History of MEMS at RIT

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The examples in this presentation represent only a few of the many achievements in MEMS at RIT over the past 20 years.
MEMS TIME LINE

1982 Microelectronic Engineering Program Starts
1986 RIT Dedicates Microelectronic Engineering Cleanroom 1987 First
Graduates of MicroE and Start of RIT’s First Full Time Masters
Program in Engineering (ME MME)
1989 First MEMS Research Project – Industry Sponsor
1990 First Federally Funded MEMS Research Project
1991 First Senior Project on MEMS
1994 First MEMS Patent Issued to RIT
1995 Student Run Factory to Manufacture CMOS Devices
1996 First Masters Thesis on MEMS Devices
1997 Incubator to Provide Lab Access for Start Up Companies
1999 First MEMS Courses Taught at RIT
2000 First Short Course on MEMS for Industry People
2001 First MEMS Courses Taught in Mechanical Engineering
2002 Start of the Ph.D. Program in Microsystems Engineering
2003 First NSF Funded MEMS Curriculum Development Project and First
MEMS Course Taught by EE
MEMS TECHNOLOGY TIME LINE

1982  2” & 3” Wafer Fab – Metal Gate PMOS
      Optical Pattern Generator and Maskmaking
      Contact Lithography
      Wafer Saw and Wire Bonder
1986  4” Wafer Fab – Metal Gate PMOS
      Stepper Lithography
1987  E-Beam Maskmaking
1989  LPCVD Poly, Nitride, LTO
      Reactive Ion Etch
      Ion Implant
1991  CMOS Capability
1995  MESA Work-in-Process Tracking System
1999  6” Wafer Fab – CMOS Capability
      CMP Tools
2002  Deep Trench Etch Tool
      PE CVD Tool
2010  ASML Stepper
1989 Dr. Lane, Dr. Fuller, David Price and Perkin Elmer Co

Research Project to make gas chromatograph channels in silicon wafers.
RIT’S FIRST MEMS PATENT – DR. LANE, 1994

U.S. Patent
Oct. 25, 1994
5,357,803

ABSTRACT

The present invention relates to a microaccelerometer employing a single free-mass and capable of measuring acceleration along three coordinate axes, and a process for fabricating through micromachining and microelectronic techniques a microaccelerometer employing a free-mass. A microaccelerometer is constructed by chemically etching and etching a silicon wafer to form a support member and a free-mass surrounding by the member. The free-mass is movable with respect to, but constrained by the silicon support member. Acceleration measurements are obtained by circuits which sense changes in the position of the free-mass with respect to an equilibrium position, induced by a change in the rate of acceleration of the accelerometer, and the electromagnetic force required to restore the free-mass to its equilibrium position.

18 Claims, 6 Drawing Sheets
FORCE BALANCE ACCELEROMETER MICRO SYSTEM

Dr. Lane, 1992
Bell Aerospace, Inc.

Feedback
If Vo positive

Measure C2

Measure C1

Feedback
If Vo negative

Vo
V1
V2
Matt Matessa, 1991, BSµE, Joined Cypress Semiconductor, San Jose, CA
Dave Borkholder, 1994, after graduation from RIT joined Ph.D. program in EE at Stanford University Palo Alto, CA

GaP wafers with n-type epilayer, add gold metal, dice and wire bond to RIT thick film ceramic package.
CAPACITOR MICROPHONE – SENIOR PROJECT

Jon Stephan, 1995, joined Intel Corporation, Folsom, CA

1 µm Aluminum

2.0 µm Gap

ALUMINUM DIAPHRAGM CAPACITIVE MICROPHONE
MICROPHONE SIGNAL CONDITIONING

\[ V_0 = -iR \]

\[ i = \frac{d}{dt}(CV) \]

\[ i = V C_m 2\pi f \cos(2\pi ft) \]

\[ V_0 = -2\pi f V R C_m \cos(2\pi ft) \]

amplitude of \( V_0 \)

