



26 August 2008

ARO Electronics Division



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Army Research Office  
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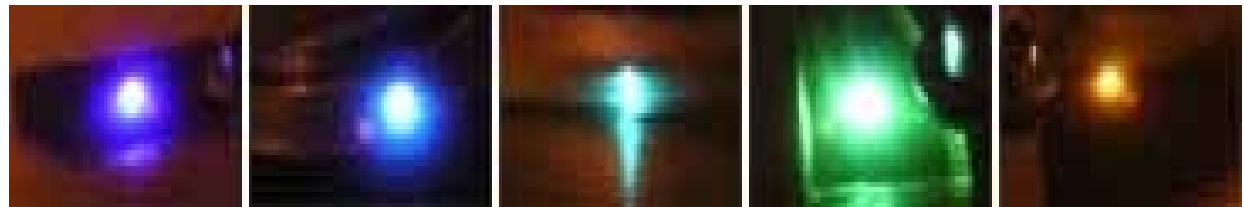
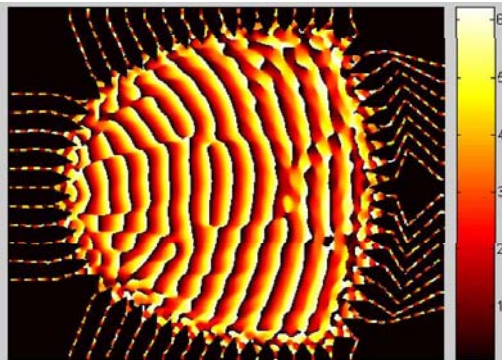
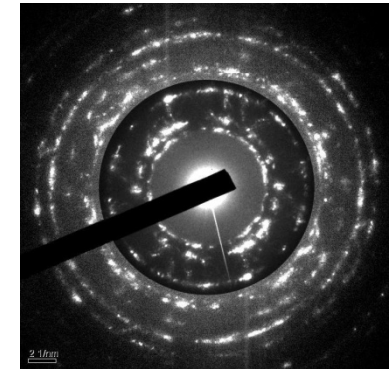
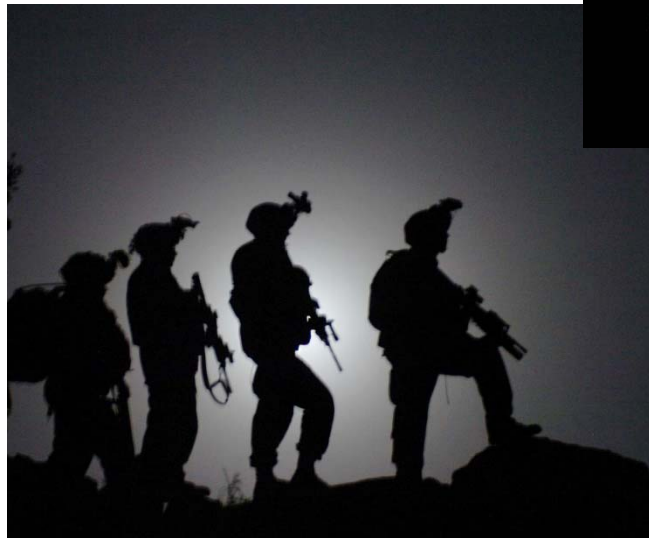
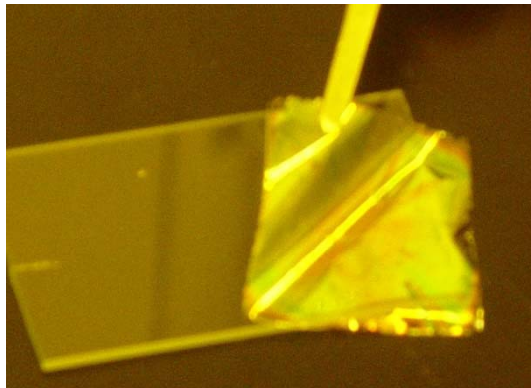
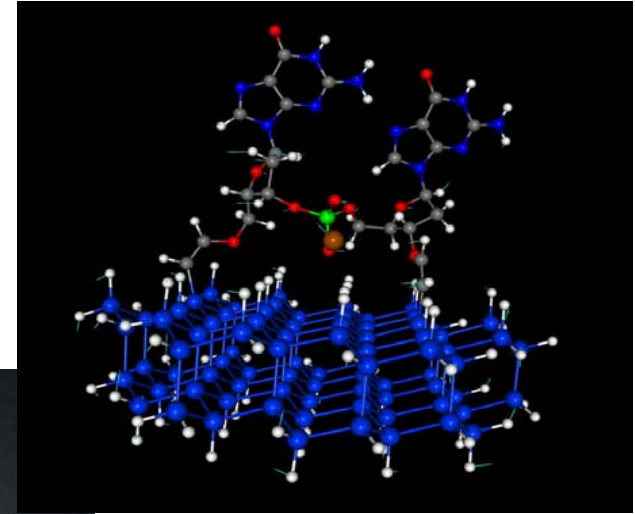




