



National Security Photonics Center

Our Vision: Serve the nation as a center of excellence for national security photonics through scientific excellence, responsive pathfinders, and fielded products.

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Capability



MESA
Microsystems and Engineering Sciences Applications

MESA Complex

- 60,000 square feet of cleanroom space with state-of-the-art growth and processing toolsets
- 100,000 square feet of laboratories, including dedicated Si photonics and III-V device development labs
- Prototype systems incorporating silicon photonics, digital and mixed signal rad-hard CMOS, FPAs, MEMS, microfluidics, and optics



60+ Photonics Staff

Device Design, Modeling, Simulation
Semiconductor Device Fabrication
Microsystem Fabrication
Testing, Rad Effects, Cryo Reliability

Compound Semiconductor Fab

- Custom epitaxial growth of GaAs, InP, GaSb and GaN materials
- Custom III-V devices

Silicon Photonic Research Foundry

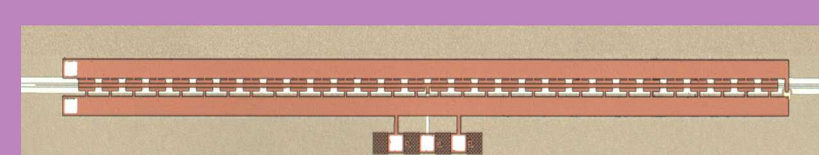
- 6 in. SOI wafers: 250nm device layer and 3 μ m buried oxide layer
- Active devices and passive structures
- Selective area epitaxy of Ge
- Multi-Project Wafers and library devices available

Flexibility

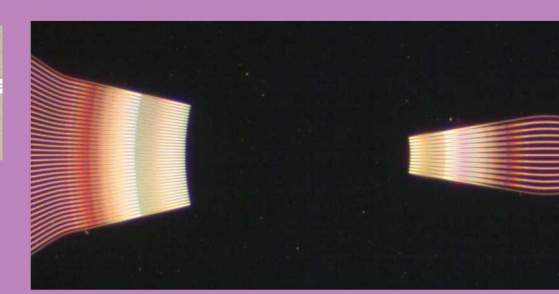
Silicon Photonics Platform

Why Silicon Photonics?

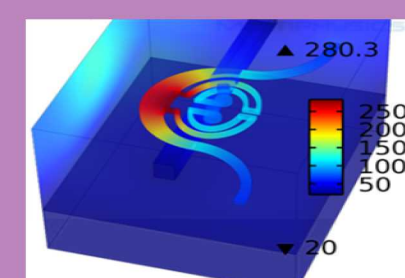
- Leverage existing CMOS infrastructure
- Close integration with CMOS electronics
- Low power, high speed devices
- Low loss waveguides (<0.1 dB/cm possible)



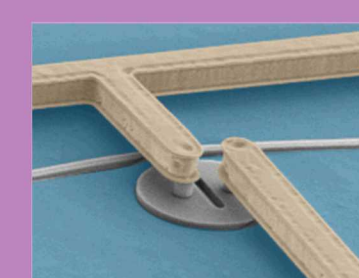
Travelling wave EO phase shifter
23 GHz Bandwidth



