

# Microsystems Technology Office Overview



**Dr. Greg Kovacs, Director**

**June 19, 2008**

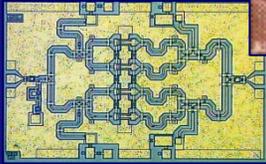


# Microsystems Technology Office: Enabling Future Capability

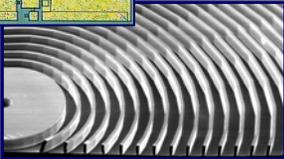


## Sense

Microbolometer

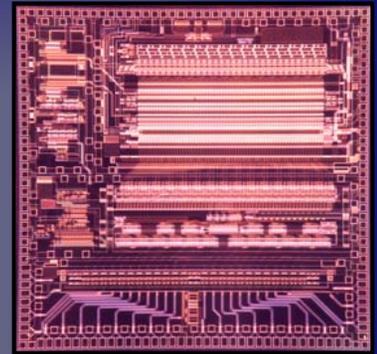


RF MMIC



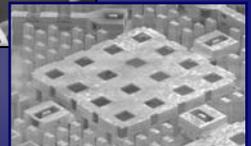
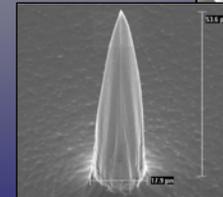
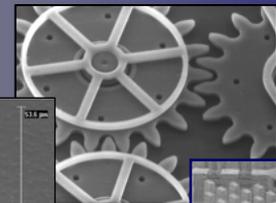
Micro Gas Analyzer

## Process



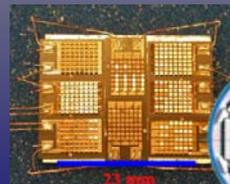
Digital Integrated Circuits

## Actuate



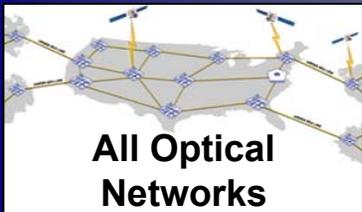
MicroElectroMechanical devices

## Energize

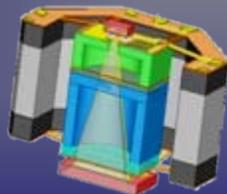


Micro Isotope Power Sources

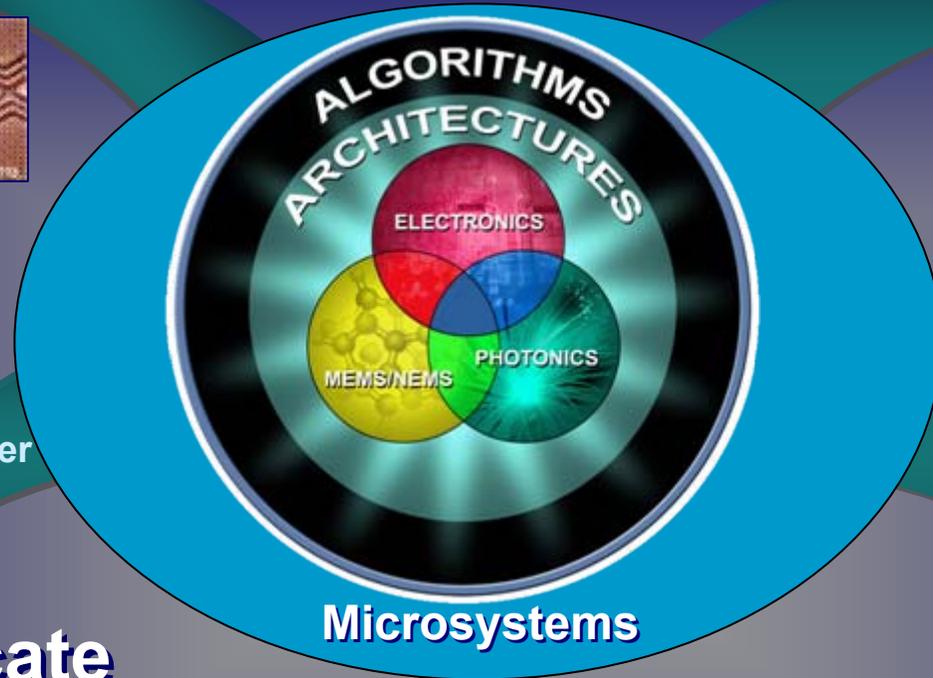
## Communicate



All Optical Networks



Chip Scale Atomic Clock





# MTO Components Have Enabled System Capability



**Bio-Agent Warning System**  
-  
2005



**SUVOS**



**MAFET**

**FAB-T**  
-  
2004



**Precision Attack Missile**  
-  
~2006



**MEMS**



**Head Mounted Displays**

**Land Warrior**  
-  
2003



**F-18 E/F**  
-  
~2005



**VCSELS**

## 2000s

**Uncooled Integrated Sensors**

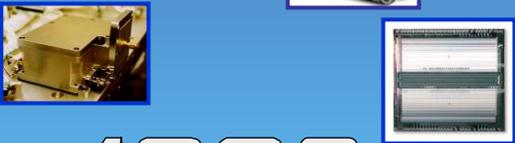
**Driver's Vision Enhancer**  
-  
2002



**HOOK-112**  
-  
1994



**MCM Design**



**IRFPA (Cooled)**

**Improved Bradley Acquisition Subsystem**  
-  
2000



**AF AWACS**  
-  
1998



**Digital Micromirror Device**

## 1990s

**MIMIC**

**Theater Missile Defense**  
-  
1995



**B-52**  
-  
1991



**Infrared Imaging**



## 1980s

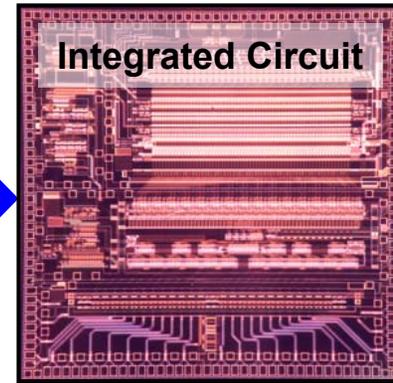
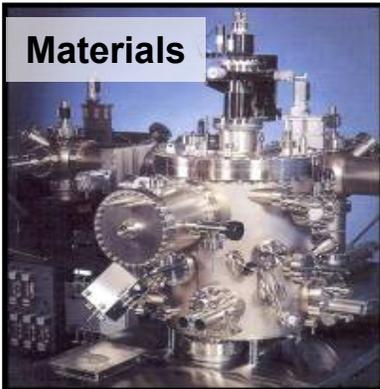
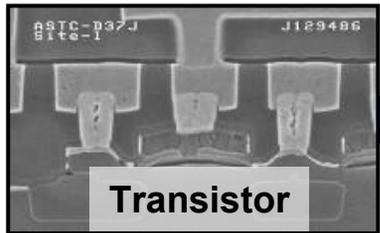
**Digital GaAs**

