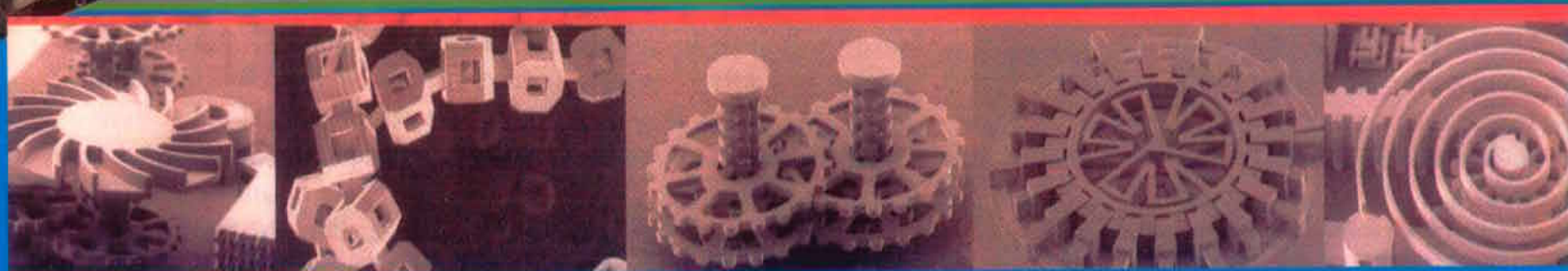


16957 RC



MEMS and Nanotechnology Workshop



An Emerging Army Technology
Presented to PM Stryker Feb 8th, 2007

Dr. Tom Meitzler, TARDEC
Speaker Topics

Oak Ridge National Labs ~ Image Fusion on a MEMS
University of Michigan ~ MEMS Fabrication Labs
Wayne State University ~ MEMS, Nanotechnology and Nano Optics



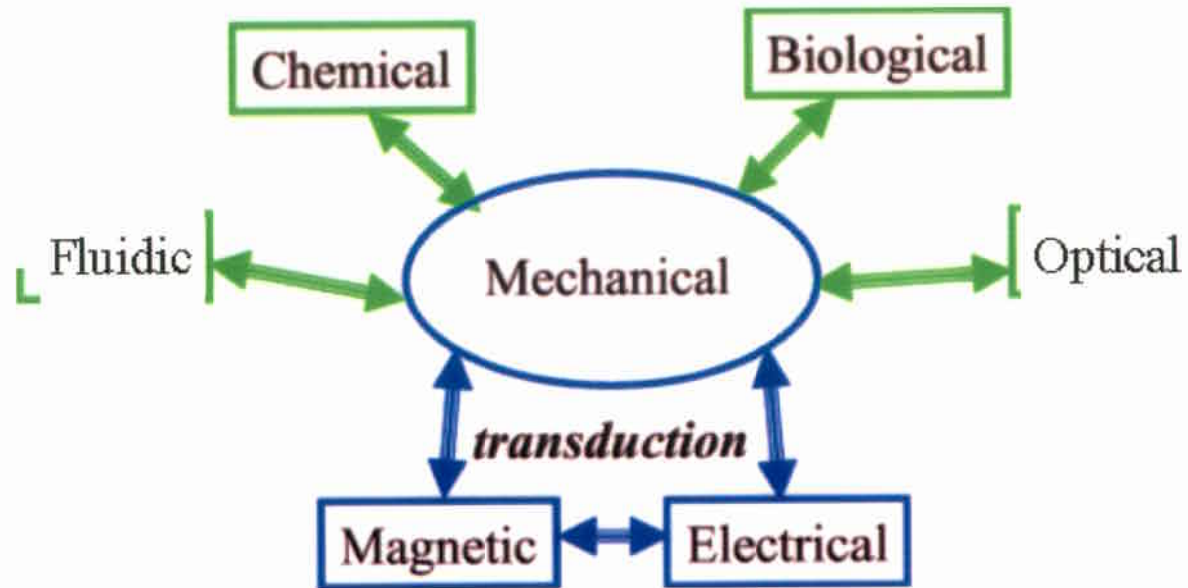
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Definition of MEMS

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MEMS: Micro-electro-mechanical system: Different physical domains within a miniaturized system

