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DARPATech

2002 Symposium

Transforming Fantasy

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Clark Nguyen

Program Manager

Microsystems
Technology Office

Transforming Fantasy

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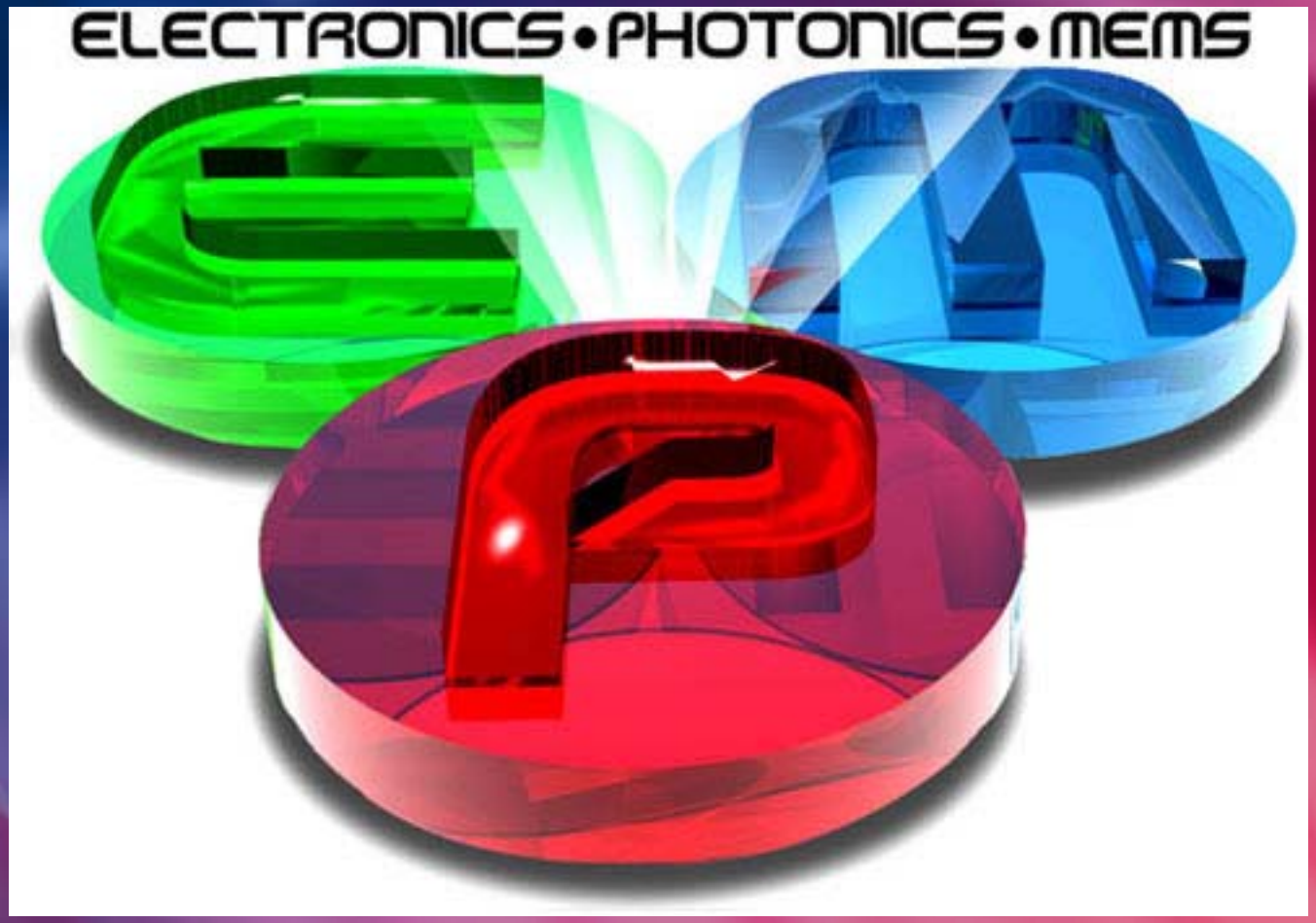
Micro Electro Mechanical Systems Programs at MTO

Clark T.-C. Nguyen
Program Manager, DARPA/MTO

Microsystems Technology Office



Technology for Chip-Level Integration of E. P. M.

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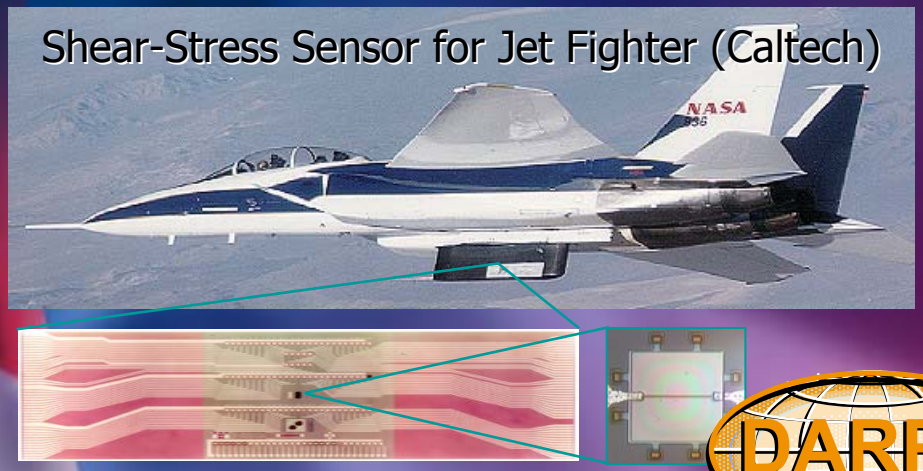
MEMS Application Domains



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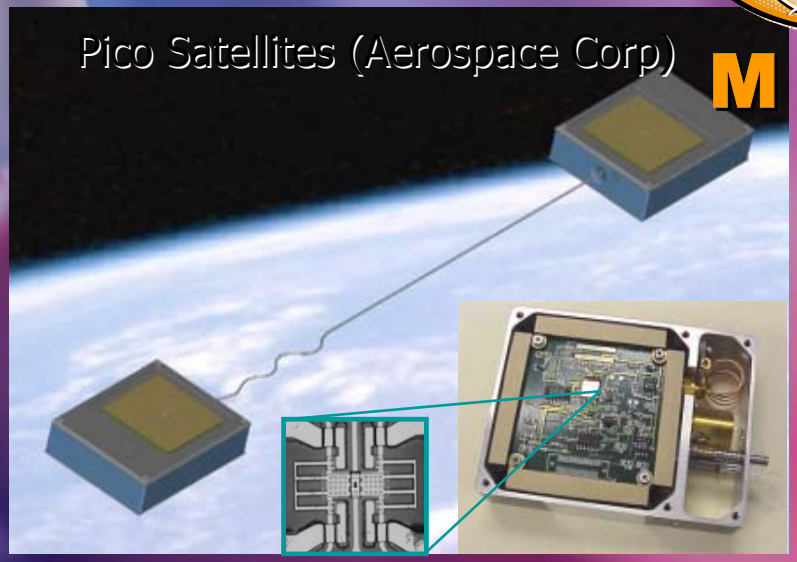
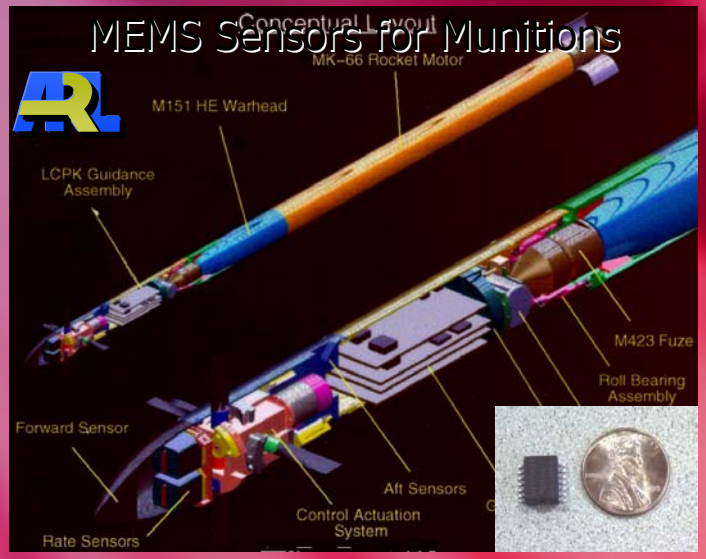
MEMS

