Harvard University:
Center for Nanoscale Systems

NNCI 2019 Annual Meeting

National Nanotechnology Coordinated Infrastructure

NSF

Center for Nanoscale Systems
Harvard University

Harvard CNS

The New England Epicenter for Interdisciplinary Nano and Quantum Science Research

CNS Overview:

- ***CNS*** is a regional one-stop shop for all things *"Nano and Quantum"* (almost fully self-use)
- ***CNS's focus is to*** serves as a important regional, Community resource. (we are open access)
- ***CNS strives to*** serves to support the primary research and innovation thrusts within the Harvard research community and beyond.
- ***CNS*** supports training and educational programs to engage large numbers of undergraduates, non-traditional, and underserved external users, in nanofabrication, advanced characterization and advanced imaging techniques.
- ***CNS*** is engaged with Harvard proposal development, Research Centers, Equipment, etc.
- ***CNS*** now offering support for new Start-up companies and is establishing alliances with local technology incubators.

Robert Westervelt
Director

William L. Wilson
Executive Director

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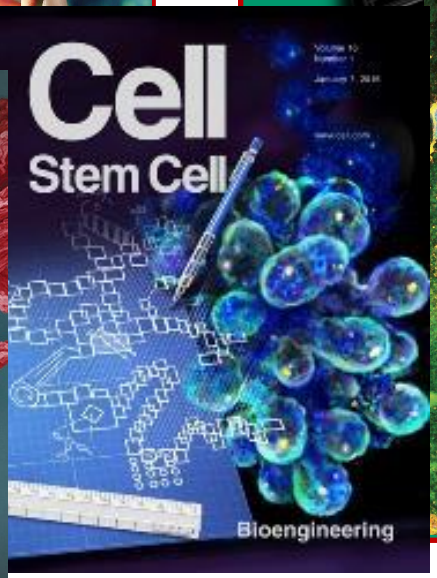

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Key: Demographics
~1300 Users (FY19)
~47% External Users
~11% Start-ups

Facilities &Tools: Technological Sustainability: Status

Proposal Successes:
NIH High-end SIG *Micro-CT Funded. (installed system)*
NSF:MRI - *LEEM (Bell) – Funded (system to arrive this winter)*
NSF:MRI – *LT Scan Probe System (Hoffman) - Funded/staffed*

Leveraging Start-up: New High Resolution, Aberration Corrected Microscope
(Install beginning NOW/ *Running this spring*)

Leasing for Sustainability (Focus on replacements for heavily used tools):
Fab tools – (PECVD / RIE)
XPS/UPS
Ebeam Lithography tool
FIB Systems / SEMs

Initially FAB focused,
But Proven Extremely flexible

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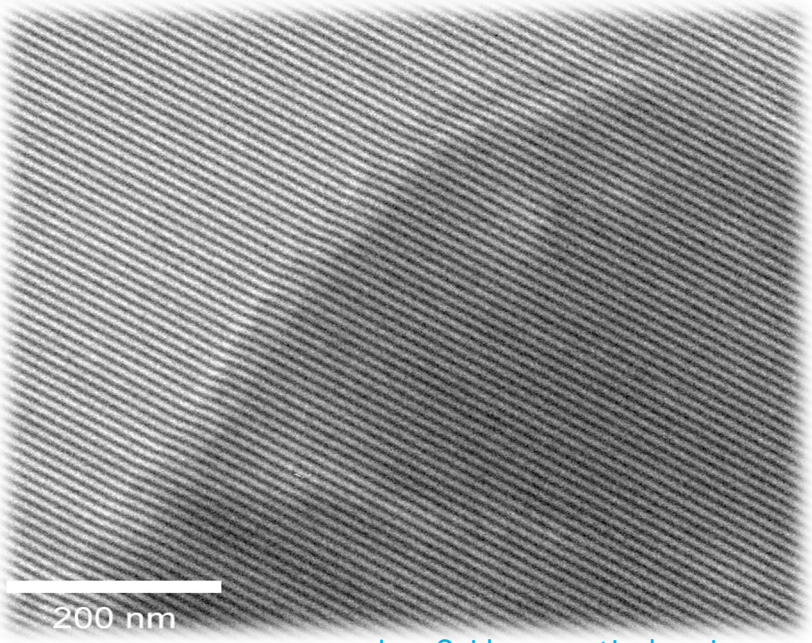
Harvard CNS: Facilities and Tools

- Facility/Tool additions (method of acquisition)
  - Example grant supported (NIH SIG)

