Quantum Photonic Microsystems

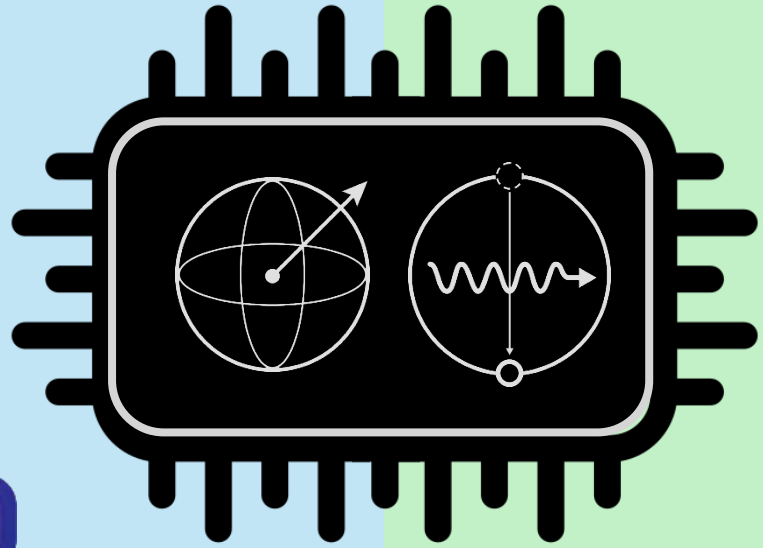
Dr. Justin Cohen, Program Manager, DARPA/MTO

July 24, 2025

Quantum Photonic Microsystems

Active Programs

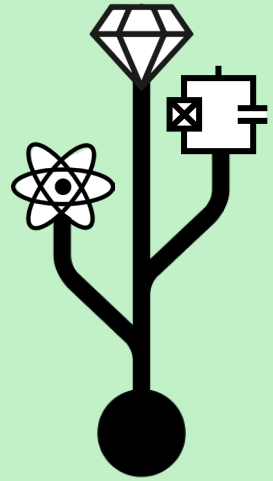
Generating RF with Photonic Oscillators for Low Noise
Deploying precision microwave to the edge

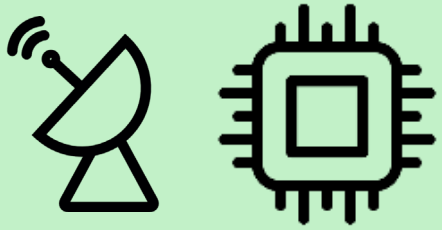


Intensity-Squeezed Photonic Integration for Revolutionary Detectors
Surpassing the quantum noise limit in optical sensing

Emerging Opportunities

Heterogeneous Quantum Computing
Exceeding the constraints of individual qubit platforms

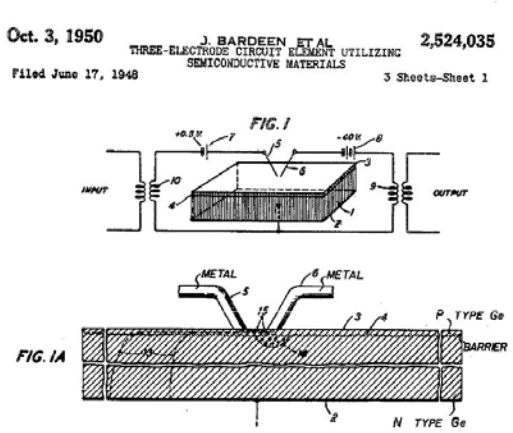




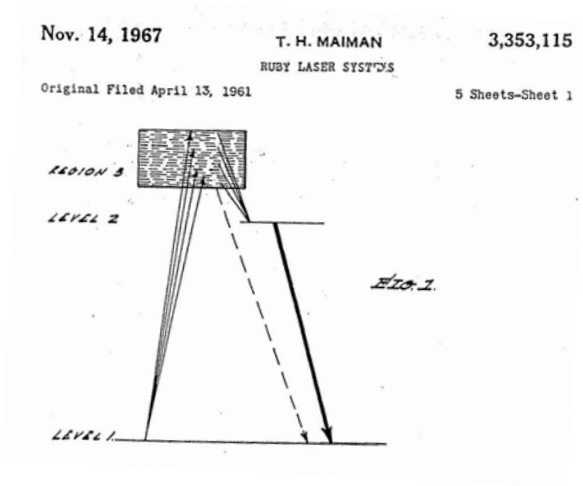
Entanglement in Quantum Sensing
Applying the full breadth of quantum physics to sensing

