



Harvard University: *Center for Nanoscale Systems*



Robert Westervelt
Director - PI



William L. Wilson
Executive Director – Co-PI



Overview: Harvard CNS Infrastructure and Mission

Our Mission at CNS:

To evolve and nurture one of the most comprehensive nanotechnology research communities in the world. Supporting the development of new advanced processing technologies, new imaging and analysis paradigms, enabling transformative basic Nano and Quantum science, and advance device research.

Nanofabrication

- Component driven
- Complete lithography tool set
- Non-traditional materials/Methods
- Multiple length-scales

"We've become an advanced prototyping shop"

Electron Microscopy/Analysis

- Advanced imaging and analytical instrumentation
- Core expertise in CryoTEM
- Atom Probe tomography

LABORATORY FOR INTEGRATED SCIENCE AND ENGINEERING (LISE):

- ✓ 10000 ft² Cleanroom
- ✓ 6000 ft² Hi-resolution EM Imaging Suites
- ✓ 3000 ft² Cell Culture Lab
- ✓ Soft lithography/BioMaterials Lab
- ✓ Optical Spectroscopy Lab
- ✓ Scanning Probe Microscopy Lab

Harvard Center for Nanoscale Systems (CNS)

- Focus on key national priorities



CNS Overview: Where do we play?

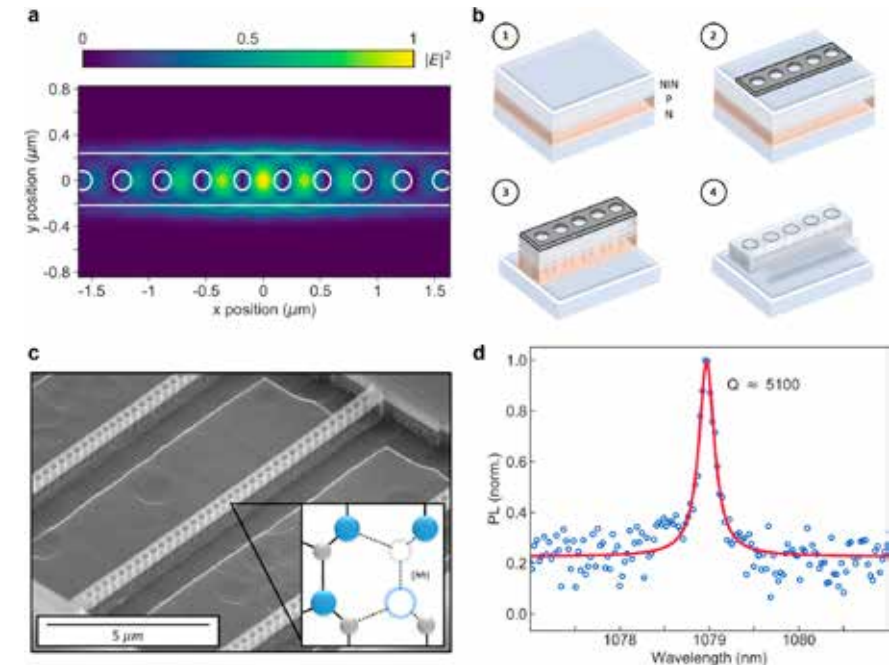
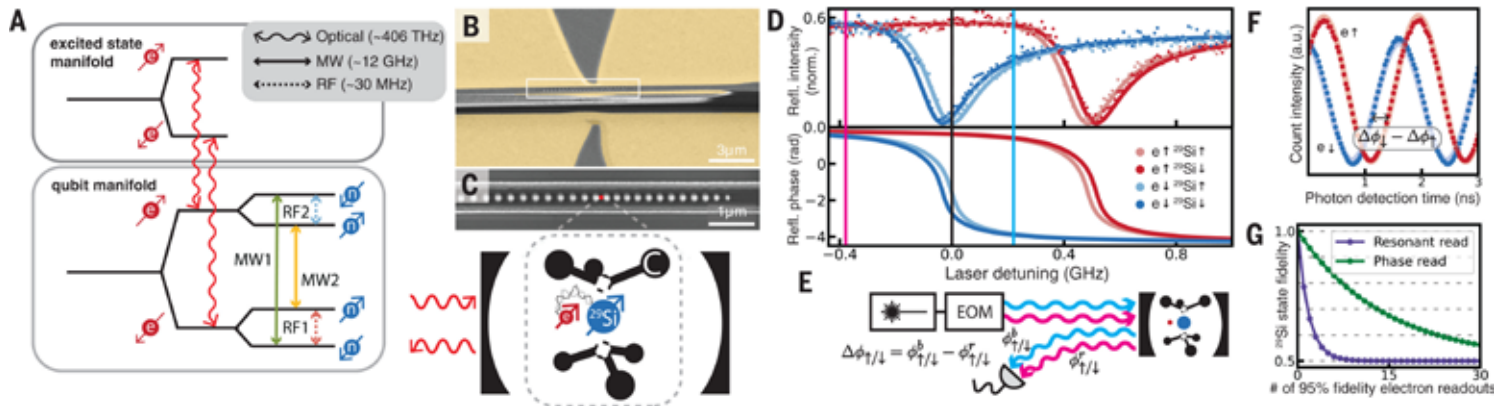
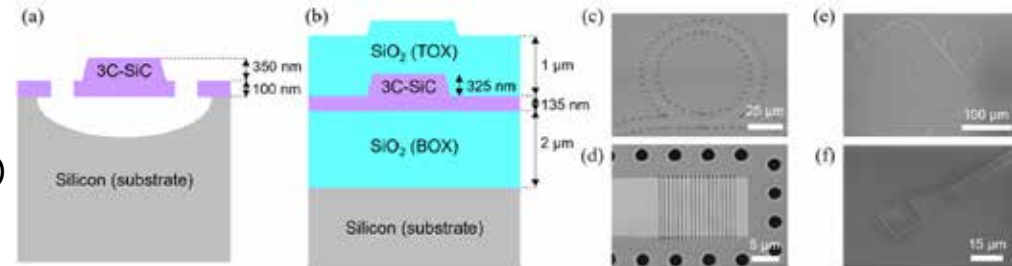
- CNS serves as a one-stop shop for all things “Nano and Quantum” (*Nano and Quantum are entangled*).
- CNS serves as an important regional and national nanoscience community resource.
- CNS offers prototyping/advanced process development support for “Lab-to-FAB” researchers, Start-up companies and we have established alliances with local incubators, (*Start-ups are ~14% of our Userbase*).
- CNS initiating new partnerships with industry.
- CNS infrastructure evolving to support the primary research and innovation thrusts within the Harvard and “Cambridge” regional research community.
- CNS have initiated new training and educational programs to engage larger numbers of undergraduates, non-traditional, and underserved external users, in nanofabrication, advanced characterization and advanced imaging techniques.
- CNS is supporting Diversity Outreach and Community building activities.
- CNS is supporting the Democratization of our Research Infrastructure.