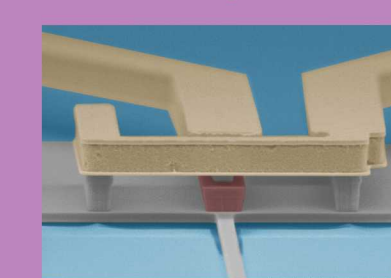
Star coupler



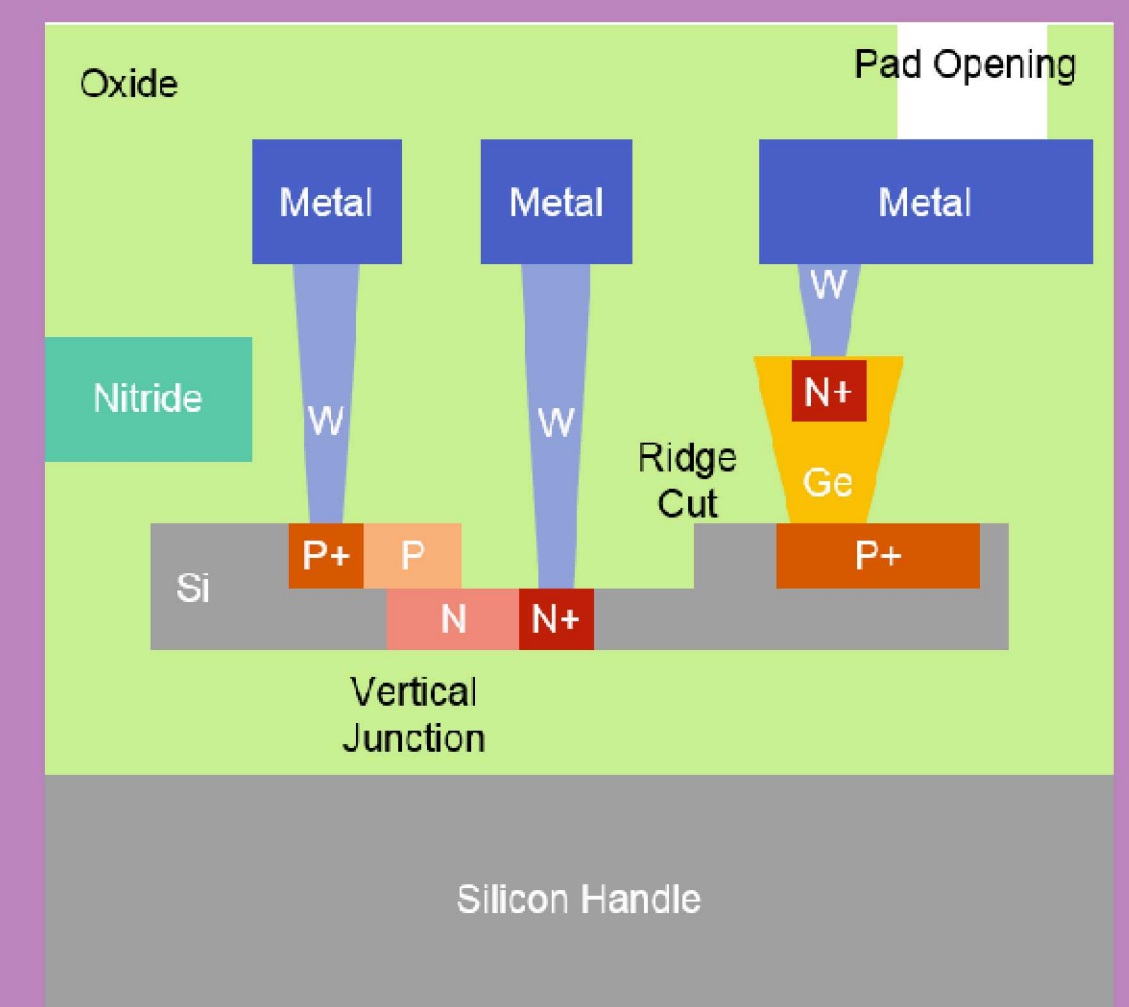
Thermal Simulation of phase shifter



High Speed EO Modulator

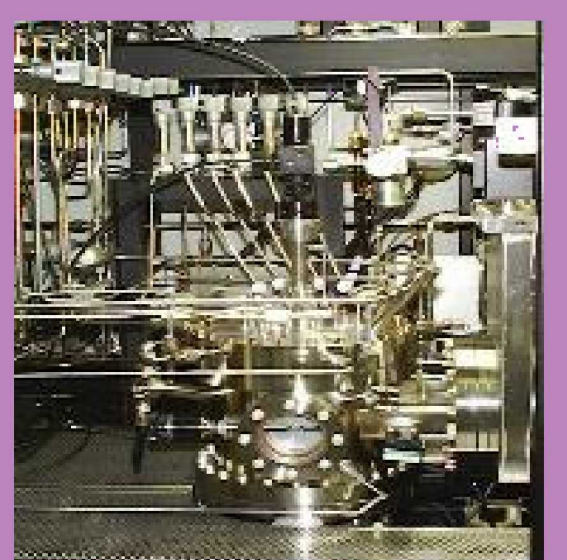
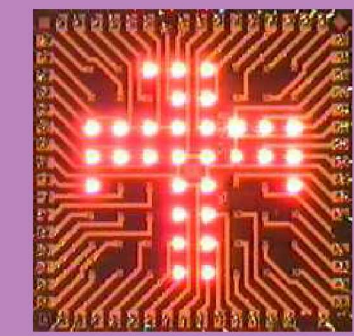


