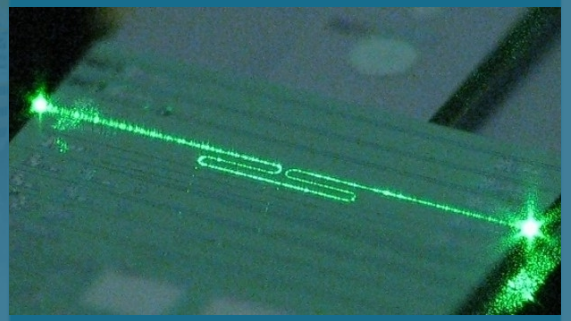
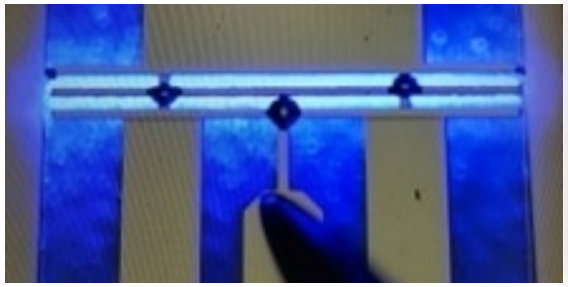
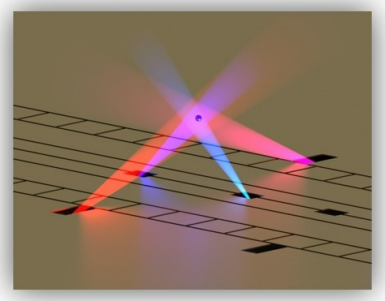
SAND2022-6833C

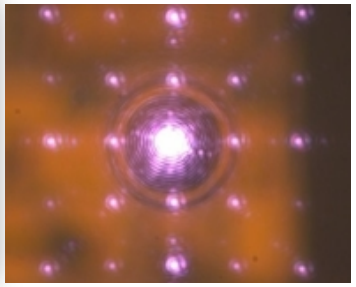
Sandia National Laboratories

Photonics at Sandia National Laboratories









Darwin Serkland, DKSERKL@sandia.gov
Sandia National Laboratories

May 21, 2022
Stanford University Photonics Retreat (SUPR)
Asilomar Conference Grounds
Pacific Grove, CA

U.S. DEPARTMENT OF ENERGY NNSA

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

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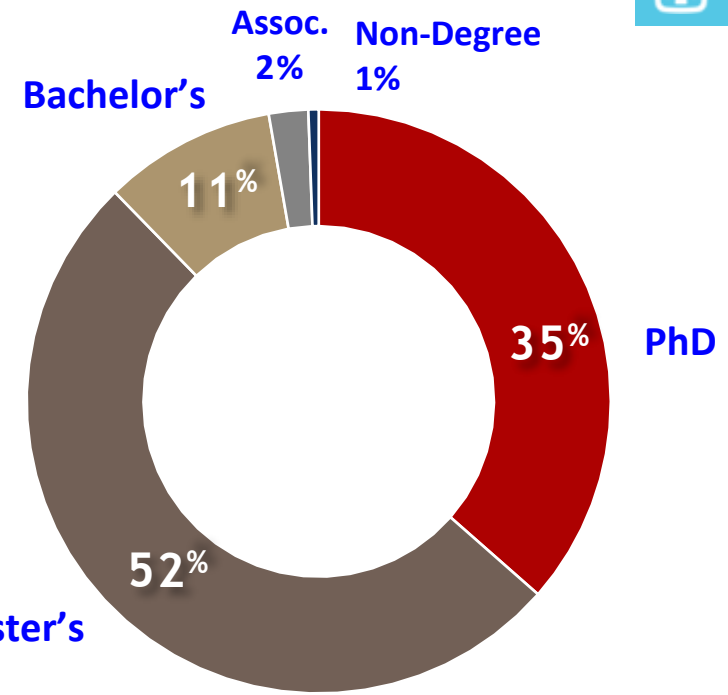
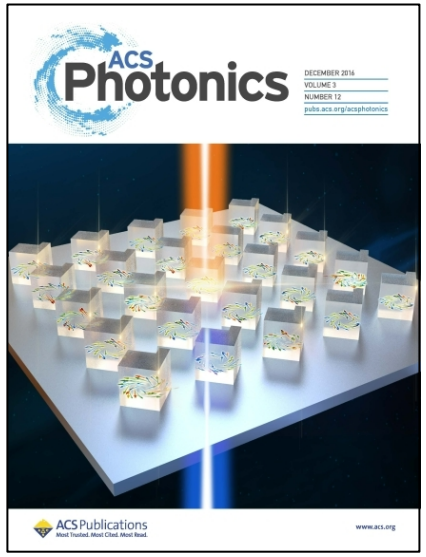
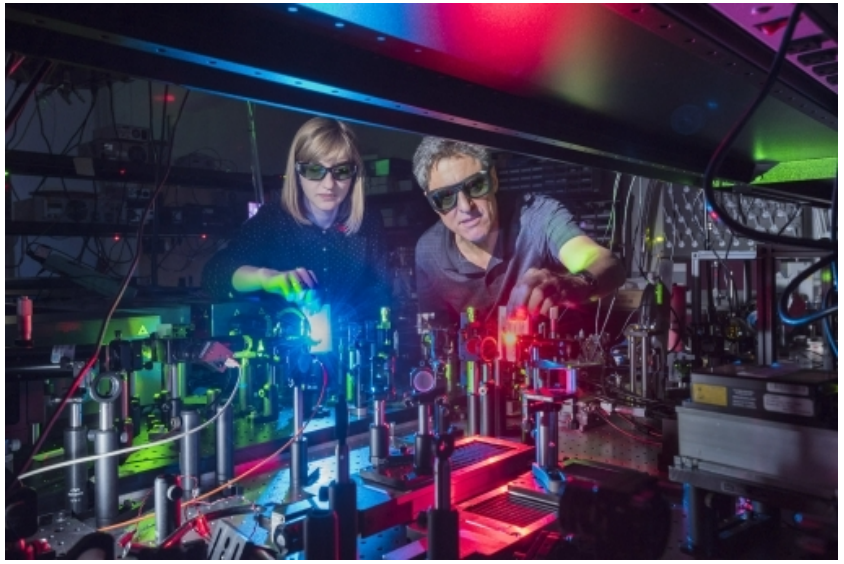
Sandia National Laboratories Introduction

