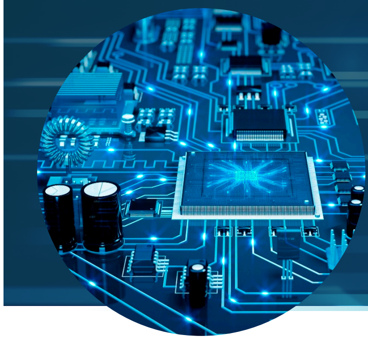


Sandia National Laboratories

Compound III-V Photonics

Sandians work on the most challenging and complex scientific problems that affect our nation's national security, contribute to broader economic development, and push the frontiers of science. Sandia develops compound semiconductor (III-V) optoelectronics components and photonics-based microsystems for communication, sensing and imaging, power delivery, computing, and renewable energy, specializing in high-performance and harsh environment applications.

Optoelectronics Capabilities

Sandia's National Security Photonics Center operates out of Sandia's MESA facility, leveraging co-joined compound semiconductor and silicon fabs, chartered to perform co-located high rigor production and ground-breaking research. Our 16,600 Square foot class 10 compound semiconductor fab has capabilities spanning semiconductor epitaxial growth through device processing with projection, stepper, and/or e-beam lithography, and includes heterogeneous integration and packaging capabilities. Sandia operates more than 10 MBE and MOCVD reactors producing custom epitaxial structures in arsenides, phosphides, antimonides and nitrides.

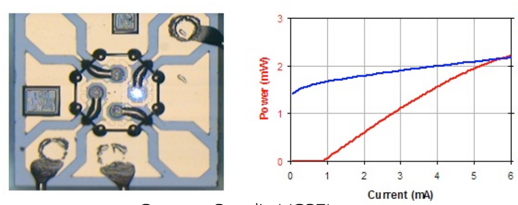
Sandia's optoelectronics team collaborates broadly with partners and customers and offers multi-project wafer (MPW) runs in InP and silicon photonics platforms. Our broader portfolio includes heterogeneously-integrated lasers and detectors, and a toolkit of 'Photonics for Quantum' technologies.

VCSEL Microsystems

Vertical-Cavity Surface-Emitting Lasers (VCSELs) achieve the lowest power consumption of any electrically driven laser, making them ideal for power sensitive applications like chip-scale atomic clocks, ultra-low power communications, and quantum sensing. Sandia has a unique ability to develop novel VCSEL devices using proprietary capabilities developed over the past 25 years that are not commercially available. Sandia has been recognized as a leader in VCSEL research since the early 1990s, with over 1000 research publications and an extensive portfolio of intellectual property.

The VCSEL research activity at Sandia is vertically integrated, with a unique breadth of in-house capabilities spanning VCSEL design, modeling, epitaxial semiconductor growth, cleanroom microfabrication, electrical characterization, optical characterization, and heterogeneous microsystem integration.

VCSELs, with typical threshold currents range between 0.5 and 1.0 mA, and operating voltages below 2V, also have high modulation bandwidth (10 GHz typical), circular output beam for coupling to optical fibers, high electron-to-photon differential quantum efficiency (50% typical), inherent single-longitudinal-frequency mode operation, and small cavity volume (a cylinder approximately 8 microns tall and 8 microns in diameter). These properties make VCSELs highly attractive for low power optical microsystems.



Custom Sandia VCSELs

Photonic Integrated Circuits (PICs)

Sandia's InP photonic integrated circuit platform includes a portfolio of components and devices including single-wavelength tunable diode lasers, modulators, amplifiers and interconnection optical waveguides. The platform is produced with state of-the-art III-V metal-organic chemical vapor deposition (MOCVD) growth and regrowth, and post-growth quantum-well band-gap modification using quantum-well intermixing (QWI) methods to achieve the multiple band-edges, self-alignment, and optical confinement needed for highly-functional PICs. PIC design and simulation is supported by experienced

MESA Research | Develop | Produce

U.S. Department of Energy NNSA National Nuclear Security Administration

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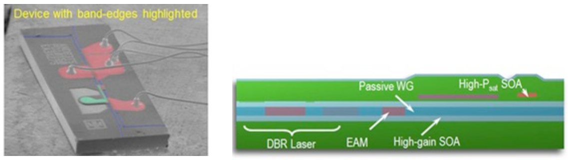
SAND2023-06389M.