ARL





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Land Applications of MEMS

MEMS Sensors for Munitions

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Sea Applications of MEMS

MEMS Exploder for Torpedoes

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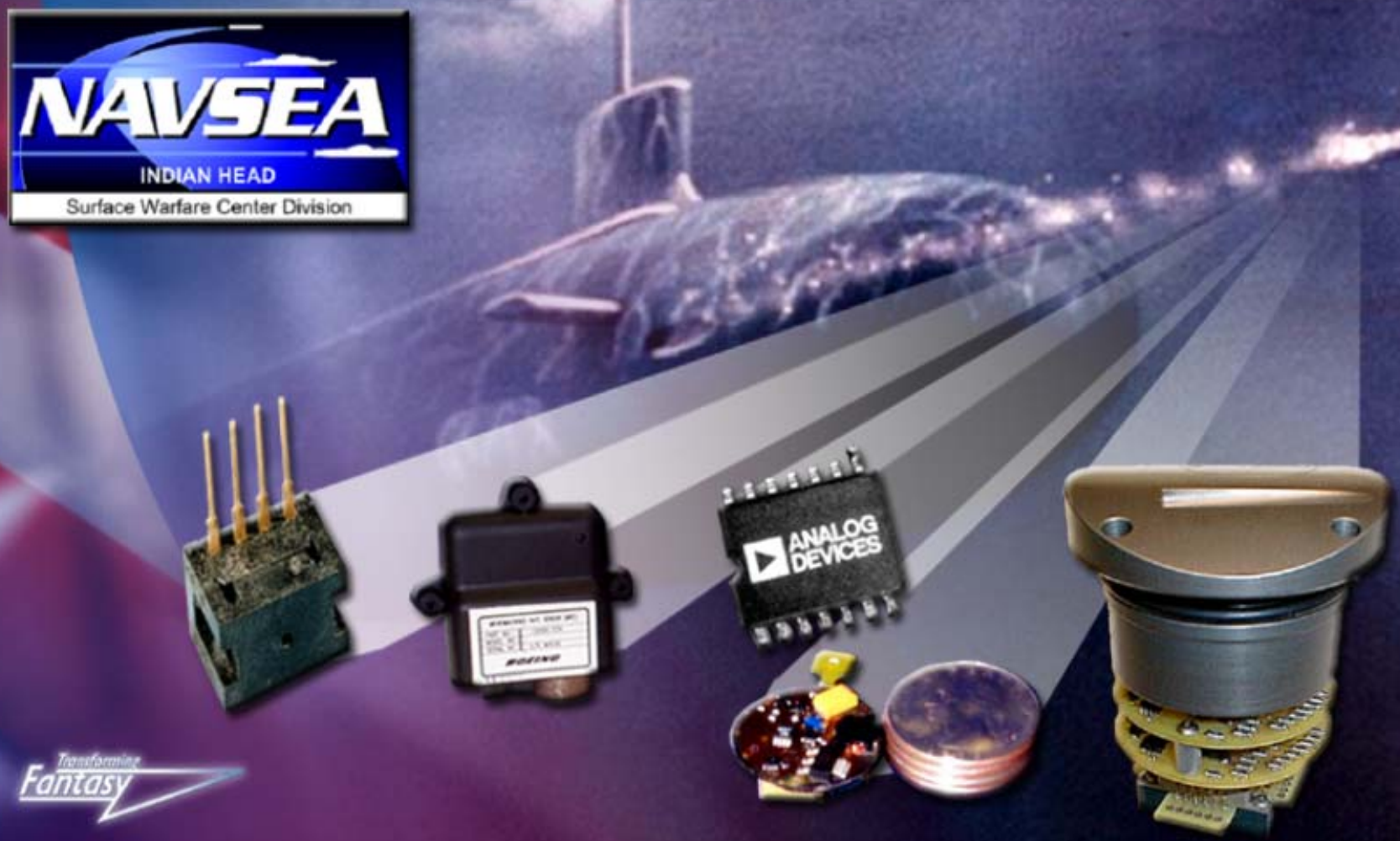
Sea Applications of MEMS

MEMS Exploder for Torpedoes



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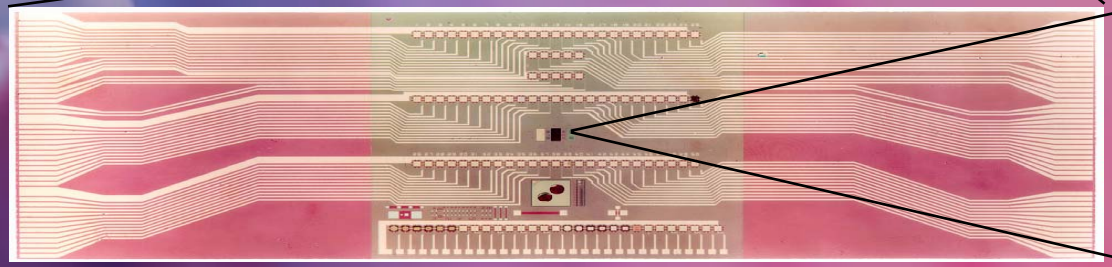
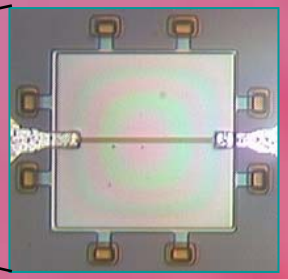
Air Applications of MEMS

Shear-Stress Sensor for Jet Fighter (Caltech)





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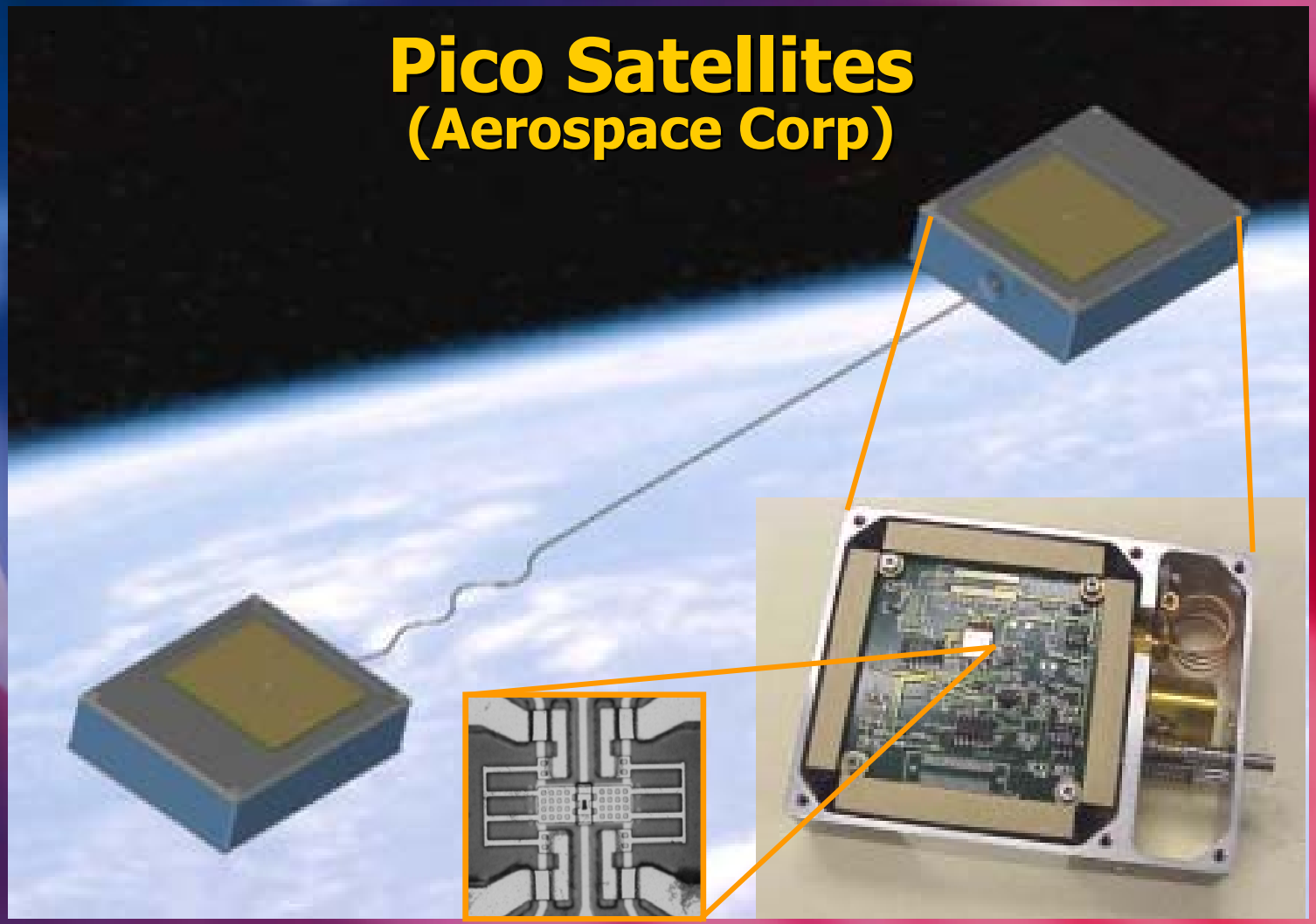
Space Applications of MEMS



