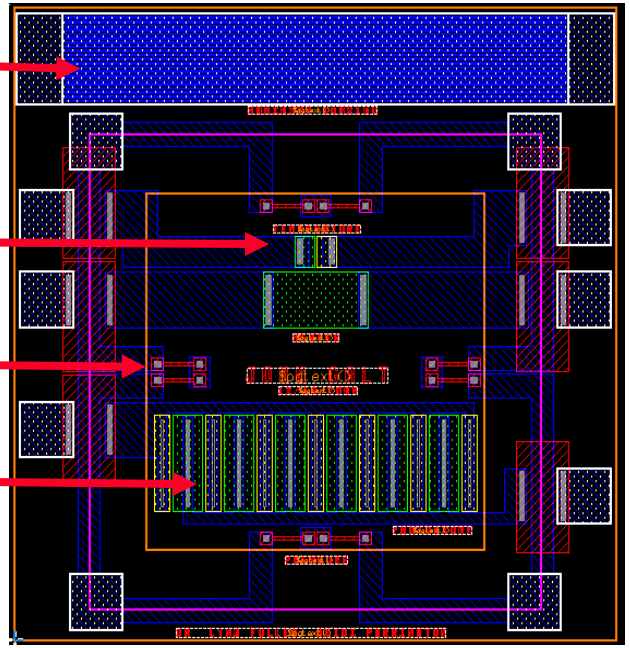


Humidity Sensor

Temperature Sensor

Pressure Sensor

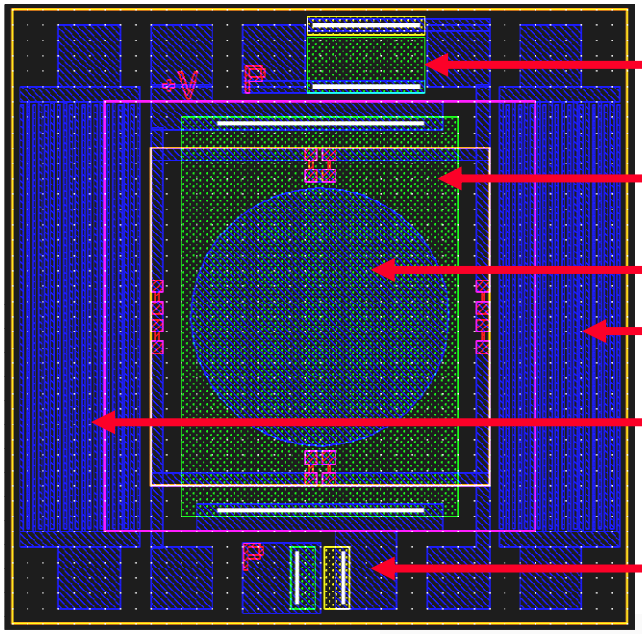
Light Sensor

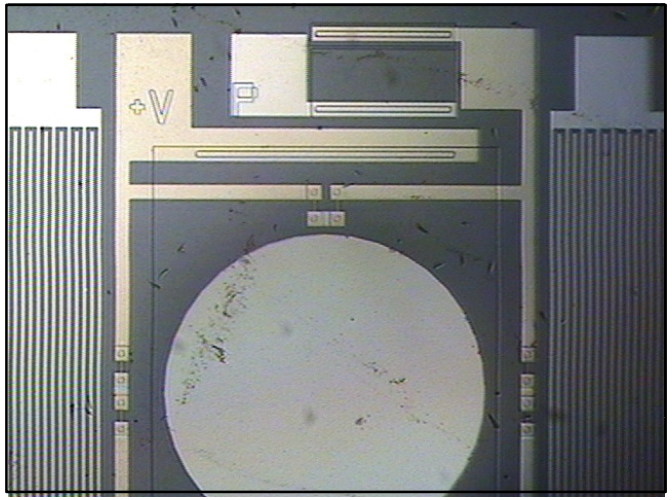


Rochester Institute of Technology
Microelectronic Engineering

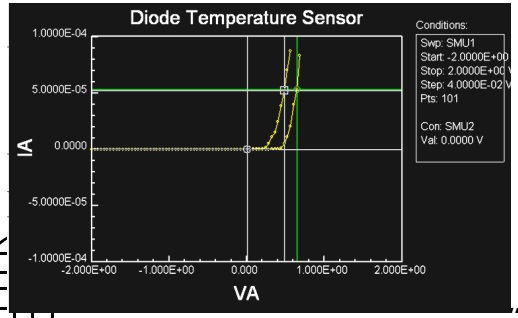
Heidi Purrington

OIL QUALITY MEMS MULTI-SENSOR

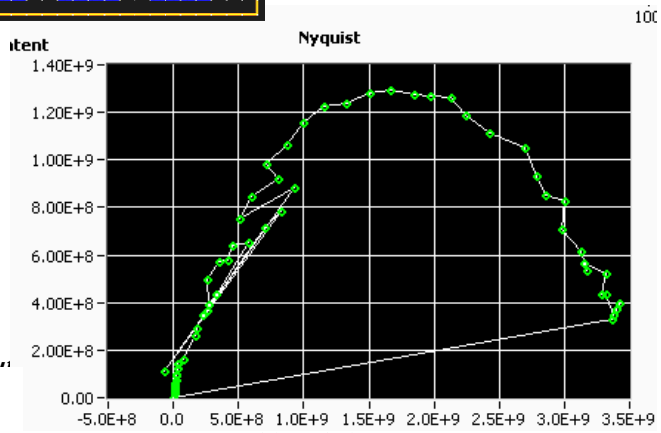




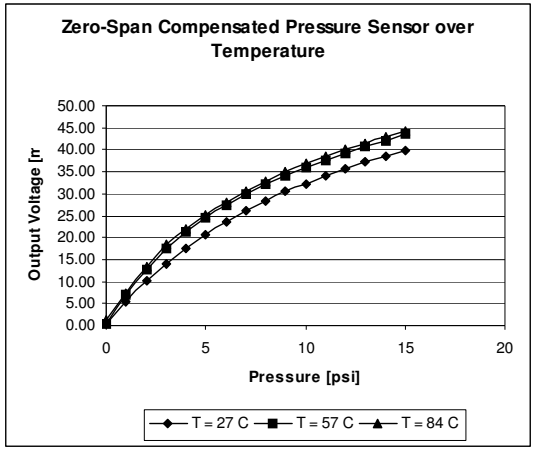
Picture of MEMS Multisensor



Temp Sensor Test



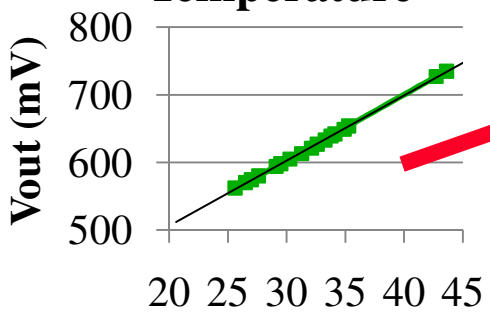
Oil with 1% Soot



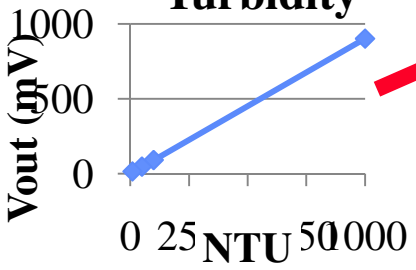
Pressure Study

MEMS Universal Fluid Interrogation Sensor (MUFINS)