**OH-58D**  
-  
1992

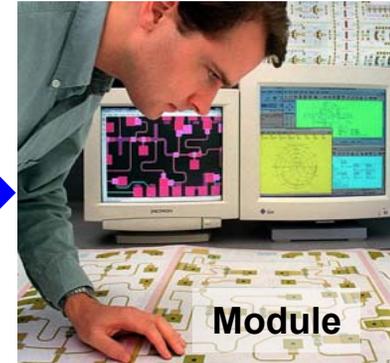


# Creating the Future From the Inside Out

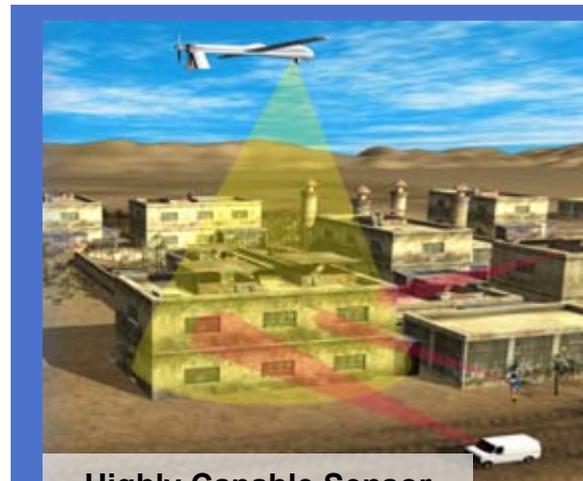
## Reducing SWaP & Increasing Performance



20 mm



**End  
Applications**



Highly Capable Sensor



Handheld Supercomputers



# Smallest, Lightest, & Lowest Power X-Band (7 – 12 GHz) T/R Module

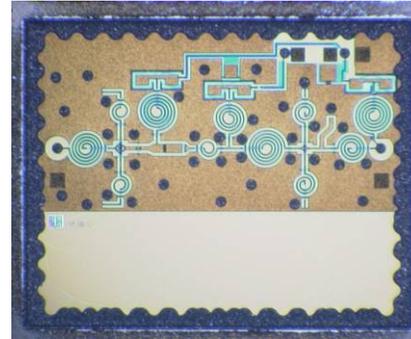
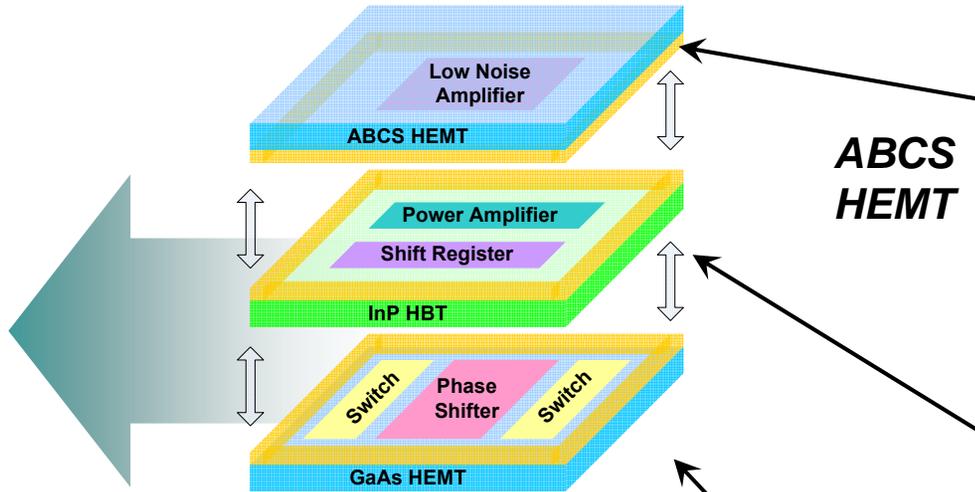


# ISIS

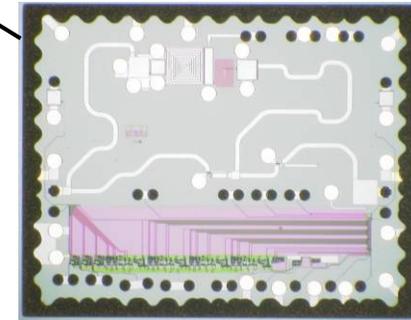


## Next-Gen Large Aperture Array T/R Module

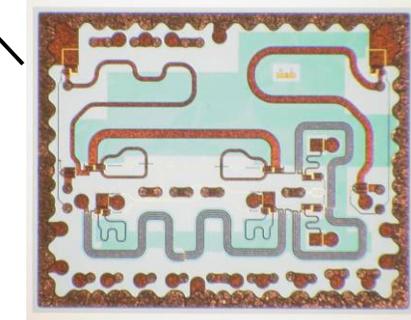
- Ultra light weight: 12 milligram (≈housefly).
- Extremely compact.
- **Can make radars skins for variety of uses.**