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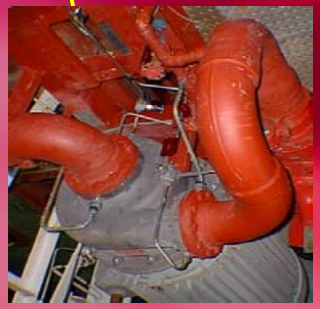
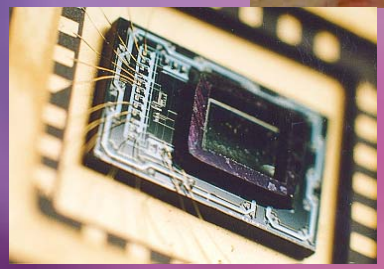
Wireless Integrated Sensors

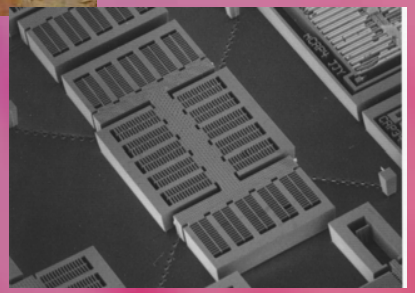
- Allow remote maintenance, health monitoring, and environmental monitoring

Army NTC / Aberdeen PG



USS Rushmore





Integrated Sensors

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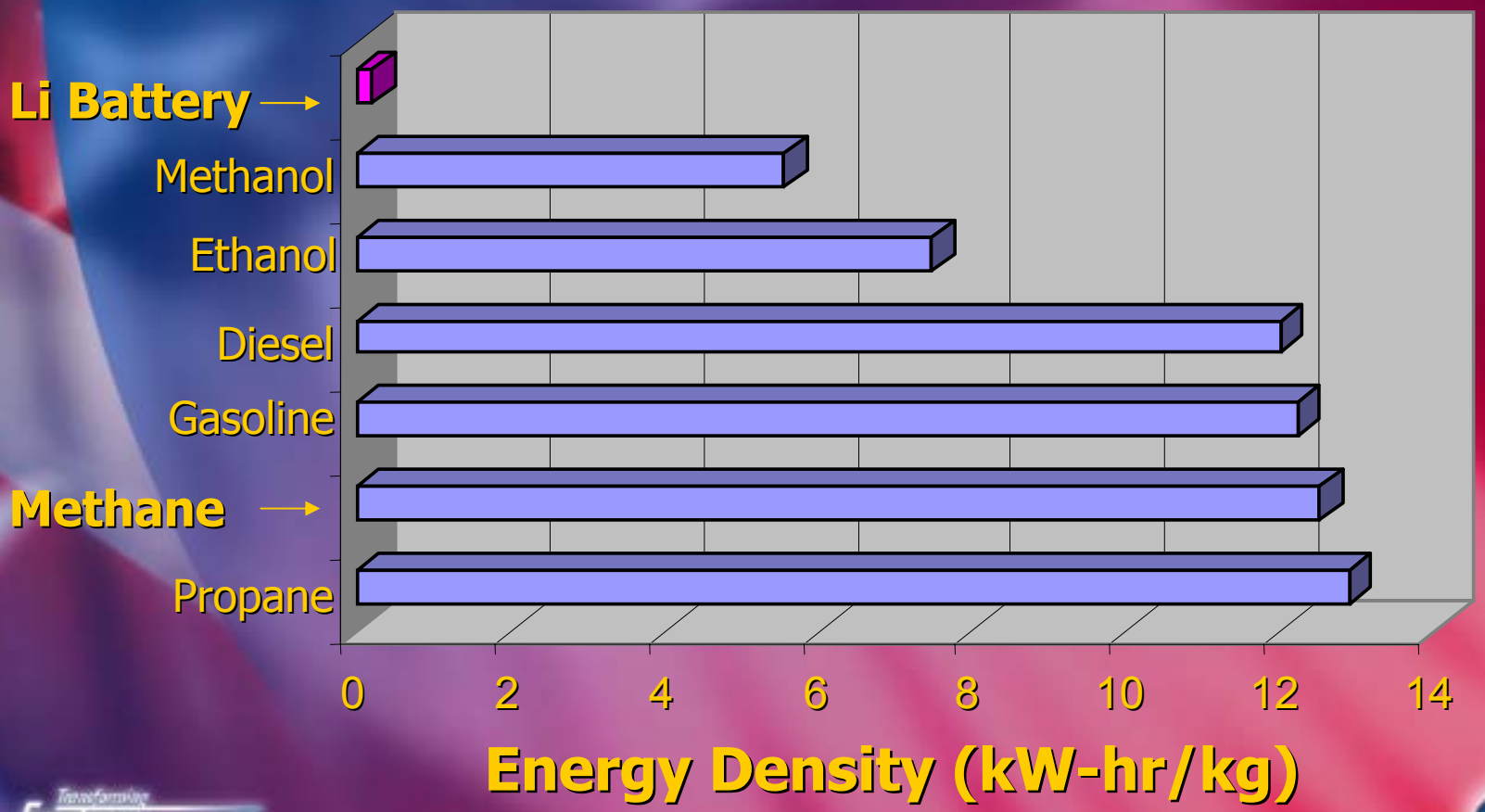
Micro Power Generation

- Harness fuels with higher energy density



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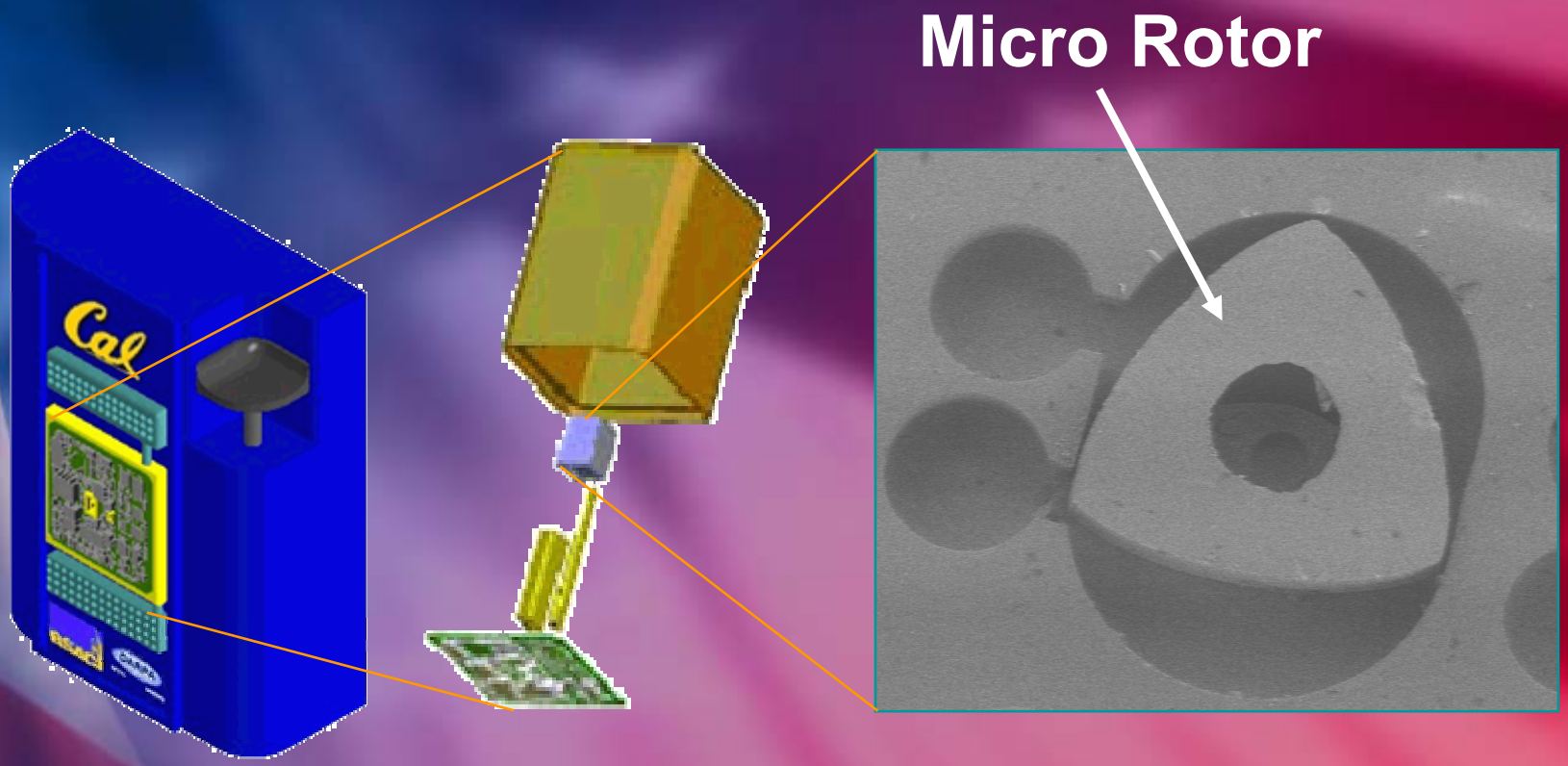
Micro Rotary Engine



[University of California at Berkeley]