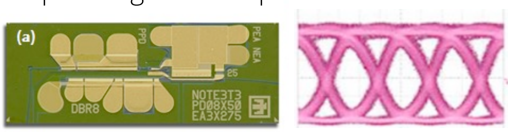
MICROSYSTEMS ENGINEERING, SCIENCE & APPLICATIONS

PhD-level staff spanning the complete design spectrum from optical guided-mode solvers and device electronics to complete optical circuits using Eigenmode expansion, finite-difference time-domain, and beam propagation methods.

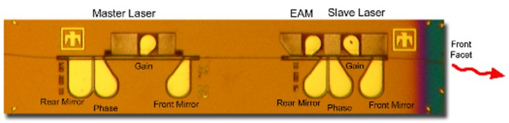


InP Photonics Integrated Circuits (PIC)

Some applications of this technology include: a) all optical domain processing of a broad radio frequency spectrum into 1-3 GHz wide channels, b) all optical logic circuits operating at 40 Gbps.



All-optical Logic Gate and 40 Gb/s eye diagram



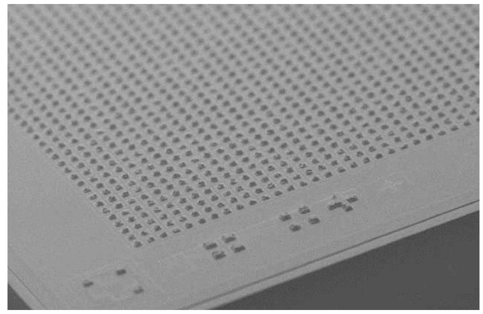
Silicon Photonic Multi-Project Wafer (MPW)

Sandia is not a pure-play foundry. Sandia also offers R&D collaborative multi-project wafer (MPW) runs for InP Photonic Integrated Circuits (PICs). Sandia specializes in MPWs for U.S. entities that need export-control, collaborative development, and/or more platform flexibility than is offered by other commercial MPWs.

Focal Plane Arrays

Sandia National Laboratories has a long history and expertise in the development and demonstration of advanced infrared focal plane array (FPA) materials, devices, and data processing. Current R&D projects are centered on superlattice FPAs in the shortwave, mid-wave, and long-wave infrared bands, leveraging novel III-V materials in phosphides and antimonides. Sandia has consistently demonstrated the highest material and device performance and is leading the development of cutting-edge infrared sensors, pushing the envelope of resolution and performance.

Furthermore, advanced photonic integration concepts and methods are being developed to realize greater functionality of infrared sensors, such as agile spectral sensing and hyperspectral imaging, to enhance mission quality while driving down size, weight, power, and cost. Capabilities include multiple molecular-beam epitaxy reactors, large-format FPA fabrication/ hybridization, and advanced nanoscale lithography.



Focal Plane Array

Optoelectronics for Radiation Environments

Radiation Hardened optoelectronics support systems that operate in space, at high altitude, in defense scenarios or in close proximity to nuclear reactors. Sandia has a 20+ year history in optoelectronics radiation effects, and we have created and tested many custom semiconductor designs. Custom components include lasers, photodiodes, LEDs, laser drivers, and transimpendance amplifiers, and these, in turn have been used in Optocomm transceivers, focal plane arrays, optoisolators, photovoltaics, and photonic integrated circuits. Unique tools radiation-aware optical link models, and optoelectronic device and circuit models, and Ion Beam Laboratory measurement capability, where individual components within a photonic integrated circuit can be individually interrogated.

Photonics for Quantum

We use a suite of application-specific quantum photonic integrated circuit (QPIC) technologies to shrink the optical tables that interface with the quantum world to chips that perform the same function. Sandia specializes in quantum device realization. In addition to a Silicon photonics integrated platform, we have a GaAs PIC platform, a dielectric multi-wavelength platform spanning UV to NIR (with heterogeneously-integrated lasers and acousto-optics), and narrow linewidth VCSELs.

Sandia engineers optoelectronics devices to operate in extremes of high and low temperature, shock and vibration, and intense radiation environments.

For additional information, visit our website at: www.sandia.gov/mesa/nspc

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