ABCS HEMT



InP HBT



GaAs HEMT

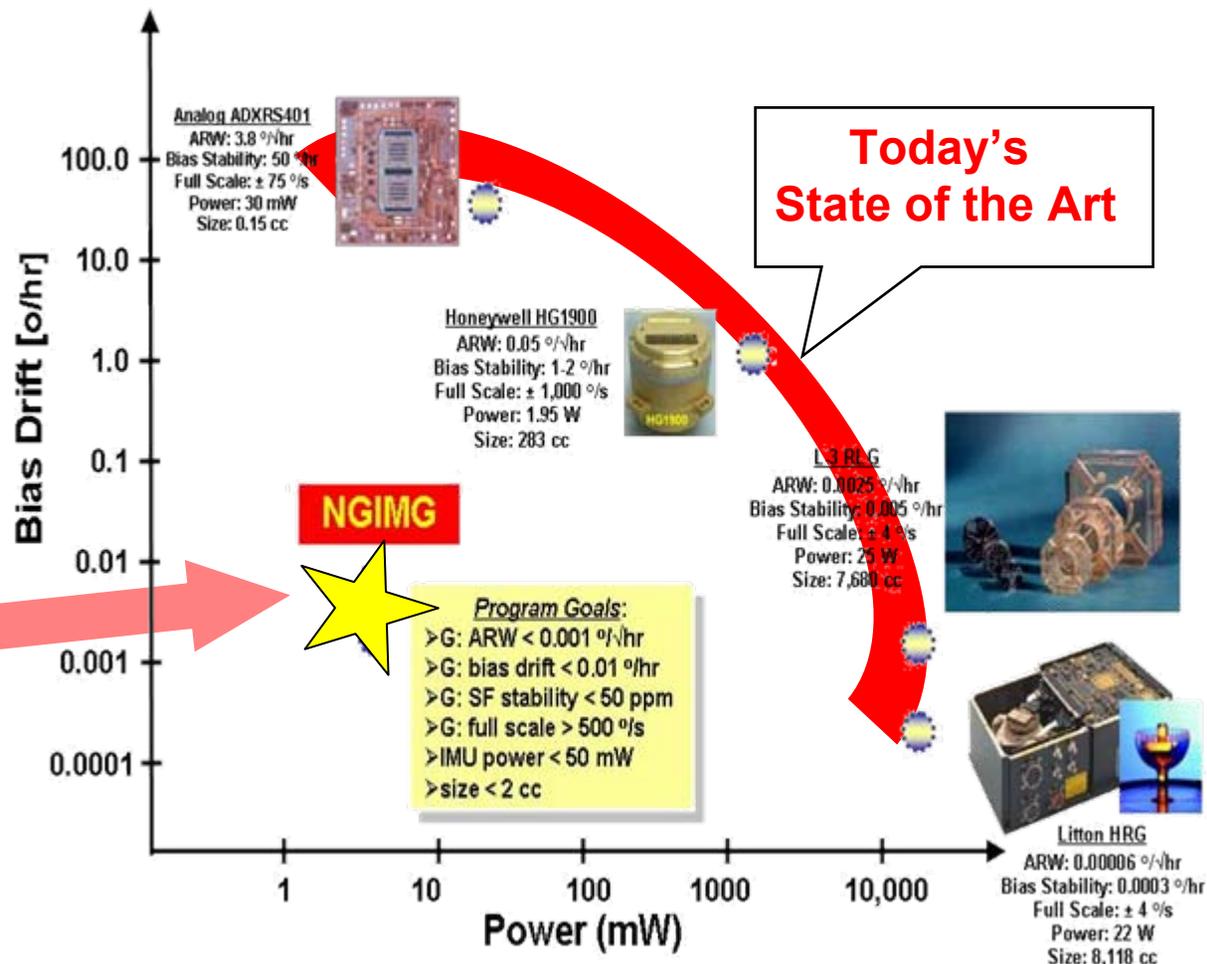
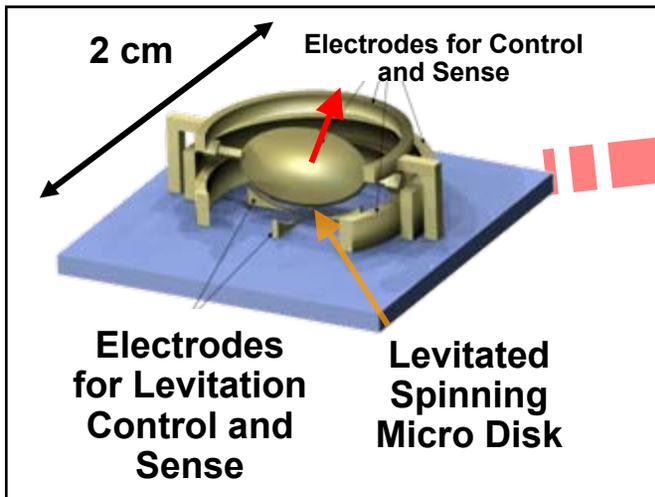
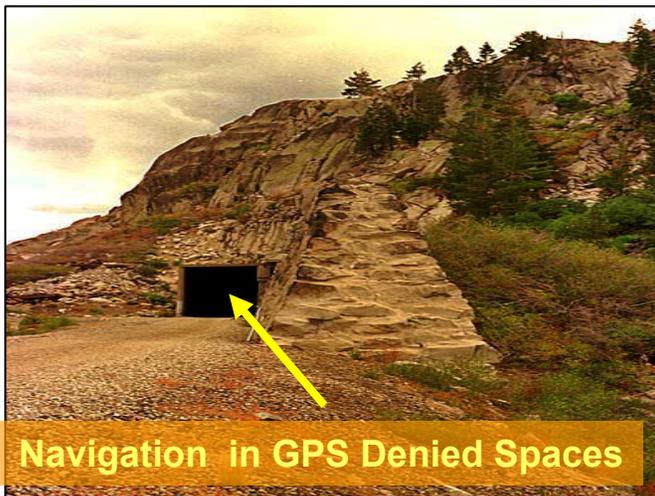
## Wafer Level Packaging