Quantum Advantage Is Already Here

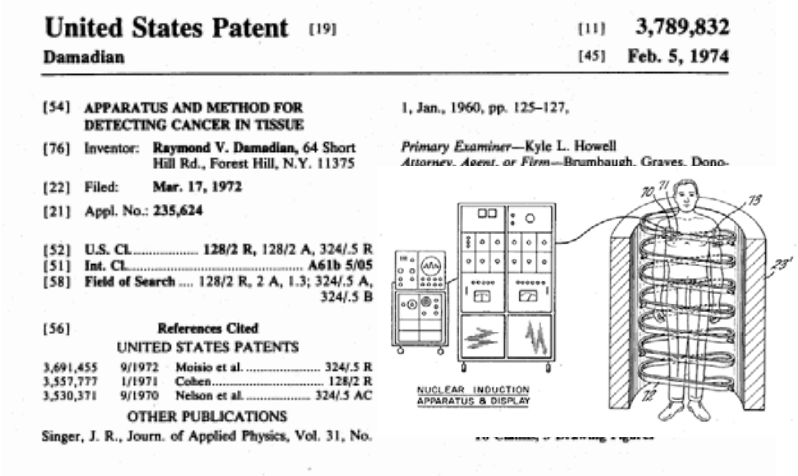
Transistors


Oct. 3, 1950 J. BARDEEN ET AL 2,524,035
THREE-ELECTRODE CIRCUIT ELEMENT UTILIZING SEMICONDUCTIVE MATERIALS
Filed June 17, 1948 3 Sheets-Sheet 1
FIG. 1
INPUT OUTPUT
FIG. 1A
METAL METAL
P TYPE Ge
BARRIER
N TYPE Ge

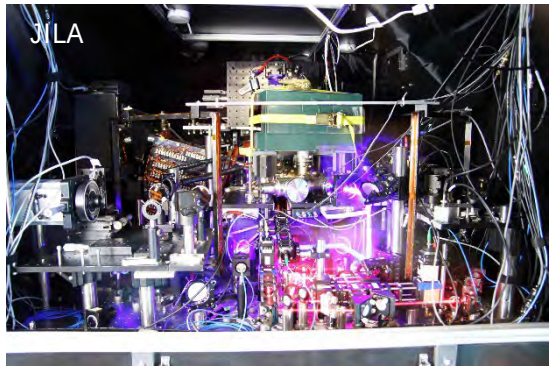
Lasers


Nov. 14, 1967 T. H. MAIMAN 3,353,115
RUBY LASER SYSTEMS
Original Filed April 13, 1961 5 Sheets-Sheet 1
REGION 3
LEVEL 2
LEVEL 1
FIG. 1