TECHNOLOGY FOCUS AREAS IN CNS2025

QUANTUM SCIENCE & ENGINEERING: QUANTUM OPTICS, QUANTUM SPIN SYSTEMS,

SUPPORTED WORK INCLUDES: *(in all work, CNS is enabling; training all researchers in tools, Fabrication, and instrumentation use. Staff help supporting device process and experimental design. CNS has strong synergy with the NSF: Center for Integrated Quantum Materials)*

- ∅ STRAIN ENGINEERING COLOR CENTERS DIAMOND/SiC / COLOR CENTER BASED QUANTUM EMITTERS
- ∅ LOCAL FOCUS ON QUANTUM NETWORKING
- ∅ UNCONVENTIONAL SUPERCONDUCTIVITY IN MAGIC-ANGLE GRAPHENE SUPERLATTICES (TWISTRONICS)
- ∅ PHOTONICS AND ELECTRONICS IN VAN DER WAALS HETEROSTRUCTURES

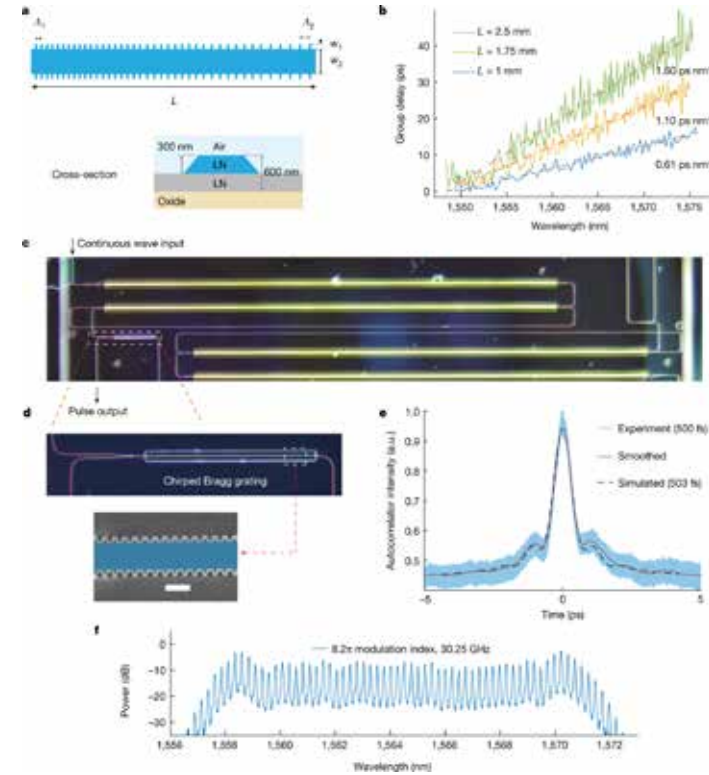
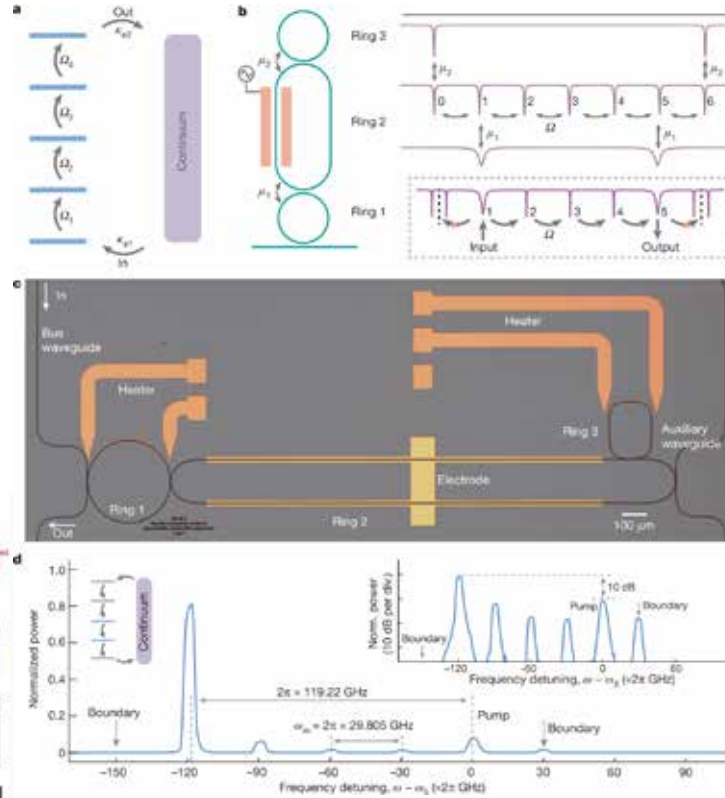
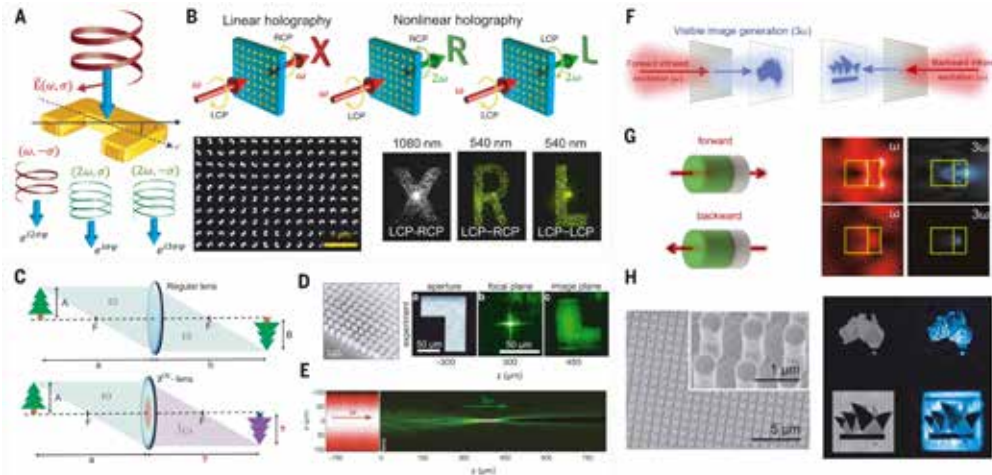