Co = Average value of C
Cm = amplitude of C change
C = Co + Cm sin (2πft)
V is constant across C
CMOS OPERATIONAL AMPLIFIER – MASTERS THESIS

p-well CMOS

dimensions
L/W
(µm/µm)

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Ed Sayer, MSEE 1991, joined Digital Equipment Corp., Hudson, MA
TOP SIDE BULK MICROMACHINED PRESSURE SENSORS – SENIOR PROJECT

Pressure Sensor with Nitride Diaphragm and Poly Piezo Resistors over Bulk Etched Cavity

300 µm

Jason Trost, 1995 BSµE, joined Harris Semiconductor Mountaintop, PA
NIH FUNDED RESEARCH ON PRESSURE SENSORS

Kerstin Babbitt, 1997
BSEE U of Rochester, joined
Motorola, Austin, TX
FINITE ELEMENT ANALYSIS

2mm x 2mm Crystalline Silicon Diaphragms 30μm thick 50psi
NIH FUNDED RESEARCH ON PRESSURE SENSORS
FIRST MEMS DEVICE WITH INTEGRATED ELECTRONICS

0 to 5 mm Hg Pressure Range
NIH FUNDED RESEARCH ON PRESSURE SENSORS

Poly Diaphragm

Etch Holes

Contact Cut to Poly Gate

Vsource

Vgate

Vdrain

2 µm n+ Poly

1 µm space (vacuum)

1000 Å Oxide

n-type silicon

Aluminum Plug

P4

P4

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NIH FUNDDED RESEARCH ON PRESSURE SENSORS

Kerstin Babbitt 1997, Motorola
Stephanie Bennett 1997, ASML
Sheila Kawati 1998, Syracuse Medical School
An Pham 1999, Integrated NanoTechnology
Dr. Lynn Fuller
**INCUBATOR - ADVANCED VISION TECHNOLOGY INC.**

Integrated Phosphor Field Emission Device

Micro-encapsulated Chamber

Color Chart of AVT Phosphors
Because the DNA is hybridized to a probe DNA with 15 matching base pairs, the probability that the attached DNA is the desired DNA is one billion to one or better. (i.e. $4^{15}$)
**CHEMIRESISTOR**

Simple inter-digitated electrodes coated with a chemically sensitive layer that changes the resistance in response to a few ppm of some (or many) chemicals.

Copper-substituted Phthalocyanine conductive polymer is sensitive to CCl4, NH3 and N2O

or

Carbon Nano-Tubes and various polymers

**Dr. Lynn Fuller**  
**Dr. KSV Santhanam**  
**Yatin Prayag 1999**
CHEMICAL SENSORS

Upper Left: Finished Sensor with chip pins
Upper Right: Close up of interdigitated gold fingers

Elizabeth Gregg 2005
CHEMICAL SENSORS

Mix a polymer with Carbon Black and apply a thin coat over interdigitated gold fingers.

Testing
30s off, 120s on, 60s off, 120s on, 30s off

0.1 ml Acetone/125 ml bottle = 800 ppm
Resistance goes from ~100 ohms (no vapor) to ~4,000 ohms (with vapor)
FLOW PLATES FOR FUEL INJECTION

Variety of different size and shape holes etched through 500 µm thick silicon wafer

Dr. Risa Robinson
Delphi Products, Inc.
BULK MICROMACHINED ATOMIZER FOR DRUG DELIVERY

[Image of micromachined atomizer]
Current Flow = 0 mA

Skinny arm is hotter and expands causing bending motion

Current Flow = 10 mA
FINITE ELEMENT ANALYSIS OF THERMAL BENDING

Small arm 300 C, 10um X 100 um
Large arm 0 C, 30 um x 100 um
Maximum Displacement = 6 um

Andrew Randles
December 2001
Kevin Munger joined IBM Burlington, VT

Maximum Deflection 9 µm at 30 µw
162,000 cycles, 6 msec.