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# ARO Electronics Vision



To identify and enable basic research opportunities in Electronics that have the potential to transform Army capabilities and help maintain U.S. technological superiority

To lead the Army by embracing long-term, high-risk, high-payoff opportunities with special emphasis on Optoelectronics, Quantum Electro-Magnetic Devices, Sensors and Detectors, Solid State and High Frequency Science, Electromagnetics and RF Circuit Integration, and Power Electronics.

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# ARO Electronics



## ARO Electronics Program

Optoelectronics

Quantum Electro-Magnetic Devices

Sensors and Detectors

Solid State and High Frequency  
Science

Electromagnetics and RF  
Circuit Integration

Power Electronics

## Program Manager

Dr. Michael Gerhold

Dr. John Zavada

Dr. William Clark

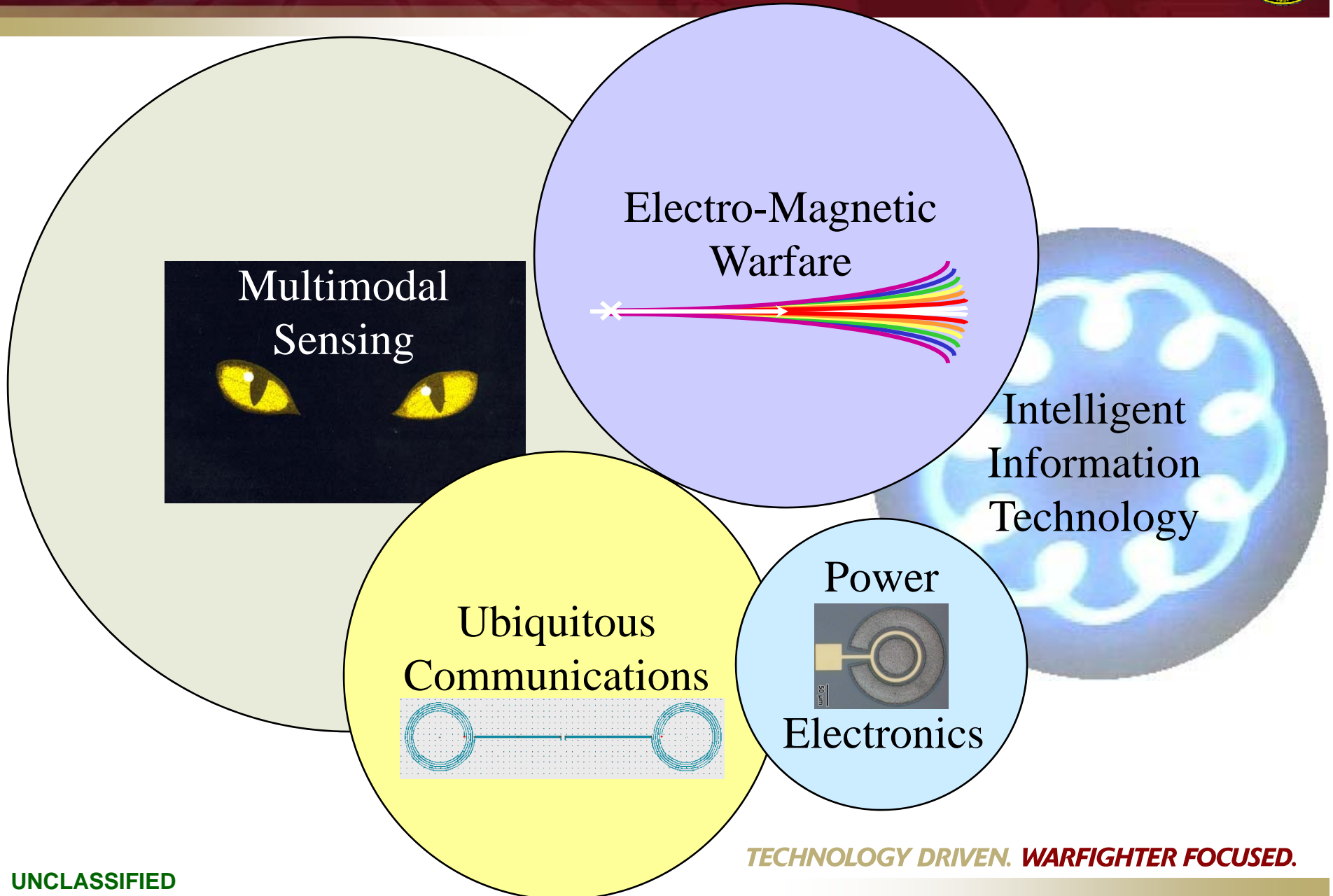
Dr. Dwight Woolard

Dr. Dev Palmer

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# ARO Electronics Optoelectronics



## Vision

*Faster, smaller, and more efficient optoelectronics based technologies for use in IR and UV spectrum sensing, free-space and integrated data communications, laser-based surveillance, and directed energy applications*



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# Optoelectronics Opportunities



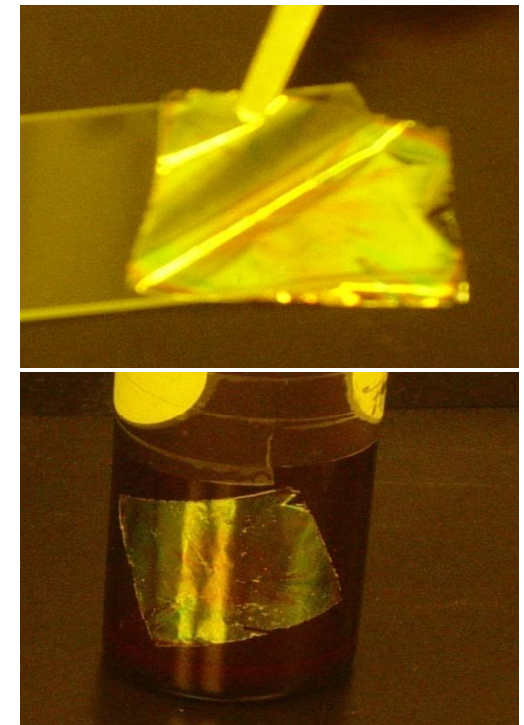
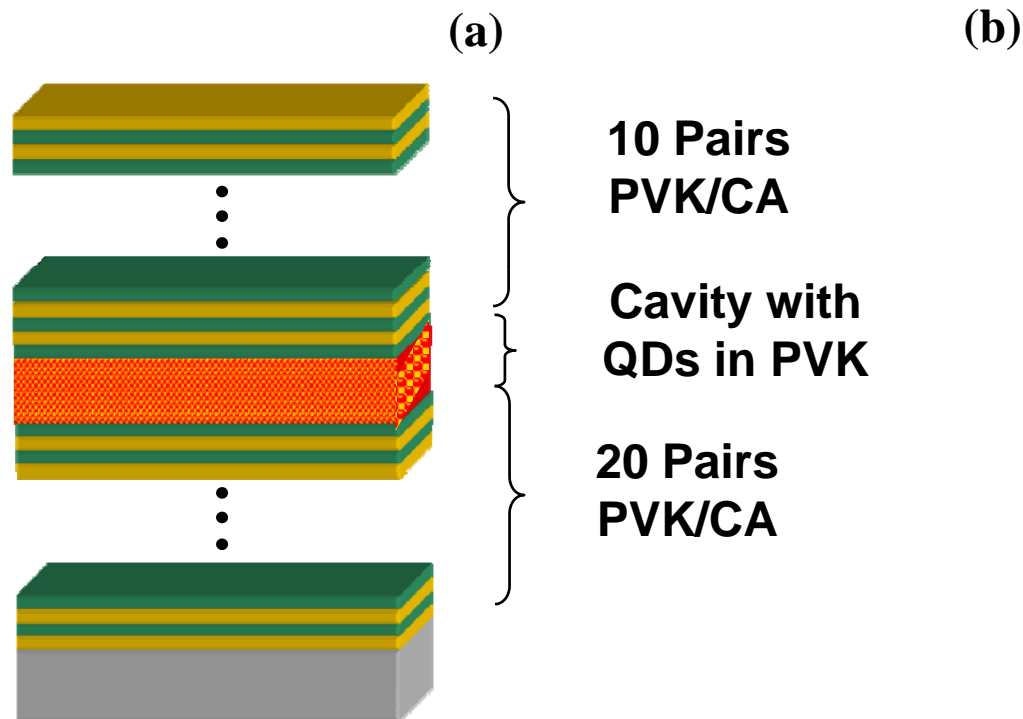
High power and efficient lasers and LEDs for various spectral windows from ultraviolet through long wave infrared.