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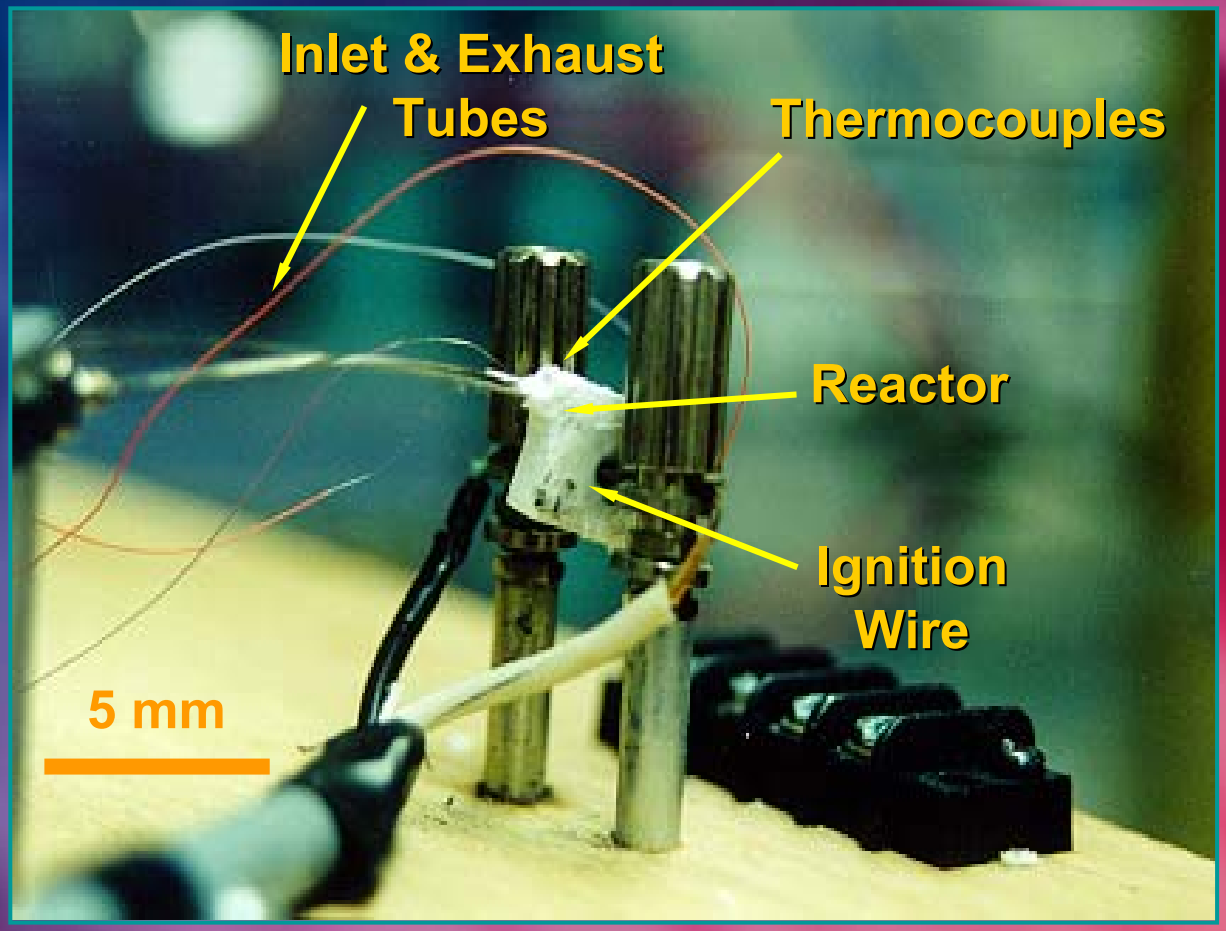
Micro Combustion Chamber



Alumina reactor with 200-µm-wide Pt-coated square channels [Princeton]

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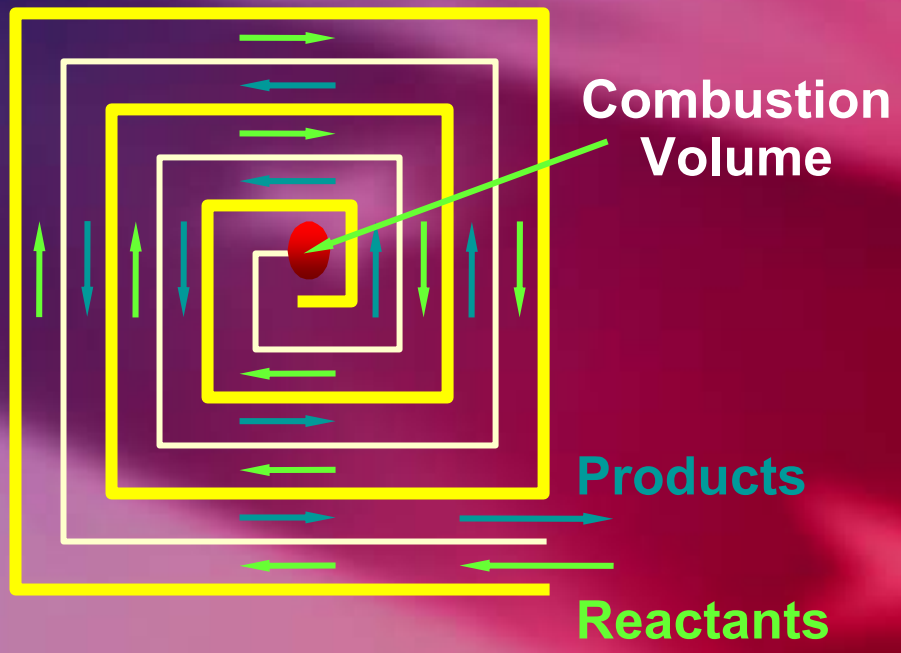
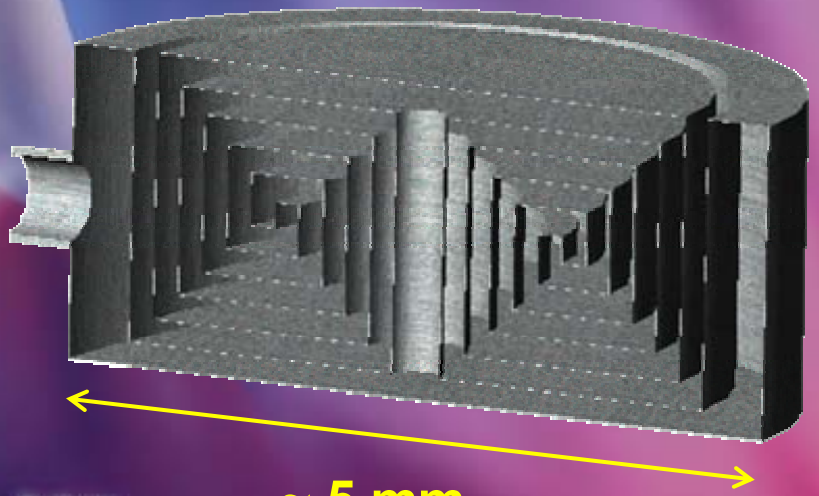
Thermoelectric Combustion

- Maximize thermoelectric surfaces between hot and cool regions





3-D Toroidal Swiss-Roll Microcombustor/Generator [Univ. of Southern Cal.]

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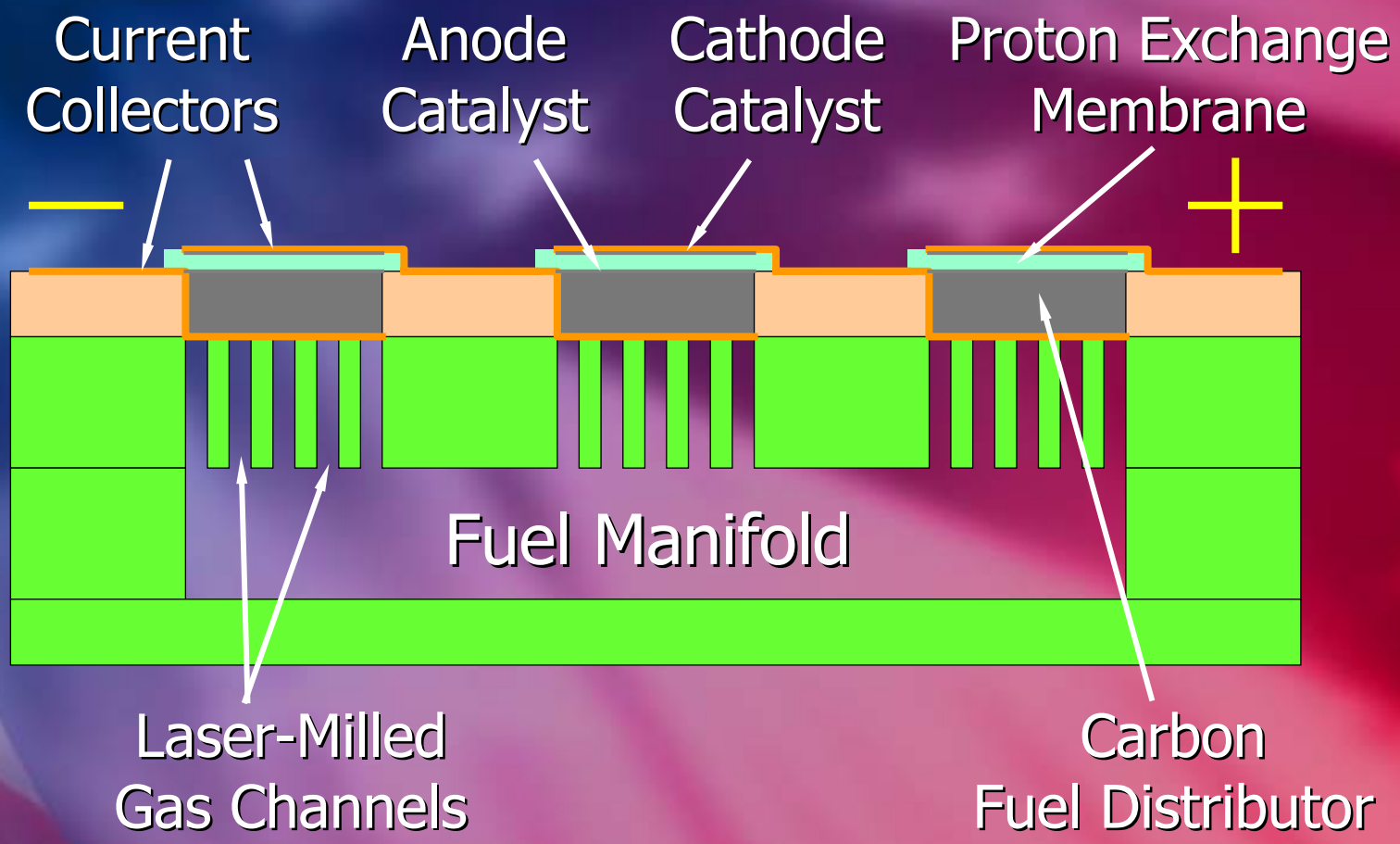
Micro Fuel Cell