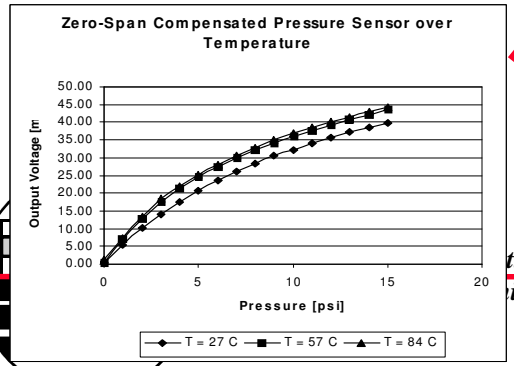
Temperature



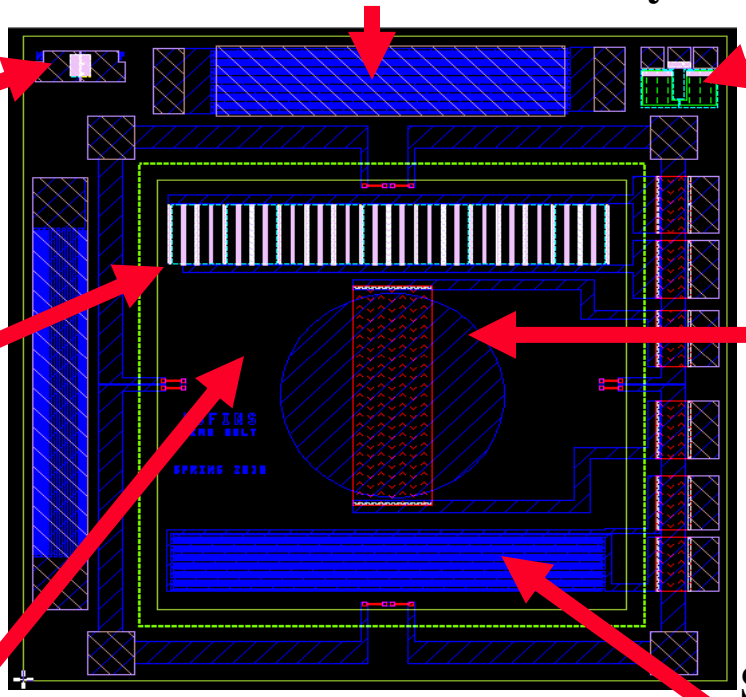
Turbidity



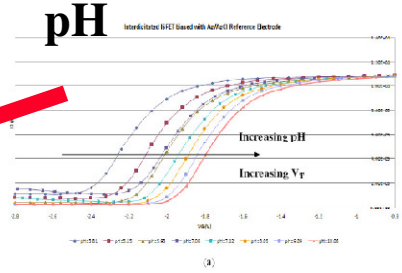
Pressure



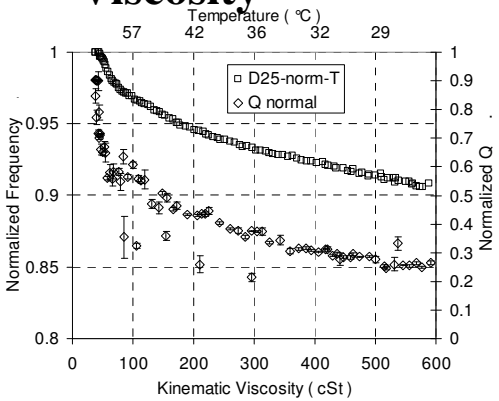
Fluid Level and Conductivity



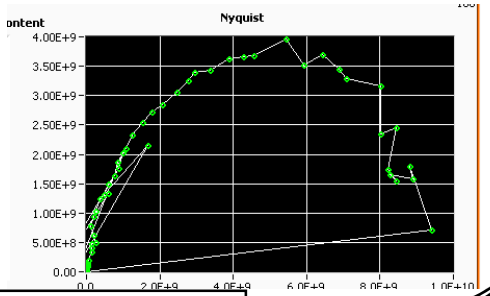
pH



Viscosity



Spectroscopic impedance

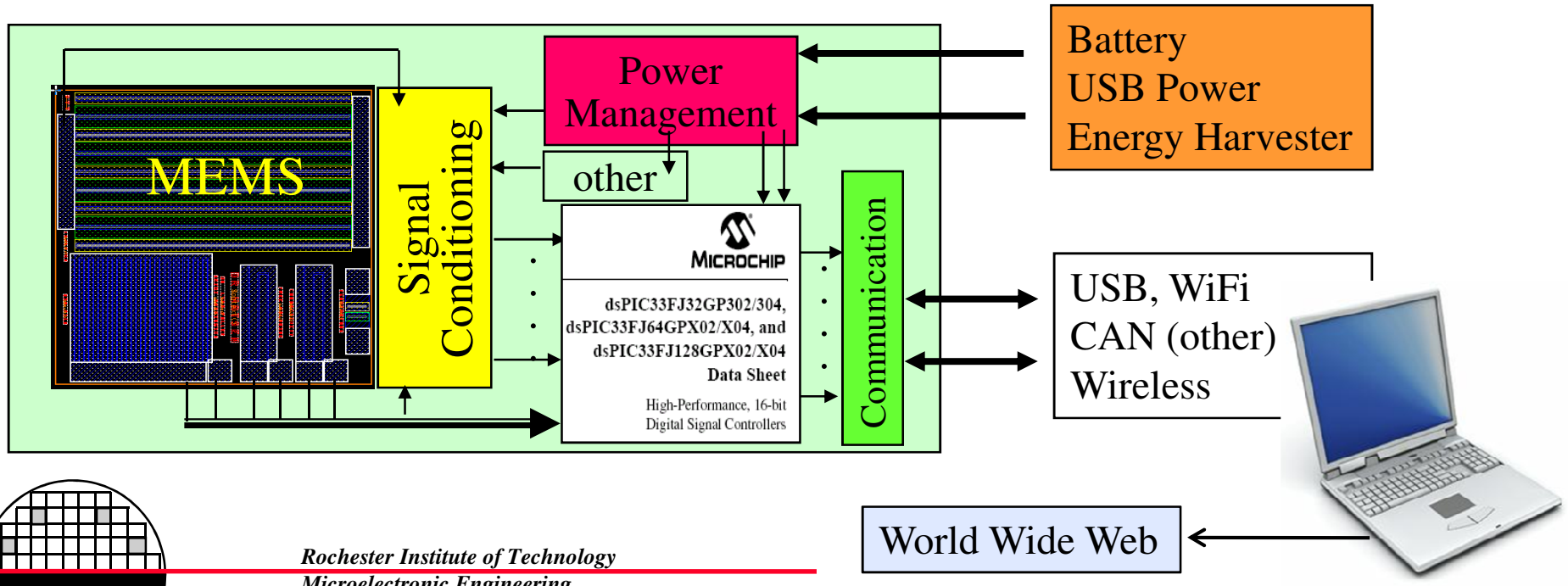


Applications:

- Drinking water
- Automobile engine oil
- Industrial Fluids

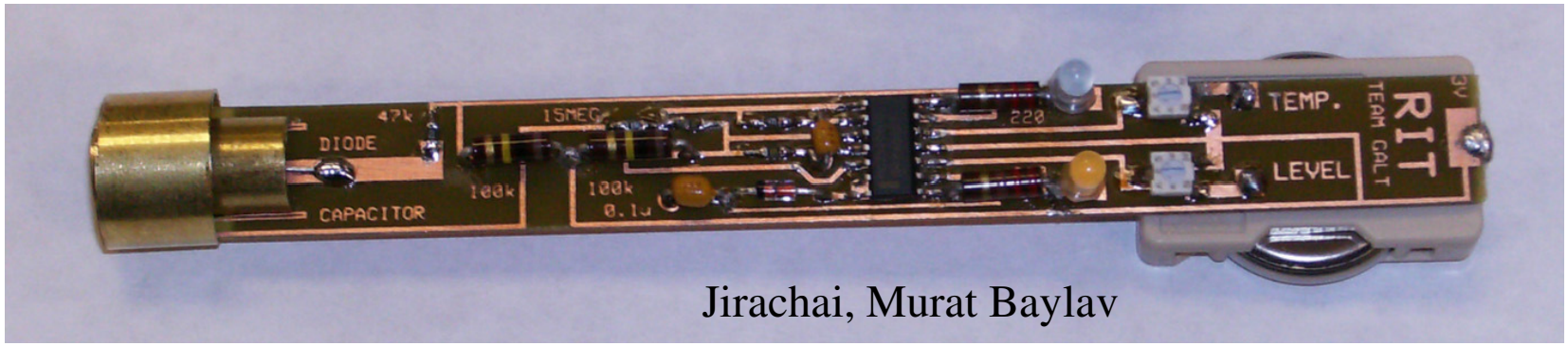
MICROSYSTEM

Team Galt's definition for Microsystems is the integration of MEMS sensors and actuators with CMOS electronics to provide solutions for a wide variety of applications including automotive, military, aerospace, consumer and biomedical.

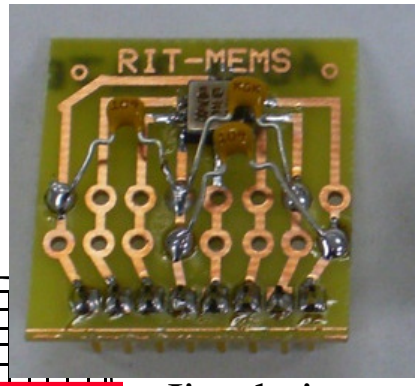


DEVELOP PCB PROTOTYPE CAPABILITY

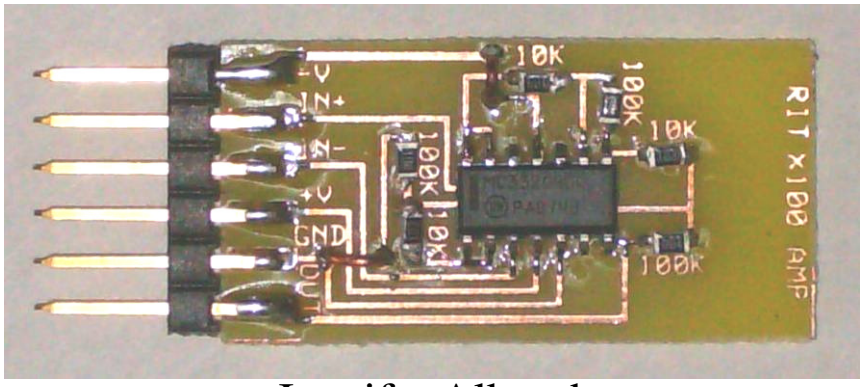
Prototype evaluation: breadboard sensors and signal processing electronics at the PCB level to evaluate different approaches for realizing microsystems.