Alignment tolerant, high-speed, low-cost, flexible optoelectronics components and circuits that capitalize on advancements in semiconductor nanomaterials, sol-gels, conductive polymers, and hybrid integration schemes

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## Flexible Optoelectronics: Polymer/Semiconductor Quantum Dot Hybrids



(a) Schematic of solution processed polymer microcavity

(b) Free-standing microcavities with embedded quantum dots



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## Quantum Electromagnetic Devices



## Vision

Explore novel devices that optimize multi-field electrical, optical and magnetic interactions, at the nanometer scale, for unique sensing, covert communications, and unprecedented information-handling capabilities.



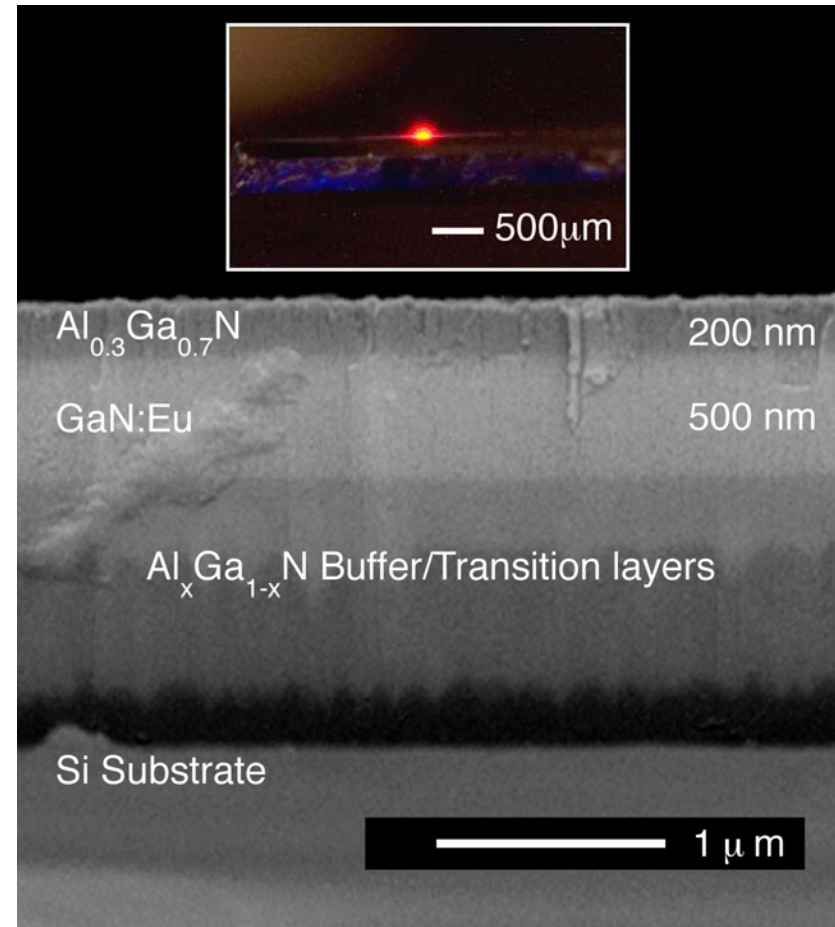
# Quantum Electro-Magnetic Devices Opportunities