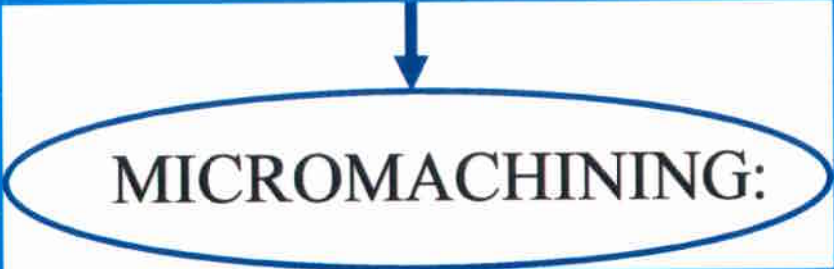




From MEMS to MEMS technology

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- Microelectronics fabrication technology extended to add mechanical degrees of freedom to the device



MICROMACHINING:

the use of lithographic and other microfabrication techniques to create miniaturized sensors, actuators and mechanical structures

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Micromachining technology

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- **What was behind the success of microelectronics is relevant to MEMS:**

1. Silicon is abundant, inexpensive, and can be produced and processed controllably with high standards of purity and perfection.
2. Silicon processing is based on thin film deposition, suitable for miniaturization.
3. Shape definition through lithography is capable of high precision and suitable for miniaturization.
4. Silicon is batch fabrication compatible: cost reduction can be applied according to market demands.

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Some commercial applications of MEMS

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- The rapid evolution of the MEMS world makes it difficult to track all emerging commercial applications. Typical established mass-produced examples are:

- Accelerometers for airbag systems
- Heads for *ink jet printers* and hard disk drivers
- Optical *micro mirrors* for *image projectors*
- Pressure and *chemical* sensors for medical applications
- Quartz watch *crystal* resonators for time-keeping





MEMS applications by industry

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Defense	Medical	Electronics	Communications	Automotive
Munitions Guidance	Blood Pressure Sensor	Disk drive heads	Optical or Photonic Switches and cross-connects in Broadband networks	Internal Navigation sensors
Surveillance	Muscle stimulators & drug delivery systems	Inkjet Printer heads	RF Relays, Switches, and Filters	Air conditioning compressor sensor
Arming Systems	Implanted Pressure sensors	Projection Screen Televisions	Projection displays in portable communications devices and instrumentation	Brake force sensors & Suspension control accelerometers
Embedded Sensors	Prosthetics	Earthquake Sensors	Voltage controlled oscillators (VCOs)	Fuel level and vapor pressure sensors
Data Storage	Miniature analytical instruments	Avionics Pressure sensors	Splitters and couplers	Airbag sensors
Aircraft Control	Pacemakers	Mass Data Storage Systems	Tunable lasers	"Intelligent" Tires

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SUPER

Absorption
of fumes
emissions



Sensors

- Actuate active suspension
- Position / motion
- Condition

ID tag

Biometric key

Mini radar / μ radar

360 vision IR mini camera

Vertical micro rocket launcher

Nanocoated bearings

Micro fuel cell with electric propulsion

Micro hybrid combustion / hydrogen motor



Adaptive camouflage
smart skin

Large LCD
command screen

Ammo with sensors

Smaller high impact
caliber gun



Super penetration

Or no barrel but
micro cruise missiles

Lightweight nano-armor

Nano rheo fluid structure
in armor

Thermal suppression

Flexible lightweight skirts with nano-armor

Radar absorption

Landvehicle

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SUPERIOR TECHNOLOGY

Sensor	Phenomenology	Strengths	Comments
Metal Detector	Maps metal content of soil	• Metal mines • Surface/shallow emplacement	• Time domain analysis improves mine/clutter discrimination
Ground Penetrating Radar (real aperture)	Measures return from dielectric discontinuities	• Metallic mines • Nonmetallic mines with dielectric discontinuity	• Complex natural environment provides theoretical basis to improve discrimination
Ultra Wideband SAR (at low frequency)	Images reflected radar returns	• Shape-based mine/clutter discrimination • Metallic mines	• SAR processing needed to achieve adequate resolution for airborne surveys
Visible Imagery	Different reflectivity vs. λ	• Surface mines on locally uniform background • Daylight • Shape-based discrimination	
Thermal IR Imagery	Temperature difference between mine & background, differences in heating/cooling rates	• Surface mines • Buried mines • Wet soil • Shape-based discrimination • Functions at night	
Multi- or hyper-spectral Imagery	Spectral difference between mine and background	• Surface mines in cluttered background • Disturbed earth	
Active Laser Polarization Imagery	Mine depolarizes incident radiation differently than clutter	• Surface mines • Freshly buried mines • Functions at night	
Passive MMW	Temperature difference between mine & background	• Damp weather	
Neutron Activation Analysis	Detects chemicals associated with explosives based on their behavior when exposed to radiation	• Shallow-buried nonmetallic mines	• May be effective in confirming cues that are marginally detected
Nuclear Quadrupole Resonance	Detects explosive contents of mine	• Suppresses false alarms by finding explosives	• Not suited for wide area search - needs companion detector