Thermal Actuator with Integrated Photodiode
Cantilevers
Springs
Accelerometer
Electrostatic Comb Drive
Mirrors
Optical Modulators
Optical Arrays
Tweezers
Inductors
Contactors
Cantilevers
Springs
Accelerometer
Electrostatic Comb Drive
Mirrors
Optical Modulators
Optical Arrays
Tweezers
Inductors
Contactors
CANTILEVERS AND COMB DRIVES
OTHER STRUCTURES

- Voltage Meters
- Mirror
- Gears
SEM PICTURES
VERIFICATION OF RELEASE
ELECTRICAL RESULTS
ELECTROSTATIC ACTUATION OF CANTILEVER

1 µm Movement
10 Volt Electrostatic Actuation
No Voltage to Heater
Resistance of Heater 1000 ohms
Resistance of Resistor 4800 ohms
SURFACE MICROMACHINED GAS FLOW SENSOR

Vee Chee Hwang, 2004
HEATER TESTING

Movie

20 Volts applied to Heater Resistor changed by 100 ohms
MOVIE OF HEATER
2002 CLASS PROJECT – PRESSURE SENSOR

- Polysilicon Resistors
- Aluminum Metal
- Silicon Nitride Insulator

Si 500 µm Silicon Diaphragm

Silicon Nitride Etch Mask

Package
Points of Maximum Stress
2mm x 2mm Crystalline Silicon Diaphragms 30μm thick 50psi

Regular Si Diaphragm

Corrugated Diaphragm
Layer 2: 1.5mm x 1.5mm Polysilicon 1μm thick

By Rob Manley
DIAPHRAGM DEFORMATION MOVIE
DIAPHRAGM STRESS MOVIE
DIAPHRAGM FABRICATION

20% KOH Etch, @ 72 C, 10 Hrs.
MOVIE OF DIAPHRAGM MOVING
TESTING

Apply and release chuck vacuum to observe change in output voltage.

- $V_{o1} = 2.4965v$
- $V_{o2} = 2.5035v$

Diagram:
- 5 Volts
- $R1$, $R2$, $R3$, $R4$
- Gnd
Fixture to hold TO-8 and TO-39 packages for wire bonding.

Rob Manley

K&S WAFER SAW
TESTING OF PACKAGED PRESSURE SENSORS

MEMS Pressure Sensor Output

\[ y = 0.0002x^2 + 0.586x + 60.593 \]

<table>
<thead>
<tr>
<th>Pressure (psi)</th>
<th>Output Voltage (mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>60.6</td>
</tr>
<tr>
<td>5</td>
<td>63.84</td>
</tr>
<tr>
<td>10</td>
<td>66.32</td>
</tr>
<tr>
<td>15</td>
<td>68.95</td>
</tr>
<tr>
<td>20</td>
<td>72.28</td>
</tr>
<tr>
<td>25</td>
<td>75.62</td>
</tr>
<tr>
<td>30</td>
<td>78.68</td>
</tr>
<tr>
<td>35</td>
<td>81.25</td>
</tr>
<tr>
<td>40</td>
<td>84.39</td>
</tr>
<tr>
<td>45</td>
<td>87.21</td>
</tr>
</tbody>
</table>

\[ y = 0.00032x^2 + 0.586x + 60.593 \]
SURFACE MICROMACHINED GAS FLOW SENSOR

L of heater & resistor = 1mm
W (heater) = 50um
W (resistors) = 20um
Gap = 10um
V applied = 27V to 30.5V
Temp ~600 °C at 26 volts
Lifetime > 10 min at 27 volts (possibly longer, did not test)

Vee Chee Hwang, 2004
BULK MICROMACHINED GAS FLOW SENSOR

Measured Resistance, V/I=1.2Kohms
Theoretical Resistance, L*Rhos/W= 400µm*60/20µm = 1.2Kohms

Raunak Mann, 2004
THERMIONIC GAS DETECTOR

- Polysilicon Micro-filament heater

- Make hot
- Thermionic emission occurs causing ionization
- Force ions to a collection plate
- Measure resulting current or voltage