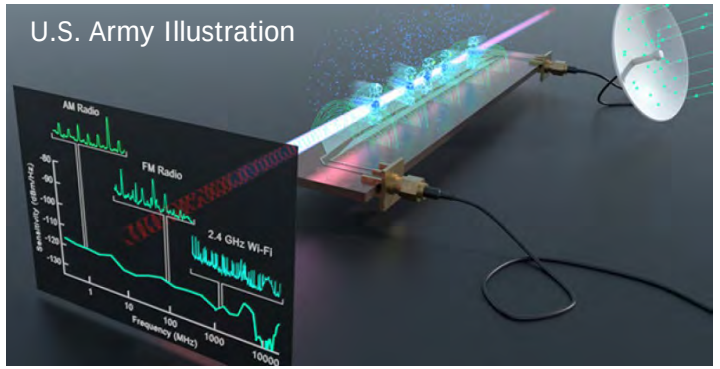
MRI


United States Patent [19] [11] 3,789,832
Damadian [45] Feb. 5, 1974
[54] APPARATUS AND METHOD FOR DETECTING CANCER IN TISSUE
[76] Inventor: Raymond V. Damadian, 64 Short Hill Rd., Forest Hill, N.Y. 11375
[22] Filed: Mar. 17, 1972
[21] Appl. No.: 235,624
[52] U.S. Cl. 128/2 R, 128/2 A, 324/.5 R
[51] Int. Cl. A61b 5/05
[58] Field of Search 128/2 R, 2 A, 1.3; 324/.5 A, 324/.5 B
[56] References Cited
UNITED STATES PATENTS
3,691,455 9/1972 Moisio et al. 324/.5 R
3,557,777 1/1971 Cohen 128/2 R
3,530,371 9/1970 Nelson et al. 324/.5 AC
OTHER PUBLICATIONS
Singer, J. R., Journ. of Applied Physics, Vol. 31, No. 1, Jan., 1960, pp. 125–127,
Primary Examiner—Kyle L. Howell
NUCLEAR INDUCTION APPARATUS & DISPLAY

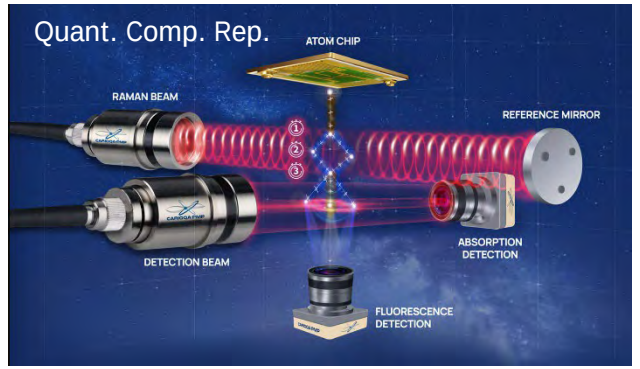
"Quantum" Clocks



"Quantum" Field Sensors



"Quantum" Inertial Sensors



Energy quantization and interference power today's quantum technology

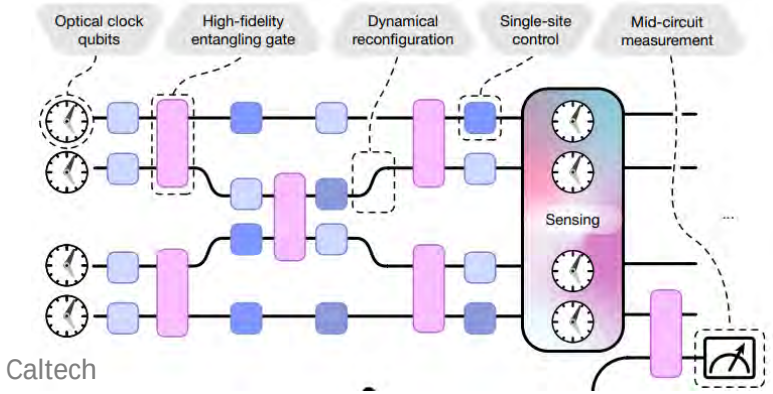
How About Sensors That Are *Actually* Quantum?

Quantum Computing

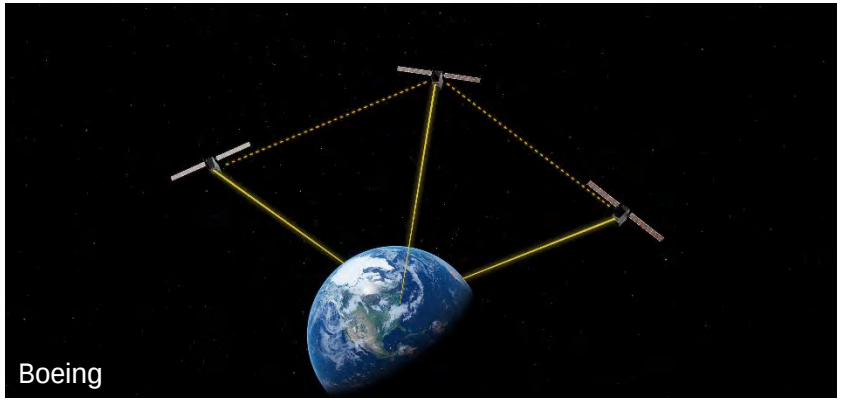
error correction and control

Entanglement in Sensing – Under-Explored!