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Night Vision (IR) and Visual Image Fusion in Real-Time

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But only infrared image fused with visible light image show all features



Visible image shows:

- Road edges
- Sign



Infrared image shows:

- Person
- Road beyond headlights



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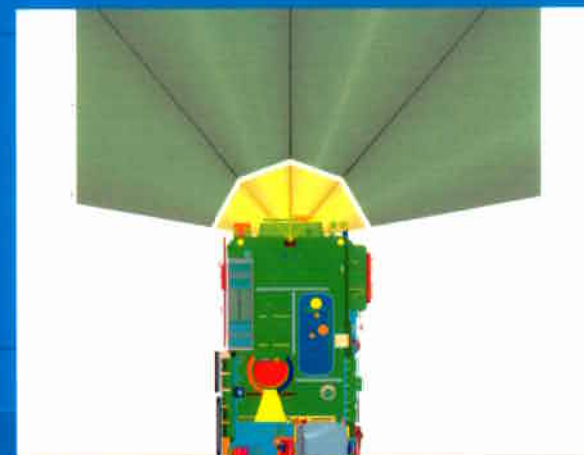




Navigator Prototype Kit

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Fully Passive 360° Image Fusion Technology for
Homeland Defense with Modular Camera Kit



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Present Version of System

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Rugged version



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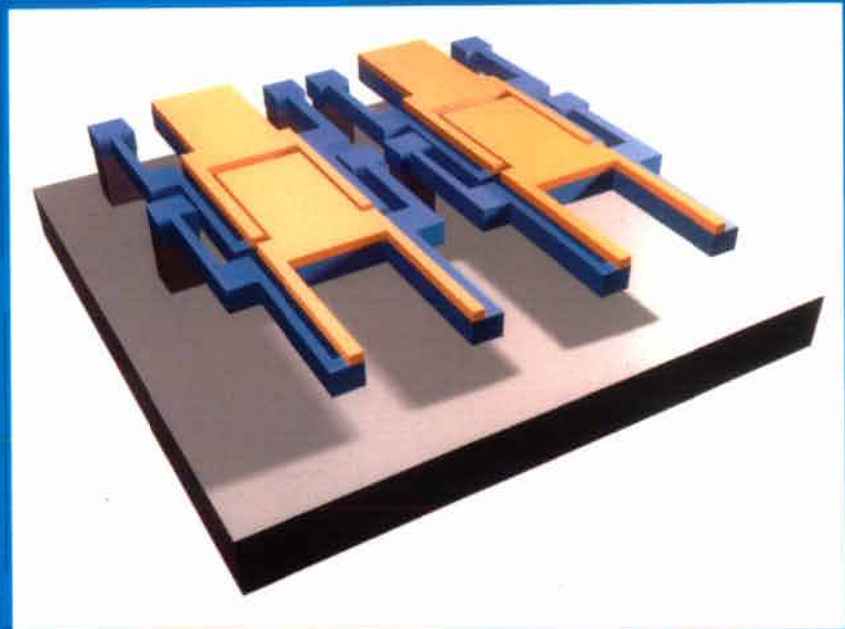
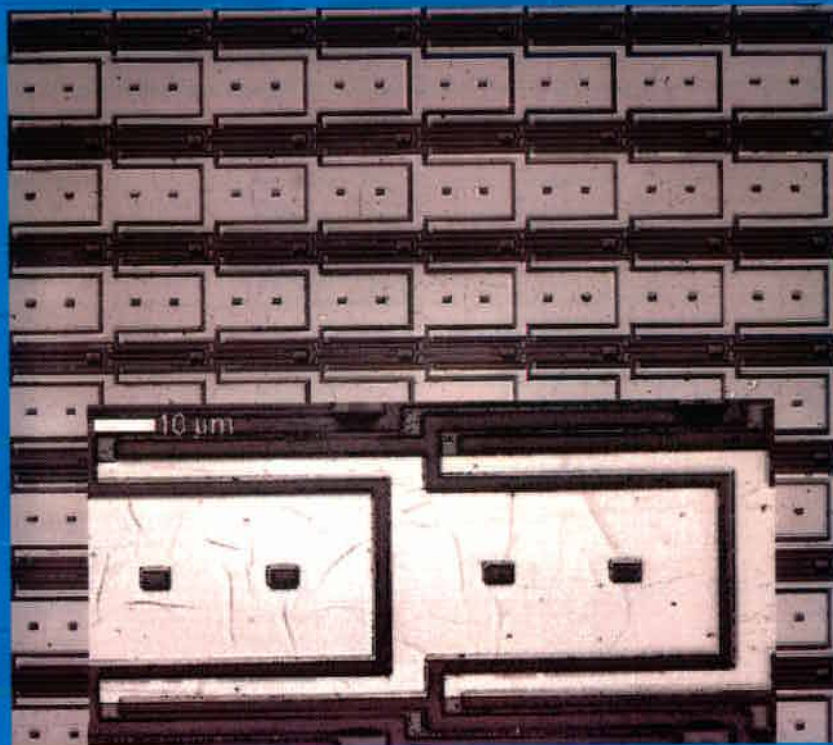
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Optical MEMS and Imaging Arrays