**ISIS T/R module - integrating the best of several technologies.**

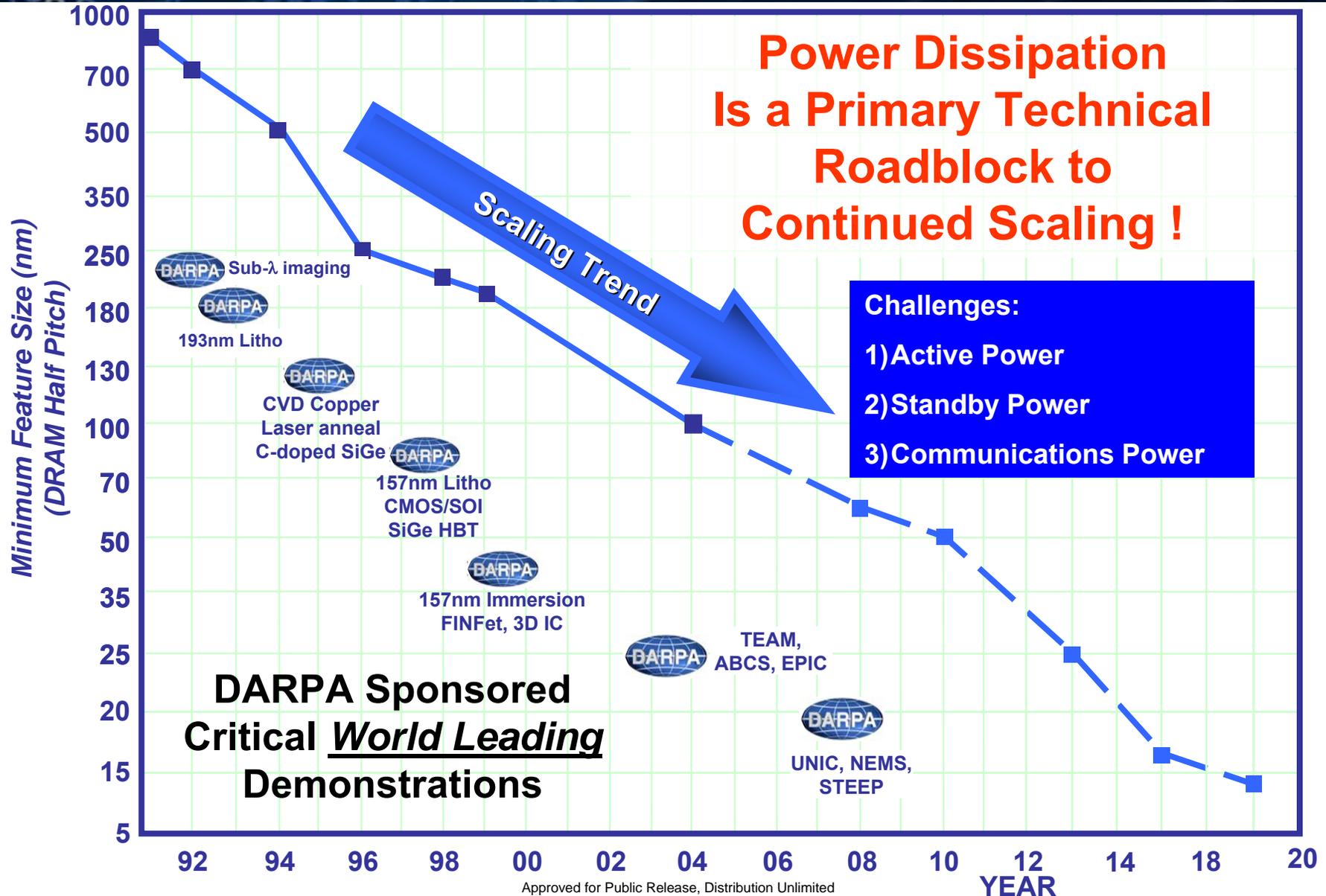


# Navigation-Grade Integrated Micro Gyroscopes (NGIMG)

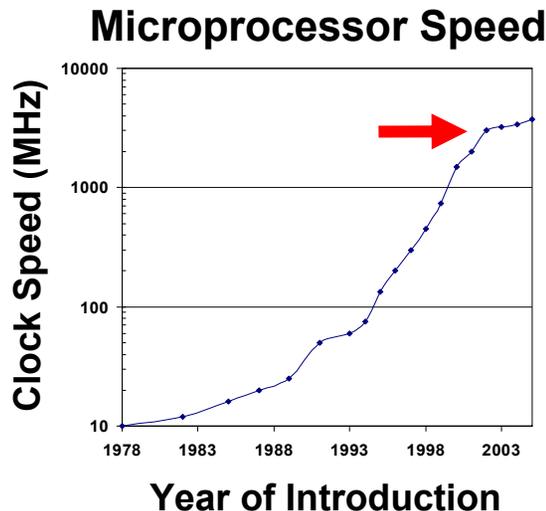
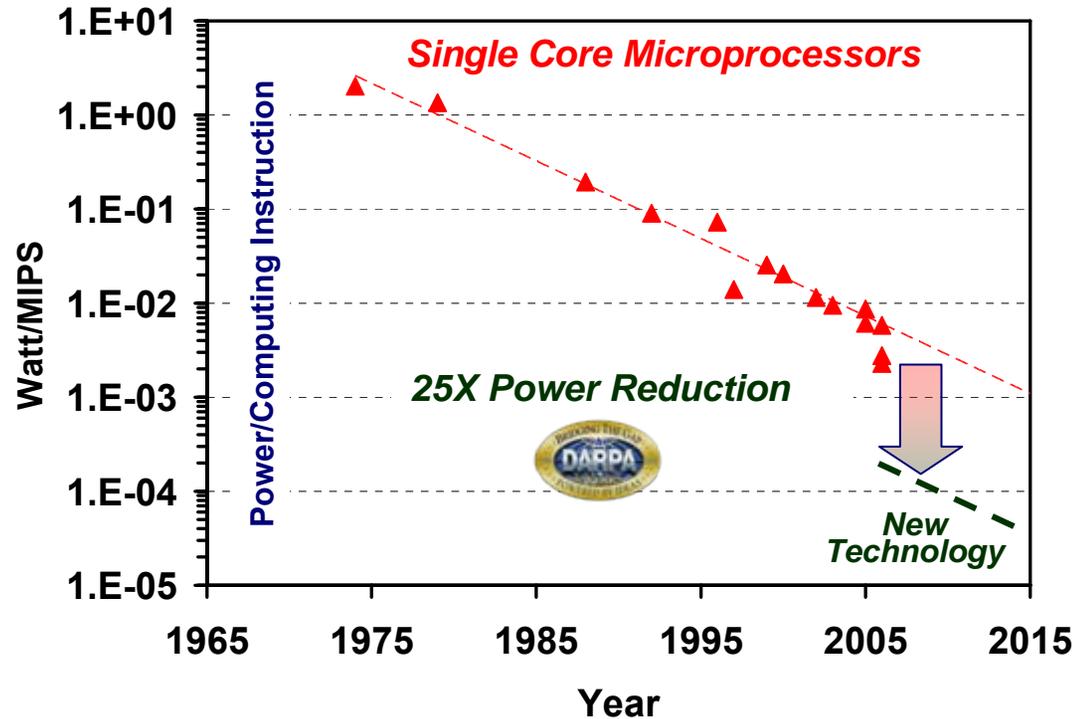
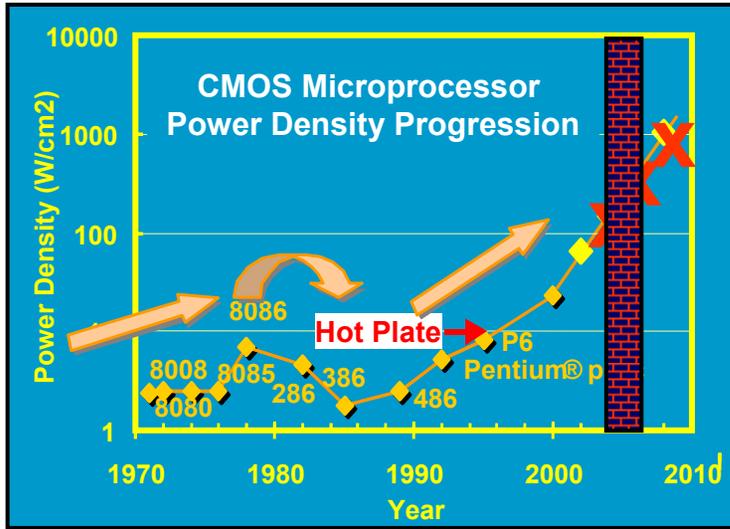


