DoD Advanced Electronics COI

NDIA S&ET Conference

Dr. Gerald M. Borsuk, Chair

19 April 2017

AE COI Membership

Executive Steering Group

Navy (NRL) - Dr. Gerald M. Borsuk, Chair
Dr. Baruch Levush, Working Group Chair
Mr. Chris Bozada, SME
Army (ARL) - Dr. Phil Perconti
Air Force (AFRL) – Ms. Ruth Moser
DMEA - Mr. Ted Glum
DARPA - Mr. Ellison Urban

Working Group Members

Army - Dr. Romeo DelRosario, Dr. Paul Amirtharaj, and Dr. James Wilson
Navy - Dr. Paul Maki and Dr. Baruch Levush (Chair)
Air Force - Dr. Steve Hary, Ms. Cathy Deardorf, and Mr. Jesse Fanning
DMEA – Mr. Daniel Marrujo, and Mr. David Pentrack
DTRA - Dr. Bruce Wilson and Mr. John Franco

MITRE Support – Dr. Shamik Das

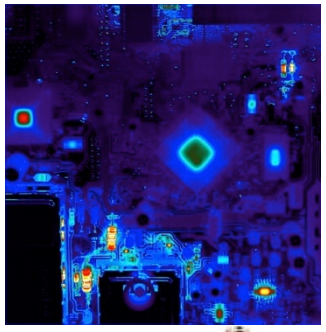
Challenge & Vision

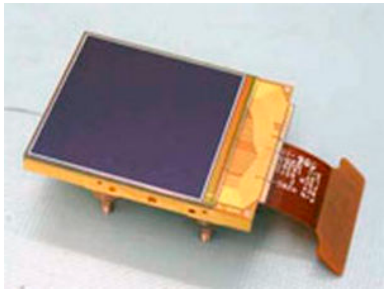
- **Challenge**
  - ***Highly capable electronics are critical but ubiquitous.***
  - ***Ensure DoD has affordable access to leading edge high performance and trusted electronics to avoid technology surprise.***
    - ***Requires maintaining US Hegemony In Leading Edge Integrated Circuits***
- **Vision**
  - ***Create and exploit S&T advances for leap-ahead capabilities ensuring military superiority in:***
    - **EM Spectrum Warfare from DC to light;**
    - **Advanced signal processing components; and**
    - **Trusted electronic components**

2016-17 Activities and Outcomes

- **Taxonomy Refresh**
  - DoD Electronics Taxonomy last updated ~20 years ago
  - New Taxonomy Better Reflects today's technology efforts in DoD Adv. Electronics
- **MEC Microelectronics Working Group Participation**
- **QSE ARAP making excellent progress**
- **OSD Quantum Strategic Road Mapping Study Underway**
- **Joint FY17 Seedling with Sensors COI for Low Temp ROHIC**
- **EDA Cloud Based Seedling Progressing**
- **Exchange Meeting with Materials, Sensors, and EW COI's**
- **IR&D-Advanced Electronics COI Workshop Planned for fall 2017**
- **Rapid Reaction Technology Office Needs Meeting in May and Fall**