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Photos courtesy of Dr. Datskos, Oak Ridge National Laboratory

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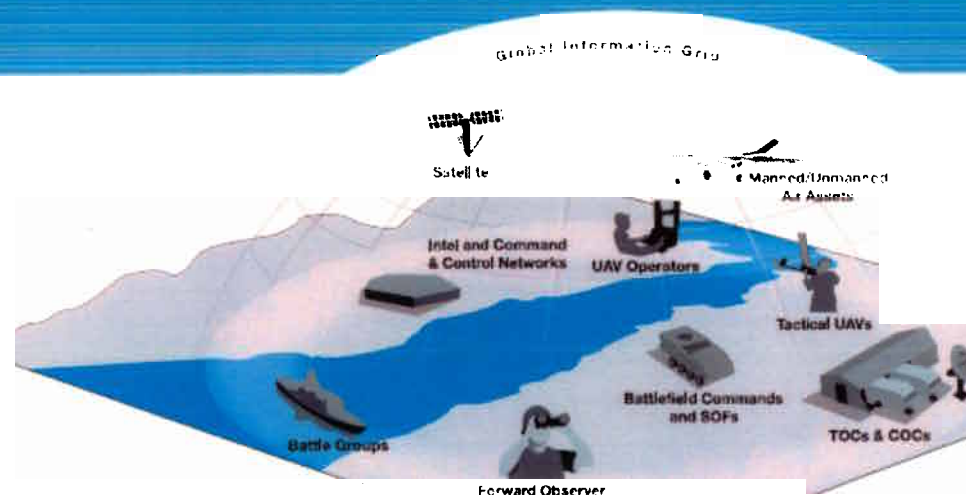
SUPERIOR TECHNOLOGY FOR

Ground Mobility Vehicles

HWMMV users installed the integrated VideoScout-Rover III 300 receiver to capture locally launched UAV video, as well as vehicle mounted EO-IR sensor systems. Incoming video can be paused and rewound for immediate analysis, and even streamed to other vehicles in the convoy in real-time, and annotated, recorded and indexed for subsequent search and review.



Capture, record, transmit



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Fusion of Multiple MEMS Sensor Suite Data

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- MEMS Sensors integrated into suite along with power, communication and control
- Multiple integrated suites placed around vehicle
- Integrated Suites communicate with “router” which transmits information through vehicle “hull”
- Powerful vehicle computer “fuses” data from many sensors and provides a “picture” of the world all around.
- Vehicle communication allows sharing of multi sensor suite data throughout entire C3 Network

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Applications of Nanotechnology and MEMS for Homeland Security

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The use of electronic-based sensors, built on MEMS and nanotechnologies, which work at the atomic, molecular levels, show promise for improvements in sensitivity, selectivity, improved detection rates, size and cost.

- ◆ Applications include: trace vapor explosive detection (electronic noses), radioactive material detection, image fusion, biological threat detection.
- ◆ Partners: Universities, government MEMS and Nanotechnology labs
- ◆ Survivability involvement : direction of academic programs on MEMS modeling and applications testing , storehouse of system information and applications.

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Workshop Program

SUPERIOR TECHNOLOGY FOR A SUPERIOR ARMY

- | | |
|------------|--|
| Speaker 1: | Introduction to MEMS and Army Applications: Dr. Tom Meitzler, TARDEC |
| Speaker 2: | Prof. Sandrine Martin, MEMS and Nano fabrication, Univ. of Michigan |
| Speaker 3: | Dr. Panos Datskos, MOEMS, Oak Ridge Labs |
| Speaker 4: | Prof. Greg Auner, Current Research, Wayne State Univ. |
| Speaker 5: | Prof. Yang Zhao, Nano Optics, Wayne State Univ. |

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