

Northwest Nanotechnology Infrastructure (NNI)

University of Washington / Oregon State University

PI: Karl F. Böhringer

NNCI Annual Conference

University of Louisville, KY, October 30, 2024



NNCI NORTHWEST
NANOTECHNOLOGY
INFRASTRUCTURE



NNI – Vision

The NNCI Northwest Nanotechnology Infrastructure acts as an engine for innovation and economic development by providing world-class nanotechnology infrastructure for a broad and diverse user base, paired with technical and educational leadership in photonic and quantum devices, advanced energy materials and devices, and bio-nano interfaces and systems.

Overview – NNI Facilities and Principal Focus Areas



★ Darick Baker



★ Karl Böhringer



Maria Huffman



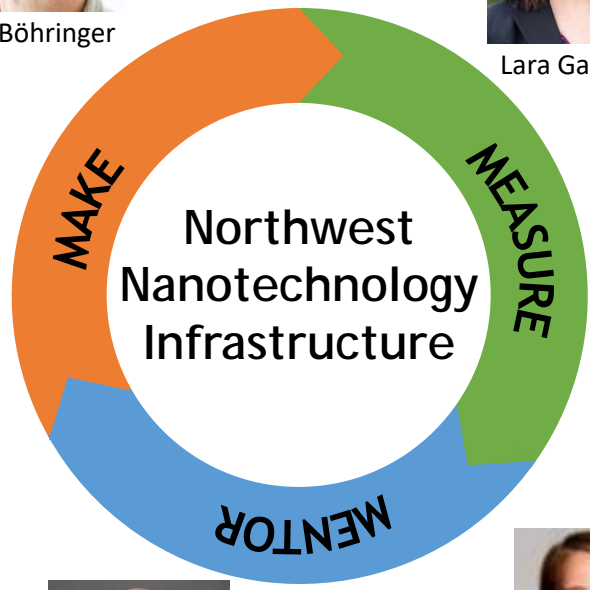
Lara Gamble



John Conley



Todd Miller



★ Joe Baio



Daniel Ratner



Líney Árnadóttir

Integrated Photonics / Quantum

Kai-Mei Fu

★ Mo Li

Oksana Ostroverkhova

Energy Materials & Devices

Chih-hung Chang

Zhenxing Feng

David Ginger

Daniel Schwartz

Bio-nano Interfaces

★ Joe Baio

Daniel Ratner

Lara Gamble

2024 Nobel Prize in Chemistry

- David Baker, Professor of Biochemistry
Director, Institute for Protein Design
... for computational protein design
 - Co-awardees: Demis Hassabis, John M. Jumper
DeepMind *... for protein structure prediction*
- Baker's group is an active user of NNI, especially
the Molecular Analysis Facility (MAF) at UW
 - 6 years ago: David Baker's keynote presentation at 2018 NNCI Conference:
De novo design of protein nanomaterials
 - 3 years ago: Vinayak Dravid's invited talk at UW, followed by joint paper:
Baker, Dravid, et al., Analytical Chemistry 94(23), 2022



NNI – New Capabilities

Numerous new investments due to extensive support from university, government, and private sources (“CHIPS Act effect”)

Recent or pending acquisitions:

WNF (UW):

- SAMCO RIE-10NR etcher
- Disco wafer grinder
- Oxford PlasmaPro 100 Cobra 300 ICP-RIE (CI/ALE)
- Goniometer
- Oxford ICP 380 fluorine etcher upgrade: CH₄, H₂
- Angstrom Engineering e-beam evaporator
- IntelVac ion beam etcher
- SPTS FI etcher
- Raith Voyager e-beam lithography
- Heidelberg MLA 150 direct write laser litho
- Bruker FastScan AFM
- SEM, PECVD, litho tools: bonder, aligner, track

- Also: 3D rendering of cleanroom for virtual tours

MAF (UW):

- ThermoFisher Apreo 2 S LoVac SEM
 - Gatan EDAX Pegasus integrated EDS-EBSD with Clarity super detector
- Bruker Icon AFM computer update
- Molecular Vista PiFM upgraded scan head
- 3 Nikon stereo microscopes
 - 1 digital camera
- CrystalMaker software
- Focused Ion Beam
- XPS

NNI – New Capabilities

Numerous new investments due to extensive support from university, government, and private sources (“CHIPS Act effect”)

Recent or pending acquisitions:

ATAMI (OSU):

- Agilent liquid chromatography / mass spectrometry
- Ocean Insight UV/VIS
- Corning Nebula flow reactor

- Jen-Hsun & Lori Huang Collaborative Innovation Complex (\$200M, 150,000 ft²).
Will include new cleanroom / nanofabrication facilities and fastest supercomputer on West Coast.
Construction scheduled to be completed 2025.