TECHNOLOGY FOCUS AREAS IN CNS2025

NANOOPTICS, NANOPHOTONIC DEVICES

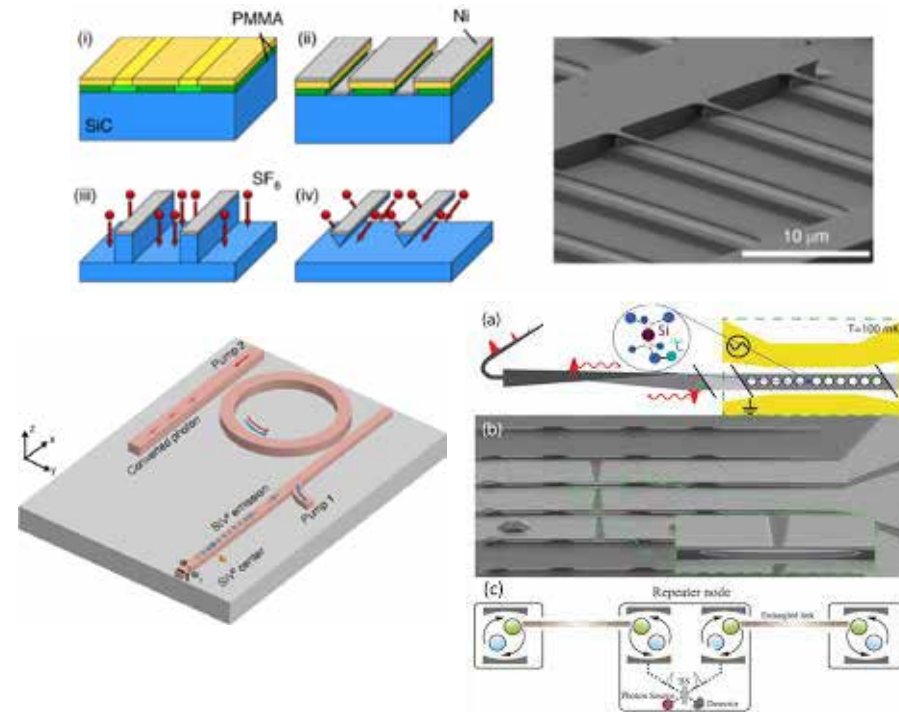
SUPPORTED WORK INCLUDES:

- Ø OPTIMIZED METAOPTICS
- Ø ULTRA-HIGH Q LITHIUM NIOBATE WAVEGUIDES, RESONATORS, AND INTEGRATED OPTICS
- Ø HIGH-EFFICIENCY CHIRAL META-LENSES