**Miniature gyros and accelerometers with navigation-grade performance and tiny power consumption**

# Power Issues and Progress

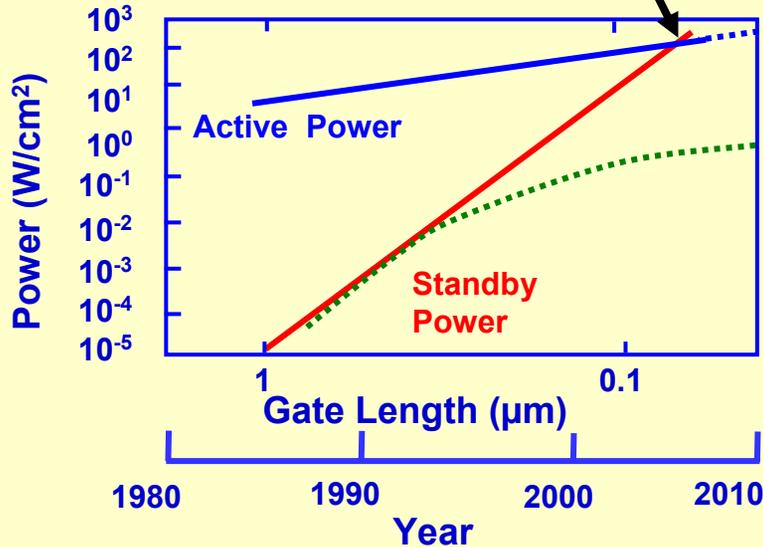


# Getting Ahead of the Power Curve

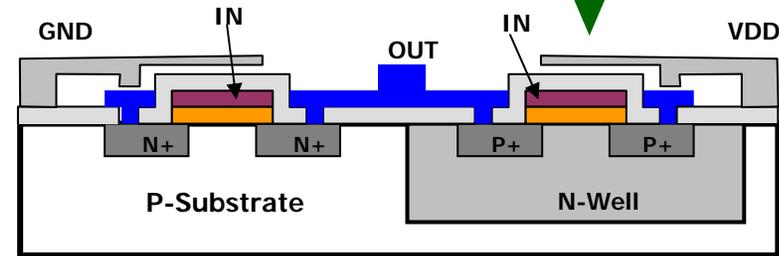
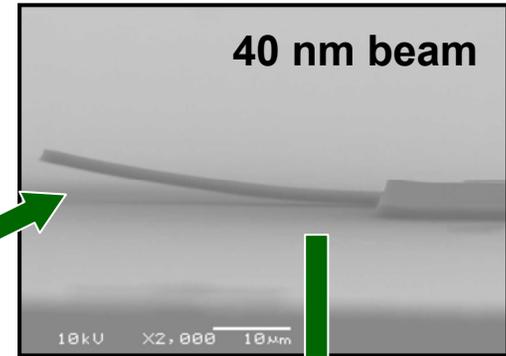


- Scaling of transistors (“Moore’s Law) is driving power reduction via lowering power supply voltages... but not enough.
- New transistor designs allow jumping ahead of the curve near the end of Moore’s Law.