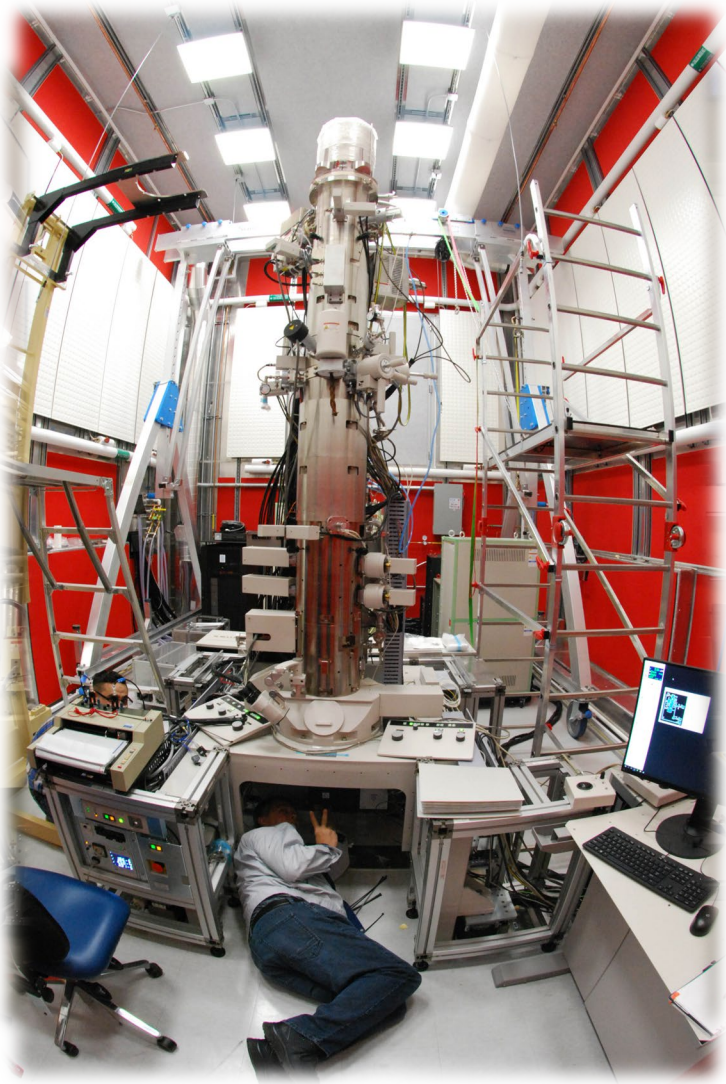
Harvard CNS: Facilities and Tools

Leveraging Start-up:

Harvard Quantum Imager (HQI)
(aka the MegaScope)
begin delivered as we speak!