AE COI Domain





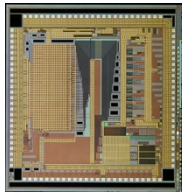
Capabilities:
C4 ISR Cyber EW
Weapons

EO/IR Components

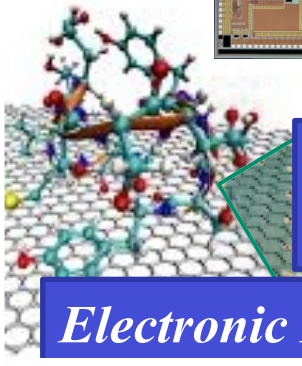
Cross-Cutting Technologies

RF Components

Power Electronics



Integrated Circuits

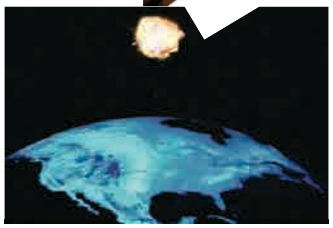


Quantum Technologies

Electronic Materials

Fundamental Research

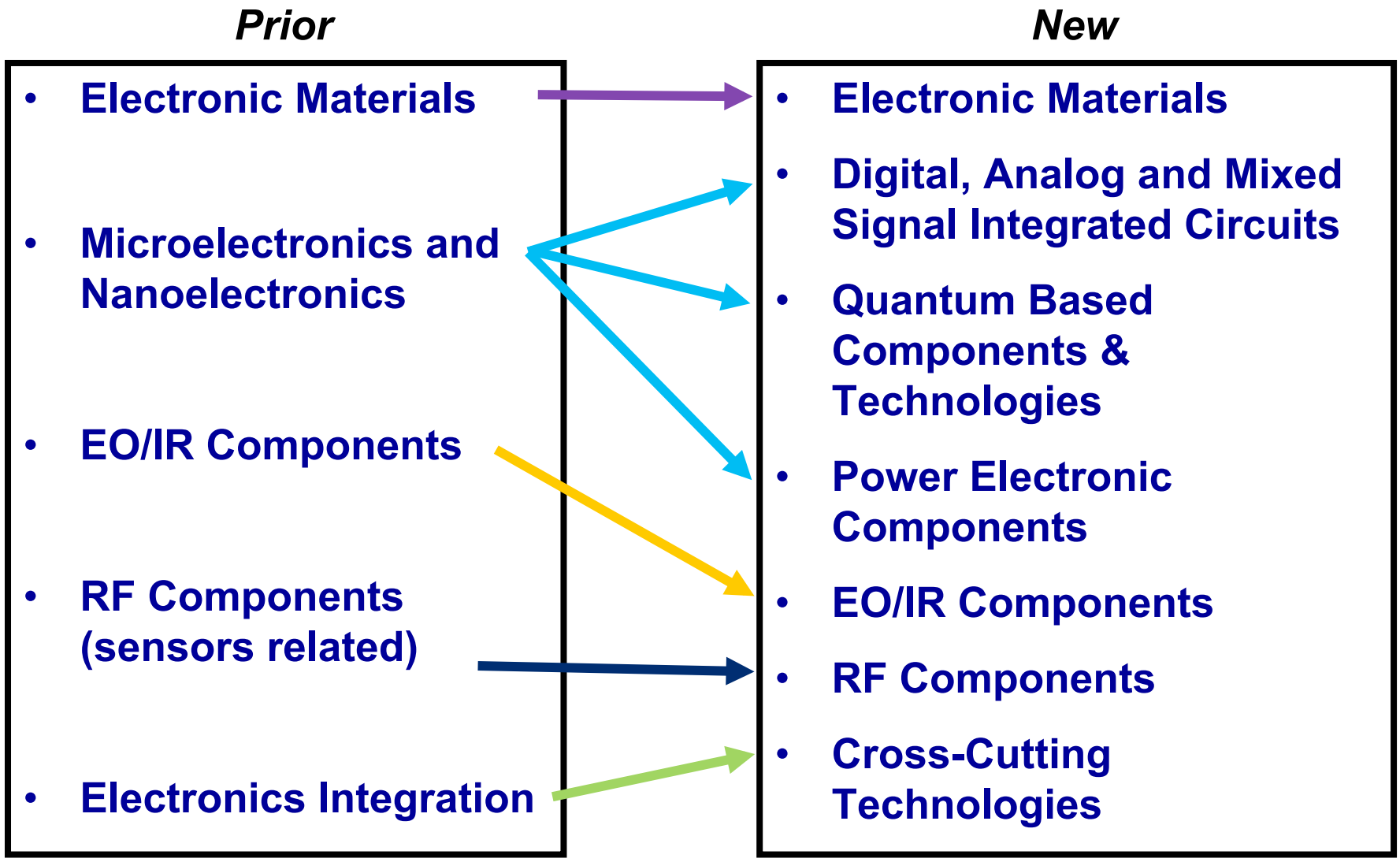
Trust and Supply Chain Security



Radiation Hardness

Industry

Updated Taxonomy Thrusts for AE COI



Advanced Electronics Linkage to other COIs

- *Cost, Size, Weight and Power Consumption Reductions*
- *Trusted and Sustainable Supply Chain – Trustworthy, Cyber-Hard, Tamper-Proof Electronics*
- *Obsolete and Counterfeit Parts*

Electronic Warfare COI	Sensors and Processing COI	C4I COI	Cyber COI	Autonomy COI	Space COI

- *Wideband/spectrum Access*
- *Reconfigurable and Agile RF Systems*
- *Advanced Sources/Transmitters*
- *Advanced Detectors/Receivers*
- *Compact, Efficient Computation*