High Speed Ge Photodiode



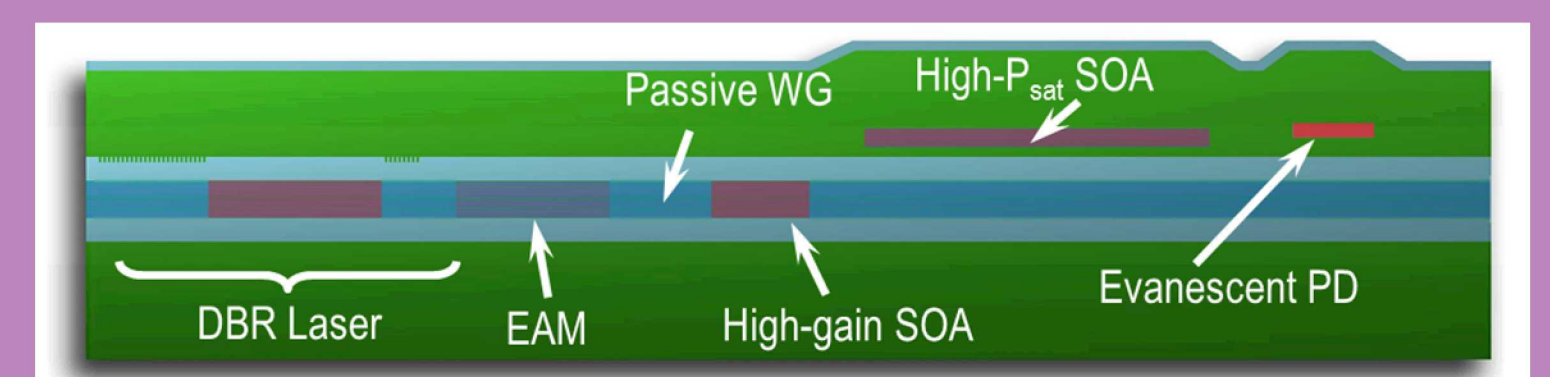
Optoelectronics and PICs

- InP PICs provide efficient, high speed generation, modulation and detection at 1550 nm
- Sandia's PIC toolkit includes:
 - Lasers
 - Modulators
 - Optical Amplifiers
 - Detectors
- Demonstrated circuits:
 - Transmitters
 - Receivers
 - Optical logic gates
 - Optical RF channelizers
 - Coupled-cavity lasers