- 12,900 employees
  - 88% in Albuquerque, NM
  - 12% in Livermore, CA
- Sandia is diverse (like Stanford)
  - Multiple experts on every topic
  - 60 Photonics/Optics PhDs
- Sandia sits in the middle of the spectrum
  - Between academia and industry



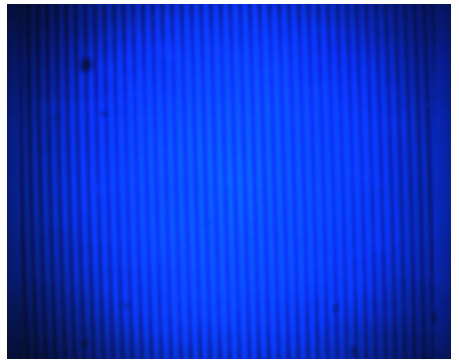




How Sandia can benefit professors and students today?

- Professors:
  - Sandia funds collaborative research at $90k/year for up to 3 years
- Professors and Students:
  - Free access to CINT resources
    - Nano-fabrication facilities and staff
    - Compound Semiconductor Epitaxy
    - Imaging FIB/TEM/SEM
    - Nano-beam ion implantation
      - Controlled single-vacancy fabrication
- Students:
  - Well-funded post-doc fellowships
    - Truman and Hruby
  - Well-paid internships for collaborative research

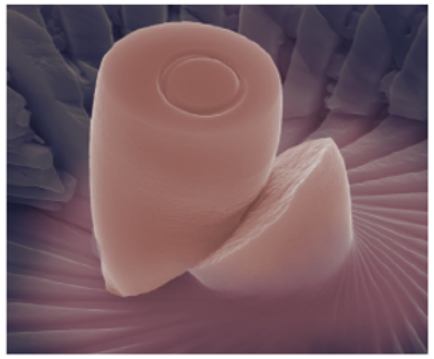
Truman Fellowship



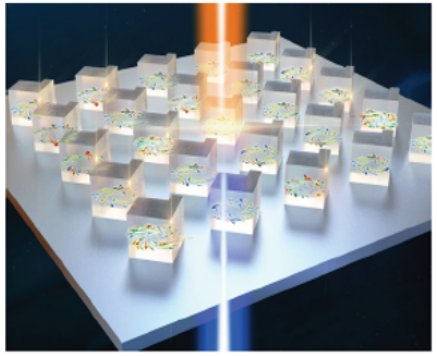
Center for Integrated Nanotechnologies (CINT): Open-Access

About CINT:

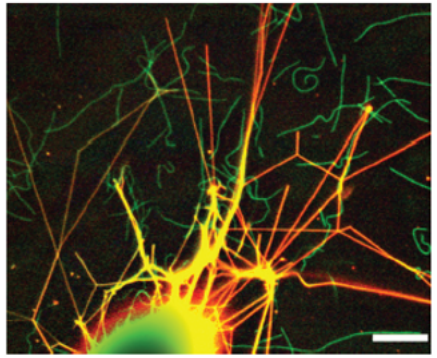
- *Free access to staff expertise and equipment for open science*
- *Two proposal calls per year; proposals for short-term projects are accepted continuously*
- *Simple 2-page proposal*
- *Proprietary research is possible with full-cost recovery*



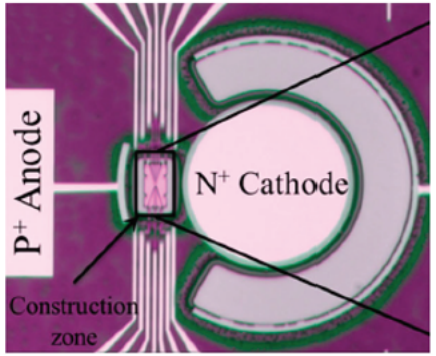
In-Situ Characterization and Nanomechanics
Developing and implementing world-leading capabilities to study the dynamic response of materials and nanosystems to mechanical, electrical, or other stimuli.



Nanophotonics & Optical Nanomaterials
Synthesis, excitation, and energy transformations of optically active nanomaterials and collective or emergent electromagnetic phenomena (plasmonics, metamaterials, photonic lattices).



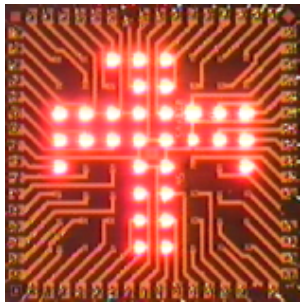
Soft, Biological & Composite Nanomaterials
Synthesis, assembly, and characterization of soft, biomolecular, and composite nanomaterials that display emergent functionality.

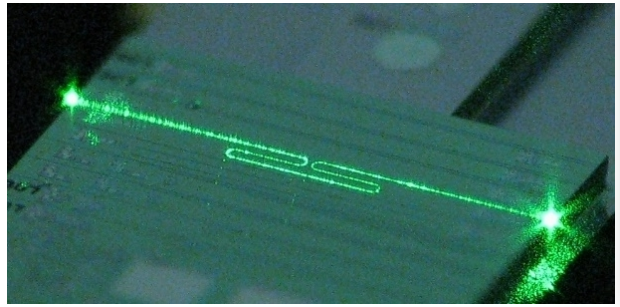


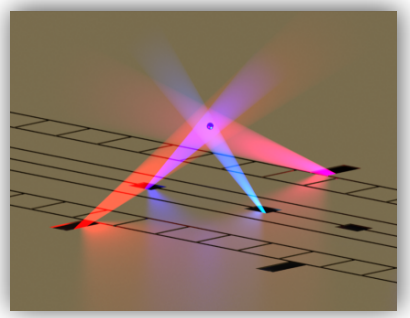
Quantum Materials Systems
Understanding and controlling quantum effects of nanoscale materials and their integration into systems spanning multiple length scales.