Iron Oxide magnetic domains



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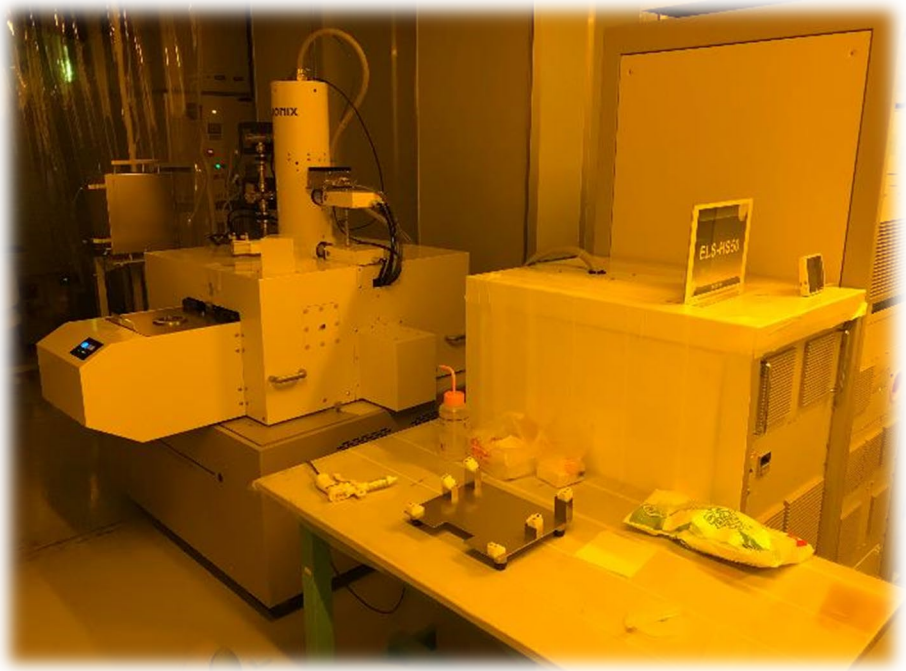
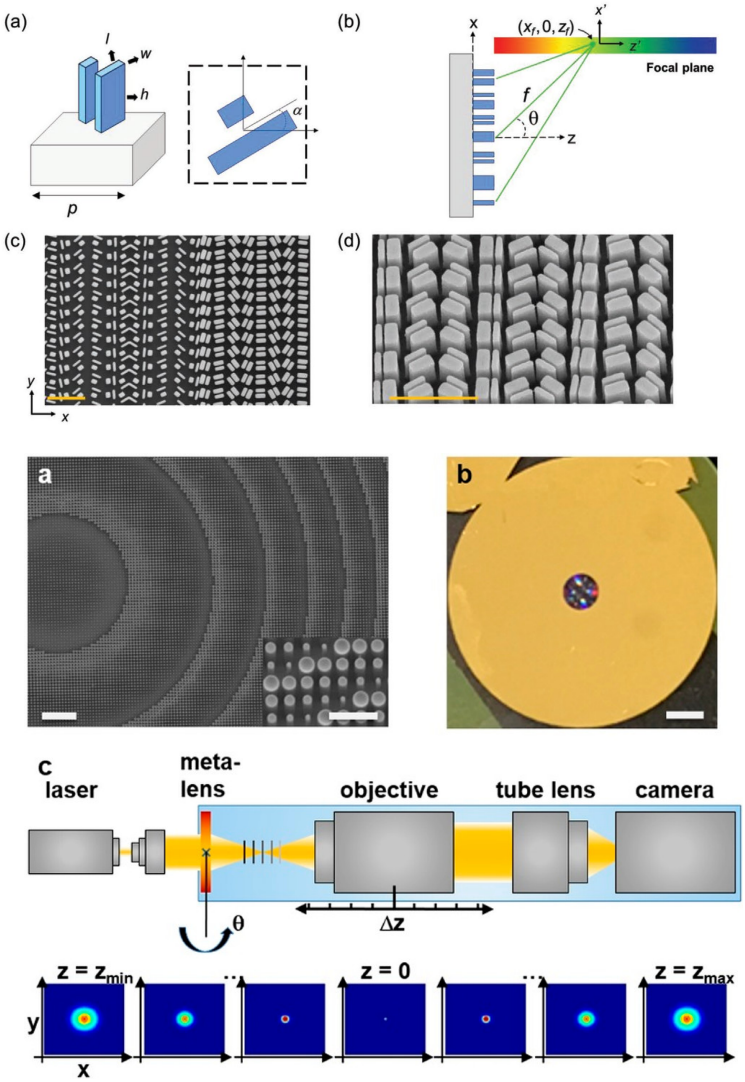
Harvard CNS: Facilities and Tools

Fab Tool Evolution / Via lease



Elionix High-Speed Ebeam Lithography tool
(delivery this Winter)



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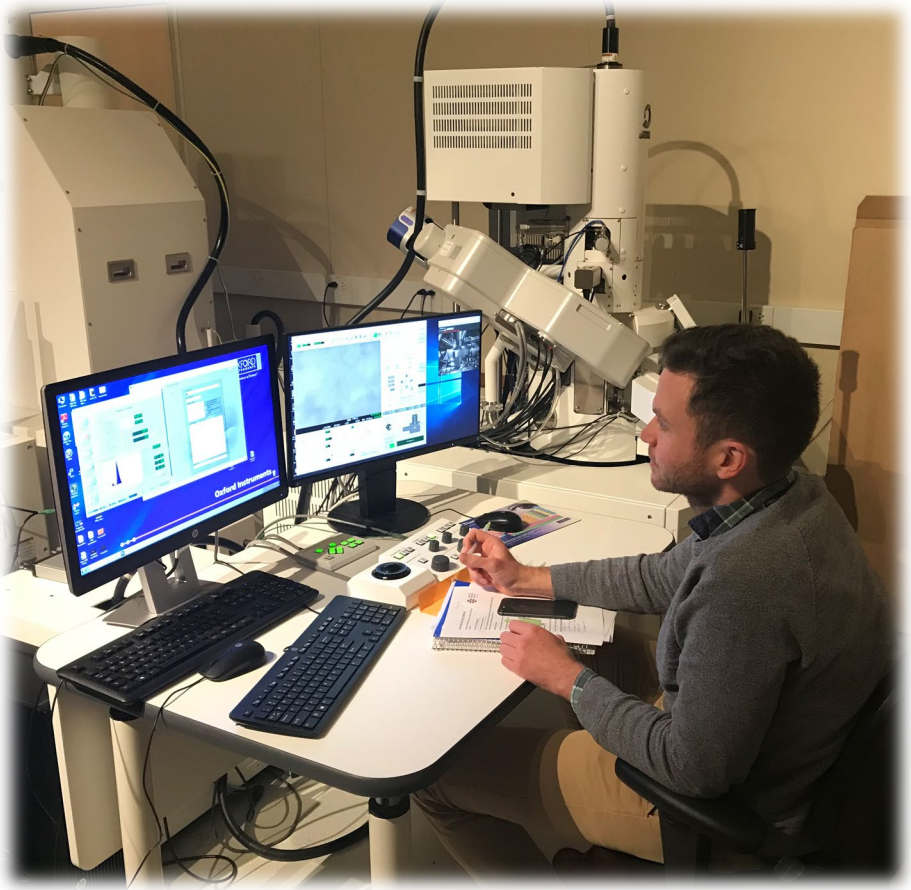
Harvard CNS: Facilities and Tools