Nano-structures and meta-materials that lead to innovative light emitters for tactical defense and full color displays.

Room temperature spin-based devices enabled by transition metal and rare earth doping of wide bandgap semiconductors

First demonstration of *lasing action* from Eu-doped GaN thin films grown on both sapphire and silicon substrates.





# ARO Electronics Sensors and Detectors



## Vision

*Achieve 100% situational awareness of vehicles, personnel, weapon platforms, projectiles, explosives, landmines, and IEDs, in day/night, all weather, and cluttered environments through natural and man-made obstructions.*



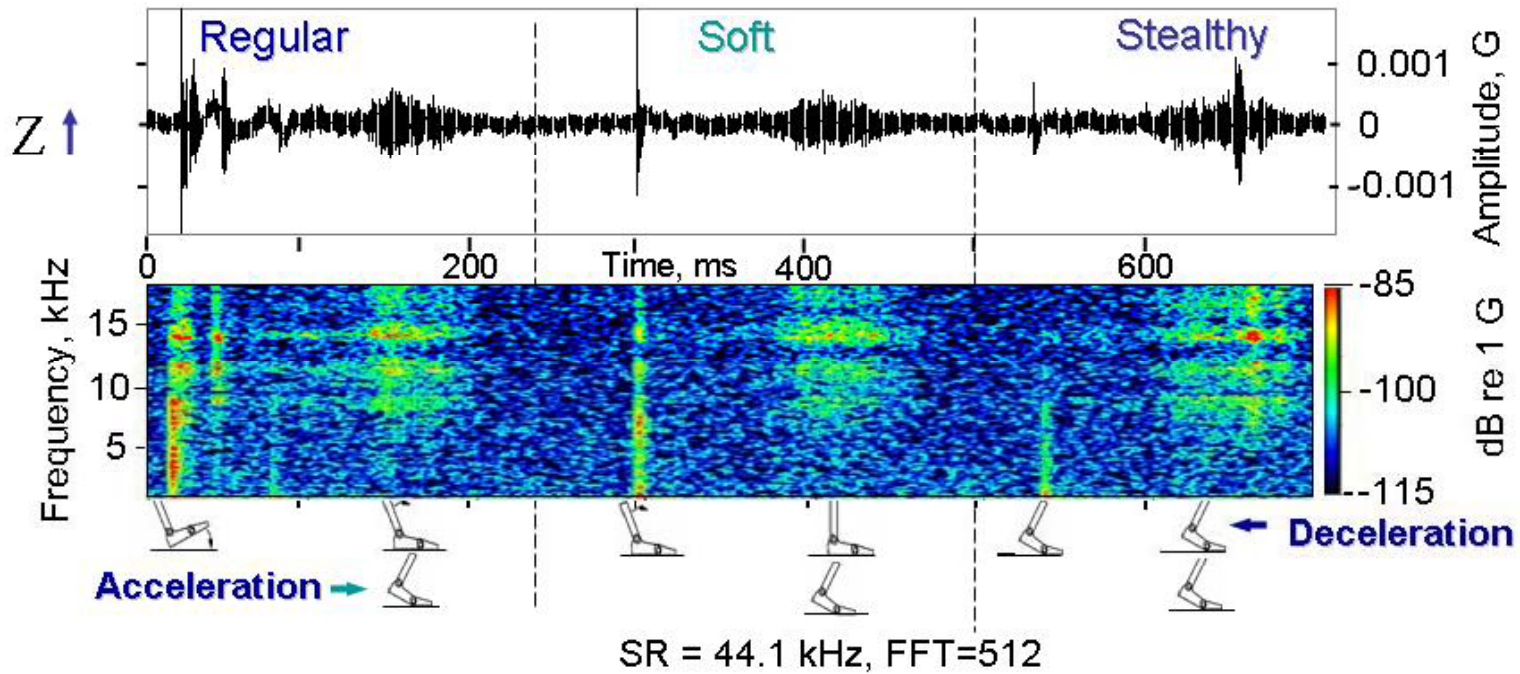
# Sensors and Detectors Opportunities



New IR detector structures enabled by nano- and MEMS technology.

Other sensor modalities (hyperspectral, acoustic/seismic, gamma ray ...) and combinations for increased detection.

### Discovery of high frequency seismic/acoustic signature for walking/running human





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# ARO Electronics

## Solid-State & High-Frequency



## Vision

A comprehensive scientific understanding of all ultra-fast and ultra-small electronic phenomenology required for achieving a maximized engineering proficiency in: nanoscale and molecular electronics; terahertz frequency and ultra-fast electronics; and advanced device/system concepts to revolutionize military relevant sensing, communications, computation and data processing scenarios.