Gate operations on sensor qubits

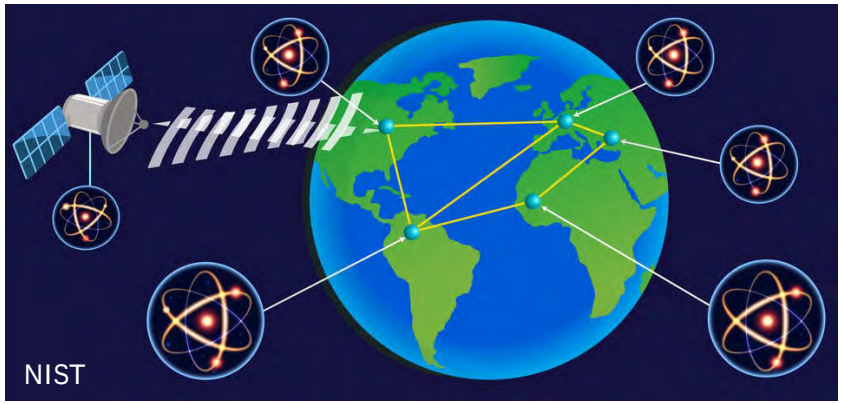


Quantum Communication



entanglement distribution

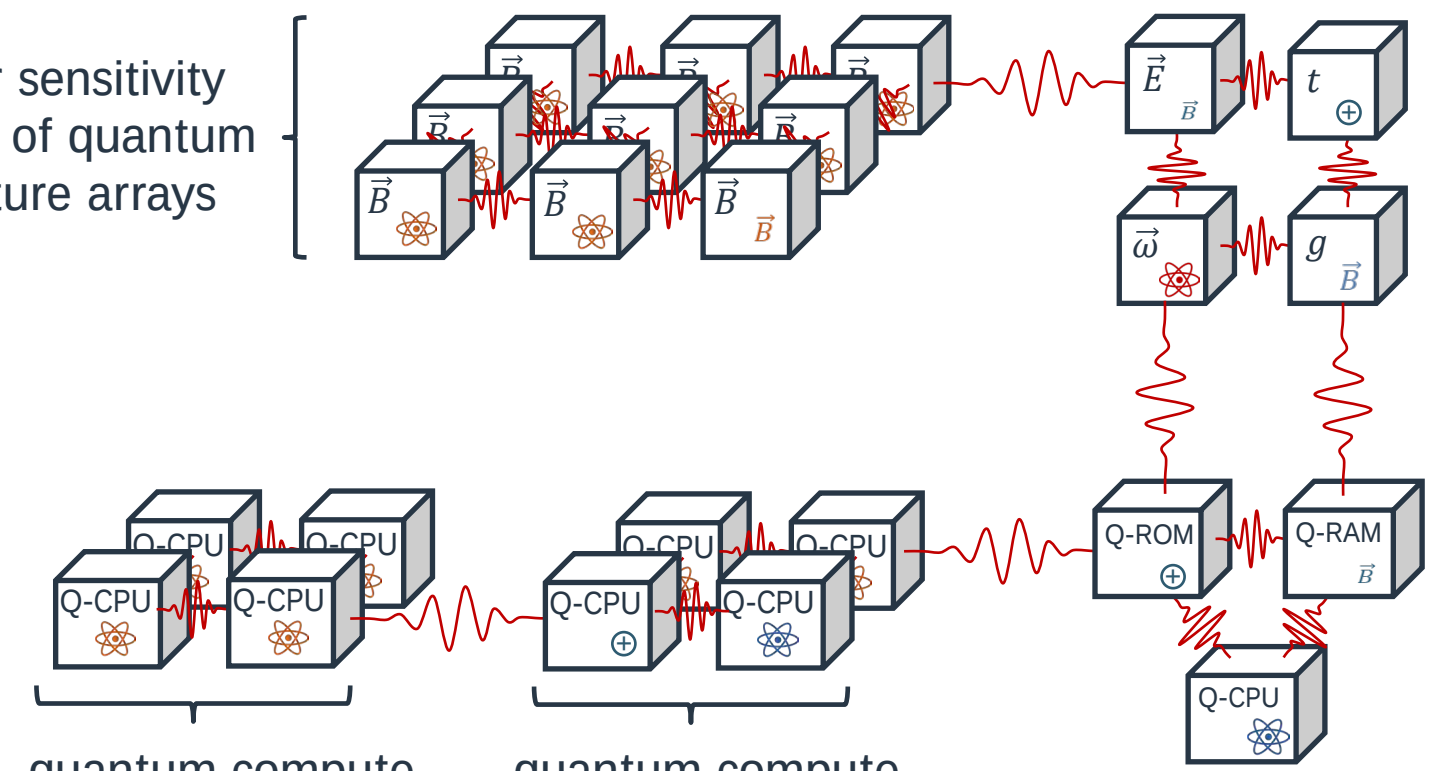
Networked sensor qubits



Apply the tools of quantum information science to practical sensing applications

Heterogeneous Quantum Systems

faster sensitivity scaling of quantum aperture arrays



