DoD’s Challenges and Approach to Expanding the National Microelectronics and Photonics Ecosystem

SPIE Photonics Industry Summit

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OUSD (R&E) Microelectronics Modernization

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CRITICAL TECHNOLOGY SYNERGIES: MICROELECTRONICS

- Autonomous Drones
- AI Chips
- Self Driving Vehicles
- Energy Efficiency For Edge Computing
- Military Applications

- Renewable Energy Generation and Storage
- Advanced Computing and Software
- Human-Machine Interfaces
- Hypersonics
- Directed Energy
- Biotechnology
- Quantum Science
- Future Generation Wireless Technology (FutureG)
- Advanced Materials
- Trusted AI and Autonomy
- Integrated Network Systems-of-Systems
- Space Technology
- Integrated Sensing and Cyber

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Semiconductors are essential to national security as they are fundamental to the operation of virtually every military system, including communications and navigations systems and complex weapons systems such as those found in the F-35 Joint Strike Fighter.

DoD will accelerate the process of turning ideas into capabilities by creating new pathways to rapidly experiment with asymmetric capabilities and deliver new technologies at scale. Doing so requires bridging the valley of death between prototypes and full-scale production.

The NSTC will be able to support technologies emerging from the Commons and will collaborate closely with DOD to ensure program coordination and sharing of resources as part of the broader whole-of-government approach in alignment with the national strategy.
T&AM Program Enabling Access to State of the Art (SOTA)

**ME COMMONS**

Lab-to-Fab Prototyping and optimization for Defense Program demonstrators

- Secure Edge Computing
- AI HW at the Edge
- Quantum Computing
- 5G/6G Technology
- Commercial Leap Ahead Technologies
- Electronic Warfare

**Core Facilities**
- CMOS + New Technology Integration
- Non-CMOS

**DoD / DIB Programs Prototypes Pipe Cleaners**

**Secure Design Infrastructure**

- Design Center

- RAMP

- On-Shore Commercial Foundry

- Government Information Zone International Traffic In Arms Regulation (ITAR)

- SHIP

- Packaging & Test Center

**Joint Federated Assurance Center (JFAC)**

- Supply Chain Awareness/Counterintelligence
- Microelectronic Quantifiable Assurance
- Policy & Standards

**Trusted and Assured Microelectronics Program**

- Compare Outcomes

- RAMP-C

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# Radio Frequency & Optoelectronics (RF/OE) Roadmap

## Fiscal Years

<table>
<thead>
<tr>
<th>Fiscal Year</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
<th>2025</th>
<th>2026</th>
<th>2027</th>
<th>2028</th>
<th>2029</th>
<th>2030</th>
<th>2031</th>
<th>2032+</th>
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</thead>
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### Material Sources

<table>
<thead>
<tr>
<th>MRL-5</th>
<th>Production qualification of advanced GaN material sources with increased capacity and quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRL-6</td>
<td>Production demos of advanced GaN material for DIB foundries, enabling max power and efficiency in mmWave devices</td>
</tr>
<tr>
<td>MRL-8</td>
<td>Pilot demos of advanced GaN material for DIB foundries, enabling max power and efficiency in mmWave devices</td>
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</tbody>
</table>

### GaN Foundry Maturation

<table>
<thead>
<tr>
<th>MRL-4</th>
<th>R&amp;D demos • &lt;150nm GaN nodes • Advanced Interconnects</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRL-6</td>
<td>Production demos • &lt;150nm GaN nodes • Advanced Interconnects • Quantifiable Assurance</td>
</tr>
<tr>
<td>MRL-8</td>
<td>Pilot demos of mmWave RF GaN foundries available to DIB for advanced packaging and integration</td>
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</tbody>
</table>

### GaN Device Demonstration

<table>
<thead>
<tr>
<th>40nm, 140nm, 150nm RF GaN Device Demos at MRL-4/5 lines</th>
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</thead>
<tbody>
<tr>
<td>40nm, 90nm, 150nm RF GaN Device Demos and IP Capture at MRL-6 foundries</td>
</tr>
<tr>
<td>40nm, 90nm, 150nm RF GaN device demos and IP capture at MRL-8 foundries enabling next generation radar, electronic warfare (EW), and communications</td>
</tr>
</tbody>
</table>

### Silicon Photonics (SiPh) Foundry Maturation

<table>
<thead>
<tr>
<th>Demonstrate early access to SOTA SiPh nodes and develop maturation plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstrate open foundry access to mature SOTA SiPh nodes</td>
</tr>
<tr>
<td>Mature SOTA SiPh foundry capability and capacity for next generation radar, EW, and communications</td>
</tr>
</tbody>
</table>

### SiPh Device Demonstration

<table>
<thead>
<tr>
<th>Demonstrate open access designs at AIM and GF 45SFCLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Datacom and EW prototype designs, which enable new warfighter capabilities and enhanced SWAP</td>
</tr>
<tr>
<td>RF Optical Transceiver SHIP Demonstrator</td>
</tr>
</tbody>
</table>

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**Major Investments to Mature the Domestic SOTA RF/OE Microelectronics Ecosystem**

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**Future RF/OE Microelectronics Needs**

- Domestic access to mature SOTA RF/OE materials, foundries, and packaging
- Ecosystem alignment to DIB and POR

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Photonics and Sensor Activities Address Increasing Data Traffic & Spectrum Congestion

Commercial and DoD applications require advanced sensors and communication systems with higher frequencies, broader bandwidths, and lower latencies.