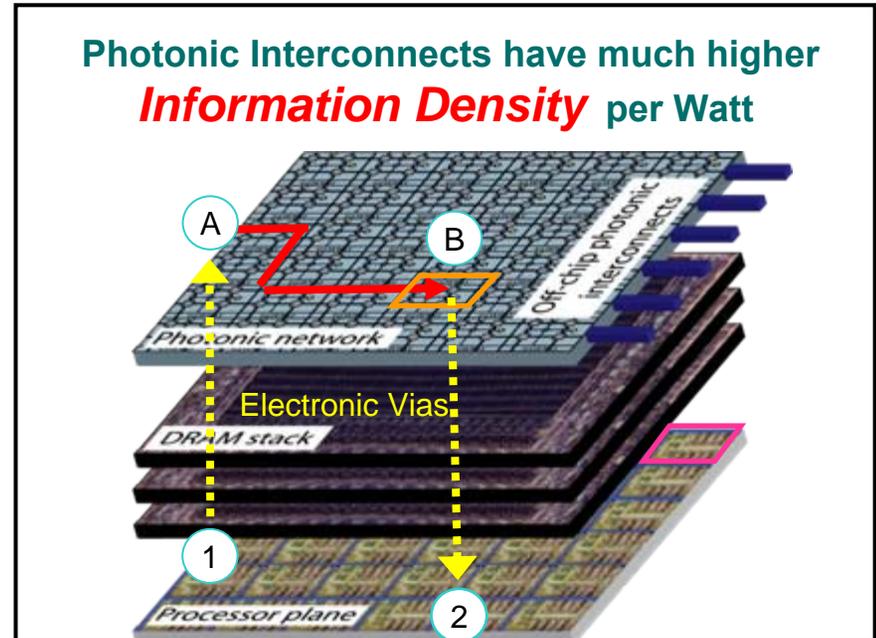
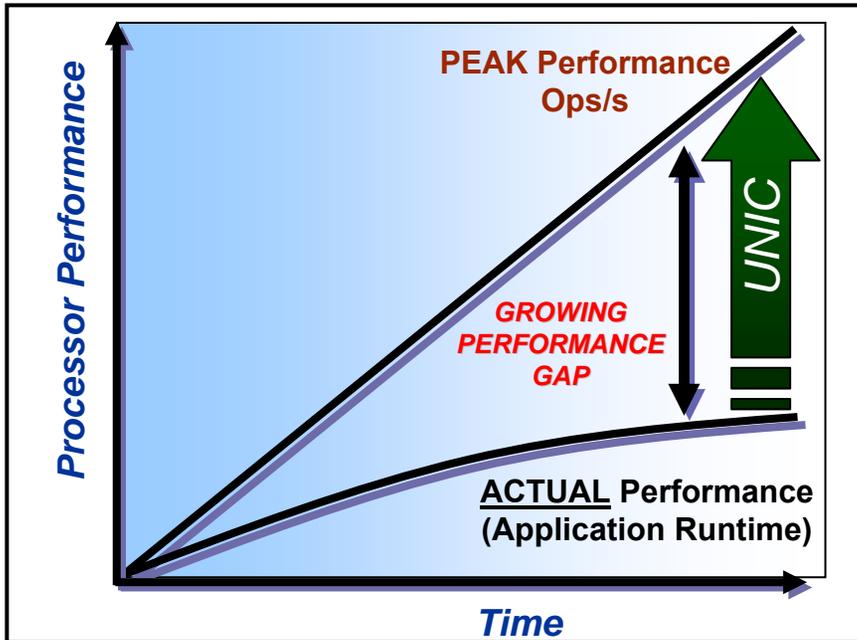
**Leakage current = active power!**



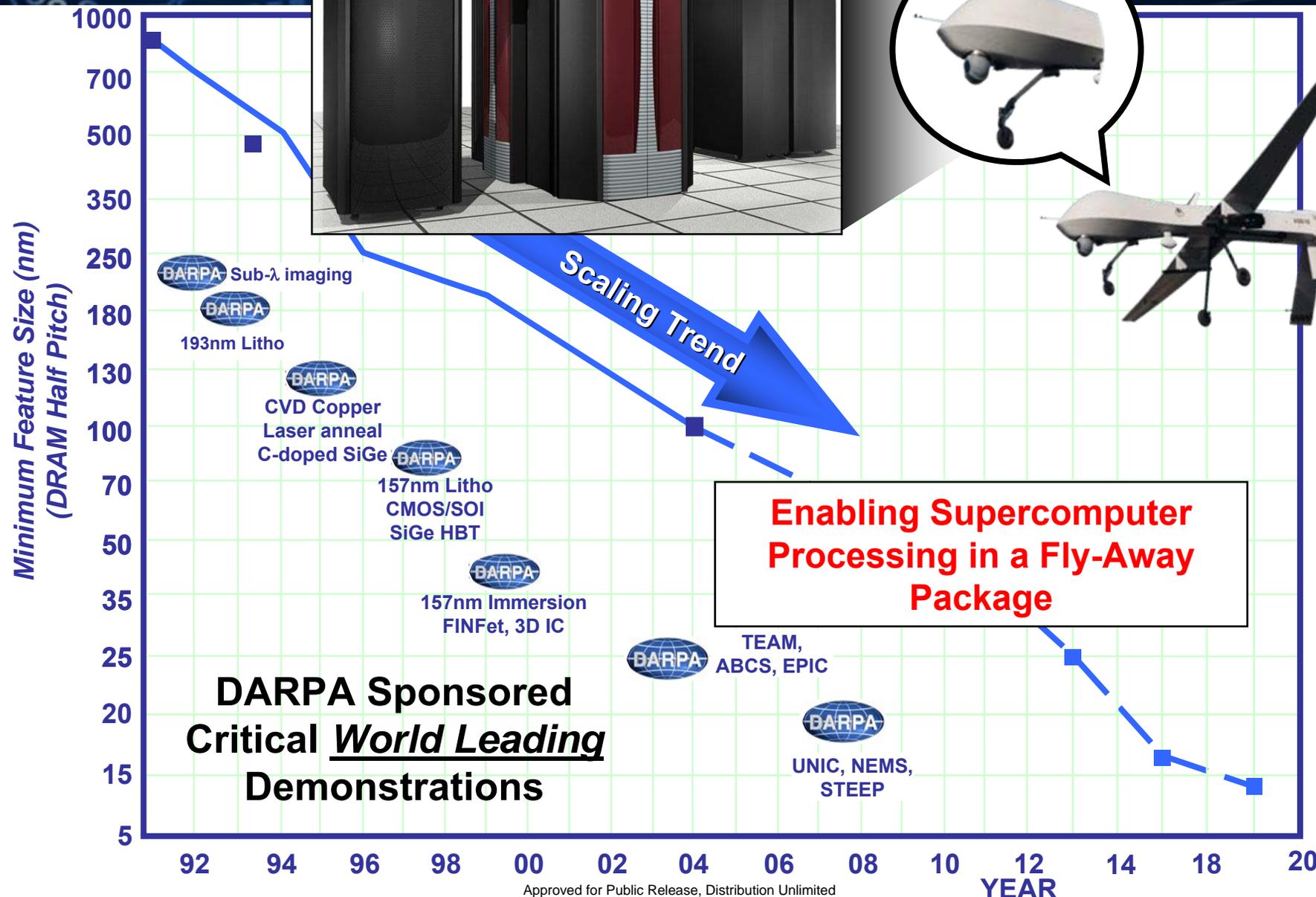
Nano-relay



- Leakage current – even when transistors are off – is becoming a critical wasting more energy than what is going into computation.
- Nano-scale switches can provide air gaps to fully turn off unused circuit blocks, dramatically reducing this wasted energy.