Robert Manley, 2004
THERMIONIC GAS DETECTOR

Polysilicon

Un-etched Sacox

Silicon Nitride

Si

Robert Manley, 2004
THERMIONIC GAS DETECTOR

Robert Manley, 2004
Pressure Sensor, diffused resistors or poly resistors
Microphone- more sensitive pressure sensor
Speaker – diaphragm with coil on it, magnet below
Accelerometer – diaphragm with mass in center from back etch donut
Diaphragm Actuator with coil and resistors for sensing and feedback
Optical pyrometer with thermocouples on diaphragm
Heater on diaphragm either poly or diffused resistor heater
Heater plus temperature sensor (diffused heater, poly resistor sensor)
Heater plus interdigitated chemical sensor
Cantilever accelerometer with piezoresistors either poly or diffusion, mass from back etch donut
Cantilever accelerometer with magnetic coil for sensor, mass from back etch donut
Gas flow sensor single resistor anemometer
Gas flow sensor with heater and two resistors
Torsional mirror with coil actuators
Gyroscope with piezoresistor sensors or coil and magnet sensors, with mass from back etch donut for each ½ of torsion bar
Transistors and logic, RF Inductors
MODIFIED BULK PROCESS FOR MEMS CLASS 2004-06

Class Project Chip

Gas Flow Sensor

Torisonal Mirror
MODIFIED BULK PROCESS FOR MEMS CLASS 2004-06

Movie

Thermopile

Accelerometer

Speaker

Inductor

Pressure Sensor
History of MEMS at RIT

VISCOCITY SENSOR JOURNAL PUBLICATION AND PATENT

United States
Patent Application Publication

Puchades et al.

Pub. No.: US 2010/0332155 A1
Pub. Date: Dec. 20, 2010

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 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 fluid in contact with the flexible membrane.
MODIFIED BULK PROCESS FOR MEMS CLASS 2004-06

Wafer Inspection

Backside of Wafer
BIO PROBES
SECOND VERSION COMPLETED DEVICES

W1 = 300 µm
W2 = 1100
W3 = 450
L1 = 1400
L2 = 1250
THERMALLY ACTUATED MEMS MICRO MIRROR

Thermal Mirror Microactuator

Dr. Lynn Fuller
Rakesh Dhull
DEVICE CROSS SECTION

- Mechanical Poly Layer
- Sacrificial Oxide
- Metal

- Bottom Poly
- Starting Wafer

- Bottom Poly 1 (Red) Layer 1
- Sacrificial Oxide (Blue Outline) Layer 2
- Anchor (Green) Layer 3
- Mechanical Poly 2 (Purple) Layer 4
- Contact Cut (White) Layer 6
- Metal (Blue) Layer 7
- Outline (Yellow Outline) Layer 9
- No Implant Yellow Layer 15
- Holes Layer 16 (combined with Poly 2)
LIST OF MEMS DEVICES MADE WITH THIS PROCESS

Resistors – Micro Bolometer
Heaters – Chemical Sensors
Micro Mirror - Two Axis Mirror
Thermally Actuated Two Arm Cantilever
Chevron Actuators
Electrostatic Comb Drive
MEMS Switch
Accelerometer
Gas Flow Sensor, Anemometer, Thermionic
Light Modulator
Bio Probes
Speaker
Humidity Sensors
Pressure Sensors - Microphone
Temperature Sensors – Thermopile, Resistor
Inductors, Capacitors – Humidity Sensor
Hall Effect Sensors – other Magnetic Field Sensors
Total 15 mm by 15 mm plus 500 um for sawing into 9 chips for overall 16.5 mm by 16.5 mm size.

