SILICON PHOTONICS PLATFORM

Low-energy, high-speed optical communication and signal processing

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.

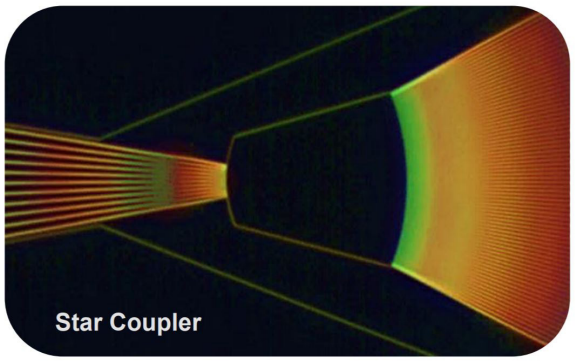
Computing Challenges

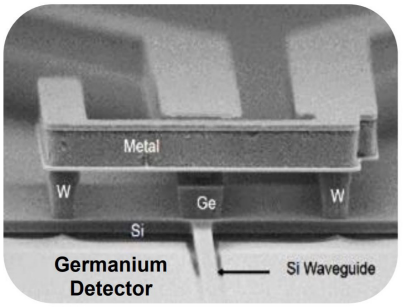
As integrated circuit chips now incorporate over a billion transistors, and single boards provide multi-teraflop (1012) computing capacity, the bandwidth and energy required to communicate data within and between integrated circuits are becoming a primary performance bottleneck.

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 with just a few microns of diameter.





These resonant electrically controlled optical modulators can have capacitances as low as 20 femtofarads, and can operate with an electrical power 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 to the optical resonant modulator, 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

Optical systems offer some inherent benefits over electrical systems due to their insensitivity to electromagnetic interference. Thus silicon photonics offers potential unique advantages over electronics for harsh environments. With promising results, Sandia researchers are actively exploring technology applications from cryogenic temperatures to high radiation environments. Silicon photonics also provides advantages beyond traditional digital applications. For RF systems that are computationally intensive and require high frequency operation, silicon photonics may be used for analog signal processing with power saving and frequency agility.

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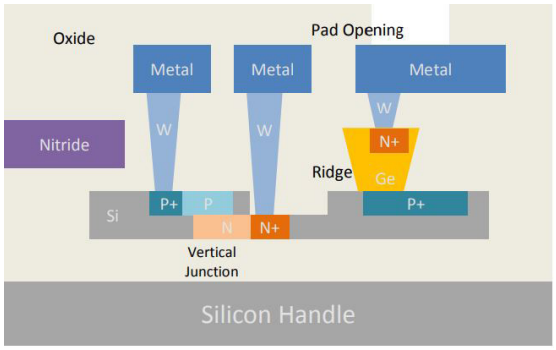


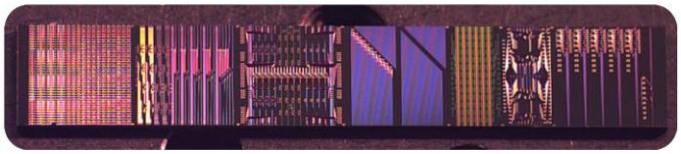
Sandia has developed optical components including filters, modulators, and channelizers that enable next-generation compact, high-performance spectrum analysis and communication systems.

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.

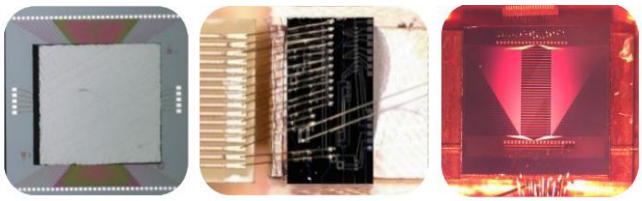
We are actively seeking collaborators on photonics projects ranging from fundamental esearch to commercialization of technologies in areas related to lowenergy optical communication and computing, as well as other areas of importance for national security such as RF signal processing, quantum information system, 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 is available for licensing through Commercial License Agreements.