- Performance limiter in advanced computing systems is *getting data on and off chips and boards* - metal wires consume too much power and limit data speeds.
- Optical local and global interconnects provide **10X power reduction** for same data flow and **3X speedup** to close the gap between data movement and computation.

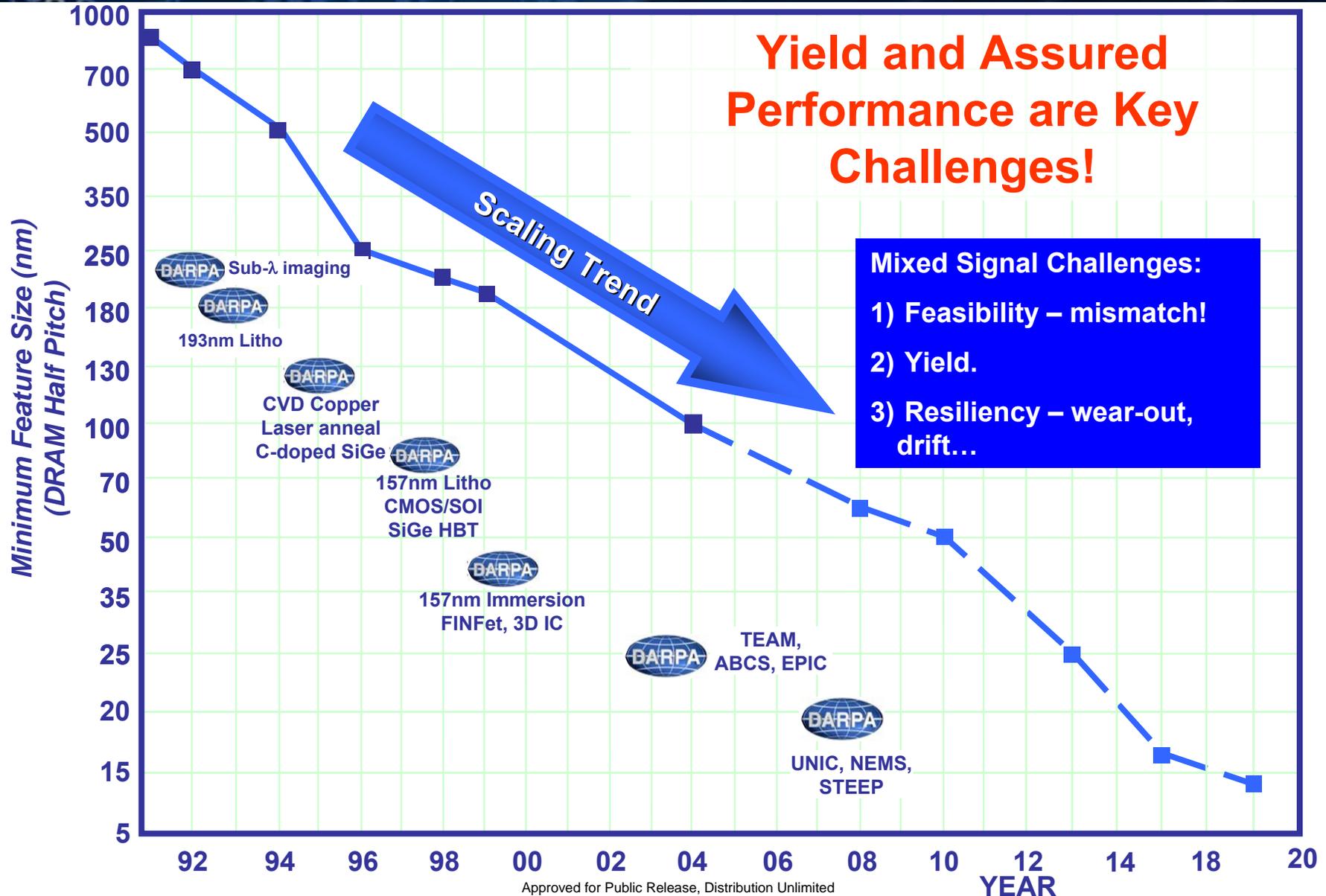


**DARPA Sponsored  
Critical World Leading  
Demonstrations**

**Enabling Supercomputer  
Processing in a Fly-Away  
Package**

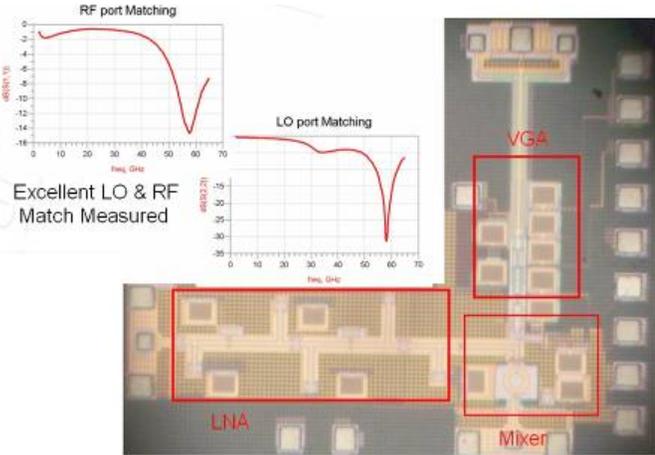


# Mixed Signal Challenges



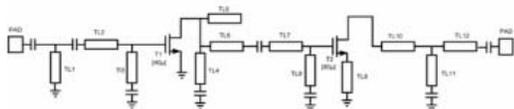
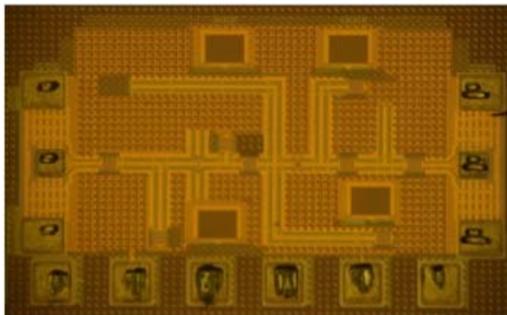
# Enabled by Scaling: RF Silicon Technologies