**Commercial**

- **Data and Traffic Explosion**
  - Work from Home
  - Socialize & Learn from Home
  - New Virtual Experiences
  - Security
  - Telemedicine & Virtual Fitness
  - Electronic Payment
  - Shopping Food Meal Delivery

**Fiber-Optic**

- High-Speed 24 GHz+(mmW)
- Mid-Band Capacity 2-6GHz
- Low-Band Coverage 600MHz to 3GHz

- Coherent Long-Haul >90km
- Multi-A Metro Core 100-400km
- SAN, LAN, Access Datacom <10km, <80km, <150km

**Defense**

- SATCOM
- Space Operations
- SATCOM
- PNT Signals
- BPS
- SATCOM
- Commercial SATCOM
- PNT Signals
- SBOG Sensors
- EOR Sensors
- SAR Marc
- CBR Sensor
- Decoy
- RF Sensors
- BRIC Sensors
- Radar
- RF Sensors
- FLIR Sensors
- Radar
- GPS Jammer
- RF Guided Artillery
- GPS Jammer
- RF Jammer
- Laser Jammer
- Electronic Warfare
- Electronic Warfare
- Optical Aperture Radar
- Radar
- Air Operations
- SATCOM
- SATCOM
- SATCOM
- Air Operations
- Satellite Broadcast
- Civil Cellular
- Civil HAMR

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KANAGAWA Goals:
(A) Mature Optical I/O chiplets and lasers
(B) Demonstrate high-performance optical links via advanced packaging

Task A: Chiplets and Lasers

Task B: Multi-Chip Packaging

Develop co-packaging capabilities and demonstrate compelling prototypes emulating Task A components

DoD Advanced Packaging Development

Demonstrate 2 Tbps, 5 pJ/bit optical I/O chiplets and laser sources for co-packaging with SerDes chipsets

Mature component fabrication and assembly to MRL-S

DoD Component and System Integration

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CHIPS Offers a Whole of Government Approach

The NSTC and Microelectronics Commons will expand the number of concepts and ideas that can transition from proof-of-concept to the market.

Figure from: the CHIPS Research and Development Office’s “A Vision and Strategy for the National Semiconductor Technology Center.”

Lab-to-Fab Transition of Microelectronics Technologies

Research Universities, Start-ups have facilities for Lab prototyping but face barriers to demonstrating manufacturability in a Fab.

Core Facilities or Foundries/Fabs provide access to early stage Fab prototyping.

Microelectronics Commons aims to enable lab-to-fab prototyping—evolve microelectronics laboratory prototyping to foundry/fab prototyping—in domestic facilities.
Microelectronics Commons Addresses the Valley of Death

Research Universities, Start ups face barriers to Technology Demonstration

Core Facilities
- CMOS + New Technology Integration
- Non-CMOS

Innovation Hubs boost research connections to facilitate prototypes targeted to regional market strengths

Secure Edge/IoT Computing
AI HW at the Edge
Quantum Technology
5G/6G Technology
Commercial Leap Ahead Technologies

Electronic Warfare

Core Facilities provide access to scale early stage prototyping, and engage with Industry and NSTC to burn down risk for integration of new technologies with commercial SOTA

Commercial Industry

Defense Industrial Base

Defense Programs

Commercial adoption and optimization for Defense program demonstrators

VC Investment

Commercial and DoD Program Investment

University & USG

“Valley of Death”

Required Investment

Proof of Concept
Prototype in Laboratory
Prototype in a Foundry/Fab
Capacity in Production Environment
Demonstration of Production Rates
Defense Program and Commercial Adoption
The Deputy Secretary of Defense announced 8 Hub Award Winners on 20 September 2023

- Arizona State University led Southwest Advanced Prototyping or SWAP Hub – $39.8 million
- Midwest Microelectronics Consortium (MMEC) Hub – $24.3 million
- North Carolina State University led Commercial Leap Ahead for Wide Bandgap Semiconductors (CLAWS) Hub – $39.4 million
- The Applied Research Institute led Silicon Crossroads Microelectronics Commons Hub – $32.9 million
- Stanford University led California-Pacific-Northwest AI Hardware or Northwest AI Hub – $15.3 million
- The Applied Research Institute led Silicon Crossroads Microelectronics Commons Hub – $32.9 million
- The Massachusetts Technology Collaborative led Northeast Microelectronics Coalition Hub – $19.7 million
- The State University of New York led Northeast Regional Defense Technology or NORDTECH Hub – $40 million
- The University of Southern California led California Defense Ready Electronics and Microdevices Superhub (DREAMS) Hub – $26.9 million

Establishment of Microelectronics Commons Program

- The Microelectronics Commons RFS was released on November 30, 2022. Solutions were received and the RFS was closed on February 28, 2023
- Source Selection Determination Completed

(U) Microelectronics Commons Request for Solution (RFS)

(U) Industry Days and Upcoming Commons Meeting

- Industry Days were successfully conducted on December 7-8, 2022. The event saw both senior leadership and significant interagency participation. There were more than 900 participants in attendance at this hybrid event held at the Ronald Reagan Building and International Trade Center in Washington, D.C.
- The Inaugural Microelectronics Commons Meeting will be held on 17-18 October 2023 in Washington, DC

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Progression from Concept to Capabilities

OUSD (R&E)'S MICROELECTRONICS PROGRAMS ARE ALIGNED TO DEVELOP AND DELIVER NEW DEFENSE CAPABILITIES.

Microelectronics Commons
- Electronic Warfare
- Secure Edge/IoT Computing
- AI HW at the Edge
- Quantum Technology
- 5G/6G Technology
- Commercial Leap Ahead Technologies

Application Platforms
- Aircraft
- Submarines
- Ships
- Space Systems
- Ground Systems
- Missile Defense
- C4ISR

Technology Maturation
- RAMP
- RAMP-C
- SHIP
- T&AM Prototypes

Lab-to-fab prototyping bridges valley of death from laboratory research to foundry/fab prototyping

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