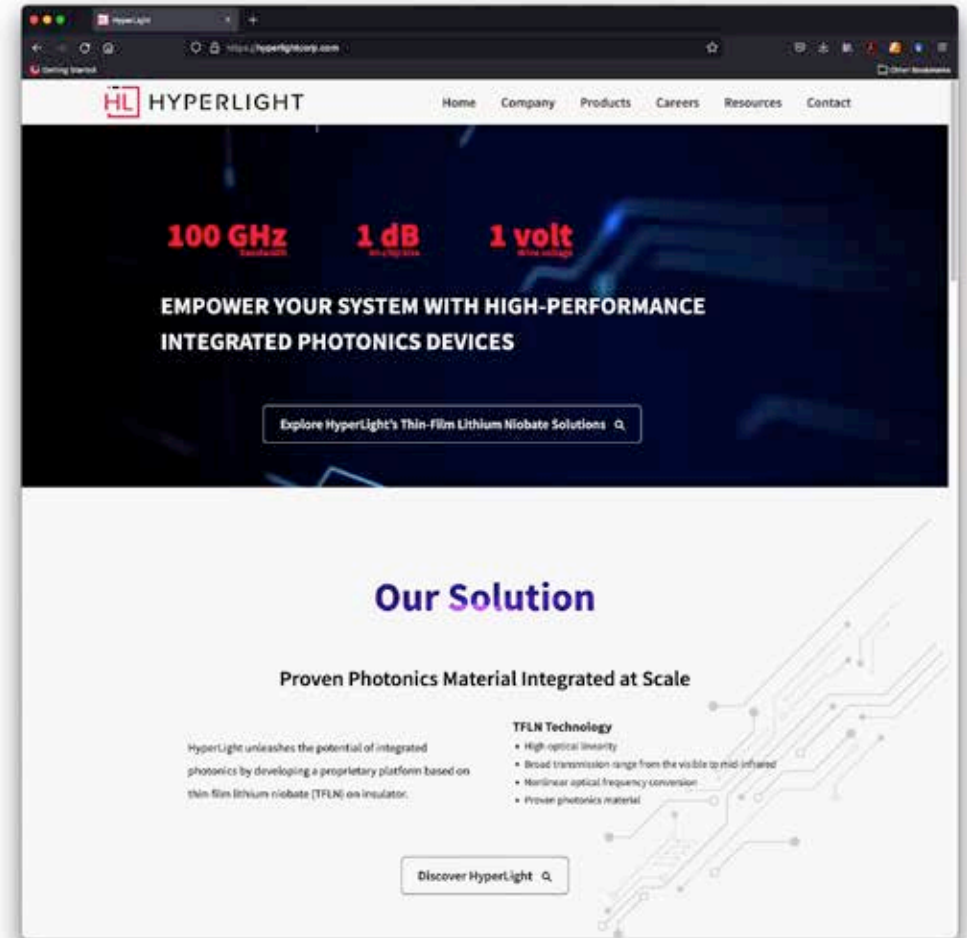
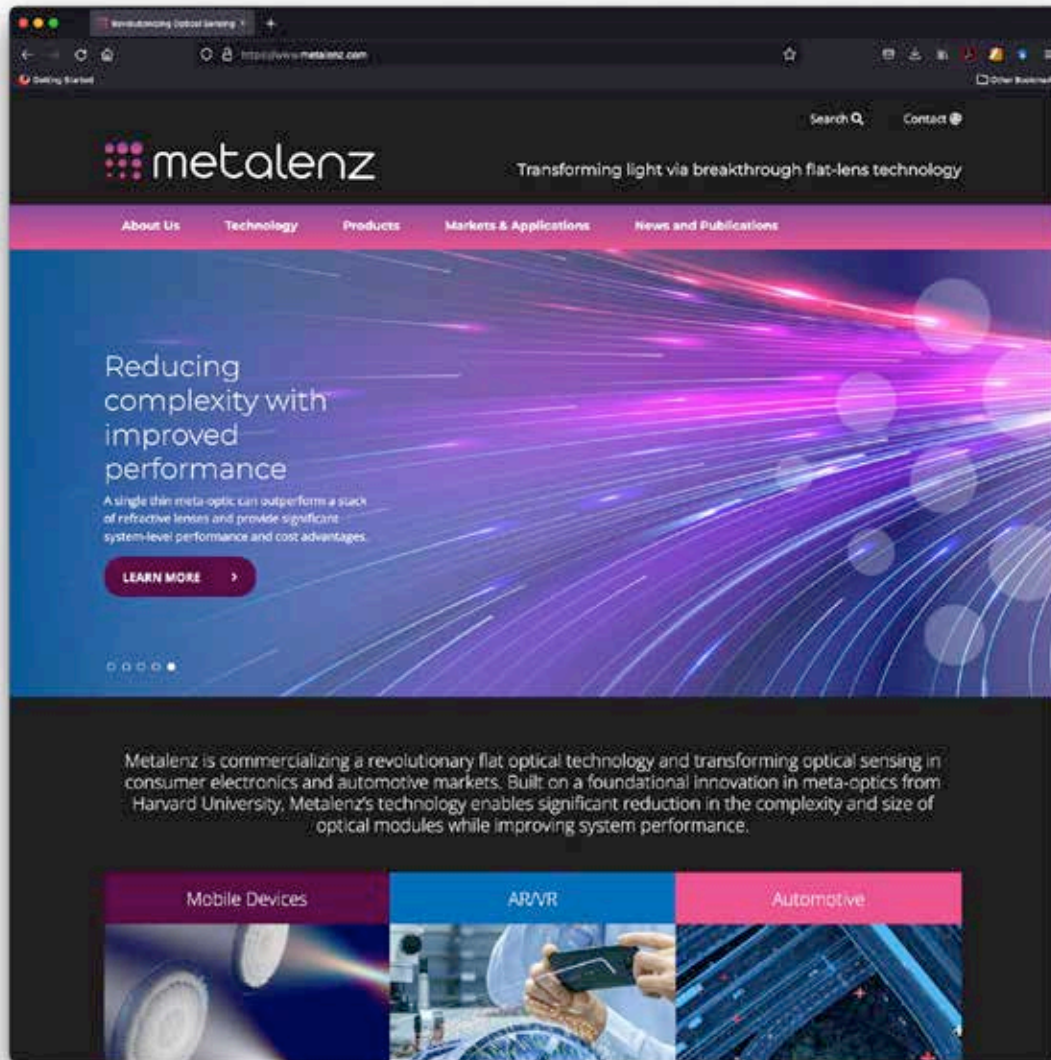
(Evolving Relationships) New Industry Partner Initiatives:

Quantum Networking Alliance with.....



