

Northwest Nanotechnology Infrastructure (NNI)



University of Washington / Oregon State University
Site directors: Karl F. Böhringer / Greg Herman
September 14, 2018



Site Overview

NNI infrastructure builds on over 30 years of operating shared facilities in nanotech, including:

- **WNF (Washington Nanofabrication Facility)**
largest publicly accessible cleanroom in WA
- **MAF (Molecular Analysis Facility)**
unique and custom-made analytical characterization tools
- **MaSC (Materials Synthesis and Characterization Facility)**
only publicly accessible cleanroom in OR
- **ATAMI (Advanced Technology and Manufacturing Institute)**
shared 20,000 sf facility for startups on HP campus adjacent to OSU
- **OPIC (Oregon Process Innovation Center)**
process development facility, collaboration space with local industry
- Close working relationship with PNNL (Pacific Northwest National Labs)

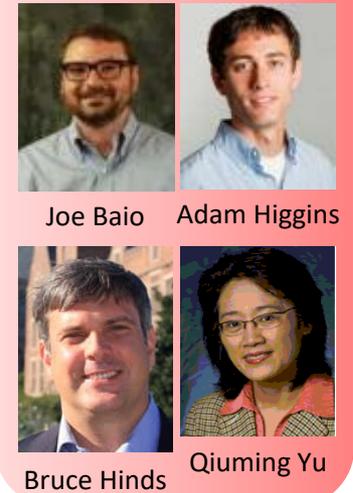
NNI Team



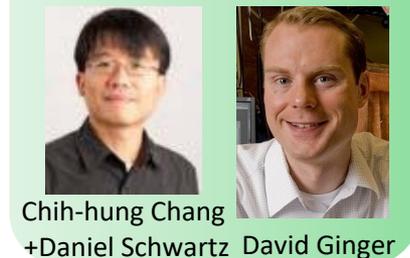
Integrated Photonics



Bio-nano Interfaces



Energy Materials & Devices



Approx. 30 staff,
20 undergrad assistants

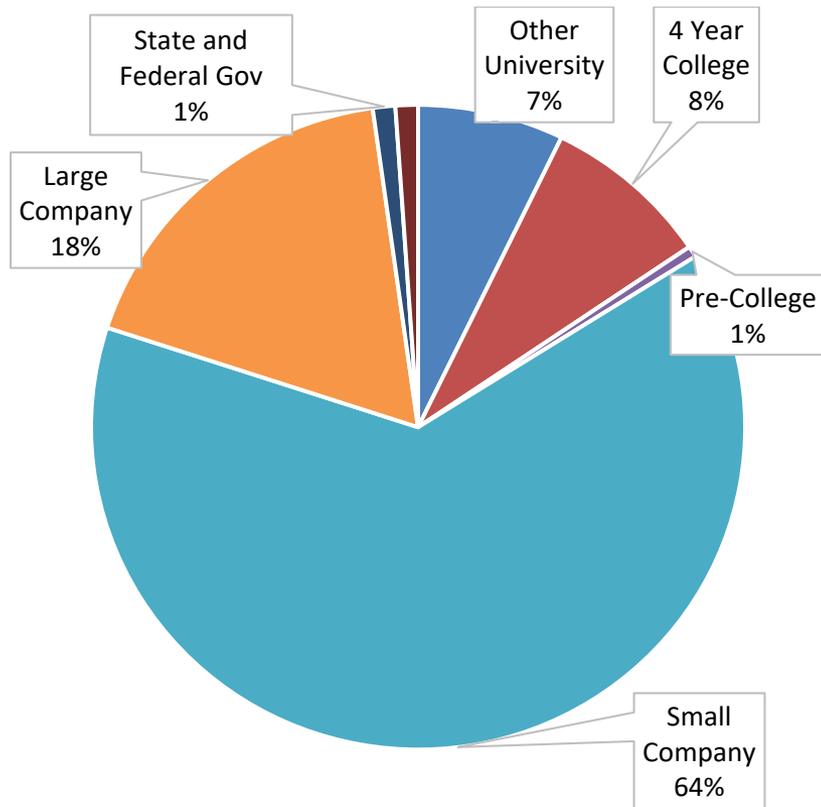
NNI User Data

\$37M renovation of WNF completed 11/17

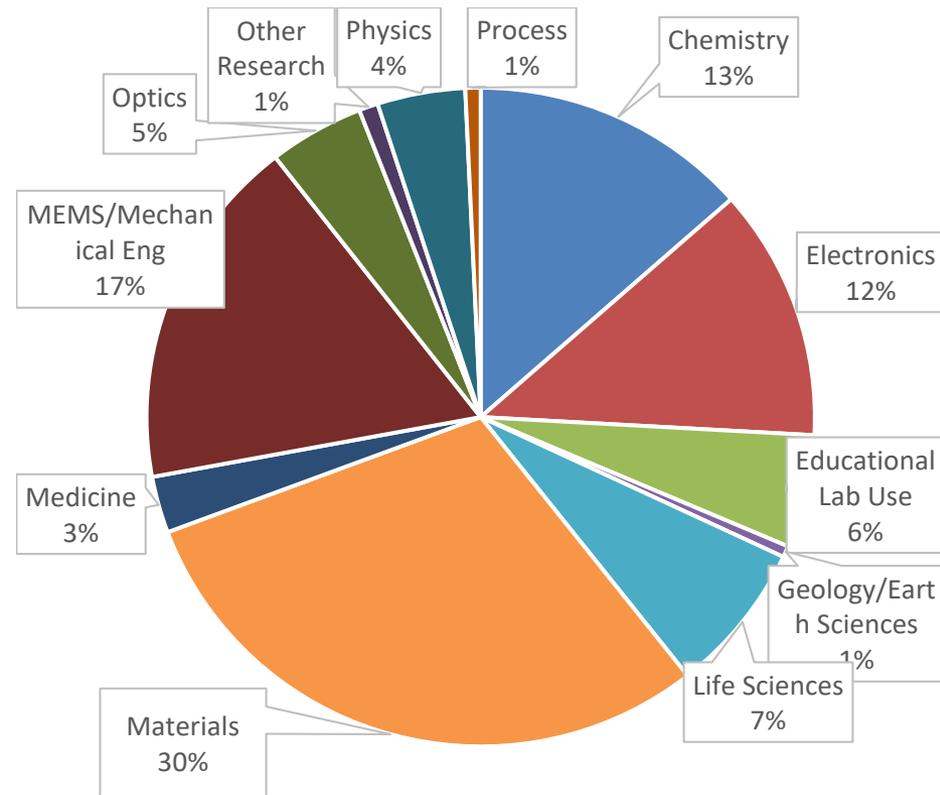
Yearly User Data Comparison			
	Year 1	Year 2	Year 3 (first 6 months)
Total Users	638	708	541
Internal Users	396	486	361
External Users	242	222	180
External Academic	27	19	29
External Industry	202	195	147
External Government	5	4	2
External Foreign	8	4	2
Total Hours	38350	46564	26378
Internal Hours	21822	30602	15100
External Hours	16582	15962	11277
Average Monthly Users	165	277	180
Average Ext. Monthly Users	103	98	99
New Users Trained	126	159	114
New External Users Trained	41	37	29