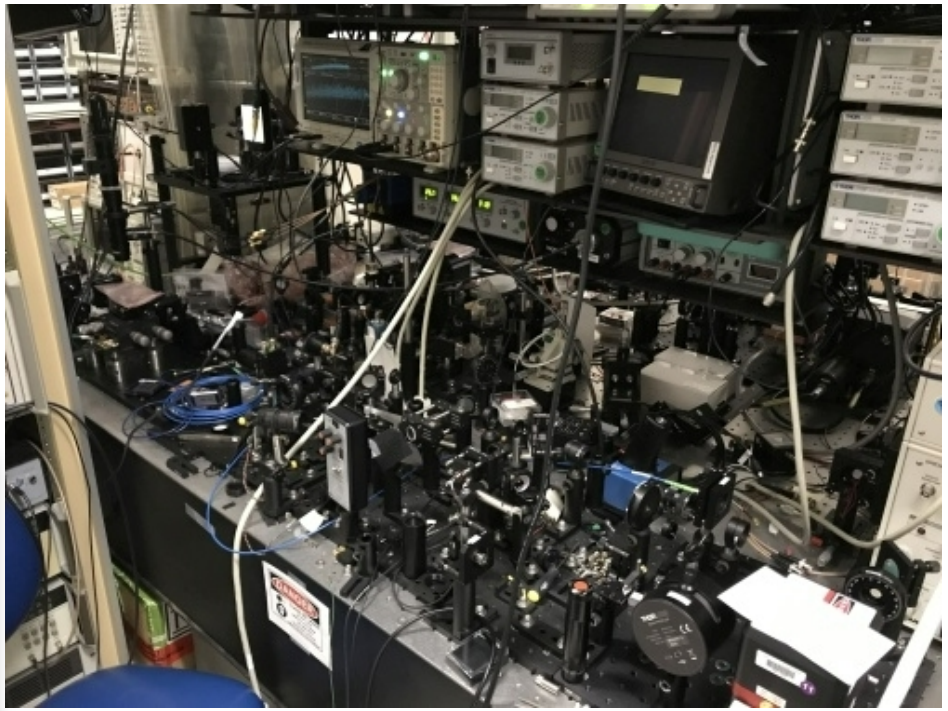
Overview of Photonics at Sandia

- 60 Photonics PhDs
- Research spectrum matches Stanford
- Facilities/resources are amazing





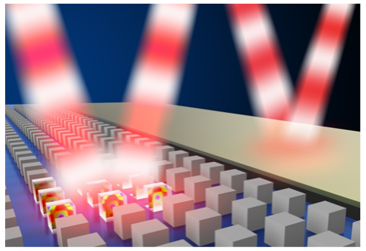




Light-Matter Interaction Using Metamaterials: Linear and Nonlinear Optics

Combining nanostructures and metamaterials with state-of-the-art compound semiconductors to achieve new behaviors

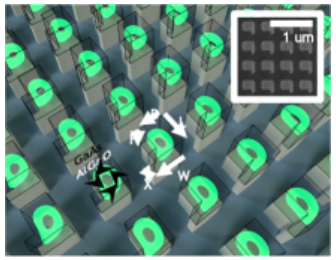
Optical Magnetic Mirror

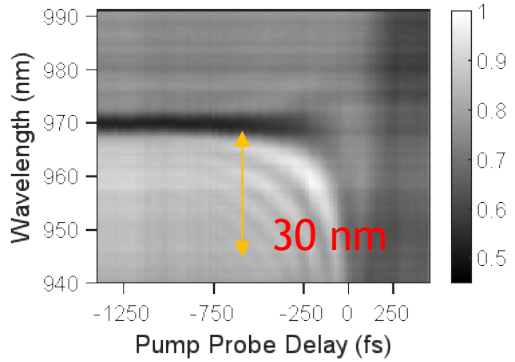


Enhances light field interactions at the mirror surface for absorbers & emitters

S. Liu et al., Optica **1**, 250 (2014)

Frequency Conversion in a Time-Variant Metasurface

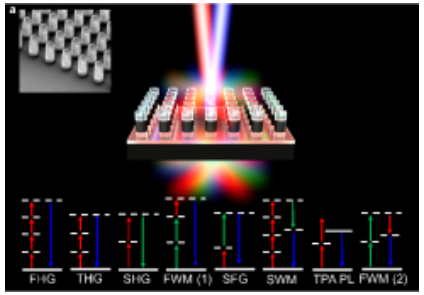




Rapidly varying high Q resonance generates new wavelengths

Karl *et al*, Nano Lett **20**, 7052 (2020)

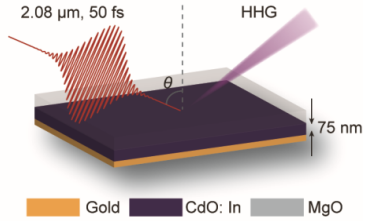
Optical Nonlinear Mixer

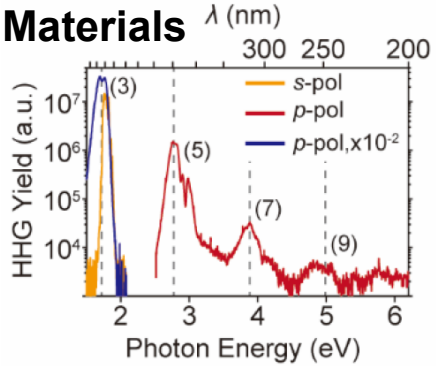


Eleven new frequencies (colors) simultaneously generated using nonlinear mixing

P. Vabishchevich, et al., Nature Communications (2018)

High Harmonic Generation from Epsilon-Near-Zero (ENZ) Materials





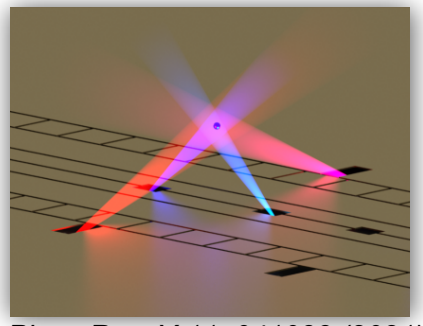
Generation of High Harmonics using a thin film of ENZ material with ~100 times less power than current approaches