multi-modal sensing to correlate signal variables and decorrelate noise

quantum signal processing to “un-measure” noise

quantum compute with sub-system diversity

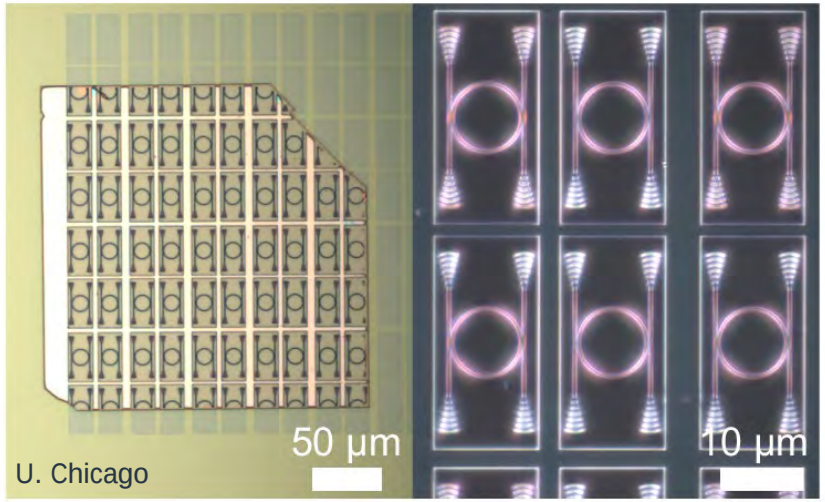
quantum compute scaling beyond platform limits

quantum compute with processor diversity

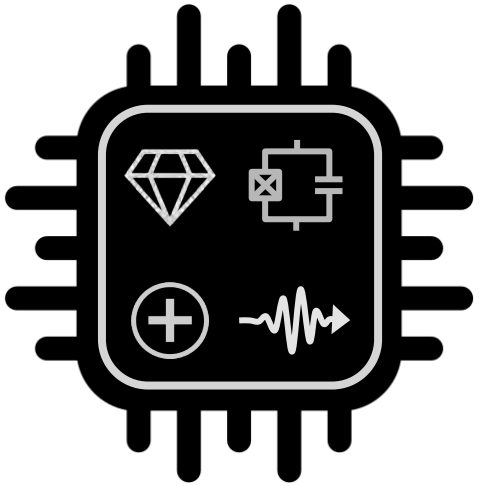
Leverage the full toolbox of qubit technologies through entanglement