- Integrated Quantum Photonics
- Quantum Repeaters
- Quantum Sources
- Quantum Devices

Outreach: Start-up Industry Support



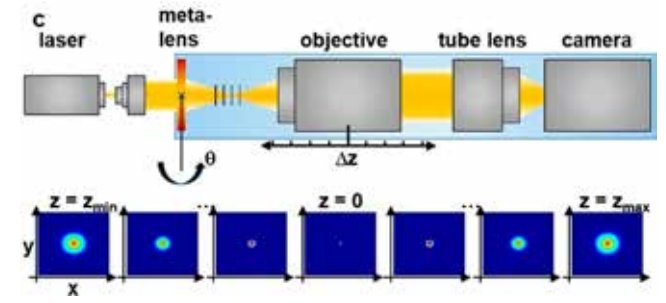
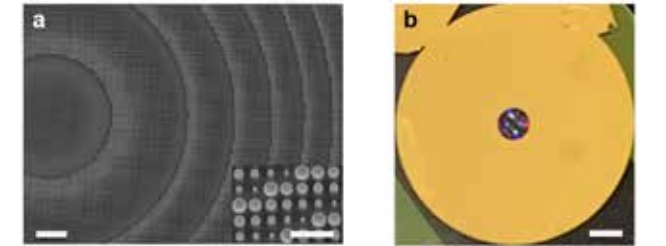
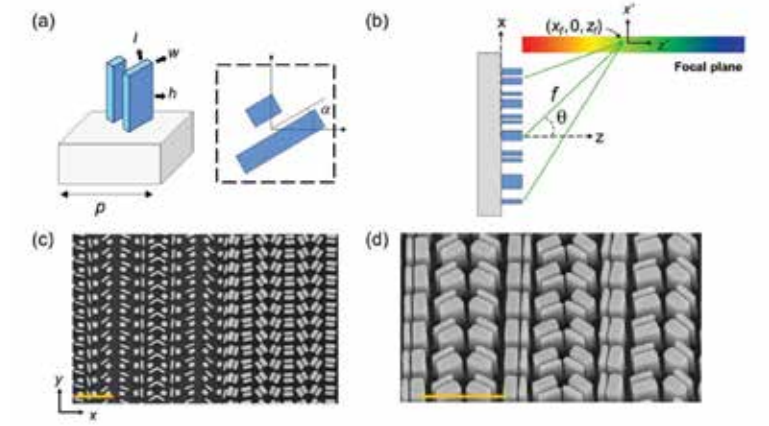
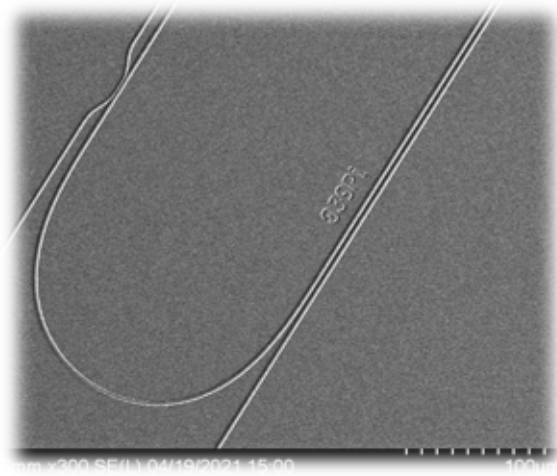
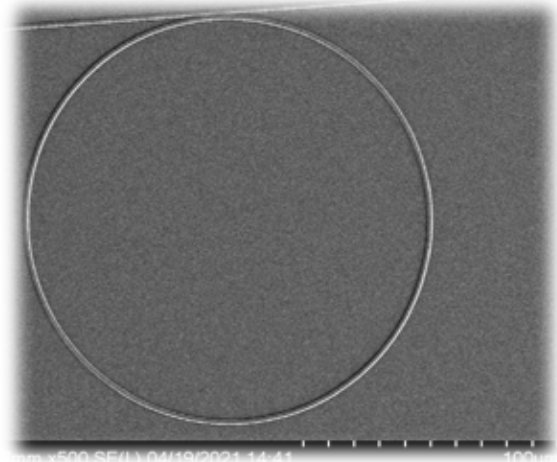
(Evolving Infrastructure) Fab tool evolution:

Enabling integrated Optics Platforms in New Materials

FAB TOOL EVOLUTION



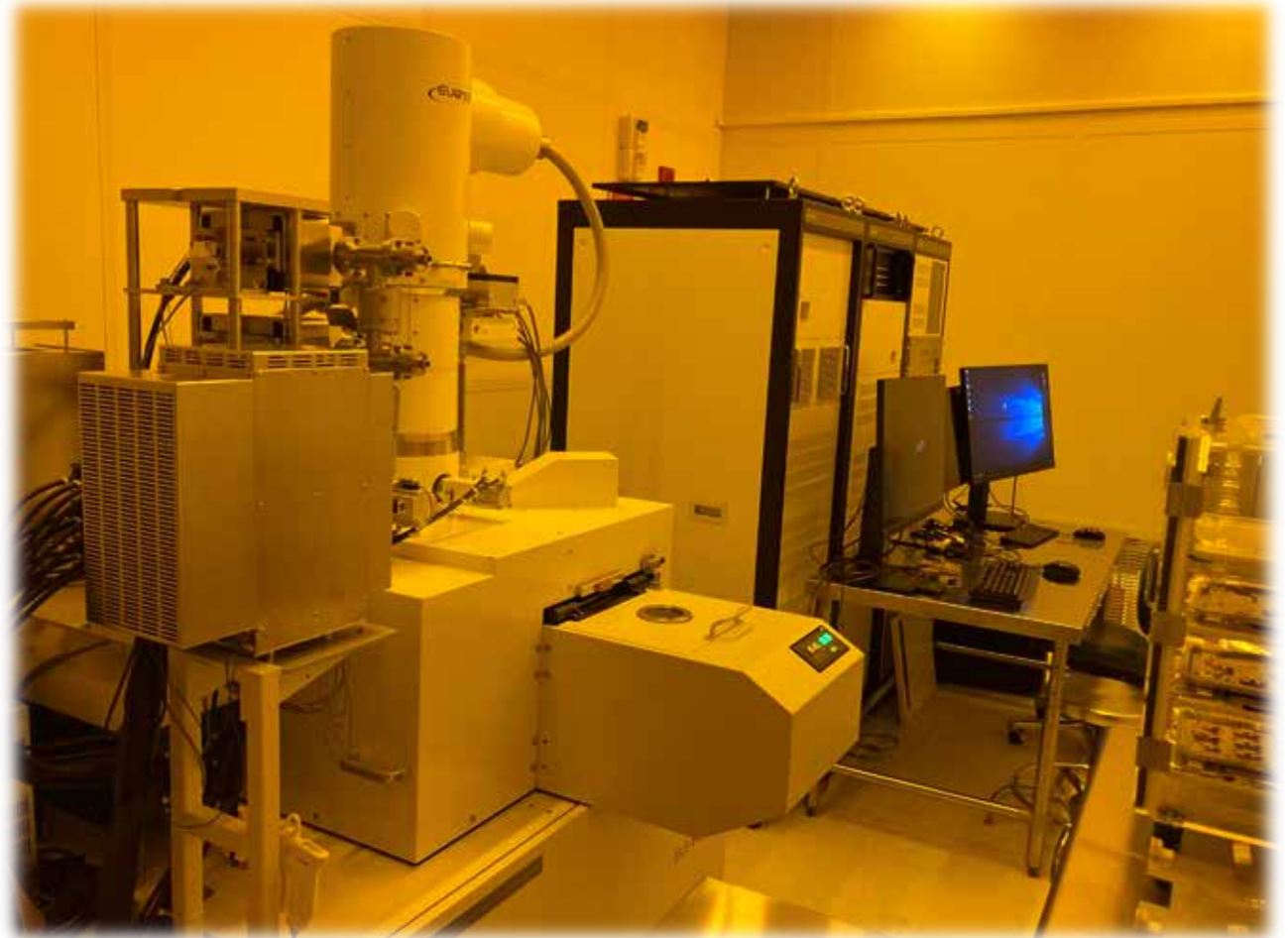
Elionix High-Speed Ebeam Lithography tool