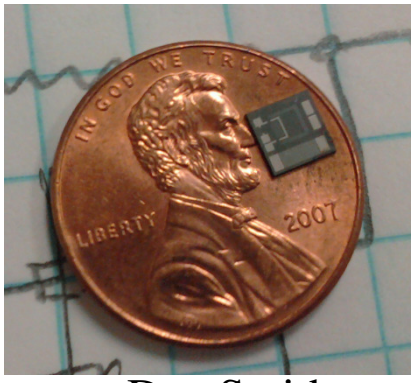
Jirachai, Murat Baylav



Jirachai



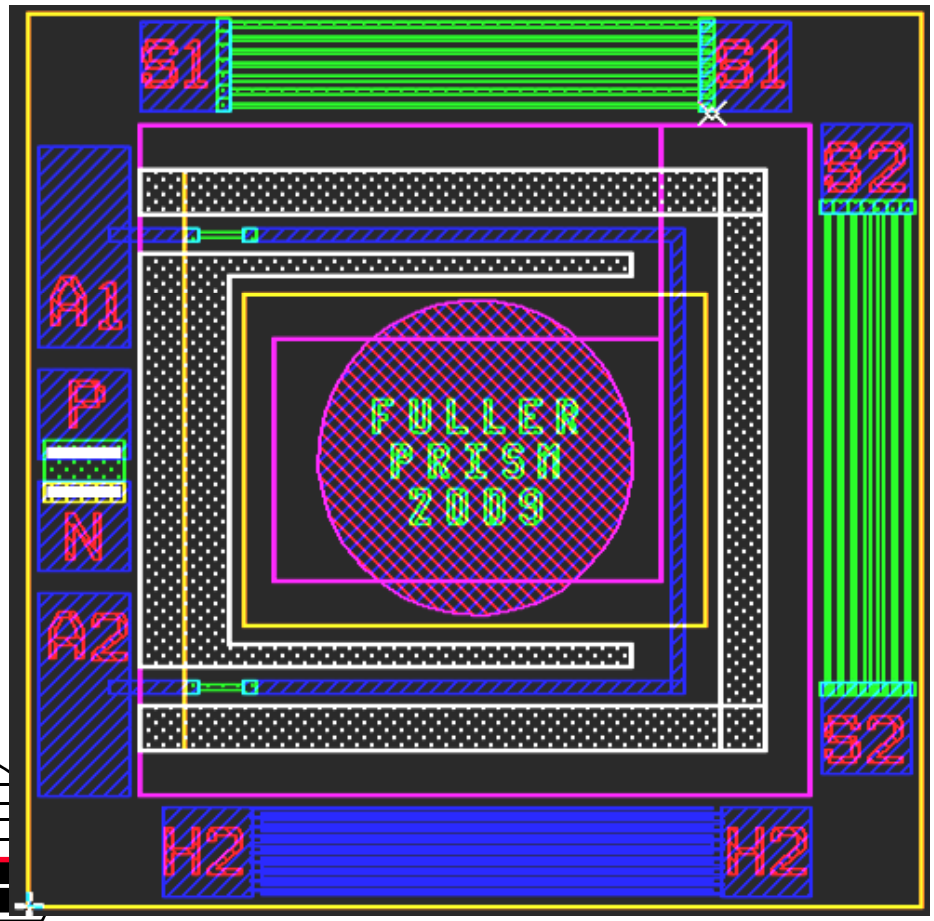
Jennifer Albrecht



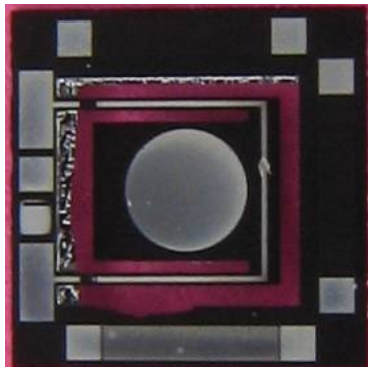
Dan Smith

MEMS MULTI-SENSOR CHIP's

Prognostic Integrated Sensory MEMS (PRISM)



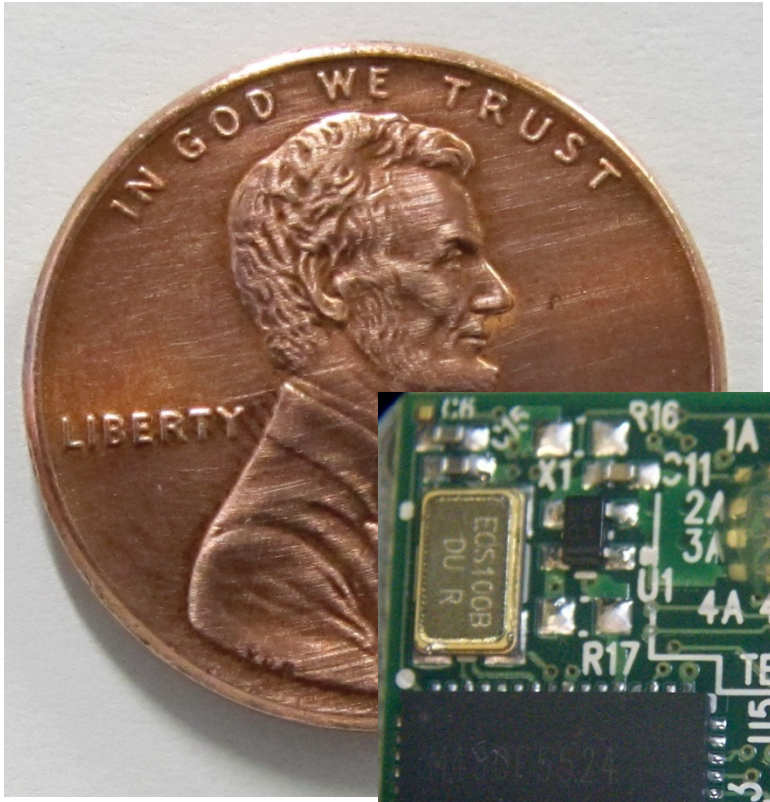
1-Axis Accelerometer
Temperature Sensor
Humidity Sensor
X & Y Strain Sensor

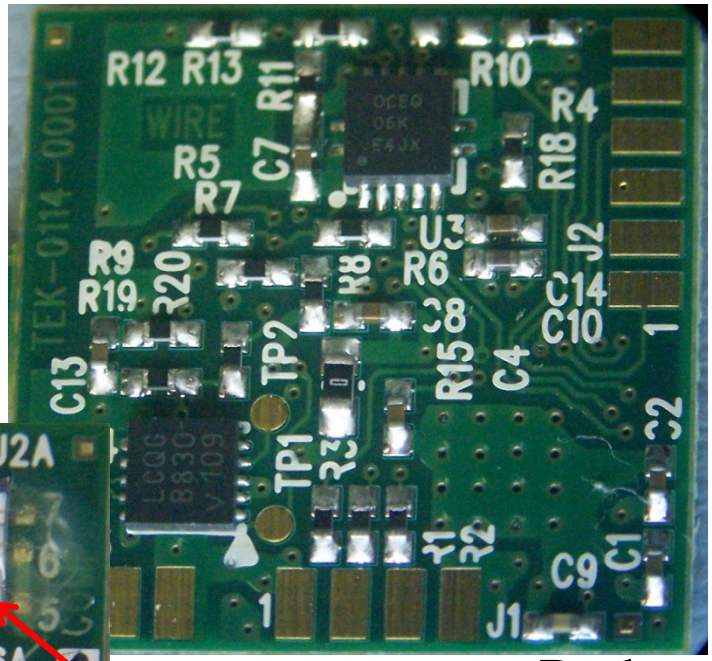


4mm x 4mm Chip

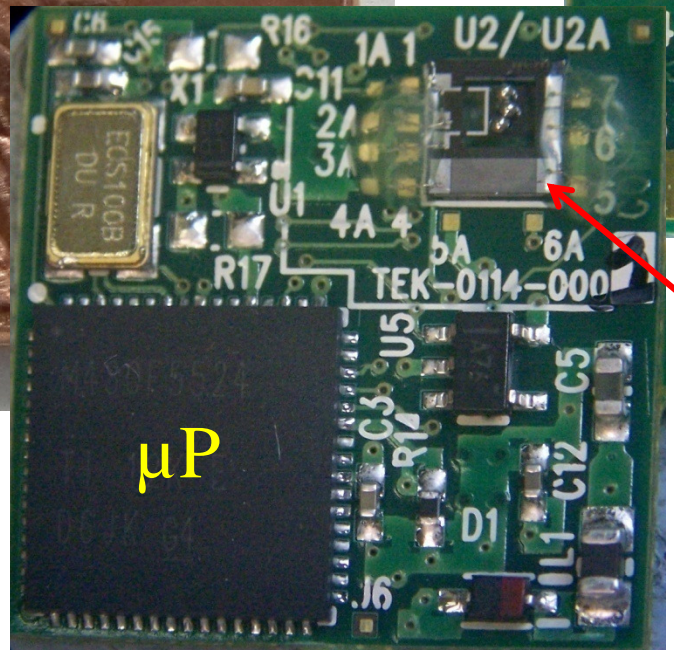
Health Management Solution to Predict Equipment Performance and Readiness