# Solid-State & High-Frequency Opportunities

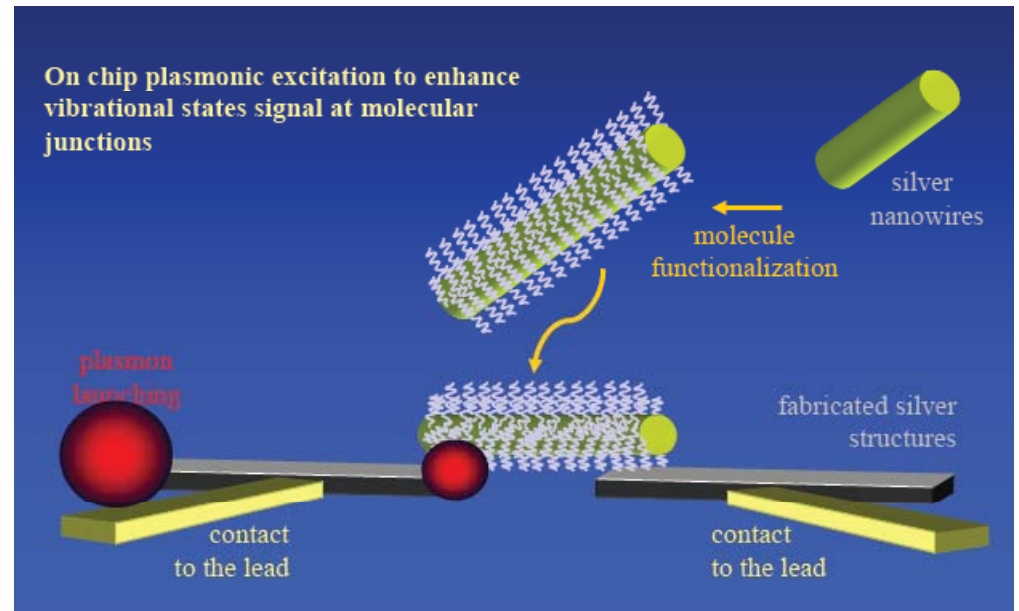
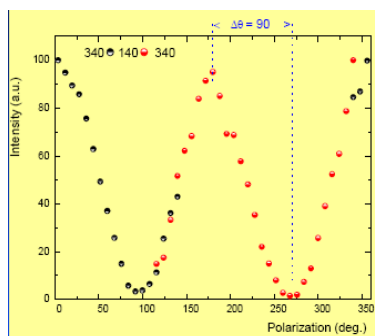
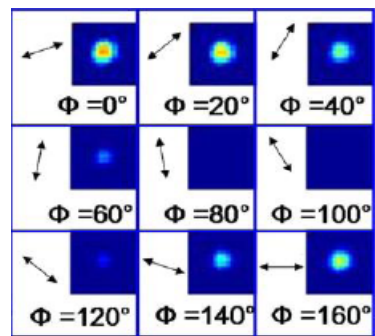
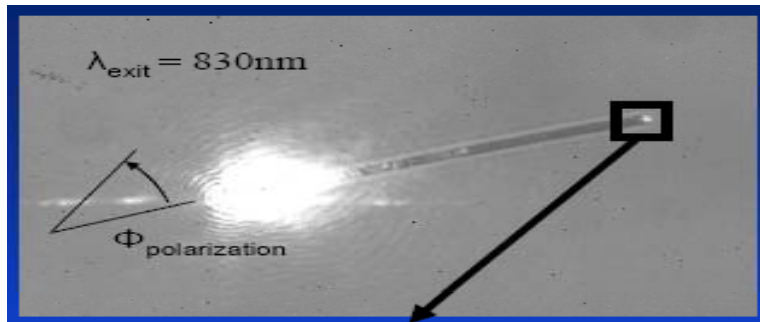
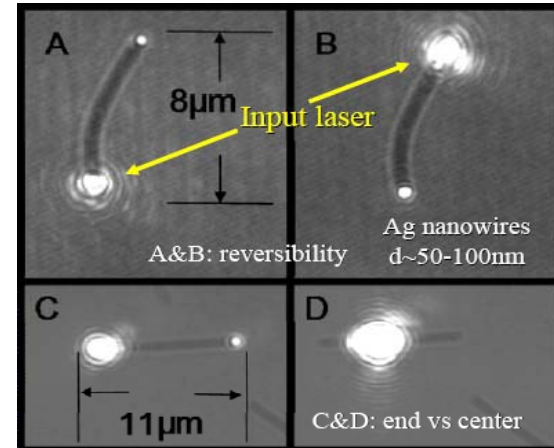
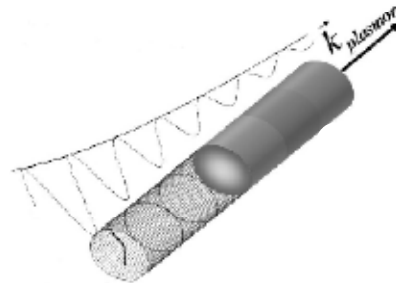


Biologically-inspired concepts, devices & algorithms that define novel **molecular-level paradigms** that allow for achieving enhanced and/or completely revolutionary sensing and data processing

THz-Frequency **Sources**, Detectors & Components that offer needed breakthroughs in performance (e.g., output power) and are compatible with warfighter scenarios

Innovative scientific methodologies and hybridized technology platforms for overcoming natural **fundamental limits** (e.g., dissipation, noise, etc. ) and defeating **engineering challenges** (sensitivity, amplification, bandwidth, etc) that limit the performance of conventional devices/systems

# Nanowire Plasmon Phenomenology Studies for Novel Devices & Sensors



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Electromagnetics and RF Circuit Integration



## Vision

Provide mobile, multifunctional, reliable, and high-performance communications and sensor systems with breakthrough capabilities for the Army of the future through basic research in electromagnetics and RF circuit integration



# Electromagnetics and RF Circuit Integration Opportunities



Research that advances modeling and analysis of wireless communications so that the soldier can be sure that the wireless systems will provide the expected function in the expected environment

New design techniques, architectures, and materials that can dramatically increase the radiation efficiency and bandwidth of tactical antennas while simultaneously reducing their size and signature.

Techniques to overcome thermal management problems stemming from the concentration of higher and higher power into smaller and smaller volumes for high-density radio circuit integration in the radio frequency (RF), microwave, and millimeter-wave frequency bands



## CONCEPT:

Can bio-inspired antenna systems enable low frequency beamforming and direction finding (DF) with small apertures?