Y. Yang, et al., Nature Physics **15**, 1022 (2019)

***Igal Brener**, ibrener@sandia.gov*

Quantum Integrated Photonics at Sandia

Ion Trap Interface w/ Integrated Photonics

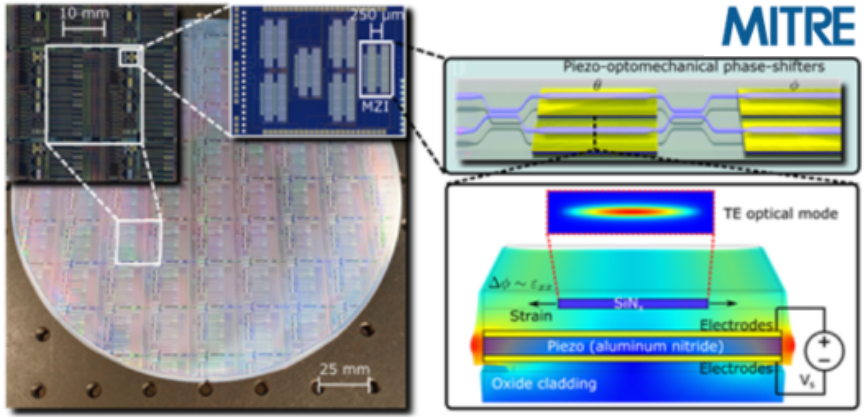


Phys. Rev. X 11, 041033 (2021)

10 Gb/s Cryogenic Optical Modulator

Optica **4**, 374 (2017)

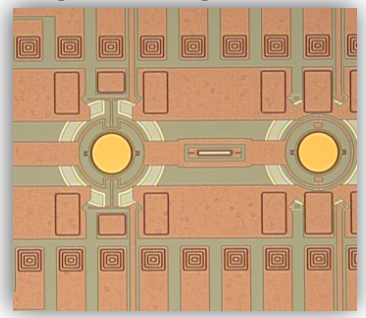
High Speed Piezo-Electric Photonic Control at Visible Wavelengths



Nat. Photonics **16**, 59-65 (2022)

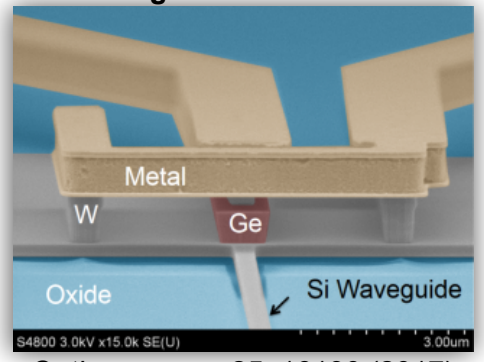
Ion Trap Integrated Single Photon Detectors

DARPA



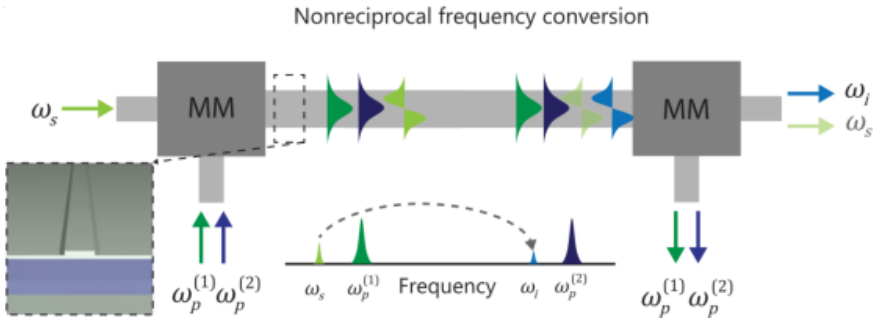
Appl. Phys. Lett. 119, 154002 (2021)

Ge Single Photon Detector



Optics express **25**, 16130 (2017)