Instrumentation Evolution / Via lease



Advancing Technology and Capability on workhorse instruments

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Evolving Tool set to Support Key Focus Areas

Quantum Science & Engineering:

Quantum information Science-Systems and Devices

NanoOptics, NanoPhotonic devices, NanoSpectroscopy

Quantitative Biology:

NanoMechanics; Nanoscale structural analysis

BioEngineering *(Translational Bioscience)*:

Advanced Imaging (CryoEM)

CIQM CENTER for INTEGRATED QUANTUM MATERIALS

Quantum Information Science and Technology

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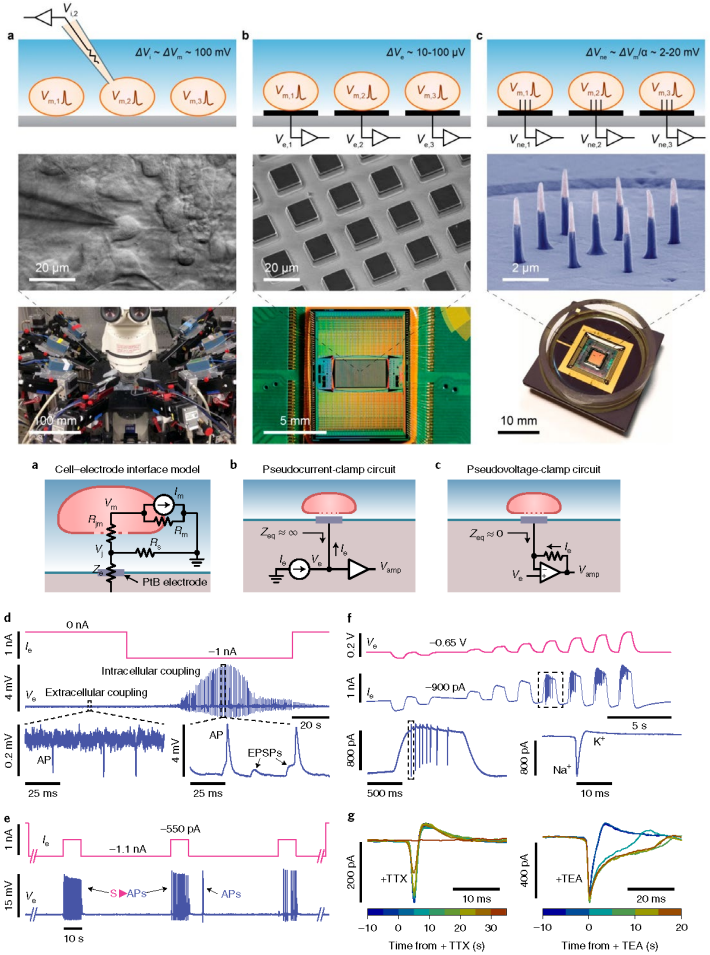
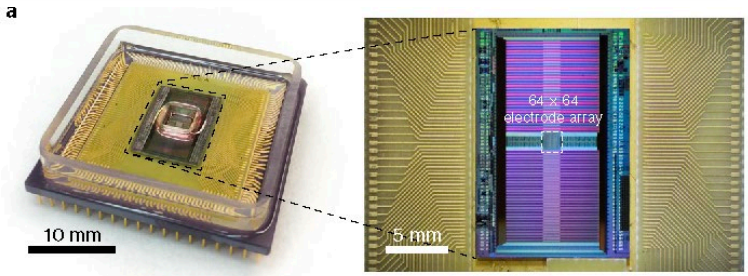
Harvard CNS: Research Highlights