## EXAMPLE:

- The human voice is centered around 1 kHz
  - Wavelength in air of about one foot
- The human vocal tract can project this frequency range with good directionality
- Distance between human ears is around six inches
  - About half a wavelength at 1 kHz
  - Still can resolve source AZ and EL to a few degrees

***Equivalent to high-accuracy VHF DF with a ~1.5 m aperture***

- *Ormia ochracea* does even better with ~1/60 of a wavelength spacing!



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# ARO Electronics Power Electronics



## Vision

Increase mission lifetime and reduce the logistics burden on the warfighter through basic research into radically innovative concepts to conserve, create, and manage power for Army electronic and electric components, systems, and vehicles



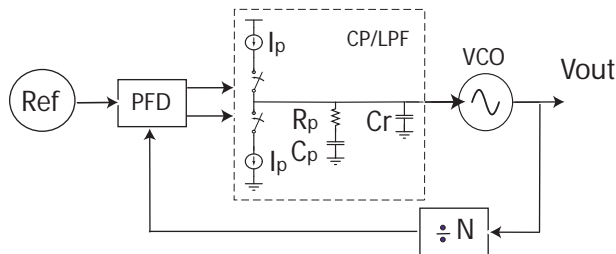
# Power Electronics Opportunities



New classes of power semiconductor devices that leverage innovations in materials science and radically new device structures to create breakthrough performance at high power and high temperature

Innovative circuit architectures that minimize power requirements while maintaining system performance

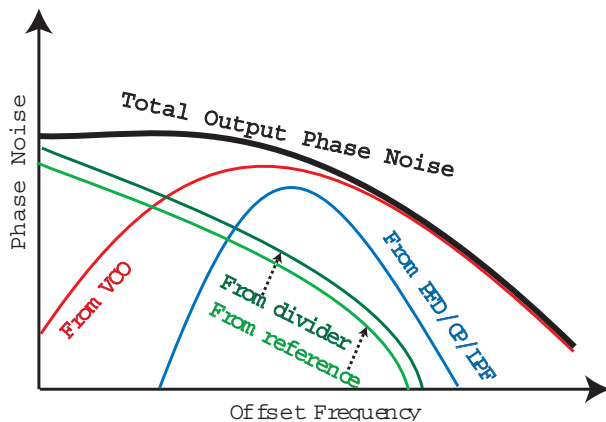
Co-design of radio waveforms, protocols, and hardware that optimize information content and maximize bits/second/Hz/acre, bits/battery



## CONCEPT:

Can system parameters be manipulated to simultaneously optimize power consumption and system performance?

## EXAMPLE:



- Phase noise is a critical parameter in clock circuits for navigation, frequency control, and time synchronization
- Phase noise in a particular circuit block and/or a particular component is a strong function of bias level
- Manipulate bias level on a component-by-component basis for best performance at lowest DC power supply point

**Optimal low-power performance for GPS synchronization, chip-scale atomic clocks, and on-chip frequency synthesis**

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# UNCLASSIFIED Complementary RDECOM Electronics Research



## Multimodal Sensing

- ARO *all divisions*
- ARL SEDD, WMRD, CISD, SLAD
- CERDEC
- ECBC
- NSRDEC
- AMRDEC

## Ubiquitous Communications

- ARO Materials Division
- ARO Computing and Information Sciences Division
- ARL SEDD, WMRD, CISD
- CERDEC
- AMRDEC
- NSRDEC

## Electro-Magnetic Warfare

- ARO Materials Division
- ARO Physics Division
- ARL SEDD
- CERDEC

## Intelligent Information Technology

- ARO Life Sciences
- ARO Materials Science
- ARO Physics
- ARL SEDD, CISD
- CERDEC

## Power Electronics

- ARO Chemistry
- ARO Mechanics
- ARO Materials
- ARO Physics
- ARL SEDD
- TARDEC

<http://www.aro.army.mil>

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