Enabling Technologies

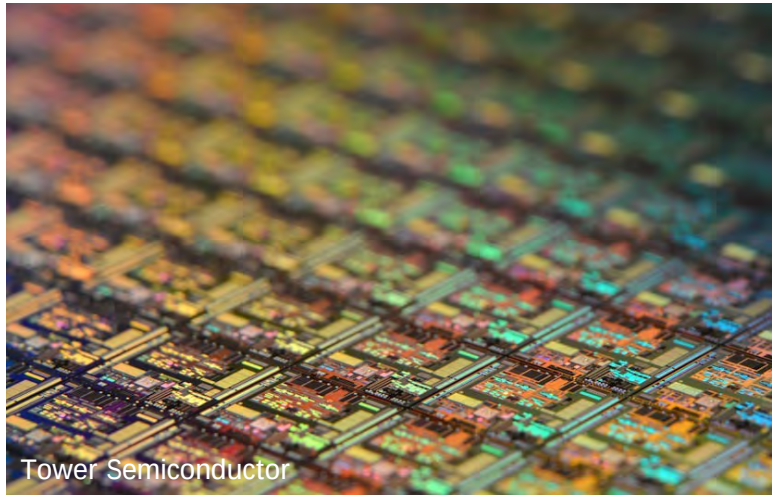
Color Center Integrated Photonics



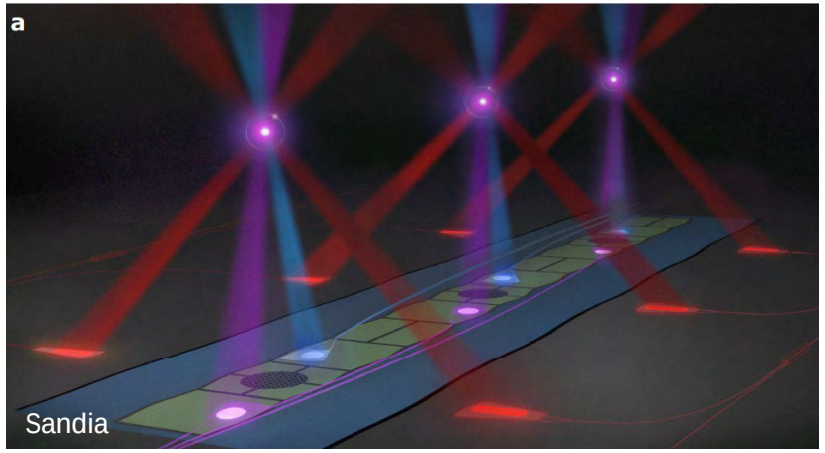
Hybrid Quantum Microsystems



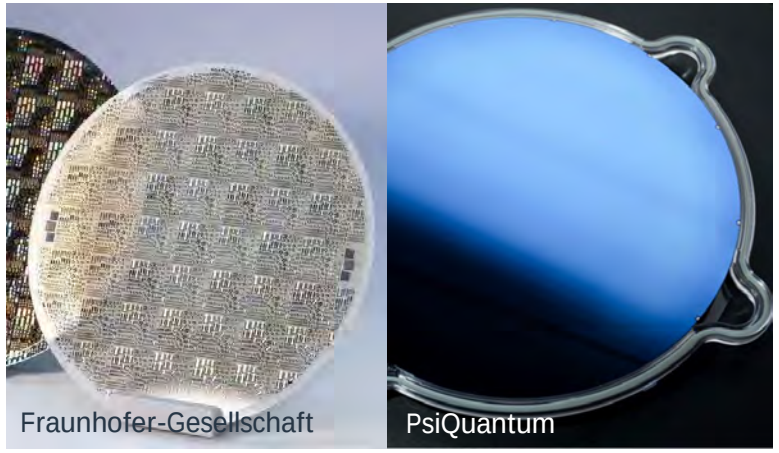
Visible Integrated Photonics



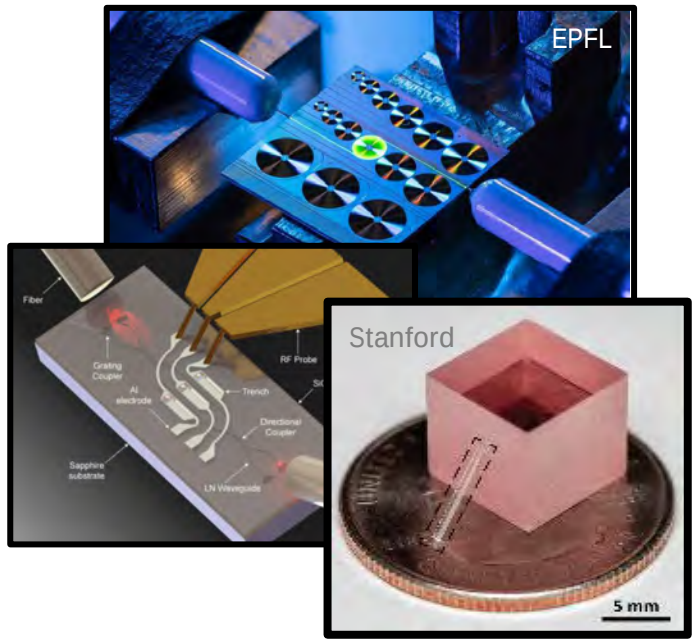
Atomic-Photonic Integration



Strong Electro-Optic Thin Films

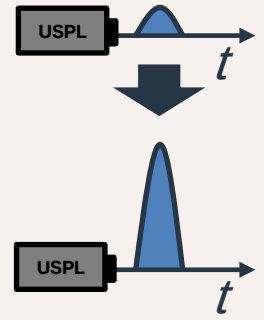


Can the reconfigurability of integrated photonics be combined with the high power and temporal resolution of ultrafast optics?