## 60 GHZ - 90 nm CMOS RF Receiver



NF~ 6dB 24 (mW) @ 1.0 V bias

## 60GHZ - 90nm CMOS RF PA

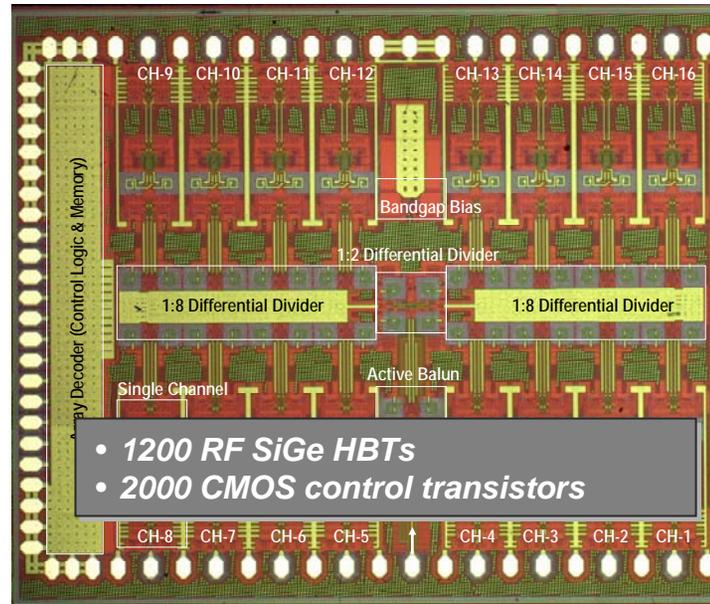


Efficiency of 20% @ < 50 mW per channel.

## Nanoscale Silicon Transistors

- Enabling a merger of RF and control circuits for System-on-Chip radio systems.
- Need to take into account issues with continued device scaling...

## Digital Beamformer-on-a-Chip



- 1200 RF SiGe HBTs
- 2000 CMOS control transistors

**44GHz**  
**16 channels**

Size: 3.2x2.6 mm<sup>2</sup>  
Power: < 5W

**World's first "MMW LSI" chip!**



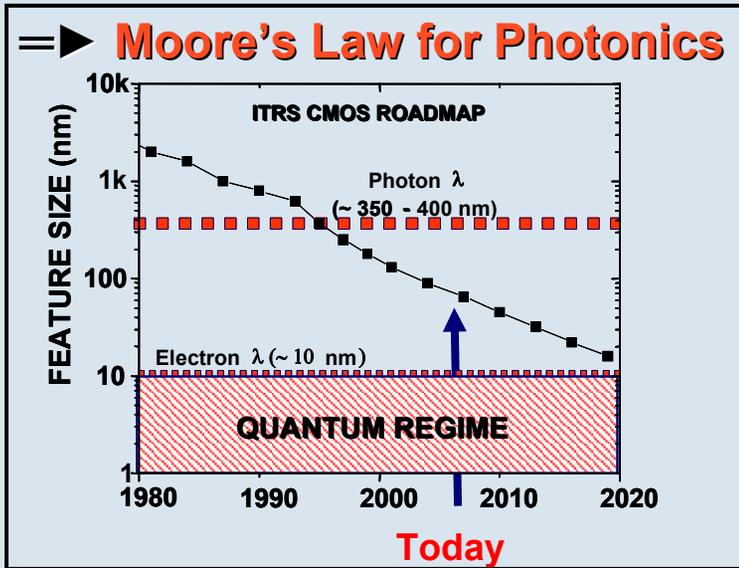
# Enabled by Scaling: Electronic & Photonic Integrated Circuits (EPIC)



PM: Dr. Jag Shah

EPIC was created to EXPLOIT NEW OPPORTUNITIES offered by advances in Si fabrication

## Moore's Law for Photonics



Photonics on Multiple Platforms; Discrete devices

Silicon CMOS ELECTRONICS

# EPIC

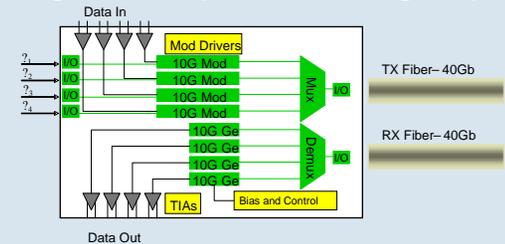
HIGH PERFORMANCE NANOPHOTONICS AND VLSI ELECTRONICS MONOLITHICALLY INTEGRATED ON A SILICON CHIP

## SEAMLESS INTEGRATION OF ELECTRONICS AND PHOTONICS IN CMOS FOUNDRY

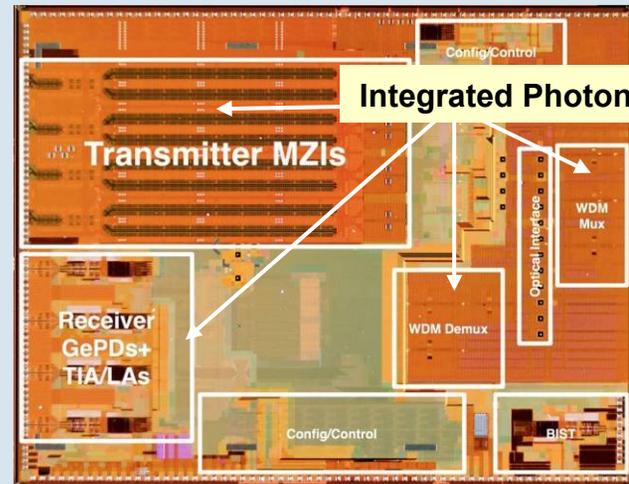
### 40Gbps Capacity Transceiver

4 Wavelengths multiplexed to single optical fiber

Functional Schematic



Die Photo



500,000 transistor integrated with > 100 photonic components  
HIGHEST LEVEL OF INTEGRATION EVER ACHIEVED



**Creating the Future  
from the Inside Out.**