Wafer sawing is easier if all chips are the same size

5 mm by 5 mm design space for each project
MEMS CLASS PROJECT FALL 2014

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Microelectronic Engineering
This is a surface micromachine process with two layers of polysilicon and one layer of metal. Poly2 can be suspended above the wafer allowing for structures that can move. The two poly layers can cross without connection or can be connected through anchor holes. The metal layer can connect to Poly2 through a via or to Poly1 through via and anchor holes. The yellow layers are silicon nitride.
The cantilever shown is anchored on the left and free to move on the right. The design includes resistive and capacitive position sensors and electrostatic actuation. The device can be used as an accelerometer.
CLEAR FIELD RETICLE FOR ASML

Poly One Non-Chrome Side

Metal Chrome Side
### SURFACE MEMS 2015 PROCESS

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Starting wafer</td>
</tr>
<tr>
<td>2.</td>
<td>PH03 – <strong>level 0</strong>, Marks</td>
</tr>
<tr>
<td>3.</td>
<td>ET29 – Zero Etch</td>
</tr>
<tr>
<td>4.</td>
<td>ID01-Scribe Wafer ID, D1…</td>
</tr>
<tr>
<td>5.</td>
<td>ET07 – Resist Strip, Recipe FF</td>
</tr>
<tr>
<td>6.</td>
<td>CL01 – RCA clean</td>
</tr>
<tr>
<td>7.</td>
<td>OX04 – 6500Å Oxide Tube 1</td>
</tr>
<tr>
<td>8.</td>
<td>CV01 – LPCVD Poly 5000Å</td>
</tr>
<tr>
<td>9.</td>
<td>IM01 – Implant P31, 2E16, 60KeV</td>
</tr>
<tr>
<td>10.</td>
<td>PH03 – <strong>level 1</strong> Poly-1</td>
</tr>
<tr>
<td>11.</td>
<td>ET08 – Poly Etch</td>
</tr>
<tr>
<td>12.</td>
<td>ET07 – Resist Strip, Recipe FF</td>
</tr>
<tr>
<td>13.</td>
<td>CL01- RCA Clean</td>
</tr>
<tr>
<td>14.</td>
<td>OX05 – 700Å Dry Oxide</td>
</tr>
<tr>
<td>15.</td>
<td>CV02- LPCVD Nitride 4000Å</td>
</tr>
<tr>
<td>16.</td>
<td>PH03 – <strong>level 2</strong> Anchor</td>
</tr>
<tr>
<td>17.</td>
<td>ET29 – Etch Nitride</td>
</tr>
<tr>
<td>18.</td>
<td>ET07 - Resist Strip, Recipe FF</td>
</tr>
<tr>
<td>19.</td>
<td>CL01 – RCA Clean</td>
</tr>
<tr>
<td>20.</td>
<td>CV03-TEOS SacOx Dep 1.75um</td>
</tr>
<tr>
<td>21.</td>
<td>PH03 – <strong>level 3</strong> SacOx Define</td>
</tr>
<tr>
<td>22.</td>
<td>ET06 - wet etch SacOx Define Etch</td>
</tr>
<tr>
<td>23.</td>
<td>ET07- Resist Strip, Recipe FF</td>
</tr>
<tr>
<td>24.</td>
<td>CL01 – RCA Clean</td>
</tr>
<tr>
<td>25.</td>
<td>CV01-LPCVD Poly 2um, 140 min</td>
</tr>
<tr>
<td>26.</td>
<td>PH03 - <strong>level 4</strong> No Implant</td>
</tr>
<tr>
<td>27.</td>
<td>IM01-P31 2E16 100KeV</td>
</tr>
<tr>
<td>28.</td>
<td>ET07 Resist Strip, Recipe FF</td>
</tr>
<tr>
<td>29.</td>
<td>CL01 – RCA Clean</td>
</tr>
<tr>
<td>30.</td>
<td>OX05- 500Å pad oxide</td>
</tr>
<tr>
<td>31.</td>
<td>CV02 – 2000Å nitride</td>
</tr>
<tr>
<td>32.</td>
<td>PH03 - <strong>level 5</strong> Poly2</td>
</tr>
<tr>
<td>33.</td>
<td>ET29 – Plasma Etch Nitride</td>
</tr>
<tr>
<td>34.</td>
<td>ET06 – Wet Etch pad oxide</td>
</tr>
<tr>
<td>35.</td>
<td>ET68 - STS Etch Poly2</td>
</tr>
<tr>
<td>36.</td>
<td>ET07 - Resist Strip, Recipe FF</td>
</tr>
<tr>
<td>37.</td>
<td>PH03 – <strong>level 6</strong> Contact Cut</td>
</tr>
<tr>
<td>38.</td>
<td>ET29 – Etch Nitride Contact Cut</td>
</tr>
<tr>
<td>39.</td>
<td>ET06 – Etch Oxide Contact Cut</td>
</tr>
<tr>
<td>40.</td>
<td>ET07 – Resist Strip, Recipe FF</td>
</tr>
<tr>
<td>41.</td>
<td>39. CL01 – RCA Clean two HF</td>
</tr>
<tr>
<td>42.</td>
<td>ME01 – Metal Deposition - Al</td>
</tr>
<tr>
<td>43.</td>
<td>PH03 – <strong>level 7</strong> Metal</td>
</tr>
<tr>
<td>44.</td>
<td>ET55 – Metal Etch - wet</td>
</tr>
<tr>
<td>45.</td>
<td>ET07 – Resist Strip</td>
</tr>
<tr>
<td>46.</td>
<td>PH03 – <strong>level 8</strong> – Release</td>
</tr>
<tr>
<td>47.</td>
<td>SA01 – Saw Wafer ½ Way</td>
</tr>
<tr>
<td>48.</td>
<td>Special Soap Clean</td>
</tr>
<tr>
<td>49.</td>
<td>ET66 – Final SacOx Etch</td>
</tr>
<tr>
<td>50.</td>
<td>ET07 - Resist Strip with Acetone</td>
</tr>
<tr>
<td>51.</td>
<td>Rinse and Dry w Isopropyl Pull</td>
</tr>
<tr>
<td>52.</td>
<td>TE01 – wafer level testing</td>
</tr>
<tr>
<td>53.</td>
<td>SEM1 – Pictures</td>
</tr>
<tr>
<td>54.</td>
<td>Packaging and Testing</td>
</tr>
</tbody>
</table>