Infrastructure Evolution: New FAB Equipment

- Elionix ELS-Boden 150
- Sentech SI-500 ICP-RIE (11/2023)
- AJA Sputtering/ E-Beam Evaporator for Complex Oxides (11/2023)
- K. Lesker High-Temp Vacuum Furnace

All Acquired with Industry support:
Focus Diamond Photonics



Quantum Infrastructure Development

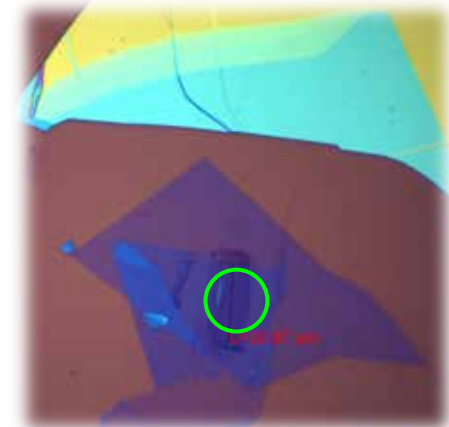
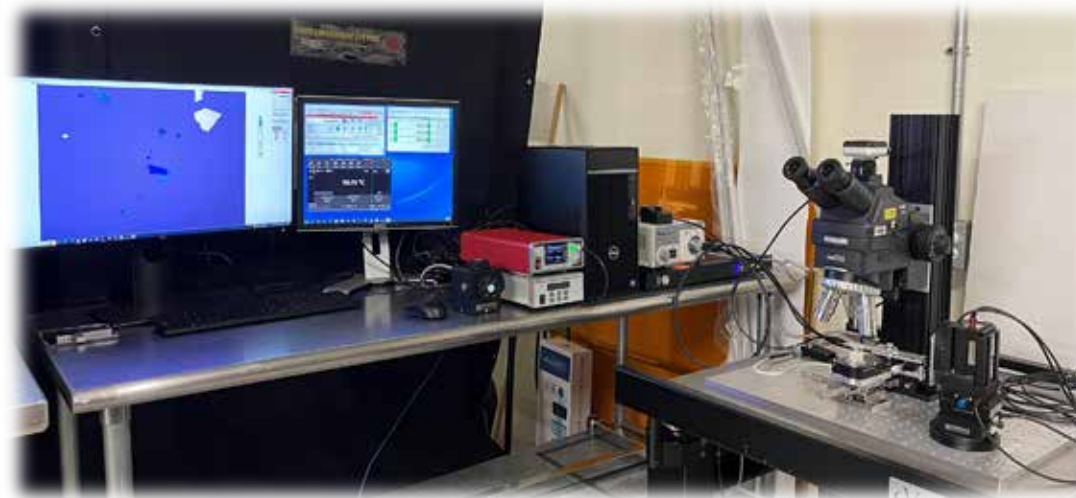
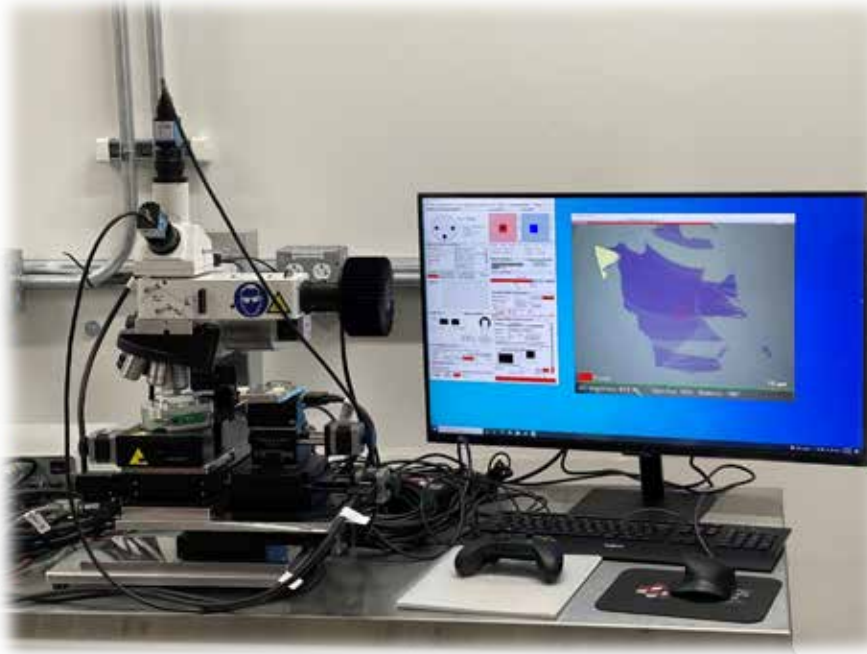
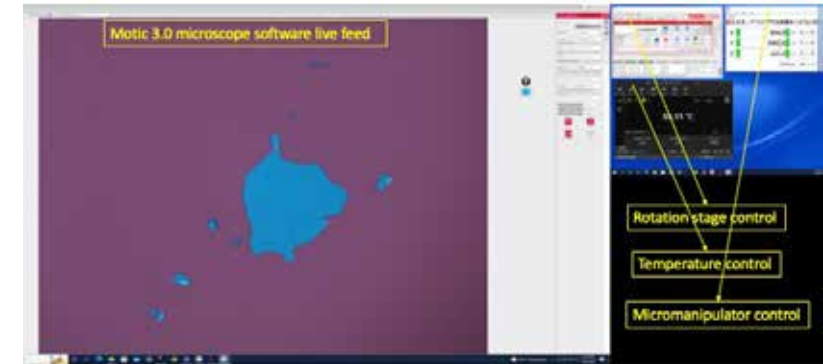
General Access 2D Assembly Platform:

(open to all users for training and use)

Note: We are currently building a additional Glovebox based system, and we've submitted a MidScale R1 proposal to build a UHV Platform.



Software and interfaces

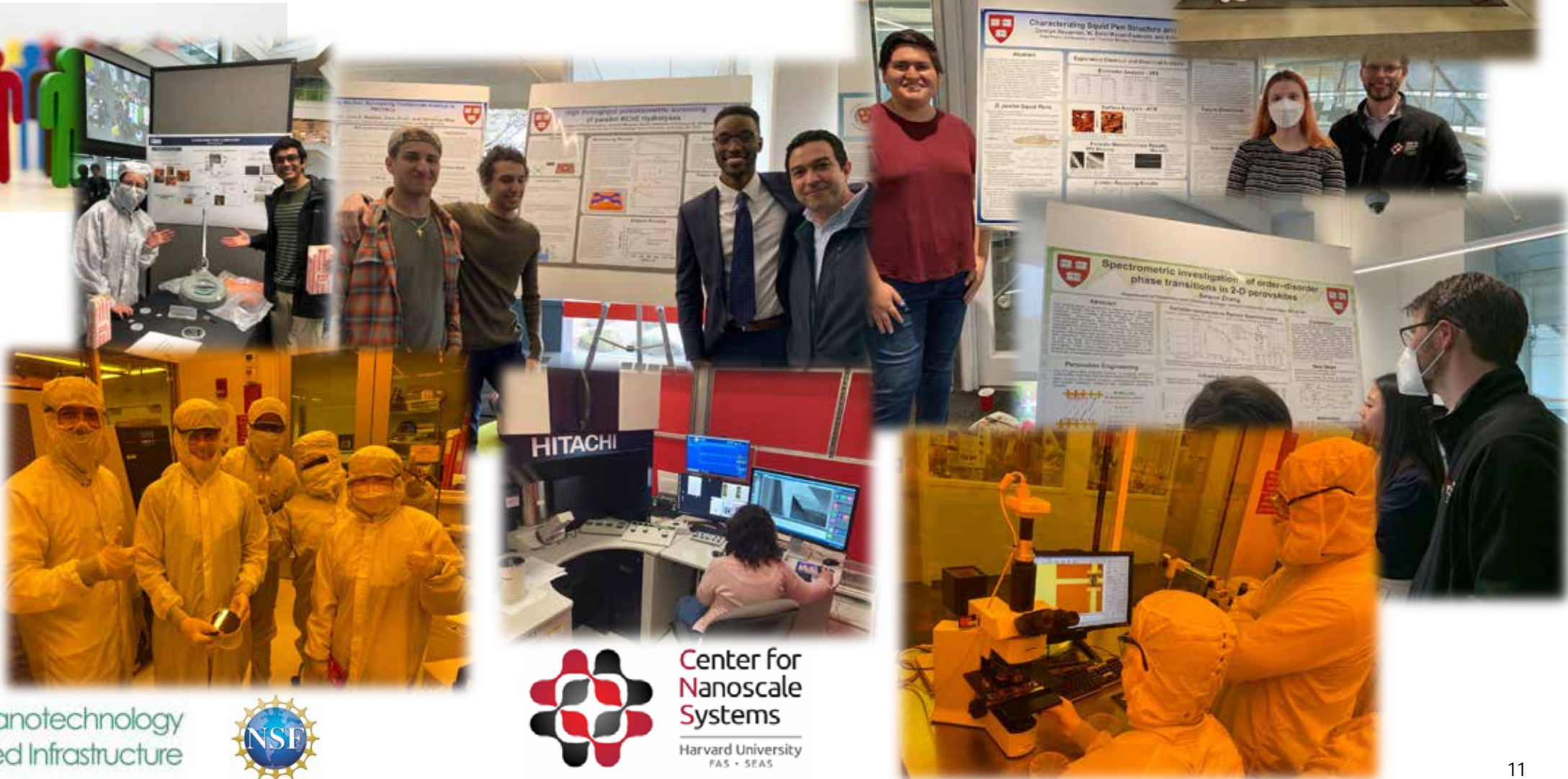


(Evolving Training) Workforce Development

CNS is actively engaged in teaching courses in our laboratories in addition to our focus on user tool and instrumentation training