NNI User Data

External User Affiliations



All User Disciplines



Facility Upgrades and New Tool Capabilities

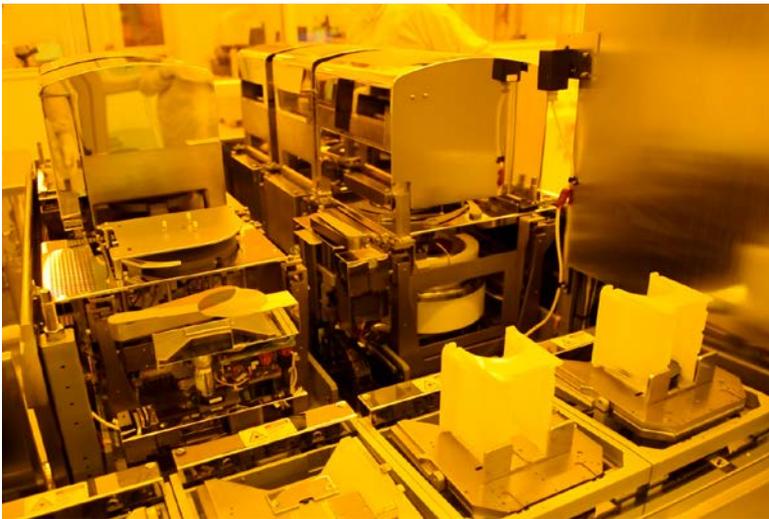
- UW Buildings
 - NanoES building
 - WNF renovation
- WNF
 - NanoScribe (NSF MRI)
 - 2 SPTS vapor phase etchers
 - Ritetrack SVG 90S coat and development track
 - Picosun ALD
 - New field service engineer
- MAF
 - Bruker D8 Discover XRD
 - Biolin Scientific Qsense QCMD
 - Bruker Hysitron TI980 Triboindenter
 - 2 Tecnai TEMs w/ cryo capability
 - FEI Apreo S LoVac SEM
- Adjacent BioChem cryoEM Center
 - FEI Titan Krios G3
 - FEI Arctica cryo-TEM
- OSU Buildings
 - Johnson Hall
 - Phased renovation of ATAMI
 - MaSC extension
- Ambient Pressure Surface Characterization Laboratory
 - Unique ambient-pressure x-ray photoelectron spectroscopy and scanning tunneling microscopy (AP-XPS/AP-STM)
- ATAMI
 - LPKF ProtoMat S103 micromill
 - LPKF MicroLine 2820P laser system

8-figure investments
in equipment

9-figure investments
in building infrastructure

WNF New Tool Capabilities – Highlight

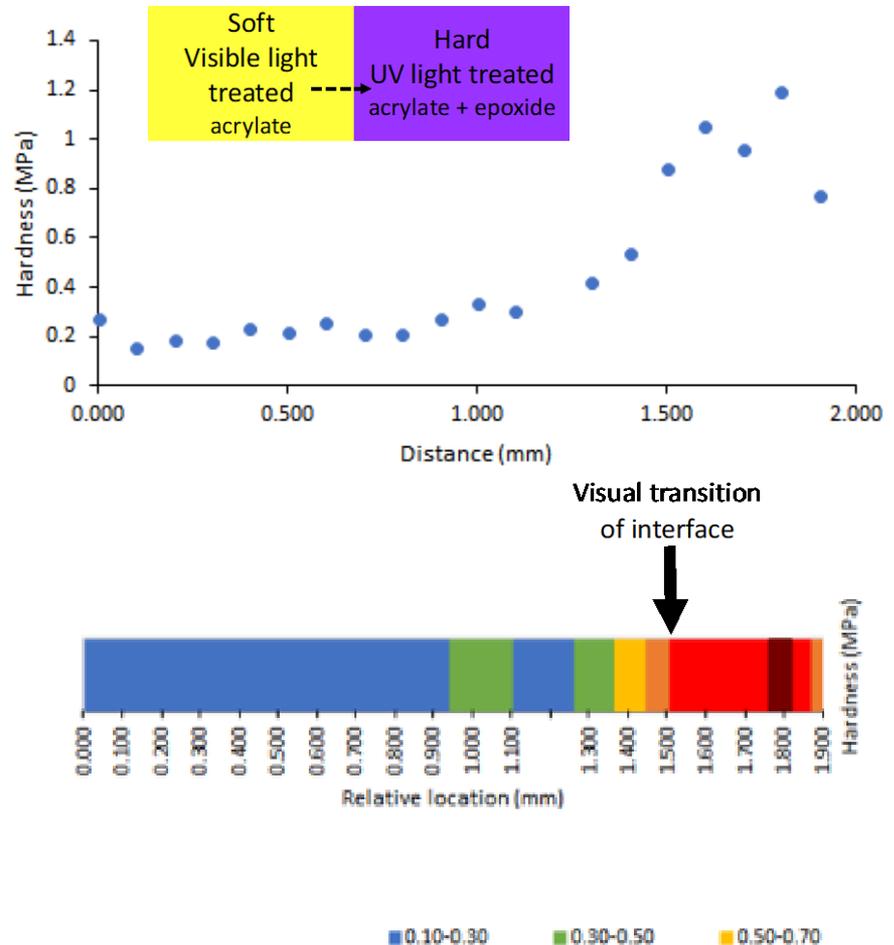
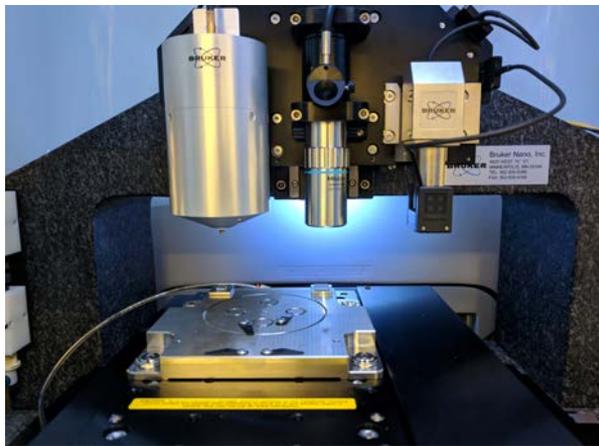
- Ritetrack SVG 90S coat/develop track
 - 4 different resists
 - 2 different developers
 - 100, 150, 200 mm capable
 - Rapid size conversion
- 2 Picosun ALD Reactors
 - MBRAUN glovebox
 - Metal and metal-nitride ALD reactor chambers
 - Plasma-ready system
 - Batch-capable for thermal