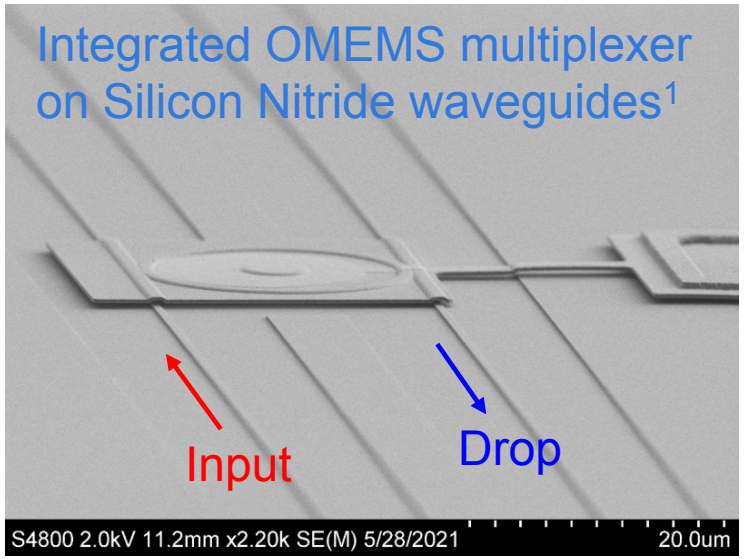
Quantum Frequency Conversion

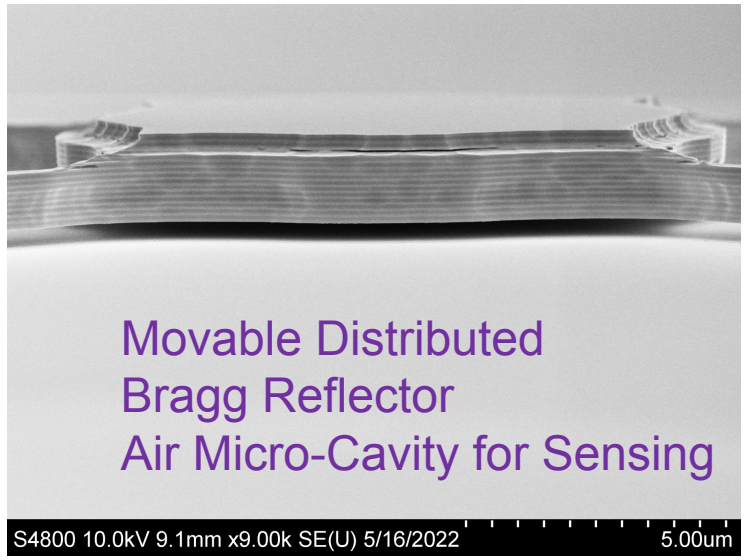


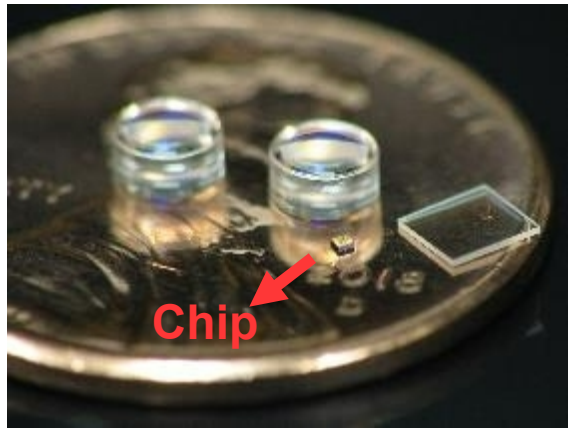
Phys. Rev. Lett. **127**, 253603 (2021)

Many Post-Doc & Collaborative Opportunities – Reach out to:
Matt Eichenfield (meichen@sandia.gov) Paul Davids (pdavids@sandia.gov)
Michael Gehl (mgehl@sandia.gov) Nils Otterstrom (ntotter@sandia.gov)

Optomechanics and Optical MEMS for Sensing and Communication





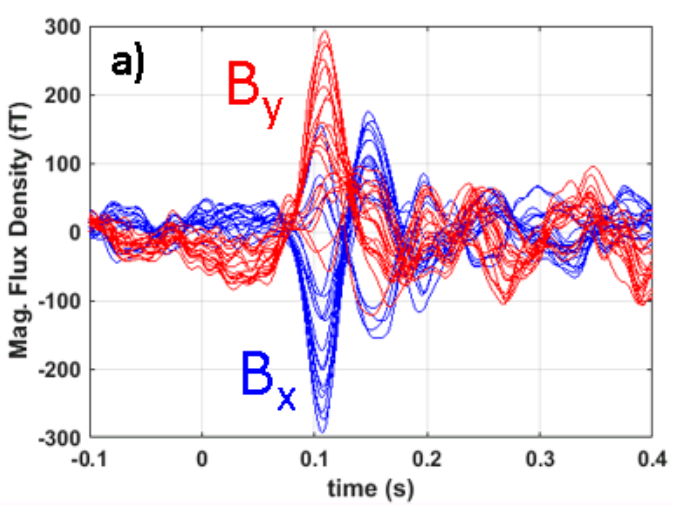


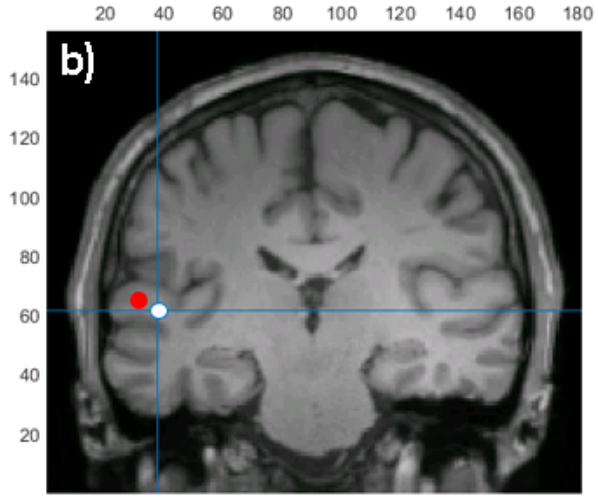
- Goal: Build micro/nano-scale sensors and actuators with performance enhanced by optical MEMS
- Diverse team of Physicists and engineers in photonics, lasers, MEMS etc
- Looking for anyone interested in quantum-limited measurements, MEMS and optical MEMS, high Q micro-cavities, or microfabrication. Post-doc posting #682483 on www.sandia.gov/careers

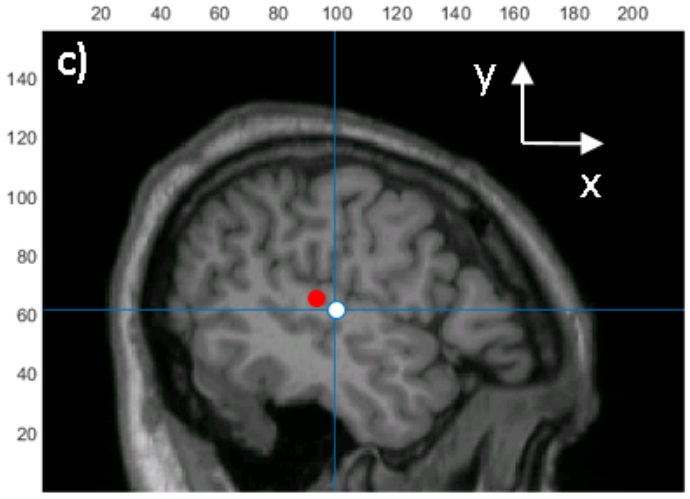
1) Ruyack, Alexander R., et al. "Compact, Pull-in-Free Electrostatic MEMS Actuated Tunable Ring Resonator for Optical Multiplexing." *FiO*, 2021.