Examples: rings, VCSELs and optical logic

Epitaxy



Layer structure for PIC active components

Success

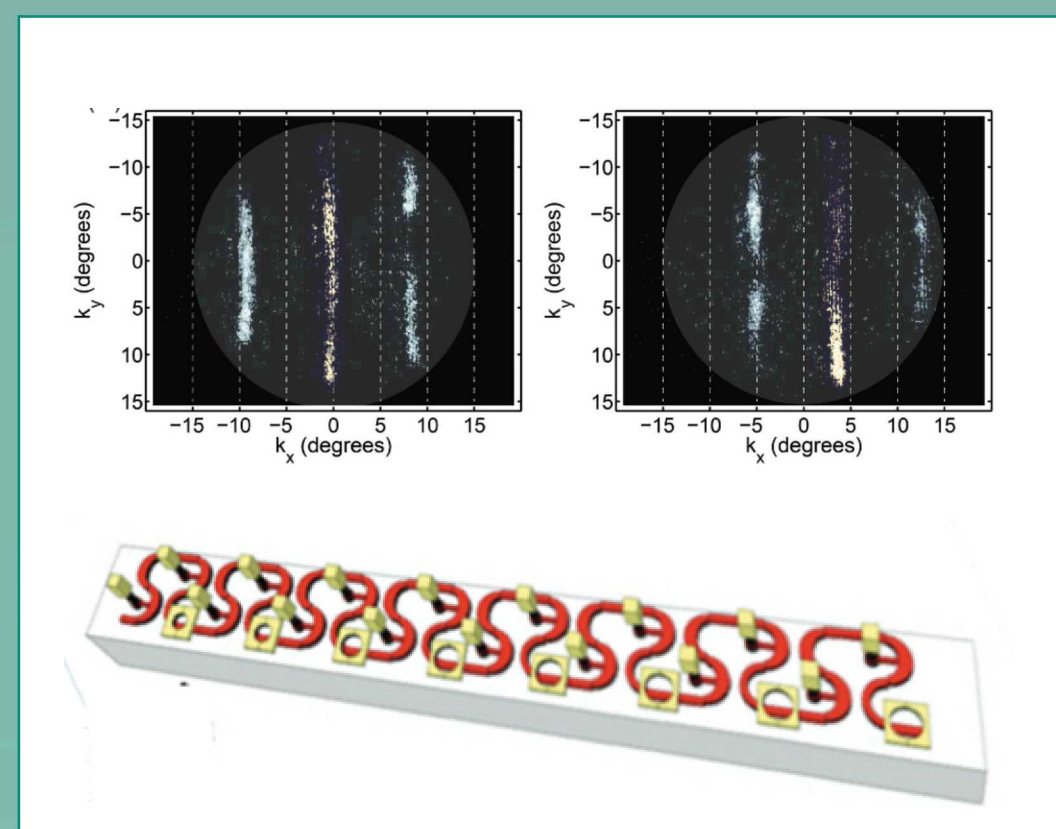
Tantalum nanoantenna for beam steering

- CMOS compatible
- 8 degree beam steering demonstrated
- Active control with phase shifters
- Telecom wavelength operation
- Patents issued

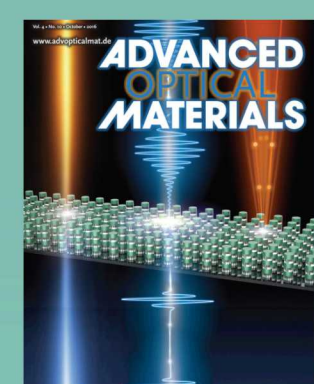
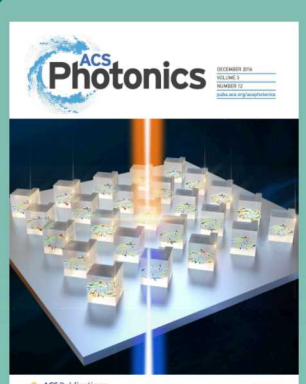


SWEeper
Program

DeRose, C. T., et al. "Electronically controlled optical beam-steering by an active phased array of metallic nanoantennas." *Optics express* 21.4 (2013): 5198-5208.



R&D Leadership & Recognition



Journal covers in FY2017



Ultralow-power Silicon Microphotonic Communication Platform



Microsystems Enabled Photovoltaics

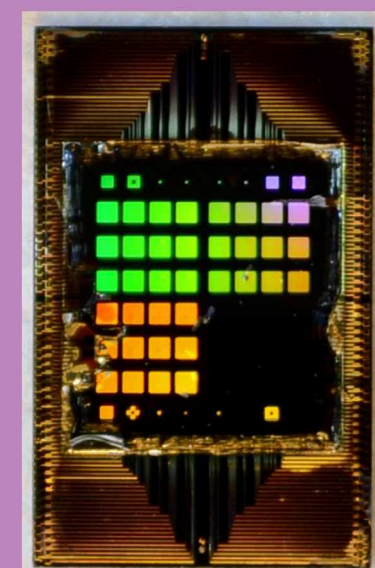
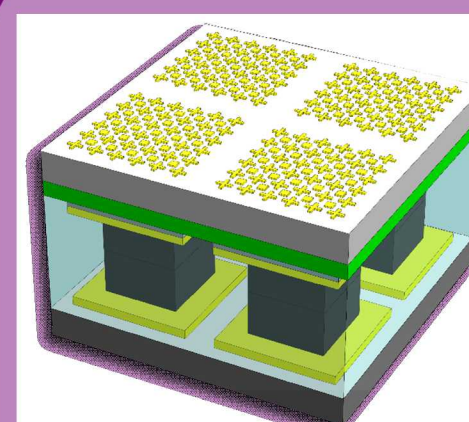