MAF New Tool Capabilities – Highlight

- MAF

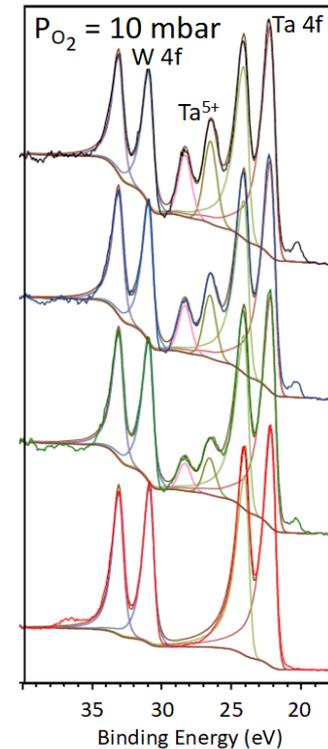
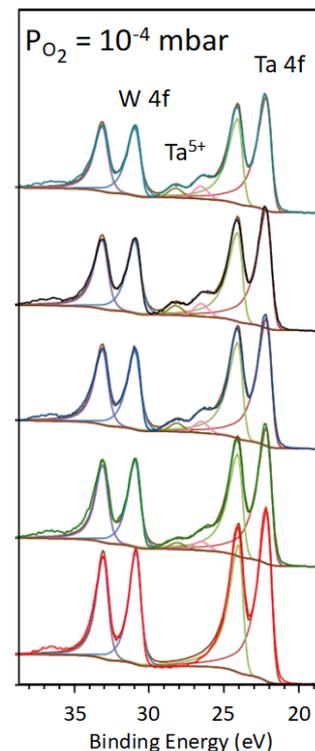
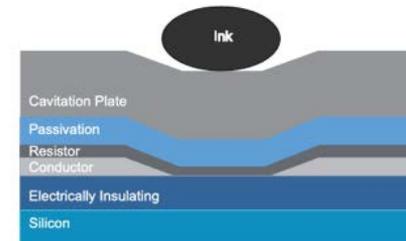
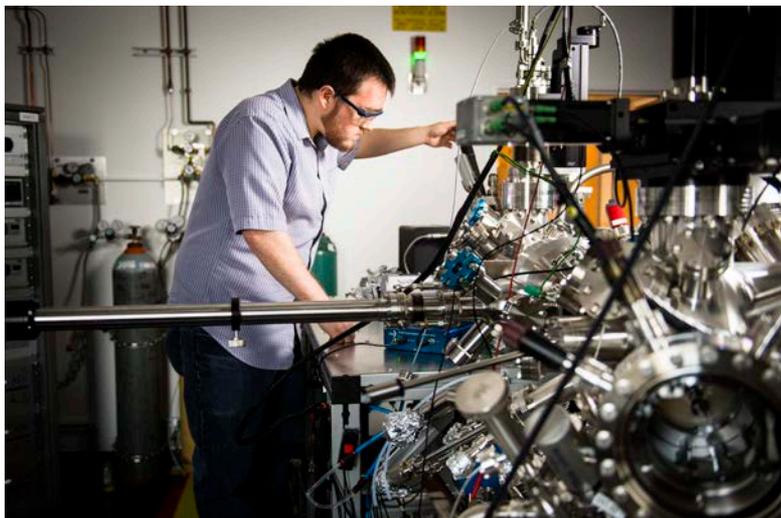
- Bruker D8 Discover with $1\mu\text{S}$ 2-D XRD
- Biolin Scientific Qsense QCMD
- **Bruker's Hysitron TI980 Triboindenter (NSF MRI)**
- CryoEM capabilities
 - FEI Tecnai with cryo added
 - FEI Titan Krios G3
 - FEI Arctica cryo-TEM