MaSC, APSCCL, OPIC (OSU):

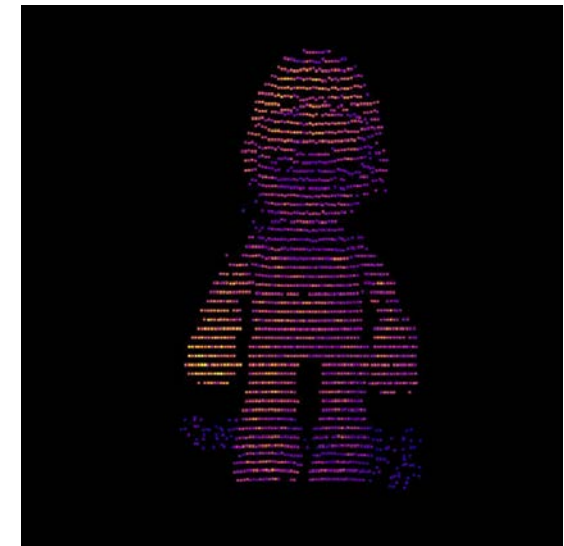
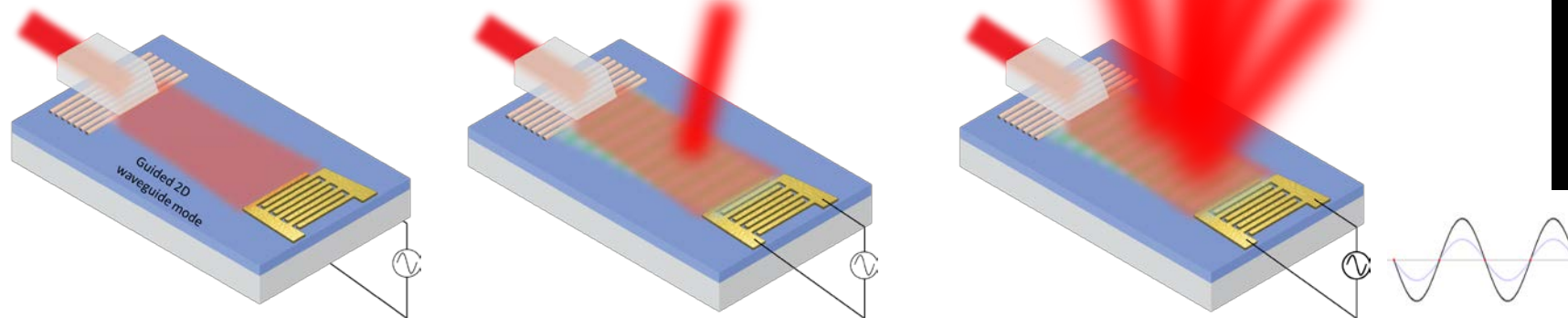
- Stanford Research Systems SR865A lock-in amplifier
- 2 Laurell WS-650MZ-23NPPB spin coaters
- Memmert HCP SD humidity chamber
- Ultimaker 3D printer
- Shimadzu UV-2600 UV-vis spectrometer
- Ossila UV ozone cleaner
- Keysight B2985A electrometer

NNI – Photonic and Quantum Devices



Frequency-angular Resolving (FAR) LiDAR by Integrated Acousto-optic Beam Steering

- Light Detection and Ranging (LiDAR) is indispensable for intelligent automation and autonomous vehicles
- Current beam steering systems are bulky and require mechanical parts
- Idea: exploit Brillouin scattering – the interaction of light with acoustic waves – to steer beams at different angles
 - Single-chip gigahertz transducer
 - Frequency-labeled angular direction