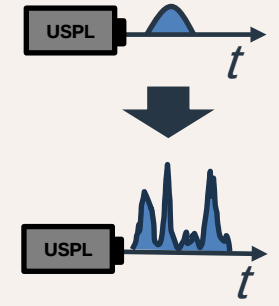
Shorter and Higher-Energy Pulses

- New materials on chip (e.g., Ti:Sa, Er, Tm)
- New waveguide structures on chip (e.g., air core)
- **Reach the femtosecond and nanojoule regime with chip-scale photonics**



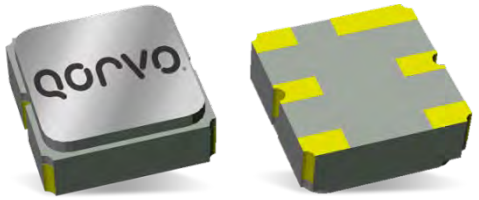
Optical Agility

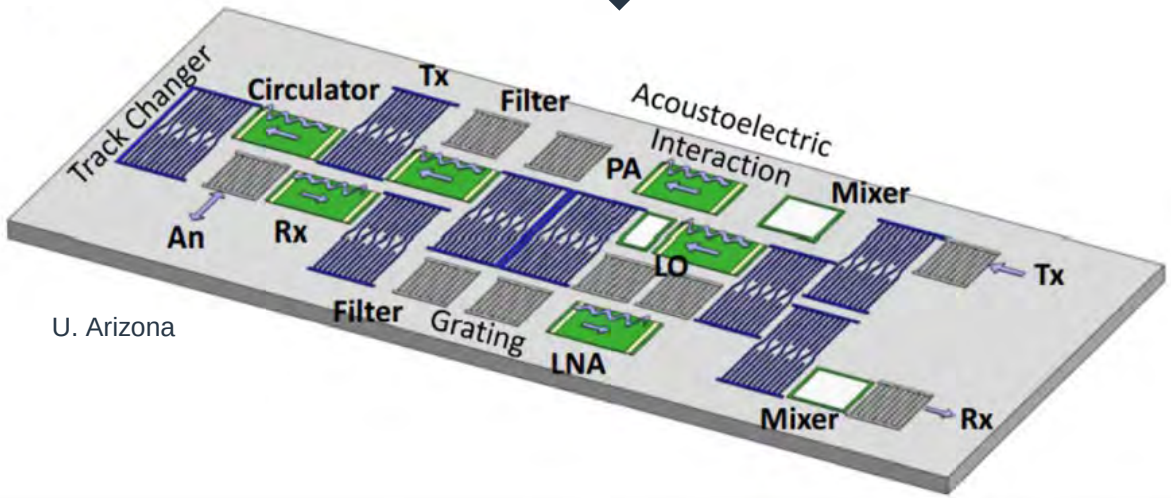
- Integrated spectral translation
- High-bandwidth modulation on-chip
- **Advance toward arbitrary waveform control**