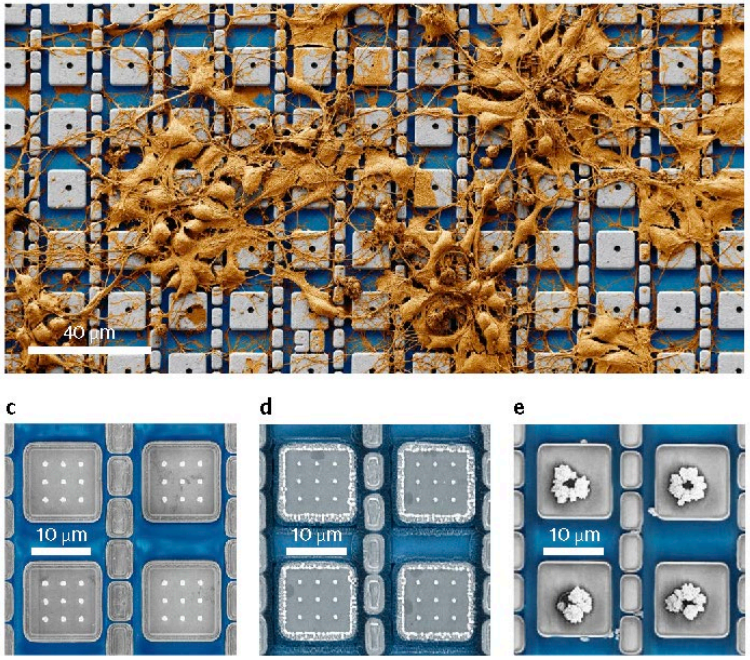
Nanoelectrode Arrays: high-throughput intracellular-recording technology for electrophysiological probe



Understanding the Rules of Life



CMOS: Neuroelectronic interface



Nature Biomedical Engineering (2019)
https://10.1038/s41551-019-0455-7

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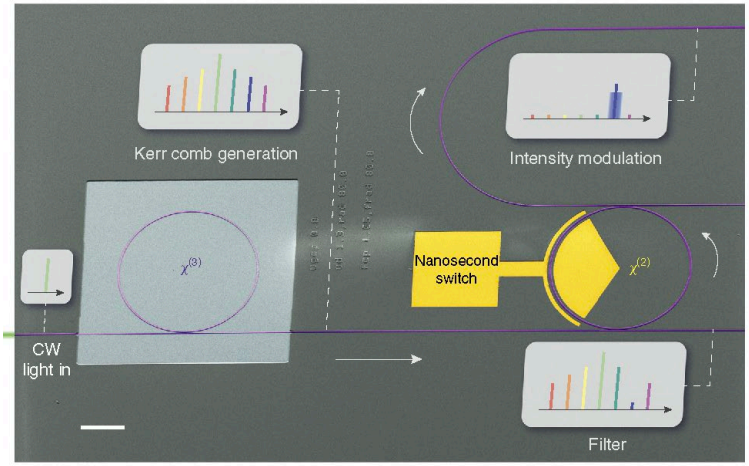
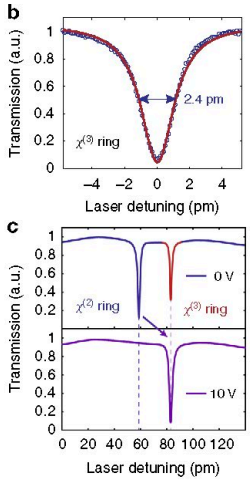
Harvard CNS: Research Highlights

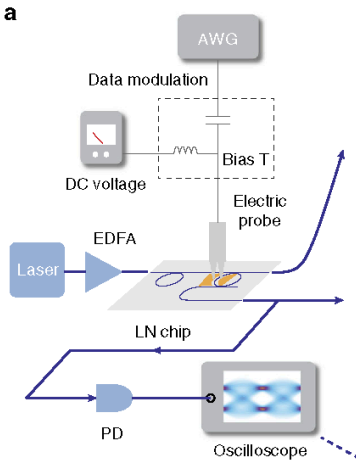
Monolithic Lithium Niobate photonic circuits;