Chem 165
ES 100
ES 177/277
ES 293
BE 128
MCB 68
AP 218
AP 291



Harvard CNS Education & Outreach

CNS is focused on an array of activities focusing on engaging Undergraduates and Veterans, as well as supporting efforts to build community

REU – conventional program : but with project offerings from entire userbase, both internal and external



***REU PROGRAM** – Advanced research opportunities for Ugrads from external, 2 and 4yr institutions; added international students in FY19

Research Experience Veterans – *staff serves as mentors*

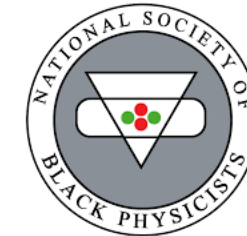
(some interns carried through school year)

Fully Re-booted

CNS Staff also supporting the nano@Stanford Middle School Teacher program (NanoSIMST)

Diversity Efforts: *Student Initiatives*

- Establishment of Student Chapter of NSBP at Harvard (now officially supported by Physics and the University)
- Sister Chapter being developed at MIT (plans for regional presence)



Nicole Taylor - Harvard
Greg Cunningham* - Harvard / MIT



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CNS Scholars (Democratizing Nano/Quantum)

CNS is focused providing collaborative access to CNS enabling *Inclusive Excellence*



*Prof. K. Dorsey – Smith College



Pheona Williams* – Harvard/MIT



Prof. R. Horton – Miss State University



Dr. Pia Sorenson – SEAS



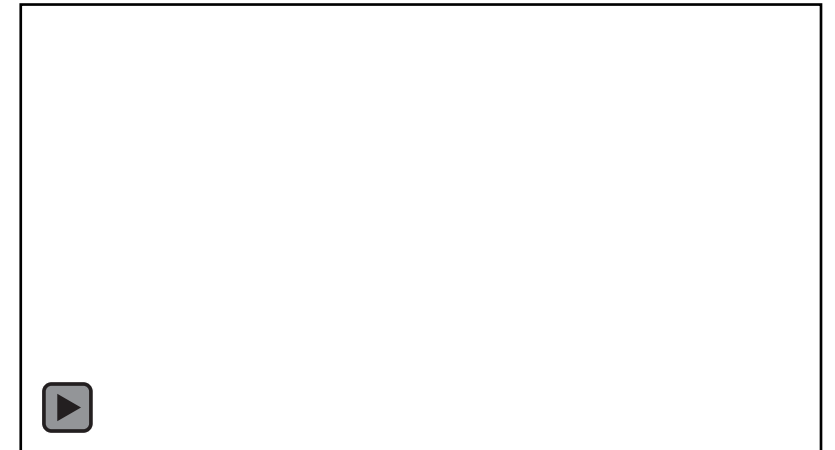
Dr. Josh Burrow – Brown University



Prof. T. Brower-Thomas – Howard University



Prof. D. Simien – UAB



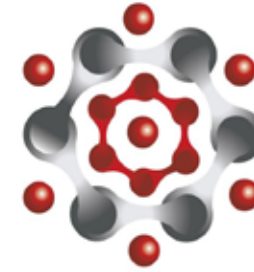
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*NSF Career Awardee

(Evolving Community) Quantum Noir

“Gordon – Style” Nano/Quantum Science & Engineering Meeting:
(2-1/2 Days / 2-year cycle)

- *Subject matter (Quantum Science / Nanoscience, broadly defined)*
- *Directed as advanced students and researchers of color(+)*



QUANTUM
NOIR 2024

tentative sessions: (Session organizers in bold)

- *Quantum Information / Simulation (Charles **Brown**, Yale / Stephon Alexander, Brown)*
- *Quantum Devices (systems / applications) (Deji Akinwande, UT / Bill Wilson, Harvard)*
 - ▶ *Quantum Networking*
 - ▶ *Quantum Logic*
- *Quantum NanoPhotonics (systems / devices / applications). (Boubacar Kante, UC Berkley / Donell Walton, Corning, Kayla Lee, IBM)*
- *Quantum / Nano Materials (Ken Evans, BNL / Nadya Mason, UIUC / Jacob Gayles, USF / Trevor Rhone, RPI)*
- *Poster Session (Grad Student focused / student travel support provided)*
- *DEI / Career Development Forum*
- *Start-up landscape*
- *Funding Agencies*



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QUANTUM
NOIR 2024

Conference Update



General Logistics (Meeting *funded*)

Venue / Harvard Physics / Cambridge

Dates (06/12/2024 – 06/14/2024)

Note: *½ - day tutorial talks on 6/11/2024 Cambridge may be available remotely*

On-going:

- § NSBP Meeting (Big Science Hour) November 10th 2023
- § Harvard Internal Support in the works
- § Exploring Options for Corporate Support; *Amazon, Corning*

Quantum Noir Seminars Pre-meeting Event: 06/11/2024 (Tutorials (4))

- Quantum Mechanics for Quantum Information Science: *James Whitfield*
- Quantum Computing, Hardware and Systems – *Will Oliver*
- Quantum Networking - *Marko Loncar*
- Quantum Materials for Robust Quantum Devices - *Natalie de Leon*

Confirmed Speakers:

- Will Oliver – MIT
- Natalie de Leon – Princeton
- Charles Brown – Yale
- Serena Eley – U Wash
- Deji Akiwande – Texas
- Dirk Englund – MIT
- Boubacar Kante – Berkley
- Marko Loncar – Harvard
- Misha Lukin – Harvard
- Pablo Jarillo-Herro - MIT
- Neil Sinclair – Harvard
- James Whitfield – AWS/Dartmouth
- Nadya Mason – U Chicago



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