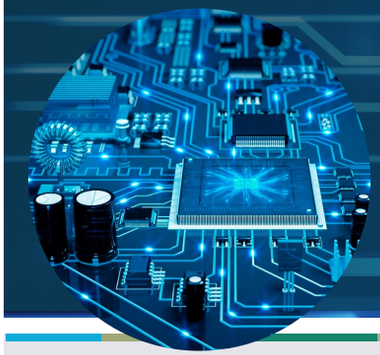


Sandia National Laboratories

Silicon Photonics Platform

To support next generation computing, communication, and sensing needs, Sandia researchers have successfully developed a silicon photonics platform that leverages the semiconductor and nanotechnology capabilities of Sandia's Microsystems and Engineering Sciences Applications (MESA) complex to create optical components for multiple applications.

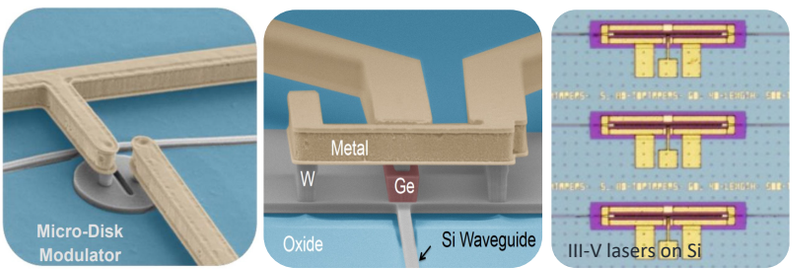
Computing Challenges

As integrated circuit chips now incorporate over a billion transistors, and single boards provide multi-teraflop (10^{12}) computing capacity, the bandwidth and energy required to communicate data within and between integrated circuits are becoming a primary performance bottleneck.

Silicon photonics offers a potential breakthrough in optical interconnection performance, not only for supercomputer applications, but also for data communication and other applications.

Power Saving and Speed

Silicon photonics devices are comprised of silicon nanowire waveguides clad in silicon dioxide (SiO2). The large refractive index contrast between the silicon waveguide and the oxide cladding allows light to be routed in the waveguide. Optical modulation may be achieved using micro-disk resonators of just a few microns in diameter. Such resonant electrically controlled optical modulators can have capacitances as low as 20 femtofarads, and can operate with an electrical energy usage of 3.2 femtojoules (fJ) per bit or lower, or 40 μW for 12.5 gigabits per second of information. This power saving is critical in high performance computing, satellite communications, and high output sensors like cooled focal plane arrays. In addition, Sandia has demonstrated many leading-edge silicon photonics devices, from integrated avalanche photodetectors, to transceivers and optical switching building blocks for low-energy optical networks.



Non-Traditional Applications

As silicon photonics technology matures, new exciting applications have emerged, from harsh environments to analog signal processing to quantum computing, communication, and sensing. Optical systems offer some inherent benefits over electrical systems due to their insensitivity to electromagnetic interference. Integrated photonics is inherently more compact and has been shown to be more rugged than bulk optical systems. Promising results also indicate immunity to radiation with a wide operating temperature range.

Sandia researchers are actively exploring technology applications from cryogenic temperatures (<4k to 70k) to high radiation environments for national security. For RF systems that are computationally intensive and require high frequency operation, Sandia is developing novel components and a heterogeneously integrated photonics platform with III-V lasers and amplifiers targeted for analog signal processing with power savings and frequency agility. Sandia has also demonstrated compact integrated beam steering and light delivery systems for multiple wavelengths to support imaging, free-space communications, and quantum inertial sensors, clocks, and computing applications.