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Microelectronic Engineering  

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Page 76
Today’s Goal: Coat the wafers with photoresist, expose with ASML stepper, develop and plasma etch ASML alignment marks on six wafers.

Step 2: Etch Silicon using Drytek Quad 482 Etcher –
   Cleaning of chamber for 5 min. in O2 plasma
   Etching the device wafer for 2 min. in CF4, CHF3 and O2 plasma
   Inspection of alignment marks on wafer
   Removal of Photoresist using GaSonics - (recipe FF)
   Microscope images of alignment marks before and after P.R. removal

Authors: Abhinav, Nikhil, Ranjana, Shruthi, Yamini
October 19, 2015
Today’s Goal: Remove organic and metallic contaminants from wafers with RCA clean, steam oxide growth of 6500Å of oxide in Bruce Tube 1.

- Performed step 6: CL01 (RCA clean)
  - Cleaned four wafers from lot
  - Processed through SRD afterwards
- Adam developed and etched the other two wafers in the lot
- Performed step 7: OX04 (oxide growth)
  - Procedure used to grow 6500Å of oxide
- Measured Oxide Thickness:
  - Mean : 6597.7 Å  Std Dev. = 0.38%
Today’s Goal: To etch Polysilicon2 on remaining wafers

- Using the dry tech quad tool, Recipe FACPOLY
- Chamber 2, Time= 18 minutes

Adam at Dry Tech Quad

Wafer Before Poly Etch

Wafer After Poly Etch
Today’s Goal: To perform Level 6, Contact cut lithography and Nitride and Oxide etch on wafers D2, D4, D6.