- Publication: Bingzhao Li, Qixuan Lin, Mo Li, *Nature* 620(7973), 316-322, 2023
- Funding: NSF Convergence Accelerator ITE-2134345 (Li, Majumdar, Böhringer), DARPA (Li)

UPWARDS for the Future Network

U.S.-Japan University Partnership for Workforce Advancement and Research & Development in Semiconductors for the Future Network



\$10 M



\$10 M

\$10 M

5 years

6 U.S. Univ.

5 Japanese Univ.



HIROSHIMA UNIVERSITY



KYUSHU UNIVERSITY



TOHOKU UNIVERSITY



BOISE STATE UNIVERSITY



VIRGINIA TECH.



Rochester Institute of Technology



NAGOYA UNIVERSITY



Institute of SCIENCE TOKYO



NCCI NORTHWEST NANOTECHNOLOGY INFRASTRUCTURE



Five Pillar Activities:

- Semiconductor curriculum
- **Experiential Learning – WNF leads**
- Women in Semiconductor
- Intl. Student & Faculty Exchange
- Memory-centric Research



Prompt Question

What are examples of programs and activities developed under NNCI that will be sustainable, independent of any continued NSF renewal funding, and what strategies or sources will be used to support them?

Prompt Question: Sustainable Programs ...

Regional Networks

- Northwest Nano Lab Alliance (NWNLA)
 - Regional platform for exchange of laboratory experiences and best practices
 - Joint effort by NNI and MONT
 - Biennial meetings, alternating with UGIM (online 11/2021, in-person 8/2023, 2025)
 - Attendees from across the Pacific NW including Canada
 - – Develop more opportunities for staff career advancement, e.g., “nano sabbaticals”
- • New alliances
 - NSF Northwest Engine for Advancing the Semiconductor Ecosystem led by OSU, with academic, government, and industry partners
 - Oregon Semiconductor Center of Innovation Excellence (CIE) led by OSU, Intel, Oregon Business Council



Prompt Question: Sustainable Programs ...

Collaboration with Industry

- More than 20% of US semiconductor jobs are in Pacific NW, even though ID, OR, WA have less than 14M (5%) of US population
- Aligning with national semiconductor technology centers:
 - New Advanced Lithography Center in Hillsboro, OR
 - New Memory Center of Excellence, \$15B Micron memory fab in Boise, ID
 - Northwest University Semiconductor Network, led by Micron has grown to 13 universities and numerous community colleges in CA, ID, MT, OR, UT, WA
- ➔ • Need integration of strategic public sector and academic institution involvement to maximize impact on workforce development, innovation, entrepreneurship

Prompt Question: Sustainable Programs ...

Workforce Development

- Extensive Undergraduate Laboratory Assistant program
 - NNI employs ~20 undergrads/year, mentored by staff, increasingly complex tasks
- Short courses and workshops
 - Started with local students, focus on URM
 - Expanded to professional students
 - Hands-on courses are expensive – but growing support from industry
- WFD at all levels
 - K-12 and tribal outreach & research experience for tribal teachers
 - Build sustained relationships with K-12 tribal partners
 - On-campus experiences for students and teachers
 - College transition programs for longitudinal engagement and tracking
 - Focus on retention in 4-year engineering degree programs
 - Target underserved populations with intrusive academic and advising support



- ➔ • Need repository for content and best practices, sharing with other sites
- ➔ • Deliver workforce development at scale – how to grow from 20 to 2000 per year?

NNI – Northwest Nanotechnology Infrastructure

Thank you!

For NNCI Research Communities,
what worked, what didn't,
and what are suggestions
for what a future network might implement
to support national priority research topics?

Panel 2: Research Communities

- What worked
 - Increased awareness, access, and utilization of facilities
 - Community-building events and workshops
 - New programs:
 - “outward” – e.g., NSF Global Quantum Leap; UPWARDS (with industry in U.S./Japan)
 - “inward” – e.g., regional networks
- What didn't
 - Limited engagement, especially from outside users
 - Limited connection with other research networks
- Suggestions for a future network
 - Engage industrial partners: WFD and translational R&D
 - Develop standardized protocols: data sharing (with AI)
 - Provide adaptive funding: fast response to emerging research needs