MULTISENSOR MICROSYSTEM





Back

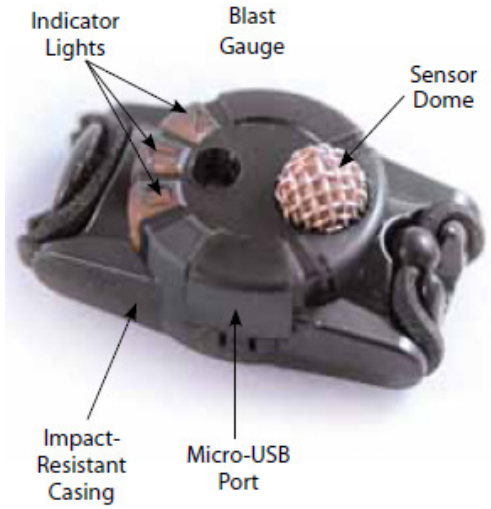


Front

MEMS Multisensor Chip
Acceleration (shock)
Temperature, Humidity

TEAM GALT SUPPORTS OTHER FACULTY PROJECTS

Dr. David Borkholder – PI
Blast Dosimeter / DARPA

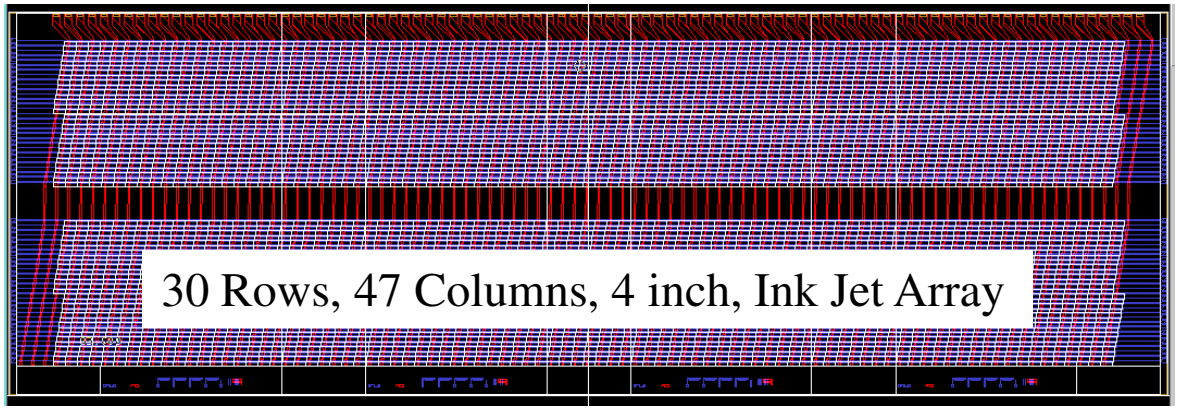


Blast Gauge: The data-logging device measures pressure, resulting head acceleration, and time to help correlate blast events with injuries. The compact device weighs less than one ounce, making it easy for soldiers to wear.

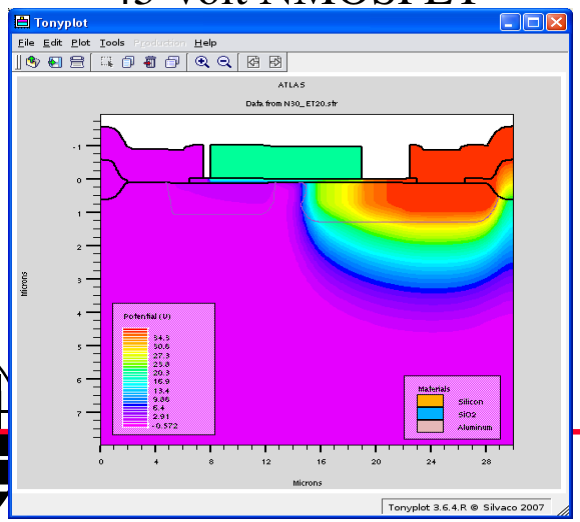
Explosives Testing: Weighted crash test dummies are used to simulate a soldier in the field. A number of orientations are used to allow the team to characterize the space and inform the device algorithms.

HIGH VOLTAGE TRANSISTOR ARRAY

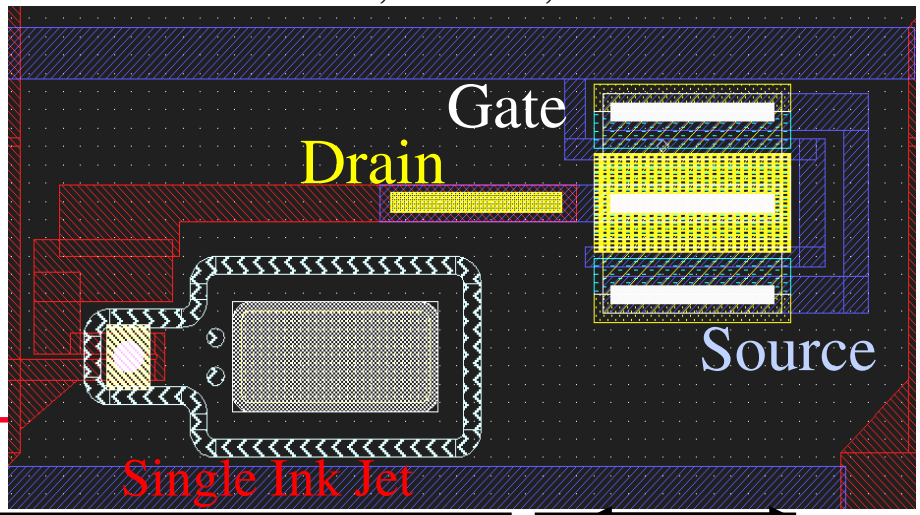
Design and Fabrication of a Custom NMOS Transistors with a 45 Volt High Side Breakdown Voltage, Integrate into a Large Array Ink Jet Print Head



45 Volt NMOSFET

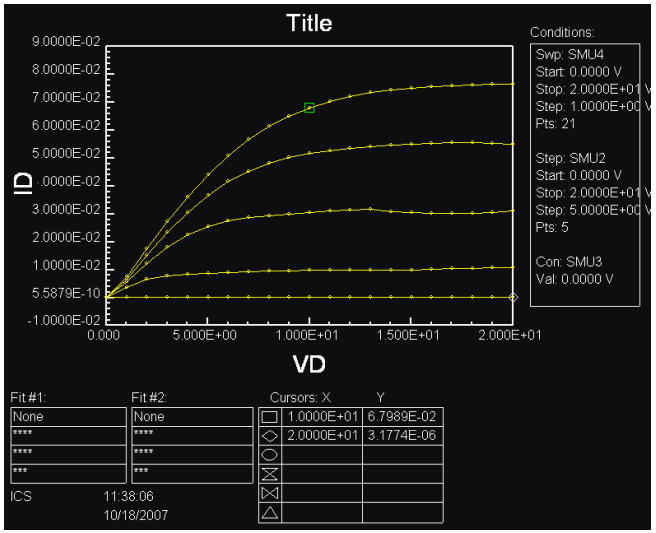


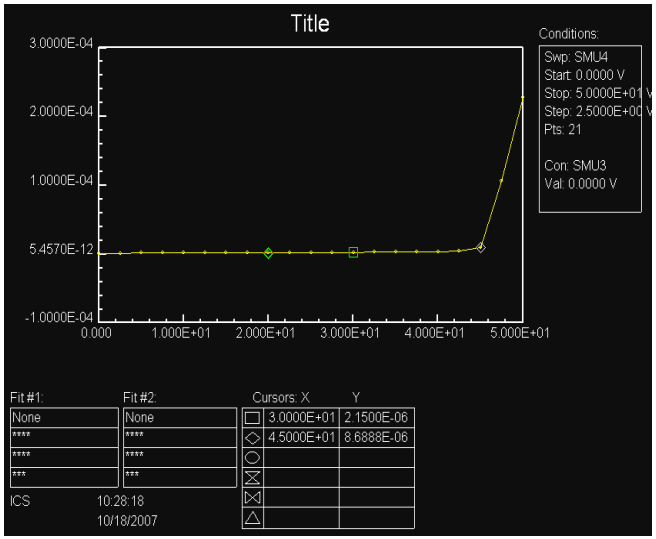
16 Masks, 8 at 1X, 8 at 5X

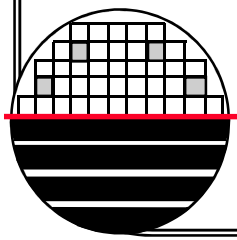


HIGH VOLTAGE TRANSISTOR ARRAY

Designed High Voltage Transistor
Delivered 16 Masks
1X, 5X, 5”sq., 6”sq.,
90 mils, 250 mils thick
Delivered 20 Wafers
4 inch by 1 inch chips
(dark field stitching, clear field 1X)
NMOS Vt = 1.12 volts
I drive = 65 mA
I leak <0.5 µA
Maximum VDS > 45 Volts