Micro Fuel Cell
[Case Western Reserve Univ.]

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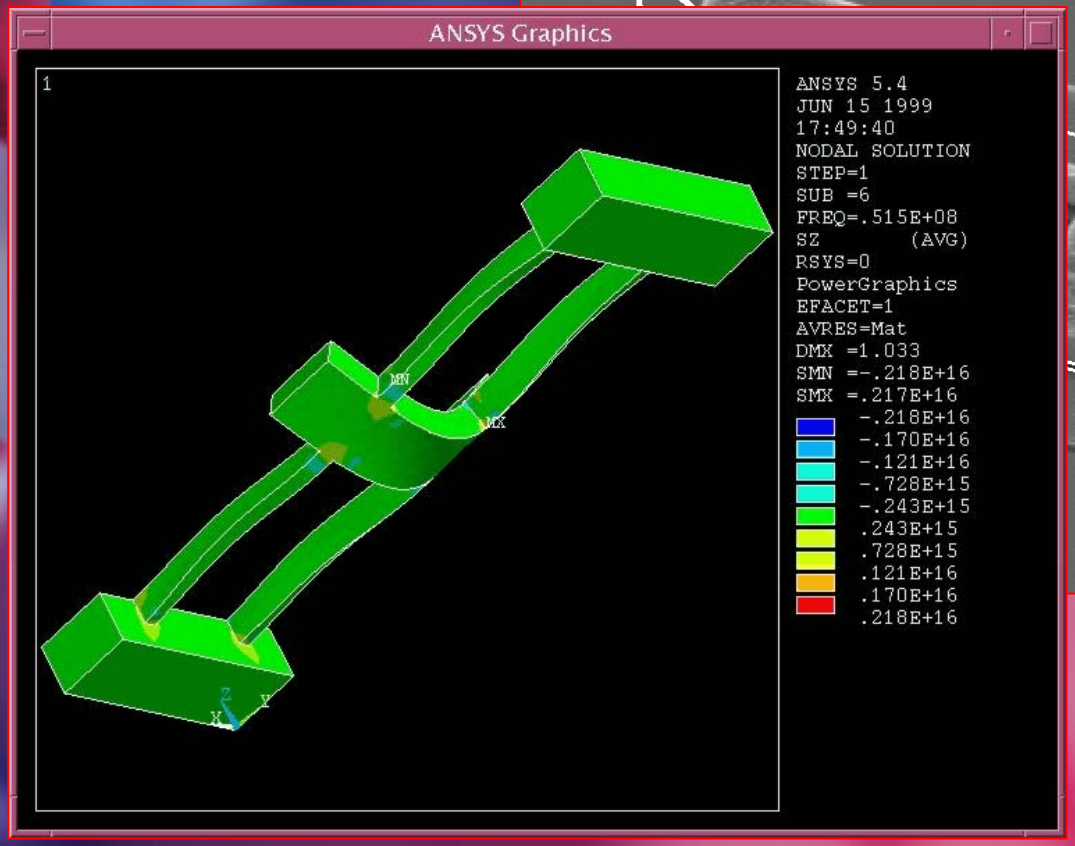
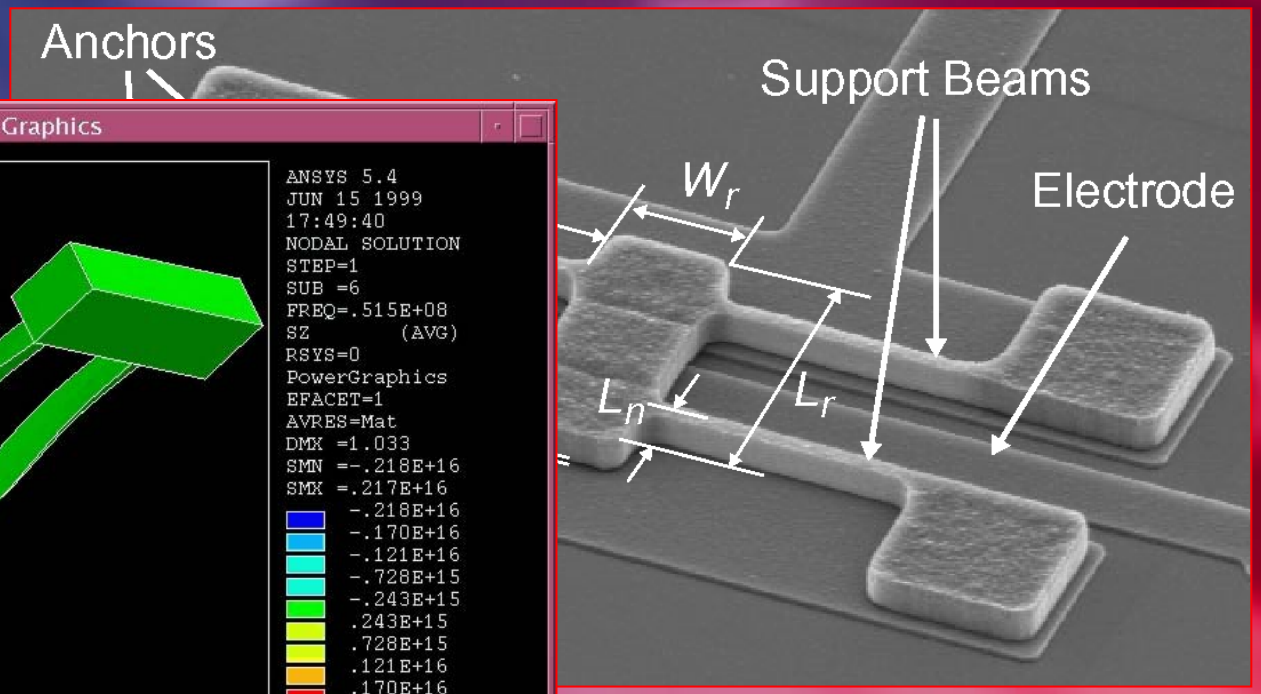
Nano Mechanical Array Signal Processors

>100X reduction in size and power consumption over conventional frequency processors





Free-Free Beam Vibrating Micromechanical Resonator [University of Michigan]