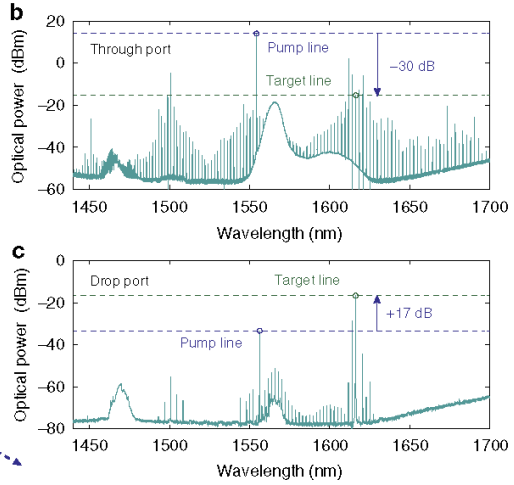
- ✓ High performance Integrated optics
- ✓ All Processes developed in-house (w/ CNS Staff Support)
- ✓ Technology being utilized by a new start-up; HyperLight

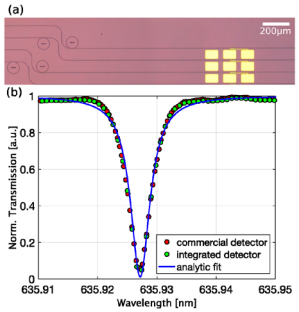
A Quantum Leap Technology

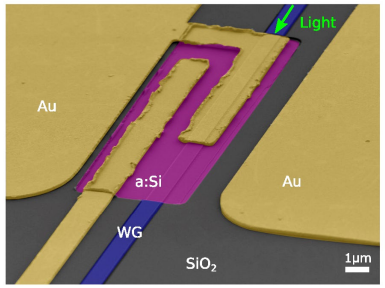


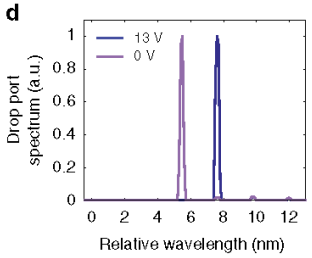


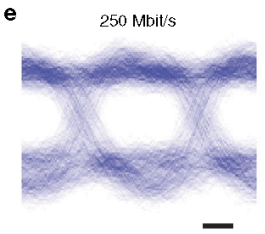


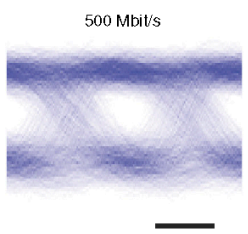












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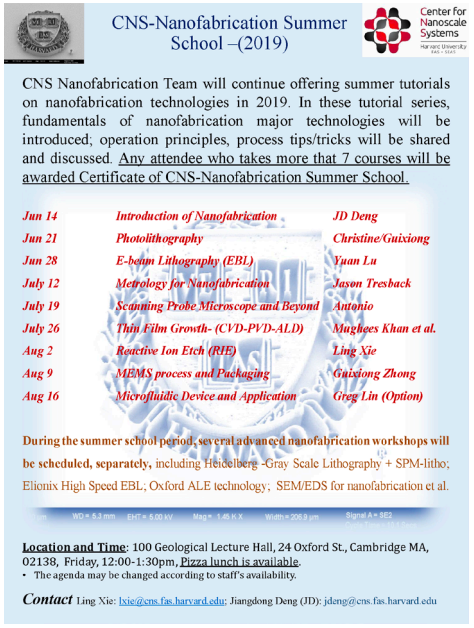
Nature Comm (2019) 10:978
Appl. Phys. Lett, **115** 12108 (2019); doi: 10.1063/1.5118901

Harvard CNS: Education and Outreach

- Education/Outreach Highlight
  - 2019 Research Experience for Veterans (REV) / REU

First name	Last name	Institution	Principal Investigato	Project Title
David	Murray	Georgia Institute of Technology	Bell, David	Characterization of In Situ TEM Heating Holders Using Silver Nanocubes
Sophia	Millay	Williams College	Capasso, Frederico	Broadband high-efficiency and polarization-insensitive metalens
Alvaro	Sahagun	University of Illinois at Chicago	Deng, Jiangdong	Photonic Wire Bonding by 3D Laser Lithography
Ethan	Kuhn	Bunker Hill Community College	Deng, Jiangdong	Nanoresist: Engineering the Refractive Index for Photonic Structures
Dominique	Pabllto	University of Utah	Hasan, Tayyaba	Enhancing Cell Death Using Targeted Photoactivable Multi-Inhibitor Liposomes (TPMIL)
Patrice	Constantin	Bunker Hill Community College	Hu, Evelyn	Gallium Nitride Quantum Dot microcavity Lasers
Danial	Haie Najafabadi	University of Massachusetts - Lowell	Kim, Philip	PC transfer optimization for van der Waals heterostructures
Riley	Flores	Northeastern University	Parker, Kit	The Effect of Substrate Stiffness On Perineuronal Net Development in vitro
Kristopher	Reynolds	University of Tennessee - Knoxville	Whitesides, George	Elucidating the Shape of the Quantum Tunneling Barrier in Self Assembled Monolayers
Tai	Nguyen	Bunker Hill Community College	Wilson, Bill	Determining Origins of Water Contamination in Atomic Layer Deposition Oxide Films Using Deuterated Water