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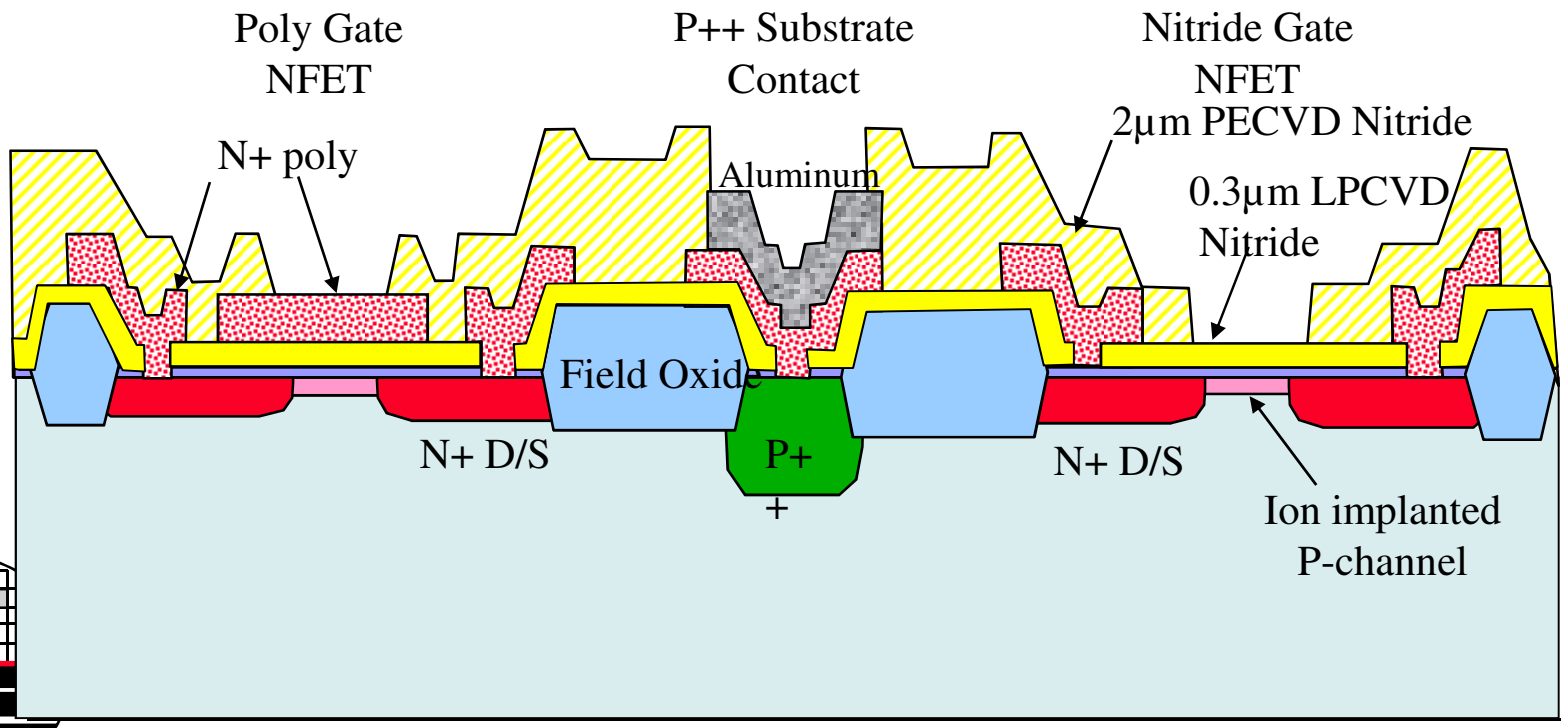
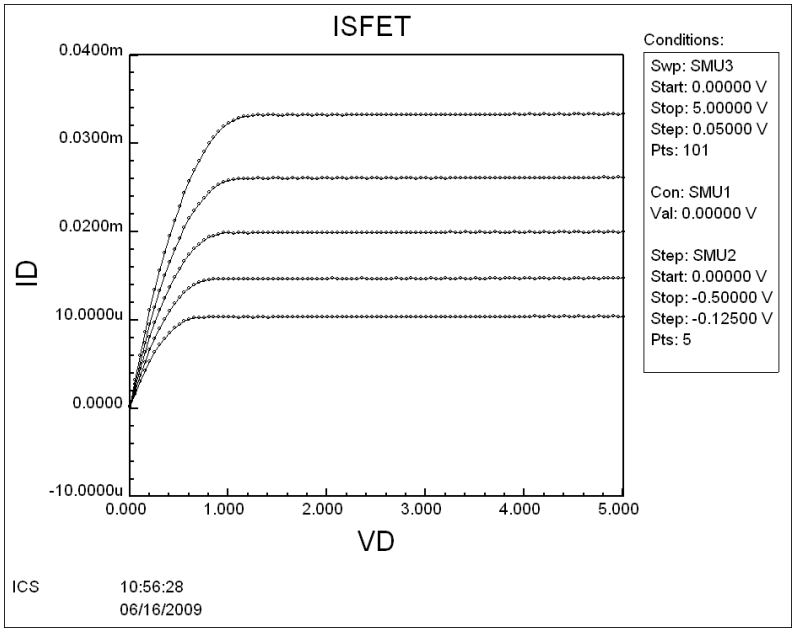
U OF HAWAII BIOSENSORS - INTRODUCTION

This project involves the design and fabrication of NMOS FETS with specific structure and electrical characteristics. Completed devices will have biomolecules attached to the gate materials resulting in specific changes in drain current.

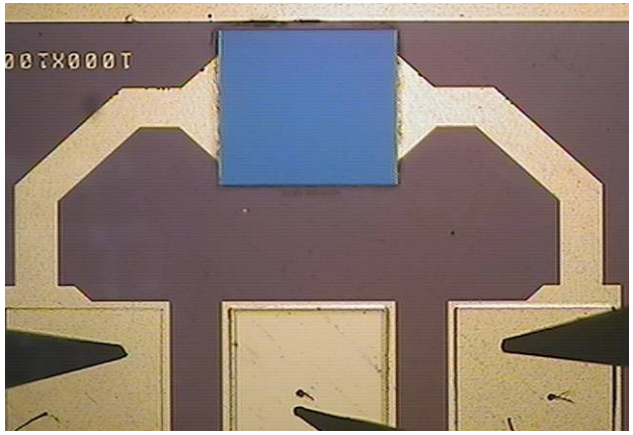


ISFETS FOR WATER pH AND CHLORINE

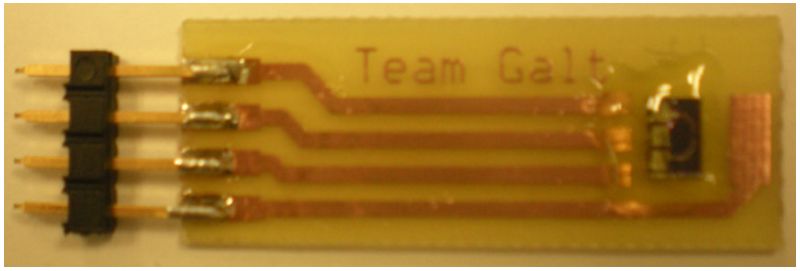


Family of curves with VS=0V, VB=0 to -0.5V and VD=0 to 5V ID=33.4 µA when VS=VB=0V and VD=2.5V