- Manual coating of PR S1827
- Contact cut lithography with-
  - Dose - 400 mj/cm²
  - Focus offset – 0.5 micro
  - σ = 0.7
- Post bake at 140 °C
- Nitride Etch –
  - Recipe – Factory Nitride Etch, Lam 490
  - Gas used – SF6
  - Time – (3 minutes for etch + 1 minute over etch)/wafer
- Buffered Oxide Etch –
  - BOE 5.2:1 - for 2 minutes
  - Deionized water - for 5 minutes, SRD
Today’s Goal: Deposit Al using CVC601 Sputter tool for a target thickness of 10,000Å.

- Step 42: ME01 – Metal Deposition – Al
- 4 device wafers (D2, D3, D4, D6) + 1 control wafer with tape for measurement
  - Time ~ 34 min
  - 2000 Watts for ~300 Å/min (Sputtering power)
  - Pressure 5 mT (Sputtering Pressure)
  - Argon Flow 28 sccm (to set the Sputtering Pressure)
  - Arc detect count -> 40

Pre-sputtering: 5 min same power - Arc detect count -> 3
Remove contaminants from target expose to atmosphere (Al₂O₃, AlN, etc.).
OIL QUALITY MEMS MULTI-SENSOR

5mm x 5mm

- Photo Diode
- Diffused Heater Actuator
- Viscosity Sensor
- Water in Oil
- EIS
- Diode Temperature Sensor

Picture of MEMS Multisensor

Temperature Test

Device 2H 30V-30us pulse v. SAE 60 temperature

Viscosity

Oil with 1% Soot

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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.
MULTISENSOR MICROS YSTEM

MEMS Multisensor Chip
Acceleration (shock)
Temperature, Humidity
OTHER 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.
OTHER PROJECTS

BlackBox Biometrics
The company was founded by RIT professor David Borkholder and recently graduated from the Venture Creations business incubator. http://b3inc.com
ENERGY HARVESTING

Indirect Conversion of Radiation for 20 Year-Life Batteries

Green Optimized Photocell

Gaseous Tritium Light Source (GTLS)

(GTLS) – Phosphor Coat Glass Vial with Tritium Inside
Tritium: Radioactive Isotope of Hydrogen, \(^{3}\text{H}\), 12 year 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
History of MEMS at RIT

VIBRATION ENERGY HARVESTER

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

Rochester Institute of Technology
Microelectronic Engineering
WIRELESS MICROSYSTEMS

Capacitor Sensor
Bluetooth Transceiver
Wireless Platform Breadboard

5” x 8” Breadboard

2.5” x 3” BT-Arduino

1” x 1” PCB

2mm x 3mm Custom CMOS & MEMS
COMPANIES WITH LINKS TO RIT

Personal Sound Technologies
Advanced Vision Technologies
Integrated Nanotechnologies
MicroGen
BlackBox Biometerics
Tenrehte
Simpore
ACKNOWLEDGEMENTS

Dr. Richard Lane          Kerstin Babbitt
Dr. Risa Robinson        Stephanie Bennett
Dr. Robert Pearson     Sheila Kawati
Dr. KSV Santhanam     An Pham
Dr. Sergey Lyshevski   Andrew Randles
Dr. David Borkholder   Kevin Munger
Dr. Karl Hirschman     Rob Manley
Matt Matessa            Vee Chee Hwang
Jon Stephan             Ivan Puchades
Ed Sayer               Team Galt
Jason Trost
TEAM GALT

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Heidi, Murat
DR. FULLER’S STUDENTS IN EMCR 890 MEMS CLASS 2002

2. View the following link and read the article on “Blast Gauge” http://www.rit.edu/research/media/documents/11_SS_Research_at_RIT.pdf What types of MEMS devices are inside the “Blast Gauge”.

3. Find the MEMS Fabrication Blog from the Fall of 2015. What types of devices were made? Look for pictures of devices.

4. Why is packaging important for MEMS devices?

5. List the MEMS devices you use have in your car or phone.