- CNS Summer school



CNS-Nanofabrication Summer School –(2019)

Center for Nanoscale Systems

CNS Nanofabrication Team will continue offering summer tutorials on nanofabrication technologies in 2019. In these tutorial series, fundamentals of nanofabrication major technologies will be introduced; operation principles, process tips/tricks will be shared and discussed. Any attendee who takes more that 7 courses will be awarded Certificate of CNS-Nanofabrication Summer School.

Jun 14	Introduction of Nanofabrication	JD Deng
Jun 21	Photolithography	Christine/Guixiong
Jun 28	E-beam Lithography (EBL)	Yuan Lu
July 12	Metrology for Nanofabrication	Jason Tresback
July 19	Scanning Probe Microscope and Beyond	Antonio
July 26	Thin Film Growth- (CVD-PVD-ALD)	Mughees Khan et al.
Aug 2	Reactive Ion Etch (RIE)	Ling Xie
Aug 9	MEMS process and Packaging	Guixiong Zhong
Aug 16	Microfluidic Device and Application	Greg Lin (Option)

During the summer school period, several advanced nanofabrication workshops will be scheduled, separately, including Heidelberg -Gray Scale Lithography + SPM-litho; Elionix High Speed EBL; Oxford ALE technology; SEM/EDS for nanofabrication et al.

Location and Time: 100 Geological Lecture Hall, 24 Oxford St., Cambridge MA, 02138, Friday, 12:00-1:30pm, Pizza lunch is available.
- The agenda may be changed according to staff's availability.

Contact Ling Xie: lxie@cns.fas.harvard.edu; Jiangdong Deng (JD): jdeng@cns.fas.harvard.edu

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CNS Scholars: building on successes.

*Prof. K. Dorsey – Smith College

Prof. T. Searles – Howard University

Prof. R. Horton – Miss State University

Prof. K. Aidala – Mount Holyoke

Prof. T. Brower-Thomas – Howard University

Prof. D. Simien – UAB

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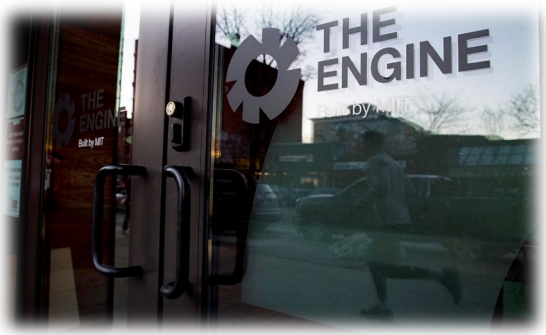
*NSF Career Awardee