ISFET



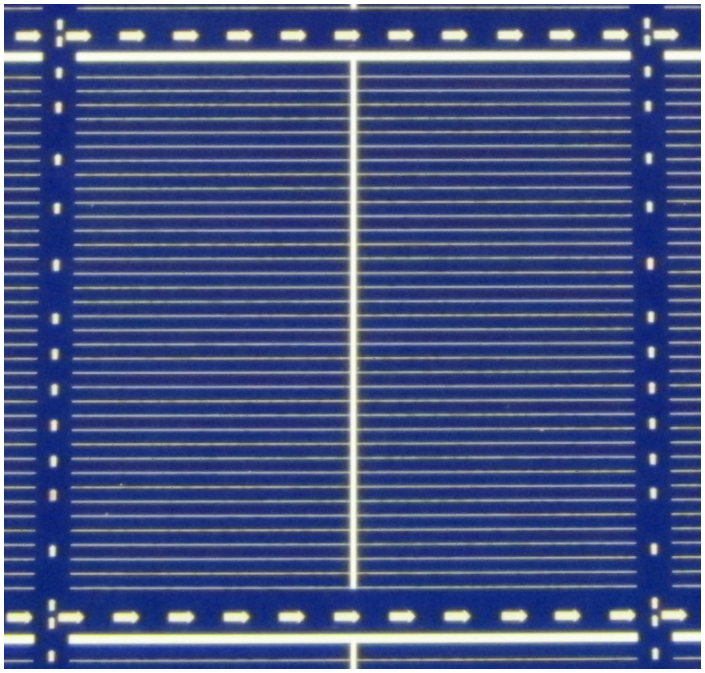
PACKAGED ISFET



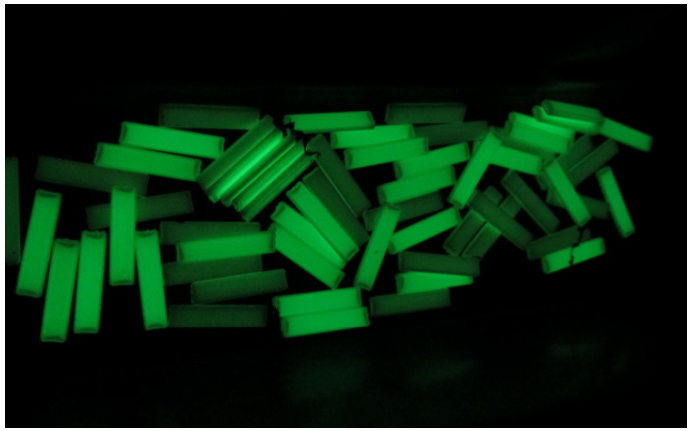
ENERGY HARVESTING

Indirect Conversion of Radiation for 20 Year-Life Batteries

Green Optimized Photocell



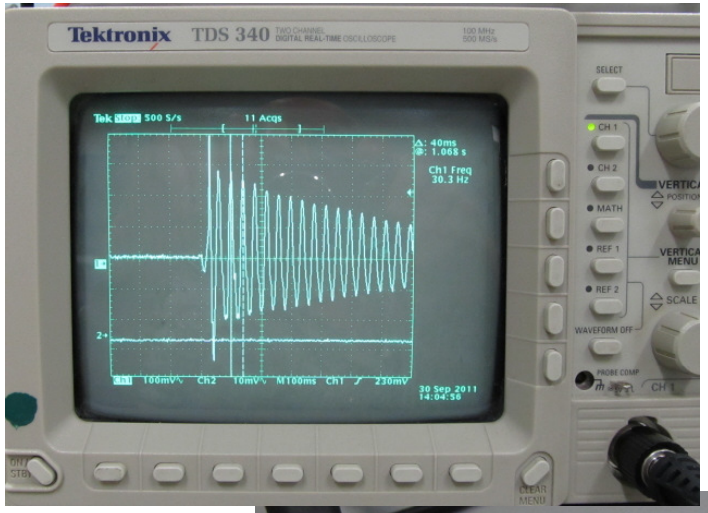
1.6 cm

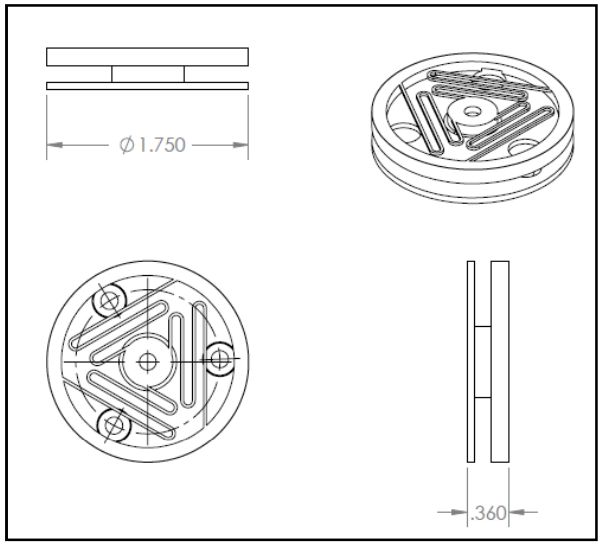


Gaseous Tritium Light Source (GTLS)

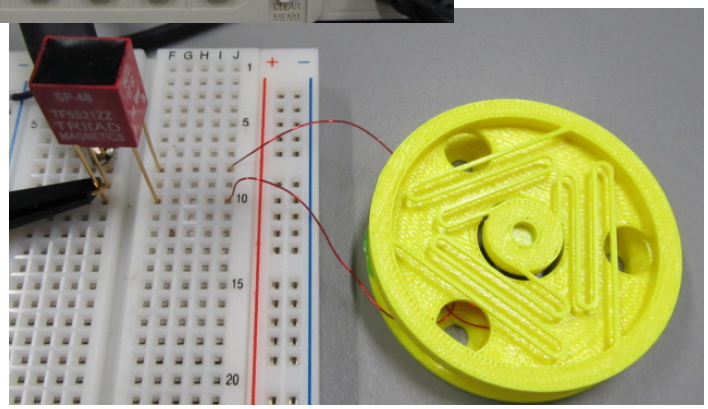
(GTLS) – Phosphor Coat Glass Vial with Tritium Inside
Tritium: Radioactive Isotope of Hydrogen, ^{3}H, 12year half life
Emits Electrons Through Beta Decay
Electrons Interact With Phosphor Material
Green Light is Emitted (Radio luminescence)
Photo Detector Captures Light and Converts to Energy
Energy Management Electronics
Stores Energy in a Super Capacitor

VIBRATION ENERGY HARVESTER

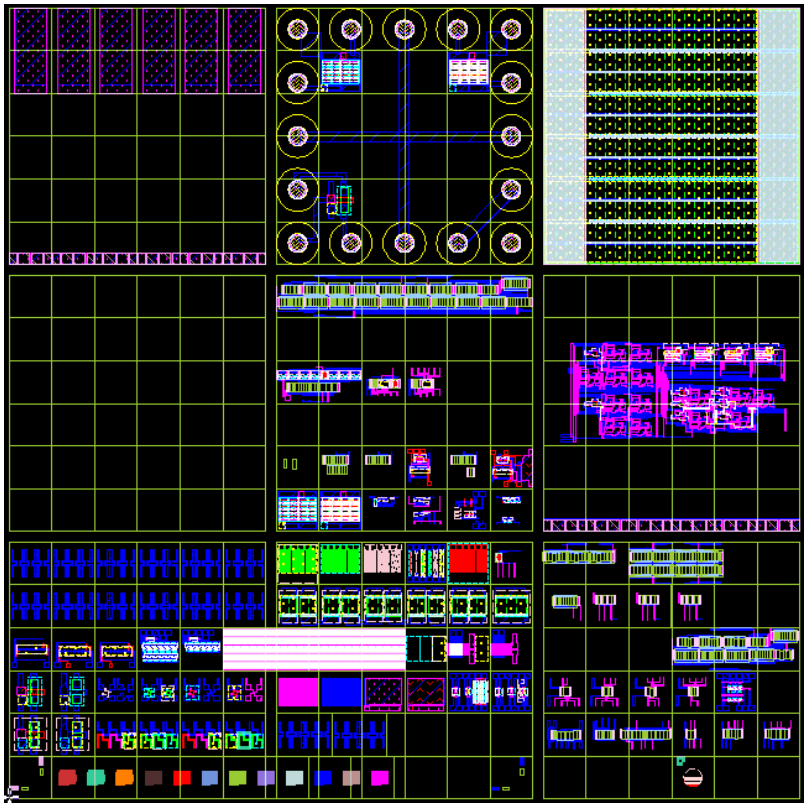




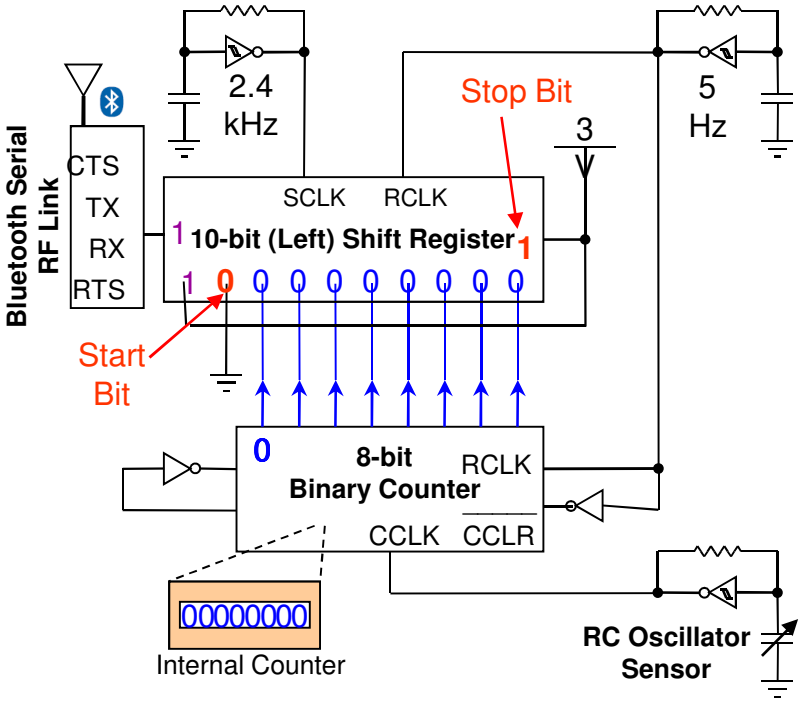
Dr. Denis Cormier
3-D Printer
Brinkman Lab at RIT

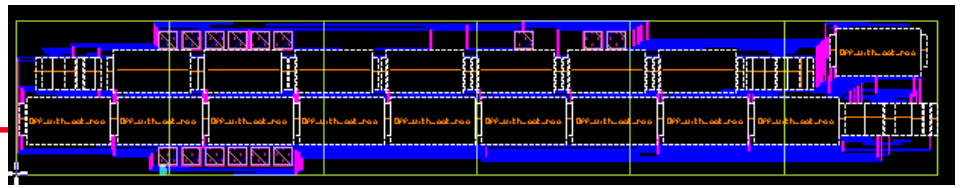


BLUE TOOTH WIRELESS PRESSURE SENSOR

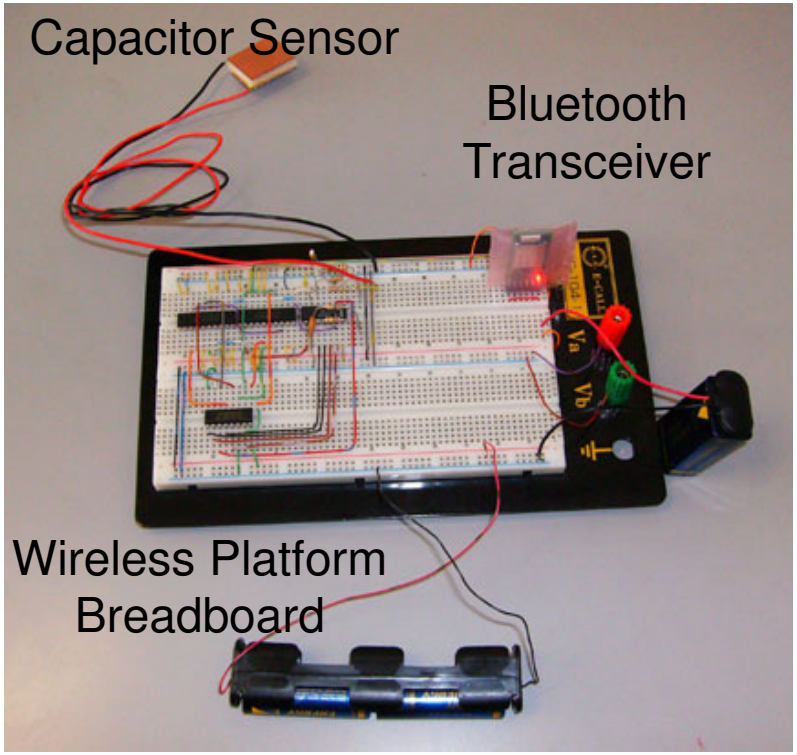


New testchip and design methodology for design of analog and digital circuits to be integrated with microsystems.