MESA Research | Develop | Produce
U.S. DEPARTMENT OF ENERGY
NNSA National Nuclear Security Administration

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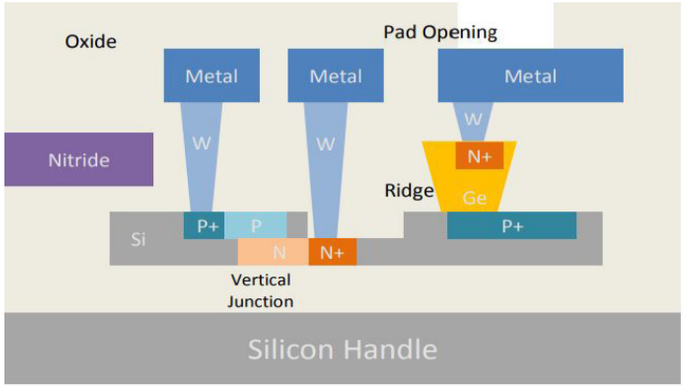


Sandia's device library includes optical channelizers, filters, and modulators that enable next-generation compact, high-performance spectrum analysis and communication systems.

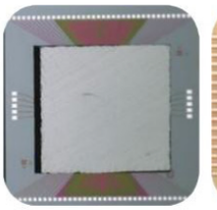
Commercialization Path

Sandia continues to advance its silicon photonics platform with integration of new materials and to develop new devices and systems for a variety of applications. We are utilizing heterogeneous integration technology to create microsystems with CMOS, silicon photonics, and III-V materials.

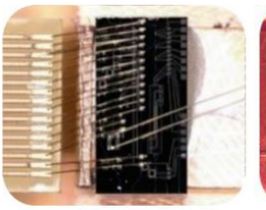
We are actively seeking collaborators on photonics projects ranging from fundamental research to commercialization of technologies in areas related to low-energy optical communication and computing, as well as other areas of importance for national security such as RF signal processing, quantum information systems, secure communication, sensing, and imaging.

We welcome discussions with academic and commercial entities interested in Sandia's Si photonics (SiP) multi-project wafer (MPW) and custom fabrication runs for research, device prototyping, and low-volume product manufacturing using our unique fabrication capabilities. Participants may leverage Sandia's SiP Process Design Kit (PDK) and device library while collaborating with our team to customize these designs or to co-develop novel concepts for their requirements. Interested parties may collaborate with Sandia through Cooperative Research and Development Agreement (CRADA) and Strategic Partnership Projects (SPP). Sandia also supports the American Institute for Manufacturing Integrated Photonics (AIM Photonics).

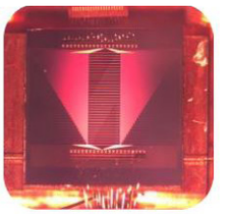
Fabricated chip from multi-project wafter (MPW) run



CMOS on Silicon Photonics



Quantum Key Distribution Transceiver

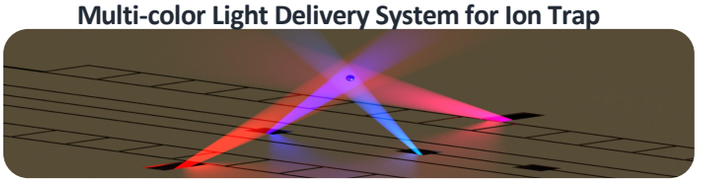


AWG Channelizer

Intellectual Property Licensing

Sandia's broad portfolio of intellectual property in silicon photonics (over 40 patents) is available for licensing through Commercial License Agreements. This portfolio includes several essential technologies for advanced optical systems: low-voltage, high-speed resonant modulators with integrated heaters for wavelength tuning; scalable methods for wavelength stabilization of resonant devices; high-frequency Mach Zehnder modulators and switches with depletion-mode vertical and heterogeneously integrated electro-optic phase-shifter; single sideband modulators, single photon and avalanche photodetectors; and many others.

Multi-color Light Delivery System for Ion Trap



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Microsystems Engineering,
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Intellectual Property & Licensing
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Low-energy, high-speed optical communication and signal processing

MICROSYSTEMS ENGINEERING, SCIENCE, & APPLICATIONS

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