- *Assured Communications*
- *On-Board Processing*

- *Rad Hard Electronics and Microsystems*

Energy and Power COI

- *Power Electronics*

Advanced Electronics COI

- *Industrial Base and ManTech*
- *Advanced Materials and Computational Electronics*
- *Beyond Moore's Law*

Materials and Manufacturing Processing COI

BA1 and University Research (not in AE COI)

Technical objectives to meet pervasive and enduring operational/mission needs

The Advanced Electronics COI bridges fundamental research and commercial investments to militarily-critical hardware capability gaps

- Watch and leverage international and commercial technology base (fast follower with investment focus on military-unique needs or opportunities)
- Understand and mitigate globalization trends and technology availability (Avoid technology surprise)
- Enable full use of electromagnetic spectrum in highly contested environments; and counter other's ability to do the same (deliver technology surprise and cost imposition)
- Increased assured communications and on-board processing (basis for autonomy and swarms)
- Extreme reductions of size, weight, power consumption and cost (basis for expendable and that will attrite)
- Enable open system architectures (provide modularity for low cost upgrades)
- Increased capability to operate in harsh environments, supply chain risk management, and sustainment (includes tamper-proofing technologies)

Some Key Technology Opportunities

- Trusted and Assured Electronics
- Ultra Wide Bandgap Semiconductors Beyond GaN
- Reconfigurable, Frequency-Agile Devices and Circuits
- Vacuum Electronics at mm-wave
- 3D Integration
- Integrated Photonic Circuits
- Neuromorphic Electronics
- IC's Beyond Moore's Law
- Quantum Information & Sensing Technologies

ARAP Quantum Science and Engineering Program

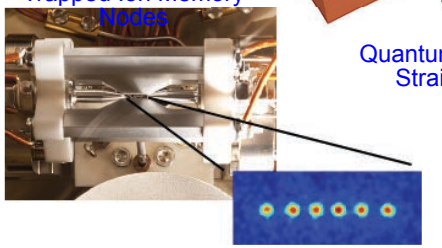
Objectives

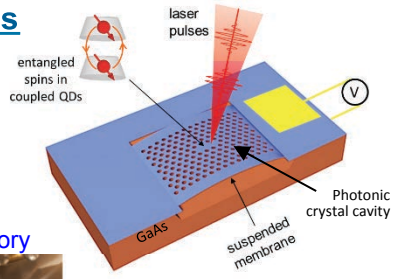
- Develop cohesive tri-service capabilities needed to define quantum applica-tions and shape their future for DoD
- Accelerate critical technologies for quantum networks and sensors that enable early prototyping opportunities

Potential Prototyping Opportunities

3d printed mockup of next gen vacuum cell for dual atom accelerometer and gyroscope prototype

Trapped Ion Memory Nodes



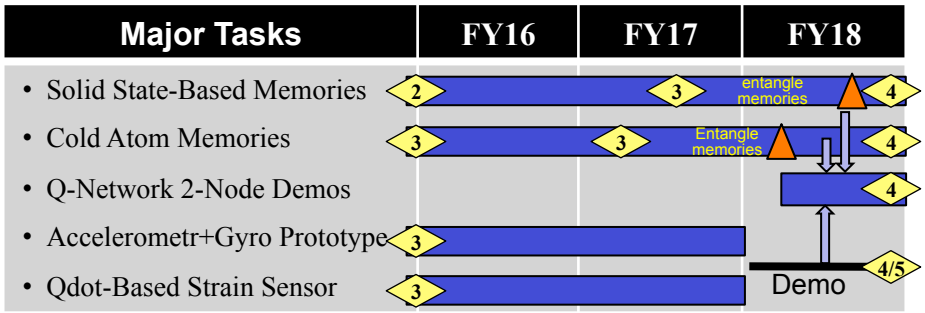


Quantum Dot Based Strain Sensor

Approach

- Develop solid state and cold atom quantum memory nodes
- Develop sources, detectors and integrated photonics needed to make practical, scalable networks
- Entangle two similar memory nodes at each service lab
- Miniaturize atom-based accelerometer and gyro for near-term prototype and follow-on flight test