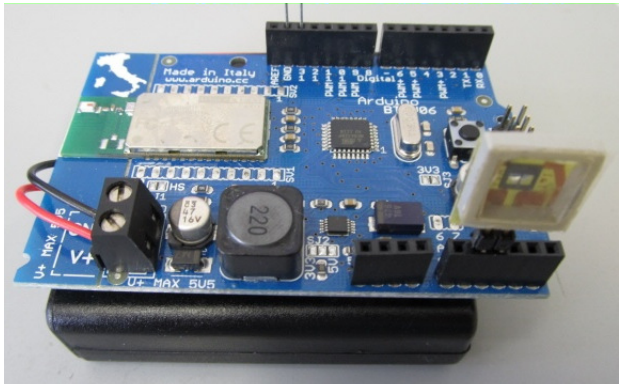




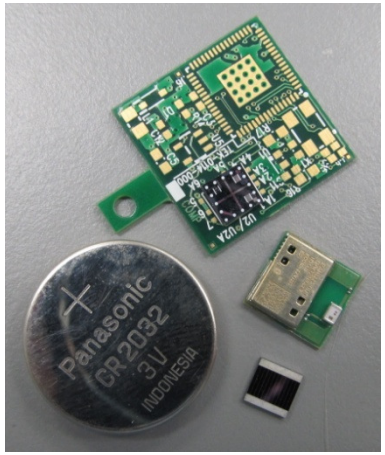
WIRELESS MICROSYSTEMS



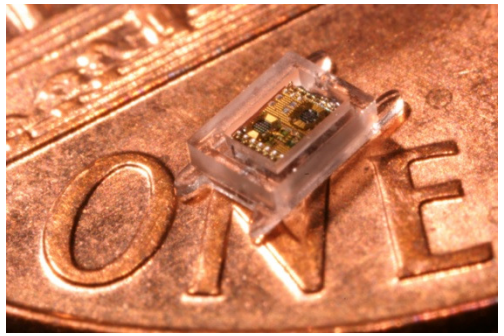
5” x 8” Breadboard



2.5” x 3” BT-Arduino



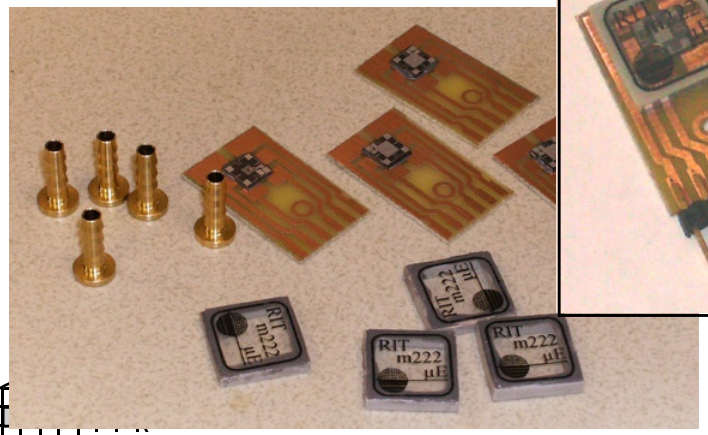
1” x 1” PCB



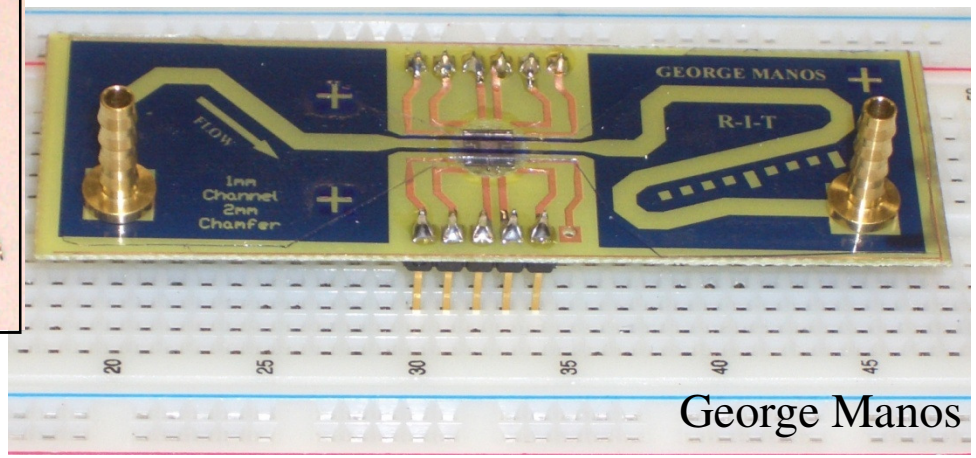
2mm x 3mm
Custom CMOS & MEMS

DEVELOP MEMS PACKAGING

Packaging of MEMS and Microsystems: Many of the devices we are now making need to be packaged to be tested. Some devices have a large number of connections thus probing is difficult. Other devices need to be interfaced with physical parameters such as pressure, gas flow, acceleration, etc. The goal is to develop flexible, low cost, approaches for creating packages for testing and evaluation. Final custom package design concepts and materials are developed and suppliers found.



Packaging of Pressure Sensor

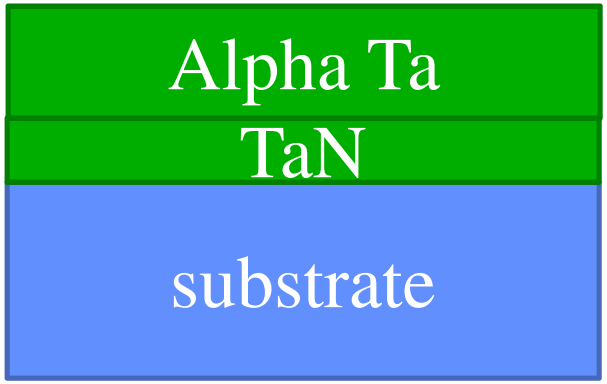


George Manos

Packaged Gas Flow Sensor

PACKAGE TECHNOLOGY DEVELOPMENT

MATERIALS SELECTION, PROCESSING, EVALUATION

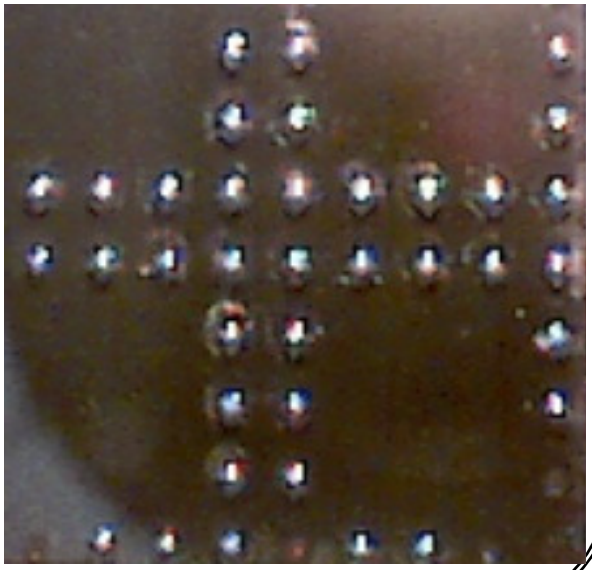


Ta Power, Time	t (Å)	Rs (Ω/sq)	rho (Ω cm)	CRT	Material
No TaN seed*	2725	6.55	178.0E-6	-250ppm	Beta-Ta
500W, 15 min	2818	7.65	215.6E-6	- 165ppm	Beta-Ta
200W, 5min	500	8.74	43.7E-6	+ 900ppm	Alpha-Ta
200W, 15min	1200	2.73	32.8E-6	+ 900ppm	Alpha-Ta
200W, 30min	2200	1.6	35.2E-6	+ 750ppm	Alpha-Ta