T-QUAKE Transceiver for Quantum Keys and Encryption

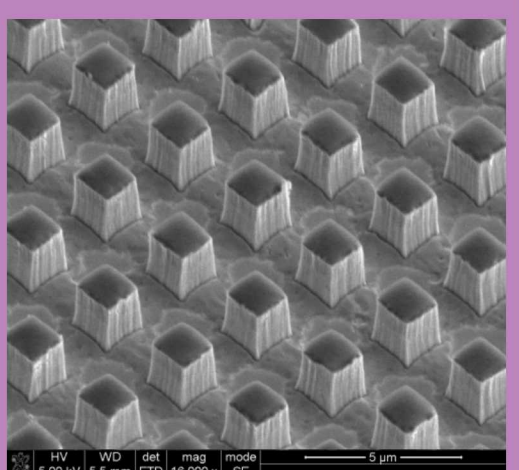
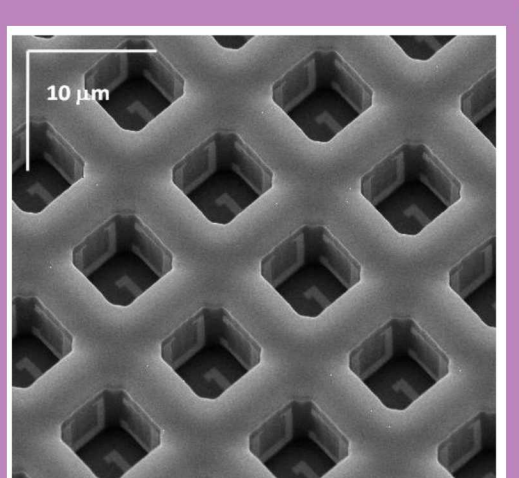
Patents and Tech Transfer

Over 100 issued patents issued,
22 patents issued in 2017
Silicon Photonics: 34 patents issued, ~10 pending
Compound Semiconductor Photonics: ~70 Issued active patents, many pending
Licensing & Technology Transfer
VCSEL laser technology to a broad list of companies
Beam Steering
Atomic Clock Integrated VCSELs to Microsemi
Microsystem photovoltaics to mPower

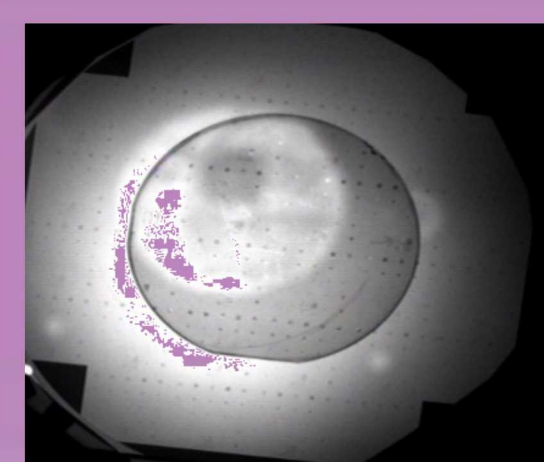
Metamaterials and Photonic Crystals



Metal and dielectric metamaterials in 2D and 3D. Photonic crystals from the visible to LWIR made from traditional and esoteric materials. Integration directly with LWIR detectors leading to increased QE and reduced dark current.



Heterointegration of materials



IR Image of Wafer Bonded III-V

III-V materials

- Wafer bonding of III-V directly to silicon photonics
- Integrated lasers and amplifiers at 1550 nm

Thin Film LiNbO3

- Second harmonic generation
- Parametric down conversion
- Low voltage, high frequency modulators
- Large spur-free dynamic range