* Nanoindenter work by: Johanna Schwartz and Prof. AJ Boydston

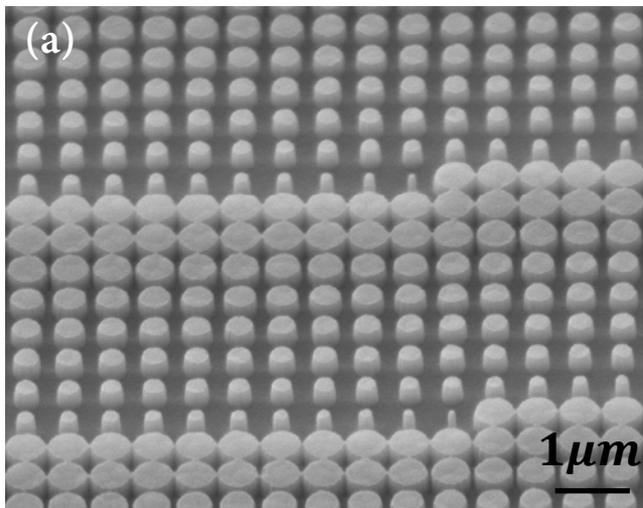
APSCL New Tool Capabilities – Highlight

- APSCL
 - SPECS ambient-pressure X-ray photoelectron spectroscopy/scanning tunneling microscopy
 - Perkin Elmer PHI 5600



* APXPS work by: Trey Diulus, Pedro Alzaga, Bill Stickle (HP)

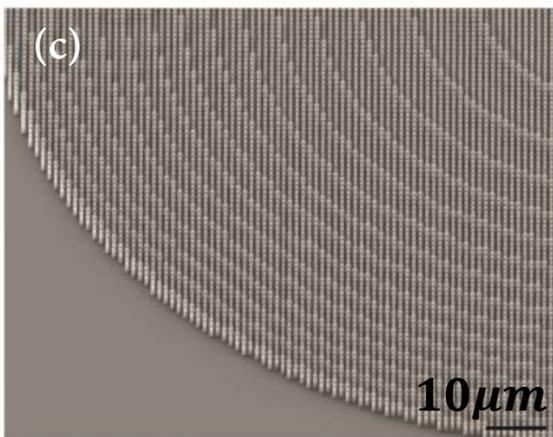
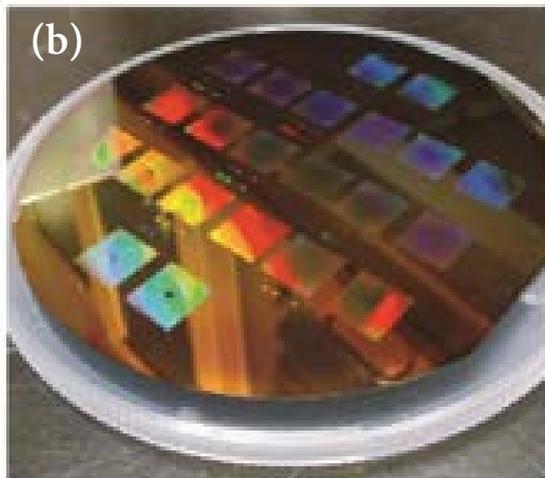
Research Highlight – Sensing via Dielectric Metasurface (Majumdar, Böhringer)