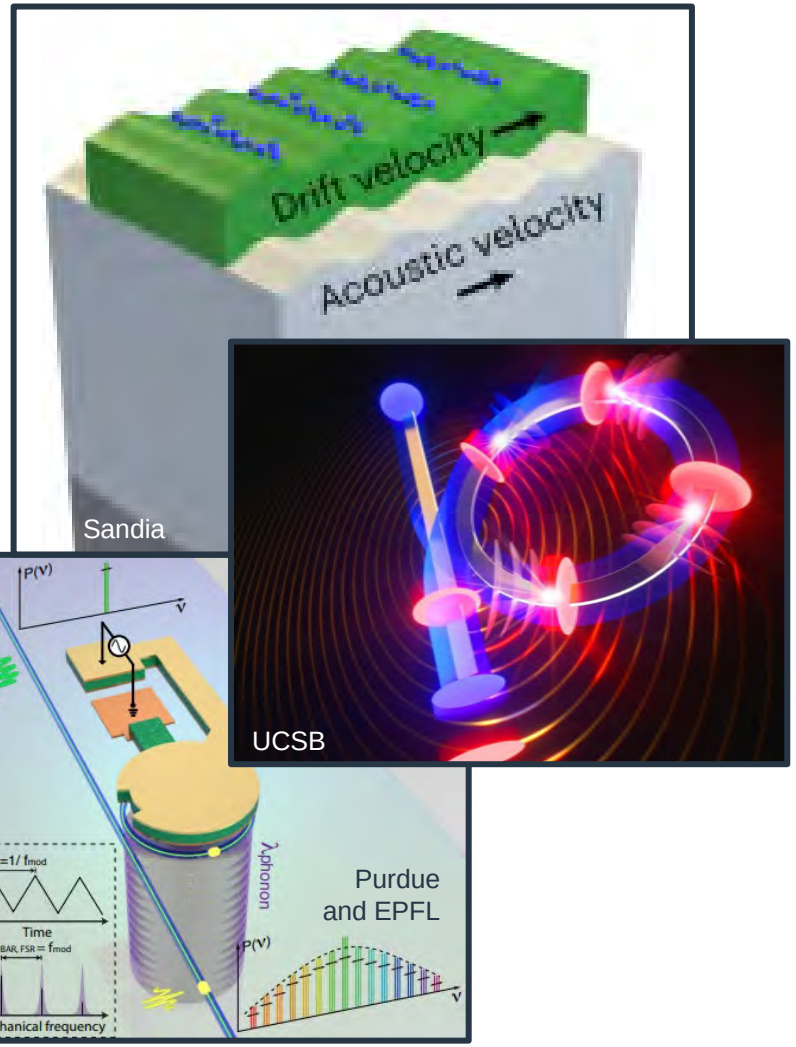
Other Ideas in Incubation: Acoustic Integrated Circuits

Can we take acoustics from discrete components to integrated circuits?





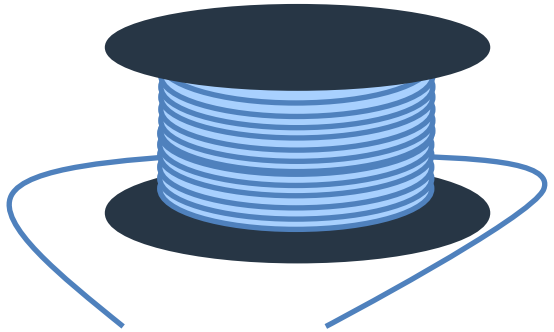
U. Arizona



Other Ideas in Incubation: Fiber-Inspired Integrated Photonics

Should we re-think the manufacturing path for integrated photonics?

Fiber Optics
Mass-manufacturable glass processing



+

Integrated Photonics
Mass-manufacturable semiconductor processing

→

New Materials and Fabrication Methods

Currently Most Interested in Hearing About:

- Heterogeneous quantum computing and sensing
- Entanglement-enabled sensing and information processing
- Squeezing-enhanced optical sensing applications
- Optically-enabled RF systems architectures
- Integrated ultrafast optics
- Acoustic integrated circuits
- Novel photonic materials and fabrication
- Coherent EUV/X-ray light sources
- High-rate, many-photon entanglement
- Electronic-photonic IP and re-use
- Attosecond spectroscopy

Help us define the future of optical microsystems!

www.darpa.mil