This portfolio includes several essential technologies for building low-power highspeed optical networks; low-voltage, high-speed resonant modulators with integrated heater for wavelength tuning; scalable methods for wavelength stabilization of resonant devices; high-speed MachZehnder devices with depletion-mode vertical p-n junction phase-modulator in MZ configuration; traveling wave carrier depletion MZ modulator; avalanche photodetectors; and many others.

Further Information:

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Silicon Photonics Patents

Sandia's National Security Photonics Center (NSPC) has developed a substantial portfolio of intellectual property in the area of silicon photonics. This portfolio includes several essential technologies for building low-power, high-speed optical network and radio frequency (RF) photonics systems.

US Patent 9759862	Adiabatic / Diabatic Polarization Beam Splitter	SD 13395.0
US Patent 9748429	Avalanche Diode Having Reduced Dark Current and Method for Its Manufacture	SD 12844.0
US Patent 9696492	On-Chip Photonic-Phononic Emitter-Receiver Apparatus	SD 13163.0
US Patent 9612459	Resonant Optical Device with a Microheater	SD 12821.0
US Patent 9467233	Power Meter Ratio Methods of Stabilizing a Resonant Modulator	SD 12707.0
US Patent 9488854	High-speed Optical Phase-shifting Apparatus	SD 12219.3
US Patent 9391225	Two-dimensional APDs and SPADs and Related Methods	SD 12391.0
US Patent 9366822	Thermo-optically Tuned Photonic Resonators with Concurrent Electrical Connection and Thermal Isolation	SD 12705.0
US Patent 9329413	Method and Apparatus of Highly Linear Optical Modulation	SD 12381.1
US Patent 9268195	Methods and Apparatus of Entangled Photon Generation Using Four-wave Mixing	SD 12348.0
US Patent 9268092	A Guided Wave Opto-acoustic Device	SD 12417.0
US Patent 9261647	Methods of Producing Strain in a Semiconductor Waveguide and Related Devices	SD 12206.0
US Patent 9239431	Athermalization of Resonant Optical Devices Via Thermo-mechanical Feedback	SD 11605.0
US Patent 9235065	Thermally Tuneable Optical Modulator Adapted for Differential Signaling	SD 12261.0
US Patent 9128308	Low-voltage Differentially-signaled Modulators	SD 12152.1
US Patent 9127983	Systems and Methods for Controlling an Operating Wavelength	SD 12413.0
US Patent 9083460	Methods and Devices for Optimizing the Operation of a Semiconductor Optical Modulator	SD 12234.0
US Patent 9081215	Silicon Photonic Heater-Modulator	SD 12151.1
US Patent 9081135	Methods and Devices for Maintaining a Resonant Wavelength of a Photonic Microresonator	SD 12207.0
US Patent 9063354	Passive Thermo-Optic Feedback for Robust Athermal Photonic Systems	SD 11279.0
US Patent 9052535	Electro-refractive Photonic Device	SD 12240.2
US Patent 8947764	High-Speed Photonics Modulator Design	SD 12219.2
US Patent 8822959	Method and Apparatus for Optical Phase Error Correction	SD 12024.0
US Patent 8625939	Ultralow Loss Cavities and Waveguides Scattering Loss Cancellation	SD 11631.0
US Patent 8615173	Systems for Active Control of Integrated Resonant Optical Device Wavelength	SD 11555.0
US Patent 8610994	Silicon Photonics Thermal Phase Shifter with Reduced Temperature Range	SD 11837.0
US Patent 8600200	Nano-optomechanical Transducer	SD 11508.1
US Patent 8027587	Integration Optic Vector-Matrix Multiplier	SD 10237.1
US Patent 7983517	Wavelength-Tunable Optical Ring Resonators	SD 10791.1
US Patent 7941014	Optical Waveguide Device with an Adiabatically-Varying Width	SD 11104.0
US Patent 7667200	Thermal Microphotonic Sensor and Sensor Array	SD 10128.0
US Patent 7616850	Wavelength-Tunable Optical Ring Resonators	SD 10791.0

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Microsystems Engineering, Science, and Applications (MESA)

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