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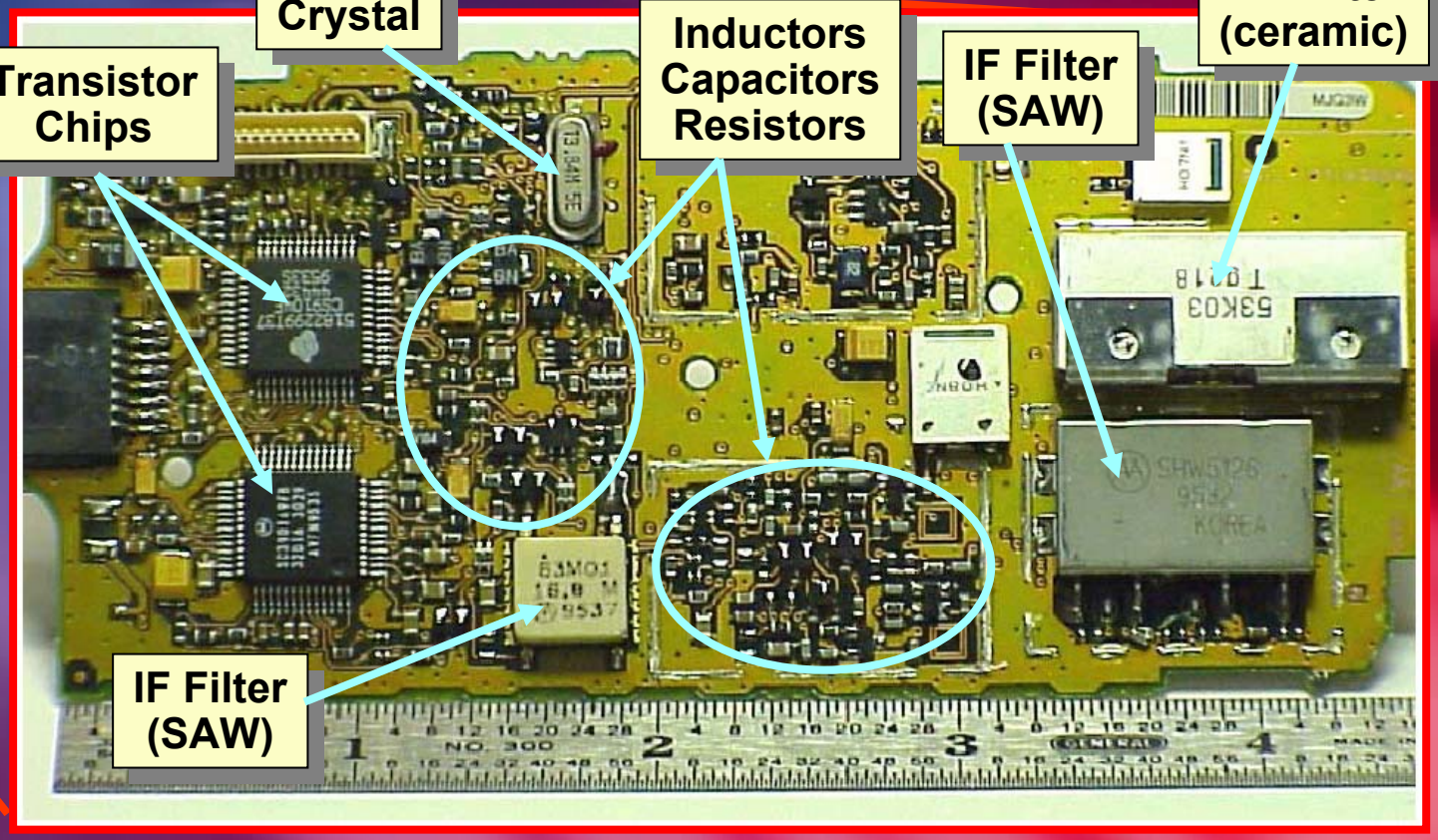
So Many Off-Chip Passives

Passives pose a bottleneck against miniaturization of wireless handsets



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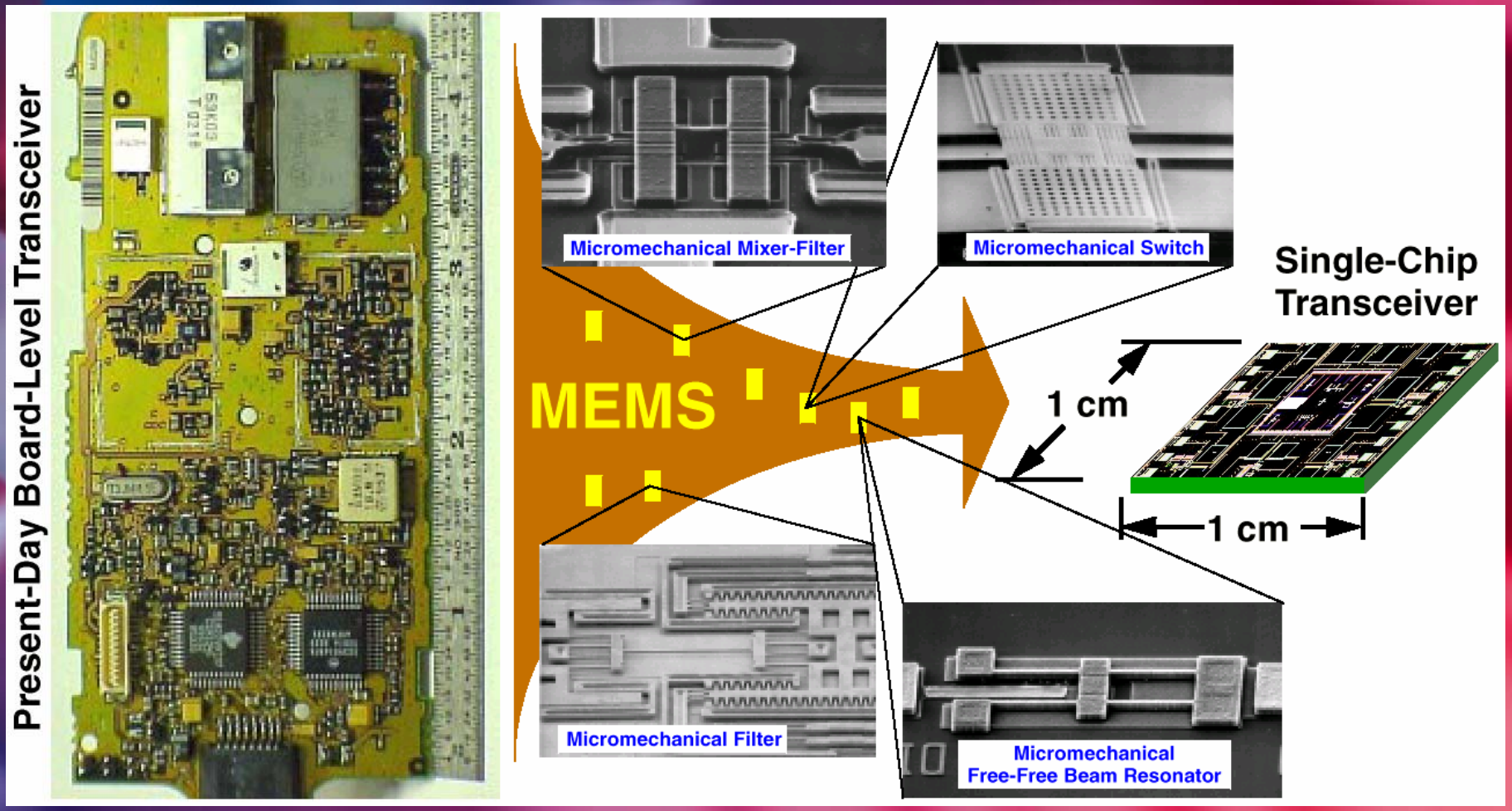
Miniaturization of Transceivers

- Replace off-chip passives with MEMS



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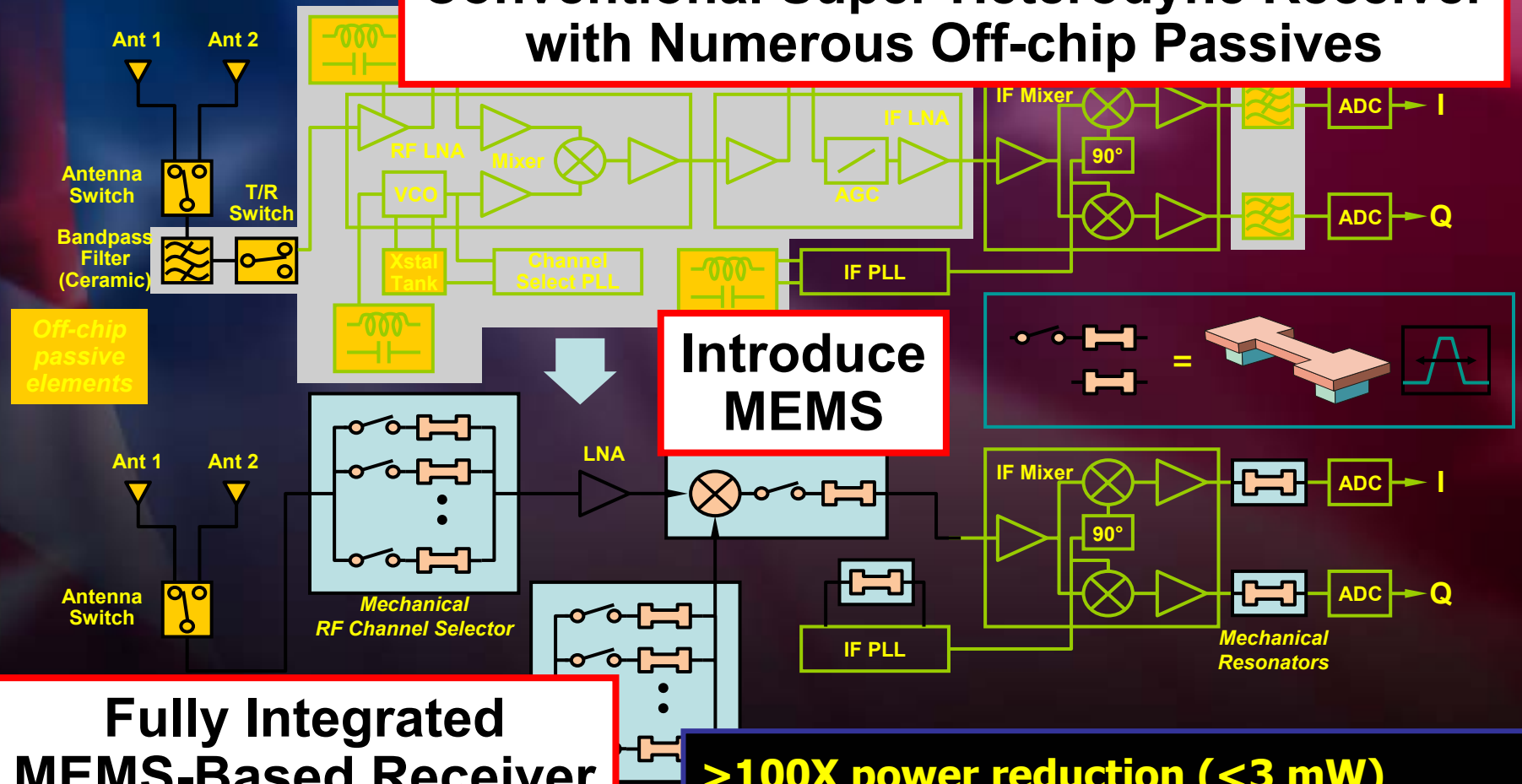
MEMS-Based Receiver Blocks