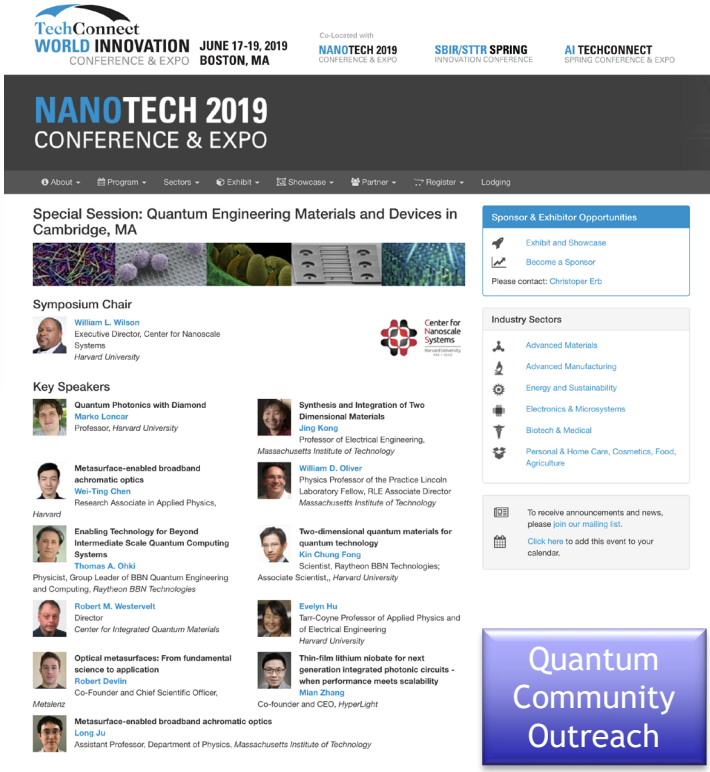
Harvard CNS: Impact

- Driving Economic Impact
  - Renewed Support for Start-ups
  - Forums to support Quantum Science and Engineering



BOLT

- Incubator engagement
- Harvard OTD



Quantum Community Outreach

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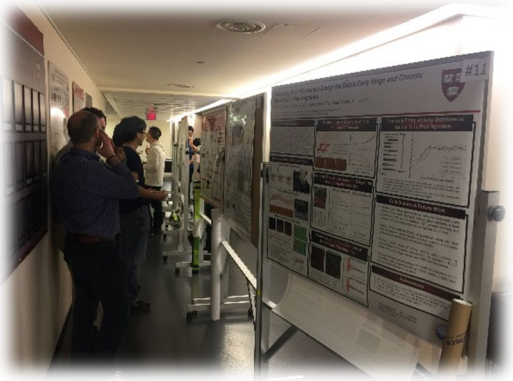
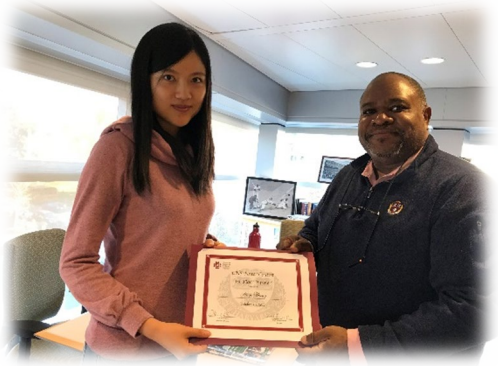
Driving Research Engagement:
2019 CNS Open House and Poster Session



11/7/2019!!!
All are Welcome!!

Best Poster winners:
Anqi Zhang - Lieber
Srujan Meesala - Loncar



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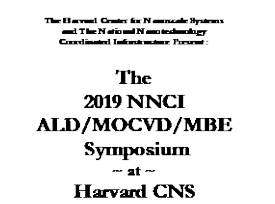
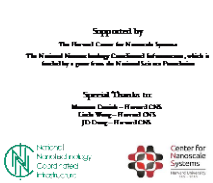
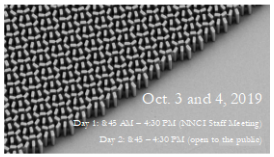
Harvard CNS: Network Collaboration

- CNS/NNCI Network Collaborations
  - CNS hosted the Network ALD/MBE Workshop (Oct 2019)







  - CNS will host the Network Etch Workshop (Dec 5th & 6th 2019)

Other Network Collaboration Activities:

- ✓ CNS Staff participation in subcommittees and working groups; Key senior staff heavily involved in many technical information sharing efforts, *Imaging, Advanced ALD Processing, Photolithography*
- ✓ Engagement in workforce and Business development Working Groups
- ✓ REU/REV attendance at REU convocation and Staff attendance at the NNCI annual conference
- ✓ WLW represented the NNCI at the Nano S&T Grantees Meeting
- ✓ Active participation on the NNCI Diversity Subcommittee
- ✓ NNCI EBL workgroup meeting in EIPBN (5/29/2019)
- ✓ GeniSys Beamer software workshop (9/10/2019)
- ✓ Georgia Tech team visit for Safety, ALD, user process interfacing (5/23/2019)
- ✓ UPenn- team (Metzler) visit for general operation discussion (9/10/2019)
- ✓ CNS will host NNCI Annual Meeting (2019)

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Harvard CNS: Panel Discussion

- ***Facility Management***
  - Primary Challenge? ***Technological Sustainability***
    - Equipment, Staff, and Infrastructure
  - Areas to explore
    - Equipment turnover: leasing, Sponsored Support
    - Staff Support and Retention: Career paths, etc.
    - Infrastructure evolution / space concerns: Balancing competing interests.
    - Mapping of tools to research needs
    - Claiming credit for teaching, etc.

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