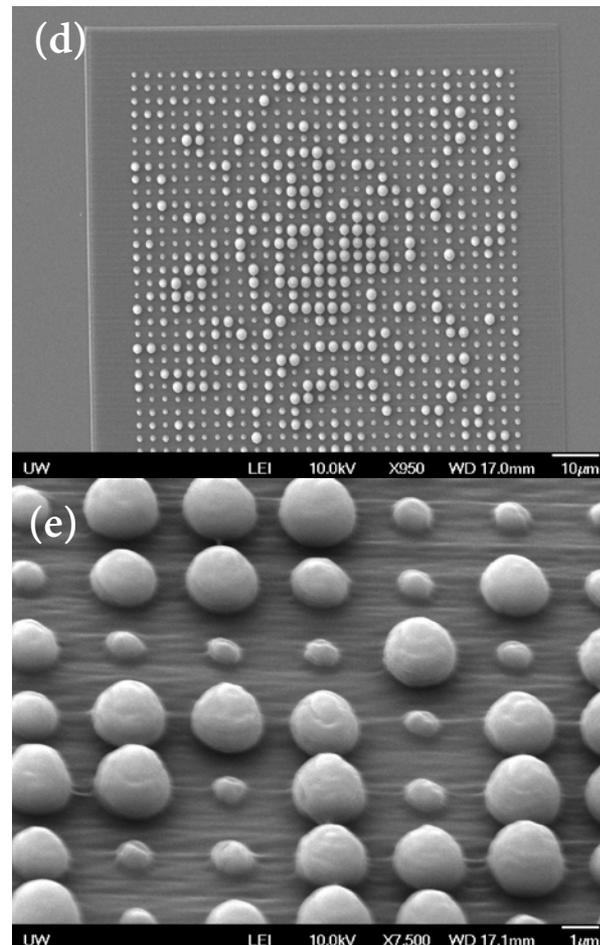
Nano-scale scatterers made by electron beam lithography



New Startup: Tunoptix

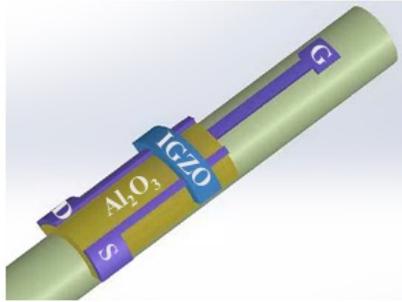
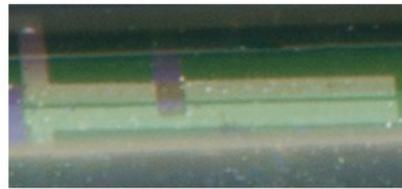
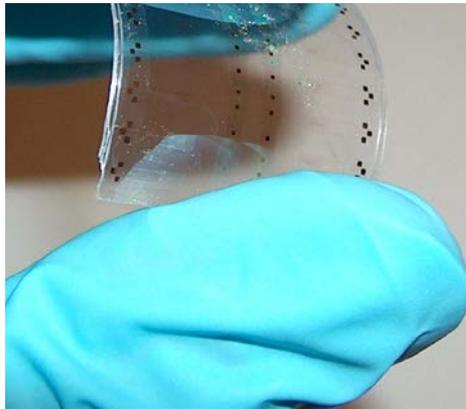