2) A. J. Grine *et al.*, "Optomechanical spring effect readout in resonant micro-optical Sagnac gyroscopes design and scaling analysis," *OMN*, 2017.

Magnetoencephalography with Optically Pumped Magnetometers: Localization of Auditory Activity

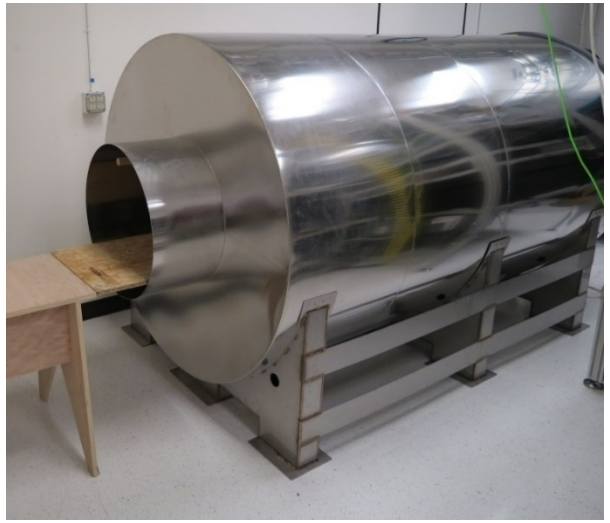




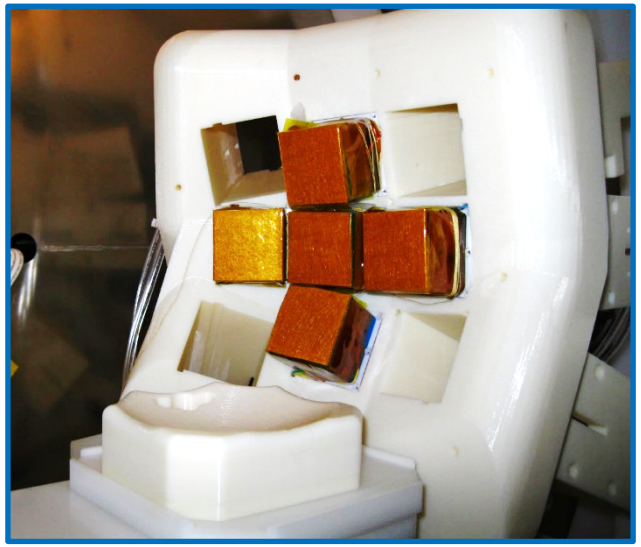


- Auditory stimulation
  - 1000 Hz tone, every 1 to 1.5 s
  - 456 trials
  - White dot: OPM location
  - Red dot: SQUID MEG location

Magnetic Shield

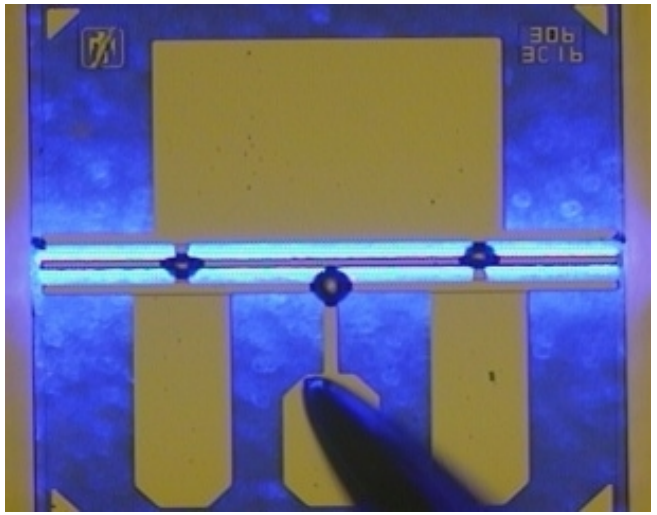


5-sensor, 20-channel array

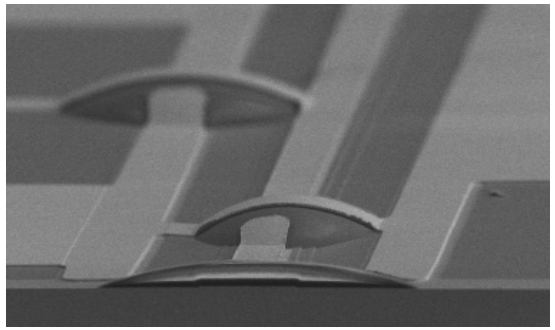


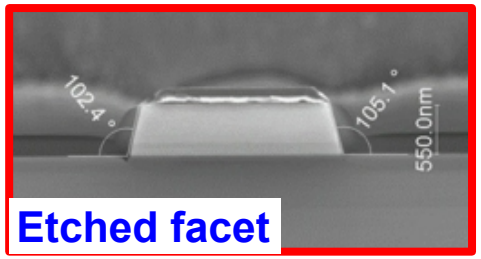
Semiconductor lasers span the visible spectrum for quantum apps