Conventional Super-Heterodyne Receiver with Numerous Off-chip Passives



Fully Integrated MEMS-Based Receiver

- >100X power reduction (<3 mW)
- >100X size reduction (<0.8 cm^2)
- >10X improvement in spectral eff. & BW

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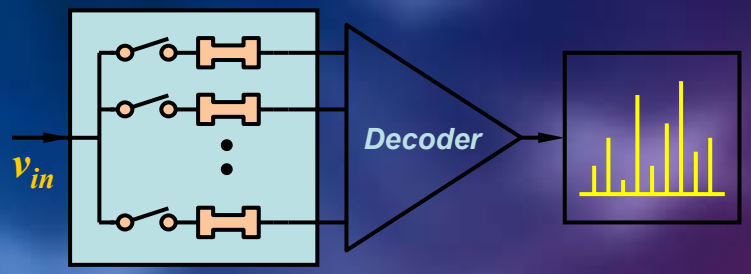
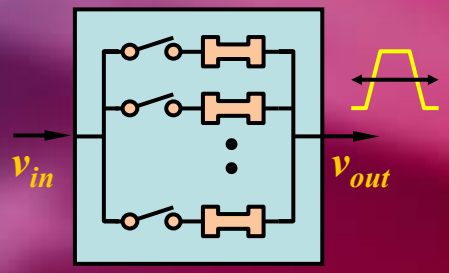
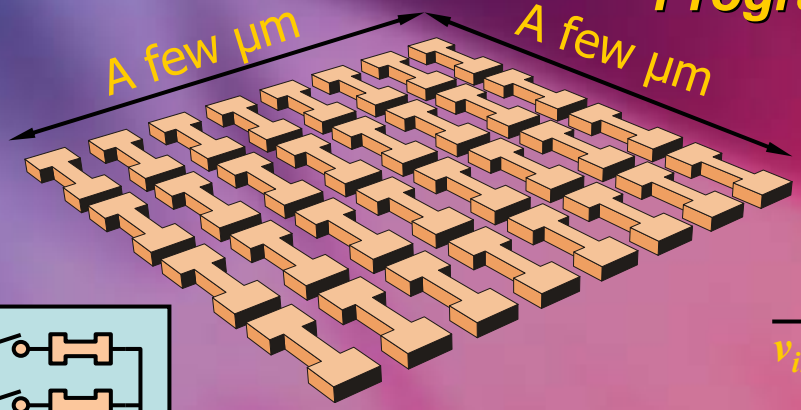
Large Arrays of Micro Resonators

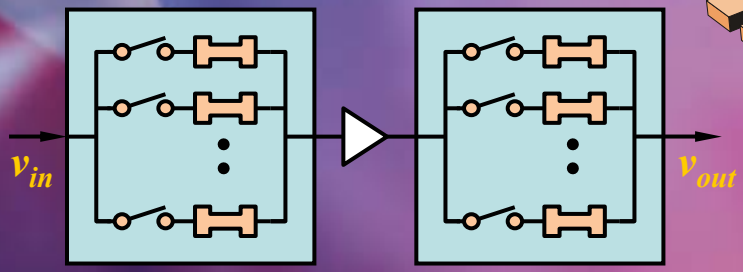


Spectrum Analyzer / Fourier Signal Transformer

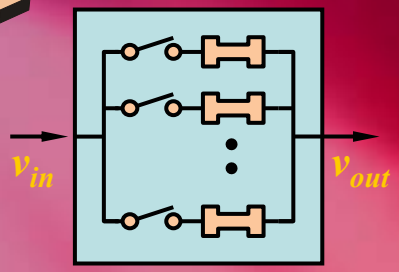


Tracking Filter / Discriminator / Programmable Equalizer





Frequency Converter



Parametric Amplifier / Digital Demodulator / Envelope Detector

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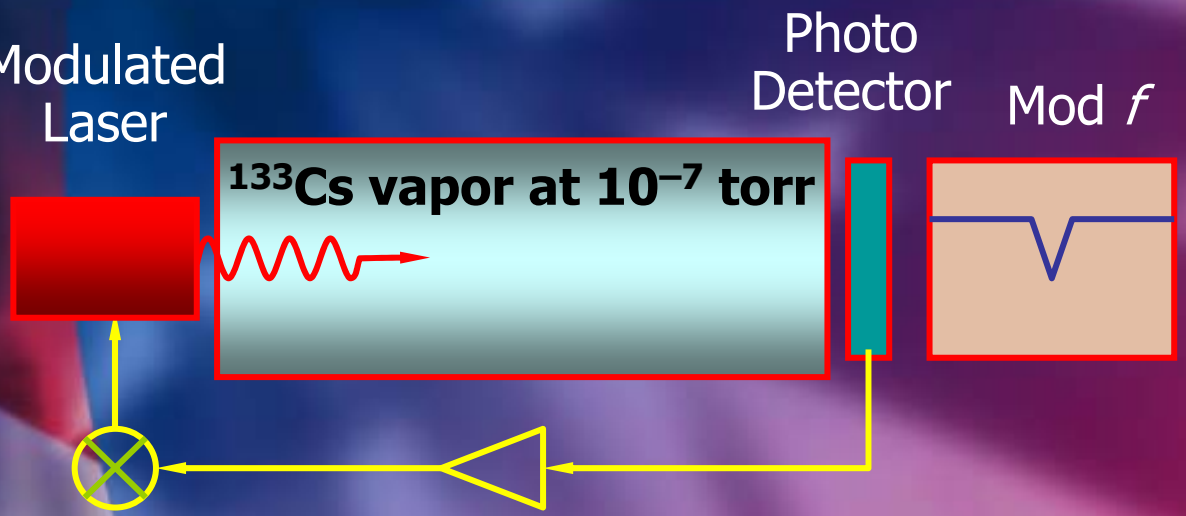
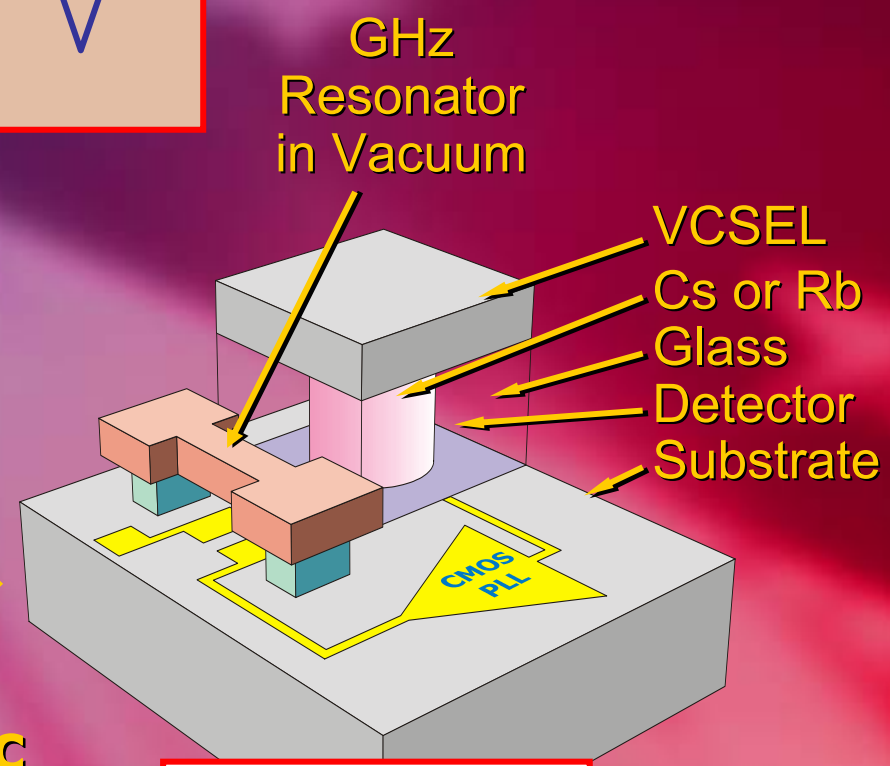
Chip-Scale Atomic Clocks