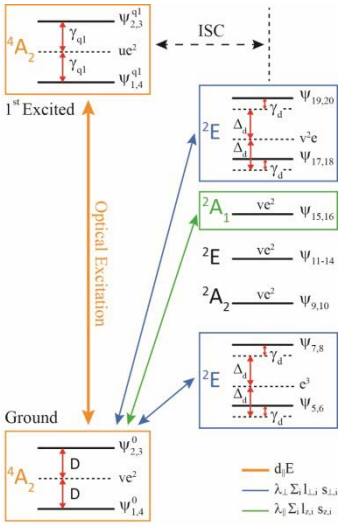
Schedule

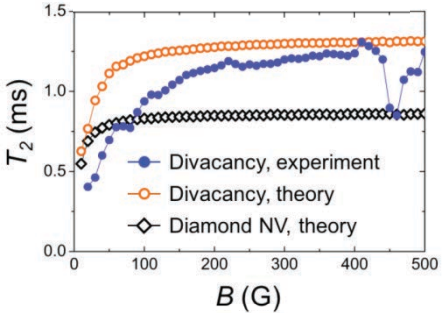


Legend: Key event # TRL

- ❑ **Entangle two quantum memory nodes in labs**
- ❑ **Develop quantum sensors and connect with memory nodes**
- ❑ **Develop enabling technologies**
- ❑ **Develop core competency concerning entanglement in service labs**

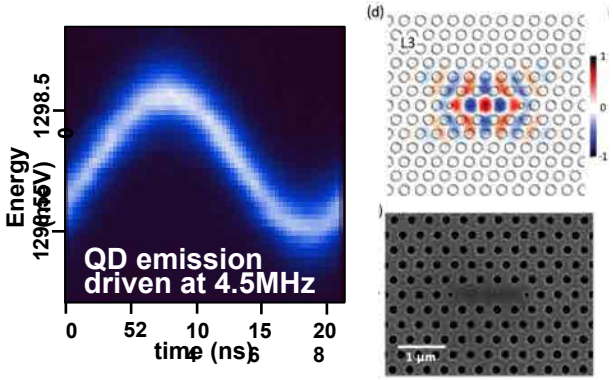
Modeling, fabrication and measurement of SiC single and divacancies

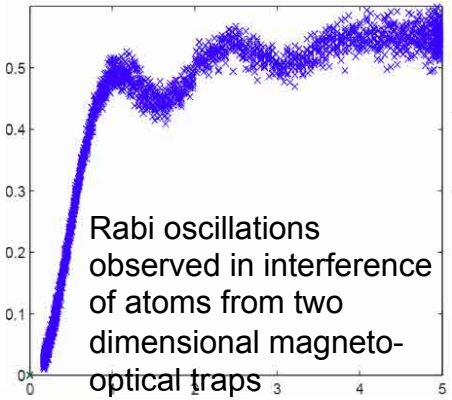




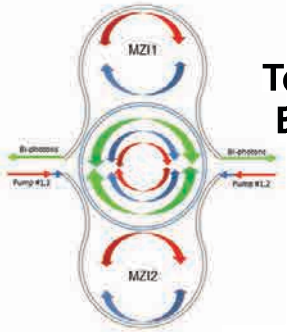
QD-mechanical coupling in photonic crystal membrane

Spin-mechanical coupling using QD optical transitions

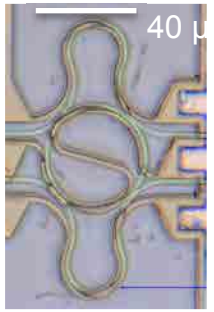




Two dimensional versus 3D magneto-optical traps key for shrinking SWAP of atomic gyroscopes.



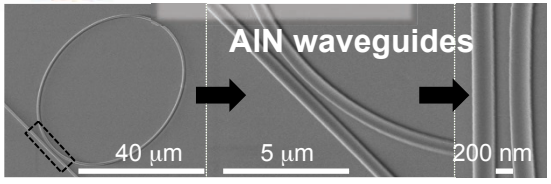
Telecom Bi/ Entangled Photons Source



Coherence times of spins are longer in SiC than diamond NV-centers

Flip-flops between different nuclear species are suppressed due to differing gyromagnetic ratios of ^{29}Si and ^{13}C