InGaN 455nm laser

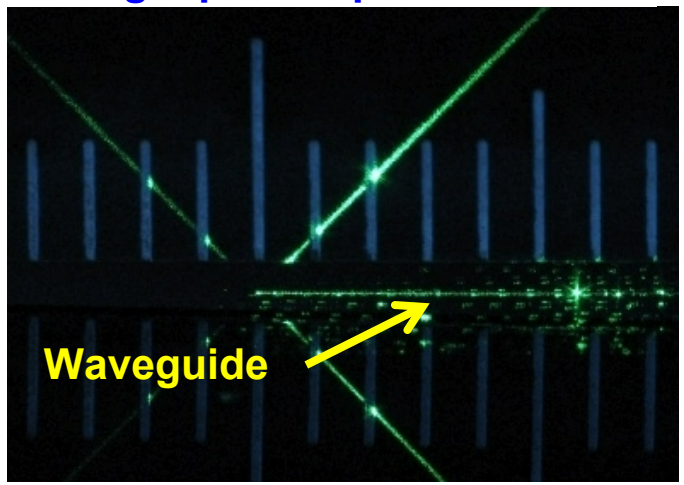


SEM of fabricated 455nm laser

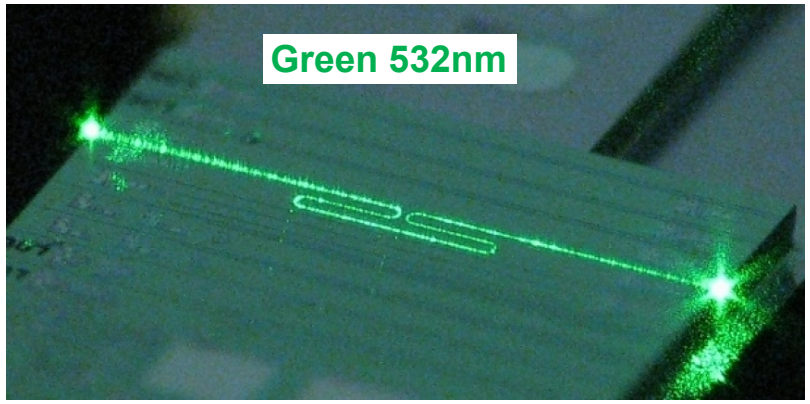


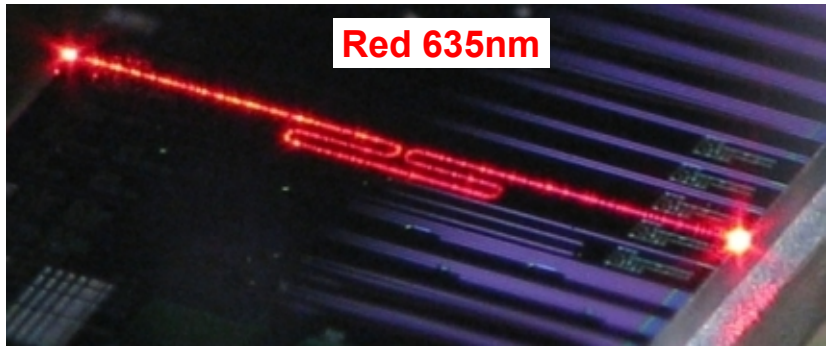


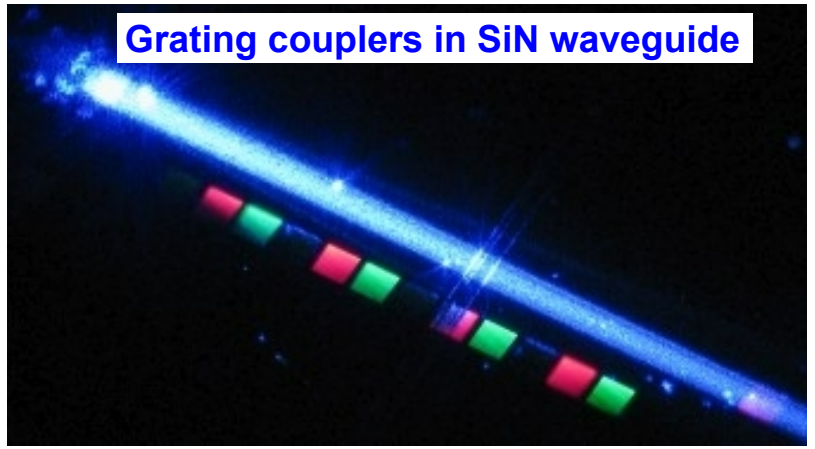
Grating input coupler at 532nm:



5 grating couplers:

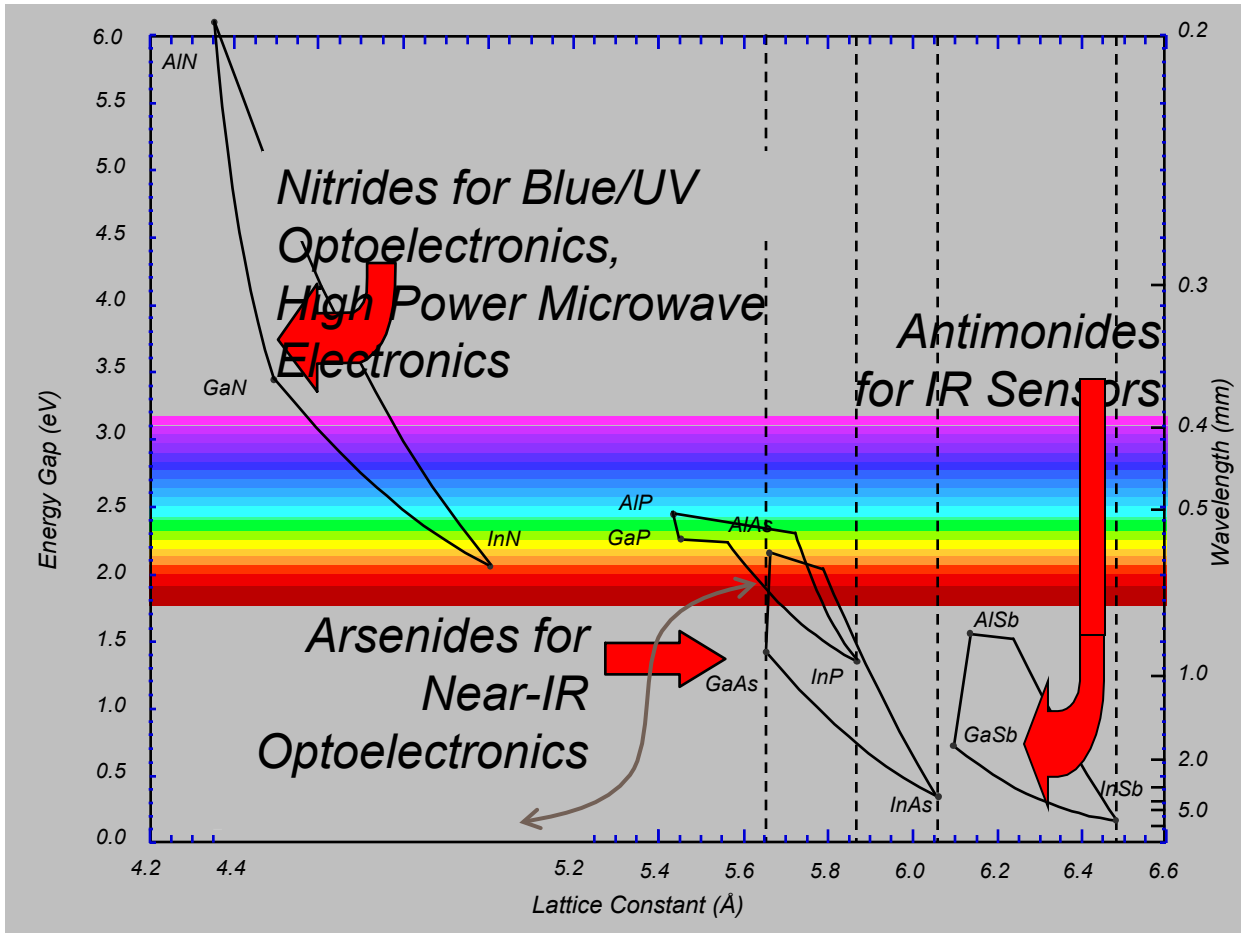




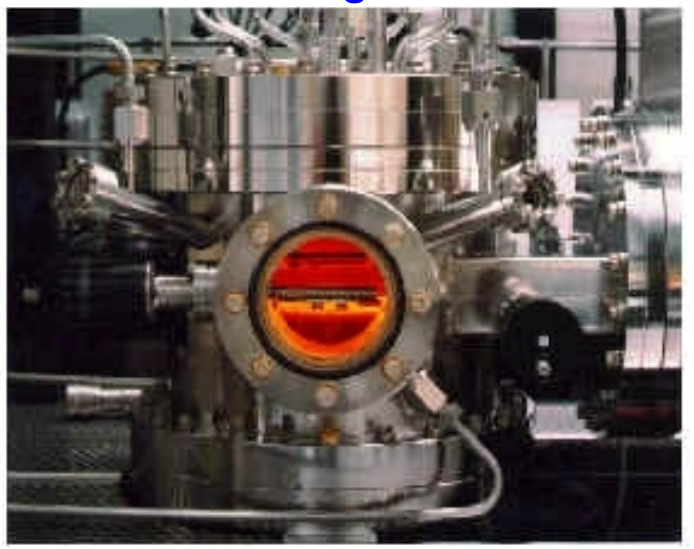


Compound semiconductor epitaxy

Sandia Grows the Full Spectrum of III-V Materials

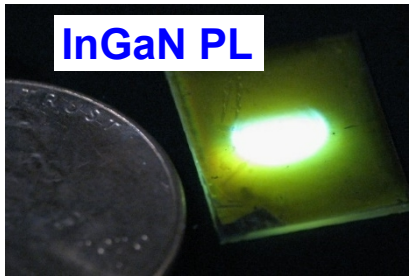


10 MOCVD/MBE growth reactors

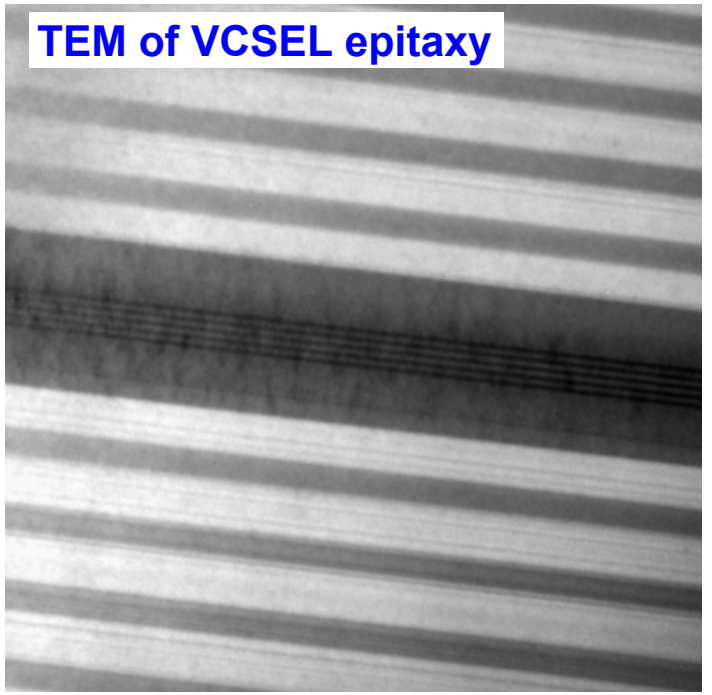


InGaP PL

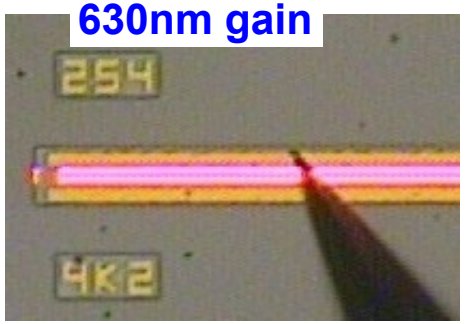
InGaN PL



TEM of VCSEL epitaxy



630nm gain



895nm VCSEL