Atomic Clock Concept



MEMS and Photonic Technologies

Chip-Scale Atomic Clock

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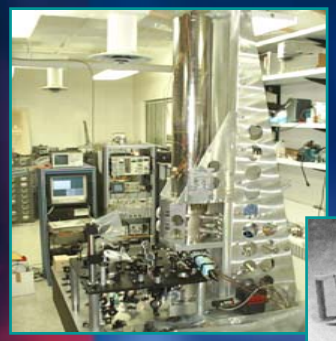
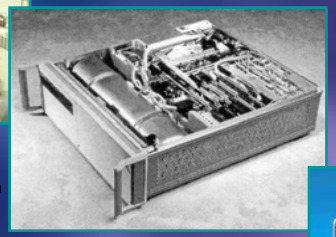
Miniaturization of Atomic Clocks

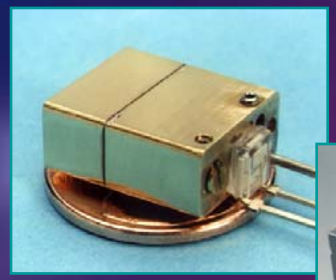


NIST- F1

Vol: ~3.7 m^3
Power: ~500 W
Acc: 3.8×10^{-15}

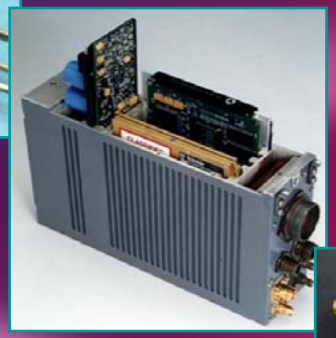


HP 5071A



NG MC250

Datum R2000



Kernco

Temex RMO

NIST CPT cell

CSAC

Vol: 1 cm^3
Power: 30 mW
Acc: 1×10^{-11}

State-of-Practice → State-of-Research

Distribution Statement A. Approved for public release; distribution is unlimited.

CSAC-Enabled Enhancements

- High channel selectivity and enhanced channel density for VHF/UHF comm.

- Better resilience against jamming
- Extended silence in radios

SINCGARS Radio

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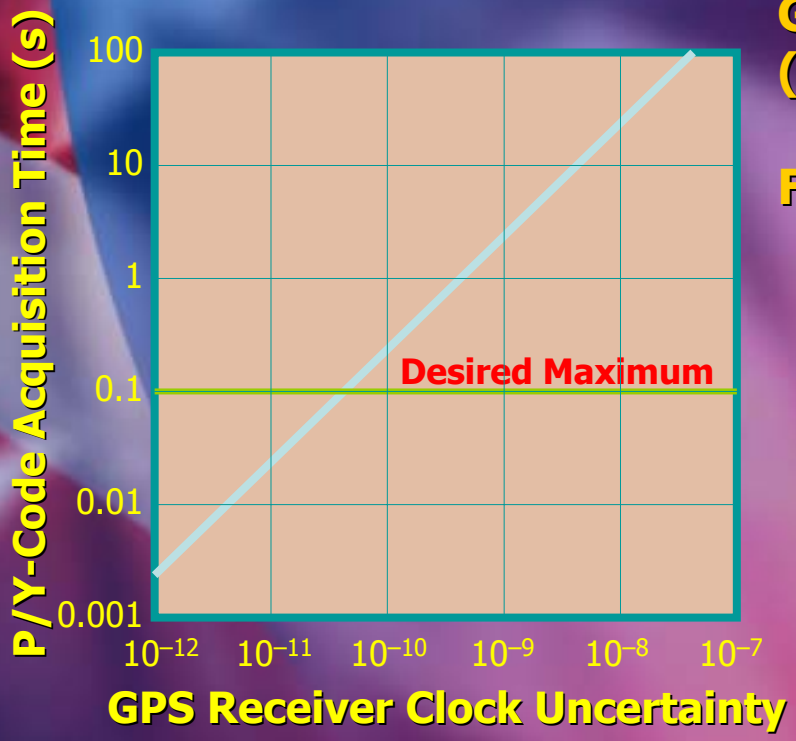
CSAC's Applied to Navigation

- Direct P/Y-code acquisition – fast acquisition at low power
- Missile and munitions guidance – g-hard precision clocks



Examples of Use:

GPS Position Location Reporting System (GPS PLRS)

- Fielded units: ~100,000 & growing

Future Joint Tactical Radio System (JTRS)

- Potential fielding: ~300,000 (FY10)

9,000 commercial handheld GPS deployed in Desert Storm

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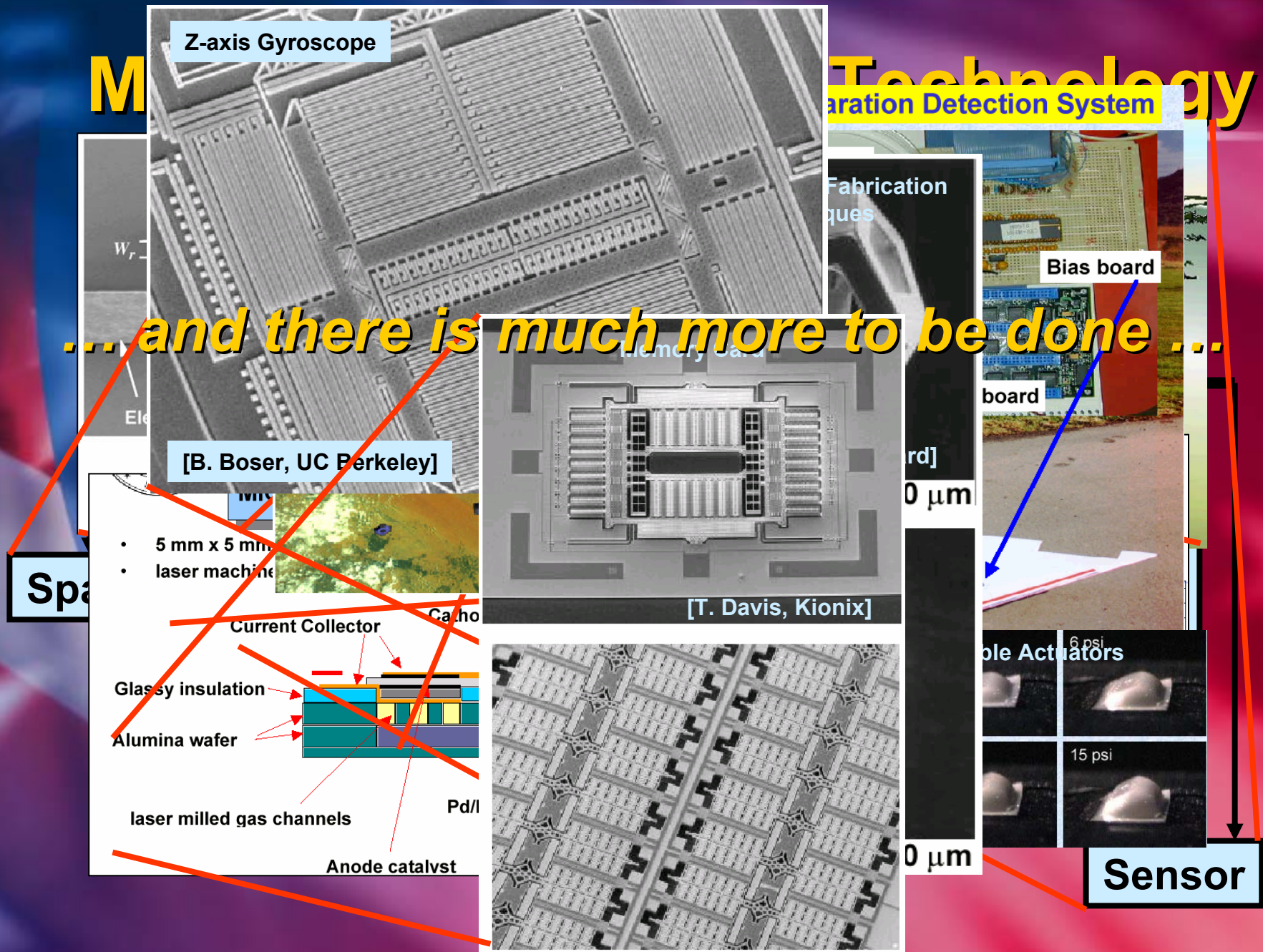
M Technology



... and there is much more to be done ...

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