Large-area metasurface via stepper photolithography



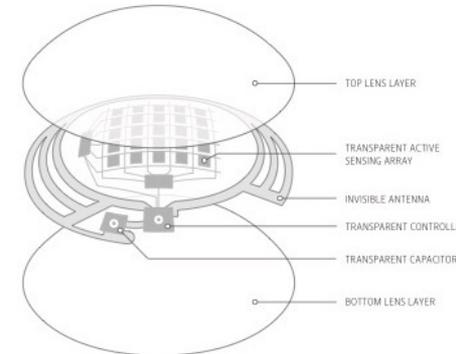
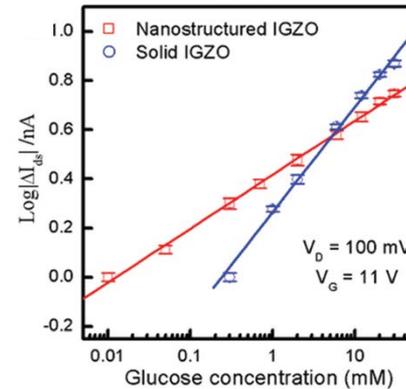
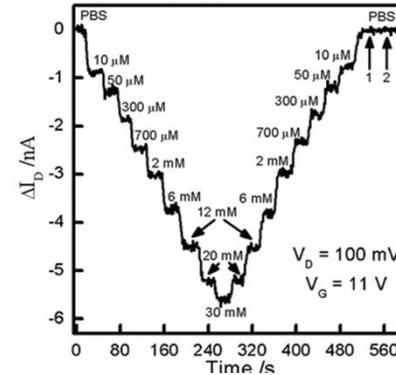
Computational design of metasurface
(fabricated via Nanoscribe)

Research Highlight – Sensing via Transparent Transistors (Herman)



Leverage transparent, flexible transistors and electronics developed at OSU and HP

Direct integration of transparent glucose sensors on catheter, and optical fibers



Potential to integrate transparent active matrix sensing array into contact lens for health diagnostics

High sensitivity to glucose and other analytes



X. Du, et al., Sensors and Actuators B **268**, 123 (2018)

<http://engineering.oregonstate.edu/season-2-episode-4-lenses-and-limbs>



NNCI NORTHWEST NANOTECHNOLOGY INFRASTRUCTURE



Impact of Education & Outreach Activities

- K-Gray Outreach (15,000+ participants)

E&O Activities	Participants
National Nanotechnology Day	2057 guests in partnership with The Pacific Science Center
Engineering Discovery Days	8,764 students and 1,781 chaperones
Introduce a girl to nano	277 girls
K-12 Outreach events	2,600 participants
Cleanroom Internships	22 (7 women, 4 URM)
First Nation Campus visits	44 K-12 students
SESEY Program	55 URM
Undergraduate research assistants	17 (5 URM)
Deployable teaching modules	K-12 classrooms and teacher training

NNI has expanded regional tribal engagement, hosting 44 K-12 students in on-campus experiences.



- Expanding portfolio of assessment instruments

- Educator/host debrief
- Interviews
- Critical feedback for continuous improvement
- Reflective exercises
 - Impacts on thinking/perception



NNCI NORTHWEST
NANOTECHNOLOGY
INFRASTRUCTURE



NNCI Cooperative Network Activities

Network-wide

- Leading the Vendor Relations working group: leveraging network purchasing power to obtain discounts and perform bulk purchases of high-cost items (e.g. e-beam resists)
- Participation in E&O, Workforce Development, Assessments subcommittees and Etch Processing working group:
 - Shared reports and best practices (e.g., XeF₂ wafer thinning, etching of unique materials: PZT, CdS, Ta)
- Participation in Nano Day activities

Multi-site

- User project support and staff technical interactions
 - Dense array TSV development (SDNI UCSD, SNSF Stanford, IEN GaTech, OSU)
- Workshop on Ambient Pressure XPS/STM (at OSU, with UW and PNNL participation)
- Conference exhibit booths at Transducers 2017, SEMICON West 2018, TechConnect 2018

On Behalf of the Network

- Equipment sharing/coordination with
 - MRSEC Molecular Engineering Materials Center – MEM·C
 - UW/PNNL DOE Center for the Science of Synthesis Across Scales - CSSAS

Panel Discussion – Commercialization

- Coordination with Tech Transfer Office
 - External users have no IP entanglement, even with design assist
 - NNCI checkbox on ROI – automatic tracking of NNCI-supported IP from invention disclosure to licensing
- Workforce development
 - Pipeline of skilled workers (undergrads, 2-year college interns, professional MS courses, short courses, ...)
- Economic impact...
 - How to measure, what are key performance indicators?
- ...tractable metrics
 - Spin-outs and licensing of site technology
 - Number of for-profit companies that use NNCI facilities