INTERCONNECT TECHNOLOGY

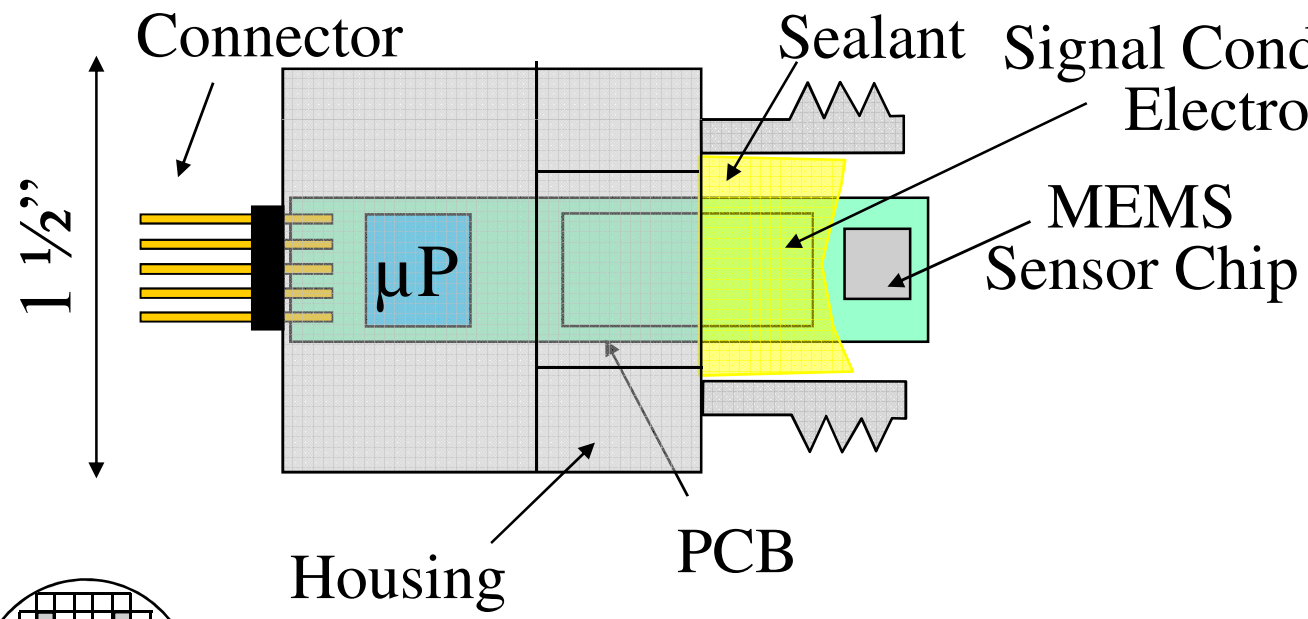
Wire Bond

Solder Bump Flip Chip

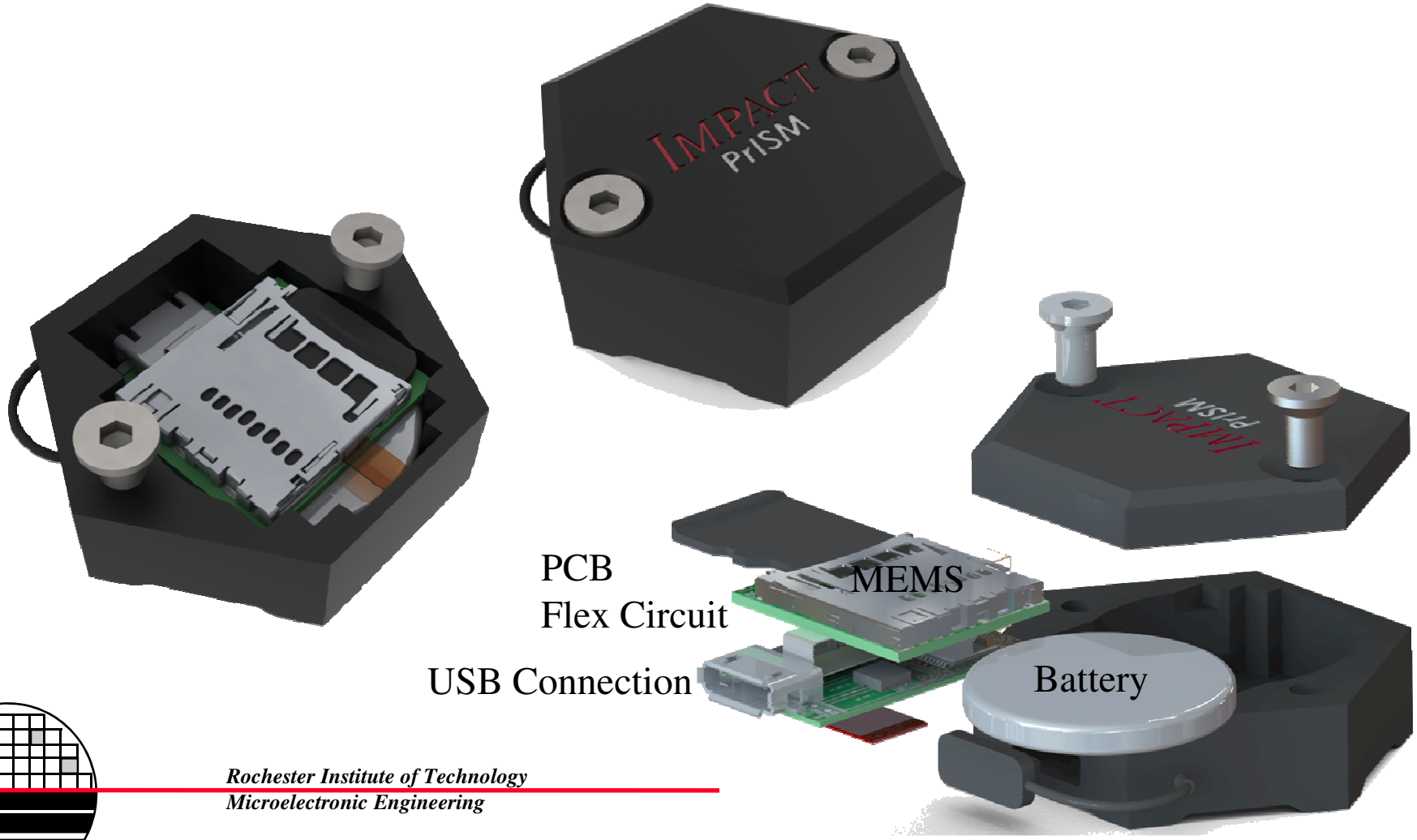


PACKAGE CONCEPT DESIGN

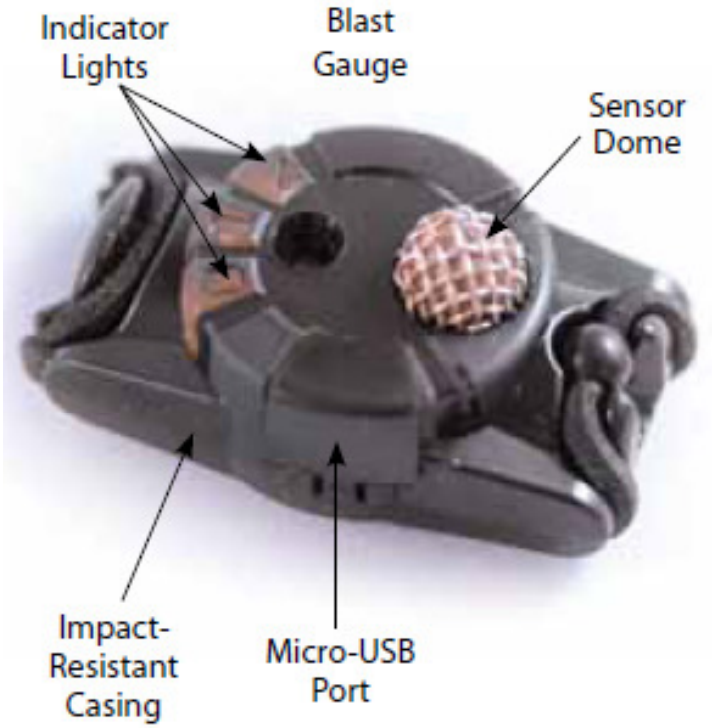
The microchip (4mm x 4mm) will be mounted on a PC board with voltage regulator chip and a few other components. Four wires will be needed (Power, Ground, Serial Communication) so the board will be soldered to a connector in a housing.



PACKAGING CONCEPT DESIGN



RESULTING FINAL MICROSYSTEM PACKAGES



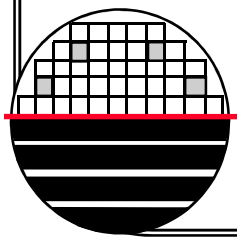
SmartMon-GB™ – Variant for Aerospace Gearbox Fluid Monitoring

WHO IS JOHN GALT?

John Galt is a fictitious character in Ayn Rand's 1957 classic novel *Atlas Shrugged*. He was an engineer who challenged his contemporaries to rise above mediocrity and to think outside the box. The question "Who is John Galt?" is posed to express frustration with being stuck with the commonplace, and the answer is really the spirit of challenging and rising above expectations.

In the novel, John Galt invented a revolutionary new motor, which was powered by ambient static electricity. Team Galt is therefore an appropriate name for Dr. Fuller's MEMS research team at RIT. Integrating CMOS with MEMS is an enabling capability that will allow the team to develop new MEMS devices for a wide range of applications, and the concept of energy harvesting can be paralleled to the work of John Galt.

Heidi Purrington



TEAM GALT - ALUMNI

Heidi Purrington, 2010 – Fairchild, S. Portland, Maine
Murat Baylav, 2010 –Intel, Phoenix, Arizona
Jake Leveto, 2010 – Small Business Owner
Ellen Sedlack, 2011 – Micron, Boise, Idaho
Tal Nagourney, 2011 – Ph.D. Student at Cornell University
Jeff Traikoff 2011- Intel, Phoenix Arizona
Christian Seemayer, 2012 –
Dan Smith, 2012 –
Nicholas Liotta, 2012 –
Jirachai Getpreecharsawas –
Jen Albrecht –
Ellie Bryon -