Flip-flops between the same nuclear species are suppressed due to SiC lattice

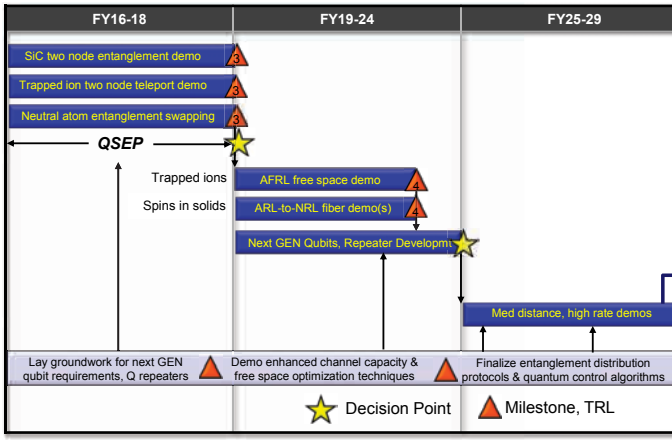


UV Quantum Integrated Photonic Circuits to integrate with trapped-ion based memory nodes for long-distance quantum networking and information processing protocols

OSD Quantum Strategic Roadmapping Study

(1 Nov 2016 – 31 May 2017)

- **Completed**
  - Review of previous Quantum Information Science & Technology (QIS&T) studies
- **70-80% Complete**
  - Survey of other national quantum programs
  - Compilation of USG QIS&T programs
- **In Progress**
  - Overview of quantum computing research
  - Linkage of QIT to DoD capability gaps
  - Formulation of overarching DoD strategy
  - Development of roadmaps



Changing Directions

- Trusted Electronics – National review, assessment and planning resulting in a highly coordinated response and division of labor
  - OSD Seedling on establishing joint cloud based integrated circuit design capability
  - Tri-service R&D planning for Joint Federated Assurance Center (JFAC) Hardware
  - Flow Down of S&T Needs from the 6.4 OSD Trust and Assurance Microelectronics Program

- Prior Tri-Service studies on advanced electronics for EW led to joint portfolio decisions:
  - Navy emphasizing mm-Wave for EW (joint with EW COI)
  - AF Reconfigurable and Agile RF Front End initiative (joint with EW COI)
  - Joint development and leadership of the Integrated Photonic Circuit Institute (also joint with MMP COI)

Technical Opportunities

Lead

– Trusted Electronics – Increased emphasis and refinement of joint activity through continued funding to address S&T

– Ultra Wide Bandgap Semiconductors – Capture untapped theoretical power, efficiency, frequency, bandwidth and linearity gains possible from emerging electronic materials

– Reconfigurable, Frequency Agile Devices and Circuits – tunable multifunctional devices, phase change materials, and tunable metamaterial-based circuits

Leverage (Fast Follower)

– Commercial 3D Integrated Circuit Technologies – for critical military applications

– Neuroelectric Devices – devices that perform electronic functions and biomimetics for autonomous systems

Watch

– Beyond Moore's Law – Understand commercial drivers and influence academic approaches in emerging material, devices and architectures

Collaboration & Out Reach Within DoD

- Annual meeting of AE COI SMEs at GOMACTech (Government Microcircuit Application and Critical Technologies Conference)
- The evolution Tri-Service advanced components for electronic warfare studies into joint portfolio decisions:
  - Navy emphasizing mm-Wave for EW (joint with EW COI)
  - AF starting a Reconfigurable and Agile RF Front End initiative (joint with EW COI)
  - Joint development and leadership of the Integrated Photonic Circuit Institute (also joint with MMP COI)
- Joint Quantum Sciences and Engineering ARAP initiative continuing
- Joint COI Seedling - DOD-Wide Cloud-based Collaborative Silicon Microelectronics Design Initiative
- Joint discussions and plans for the way-ahead on trusted and assured electronics including obsolescence and supply chain issues
- Joint GaN Amplifier Performance and Reliability Investigation of COTS (GaN APRICOTS) Program

Collaboration & Out Reach External to DoD

- NDIA SE&T Conference Engagement
- Defense Innovation Market Place
- GOMACTech Annual Conference

Summary

The AE COI is a critical foundational element of DoD's S&T Enterprise leading the understanding, exploitation, and transition of breakthroughs in materials, devices, circuits and highly integrated microsystems for next generation electronic systems capabilities

- Critical linkages to other COIs – many unintended consequences when one COI has funding and emphasis changes
- Primary driver for Increased performance, miniaturization, multi-functionality and efficiency
- High potential to lower development, acquisition and life cycle costs
- DoD lead on the preservation and evaluation of the electronics supply chain and sustainment S&T in military relevant electronics technologies.