Northwest Nanotechnology Infrastructure (NNI)

Vision

The NNCI Northwest Nanotechnology Infrastructure site
specializes in world class infrastructure
paired with technical and educational leadership in
integrated photonics,
advanced energy materials and devices, and
bio-nano interfaces and systems;
for a broad and diverse user base,
its facilities act as a center for innovation for
making, measuring, modeling, and mentoring
to advance the use of nanotechnology
in science and society.

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OSU Oregon State University


Integrated Photonics
Kai-Mei Fu
Alex Jen★
Doug Keszler
★ Now Provost at City U HK
Bio-nano Interfaces
Joe Baio
Adam Higgins
Bruce Hinds
Qiuming Yu
Energy Materials & Devices
Chih-hung Chang
+Daniel Schwartz
David Ginger
Michael Khbeis
Lara Gamble
David Castner
John Conley
Brady Gibbons
Karl Böhringer
Greg Herman
Daniel Schwartz
Jim Pfaendtner
Daniel Ratner
Liney Árnadóttir
MAKE
MEASURE
MODEL
MENTOR
NNCI
NNI
Approx. 30 technical staff, 20 undergrad assistants
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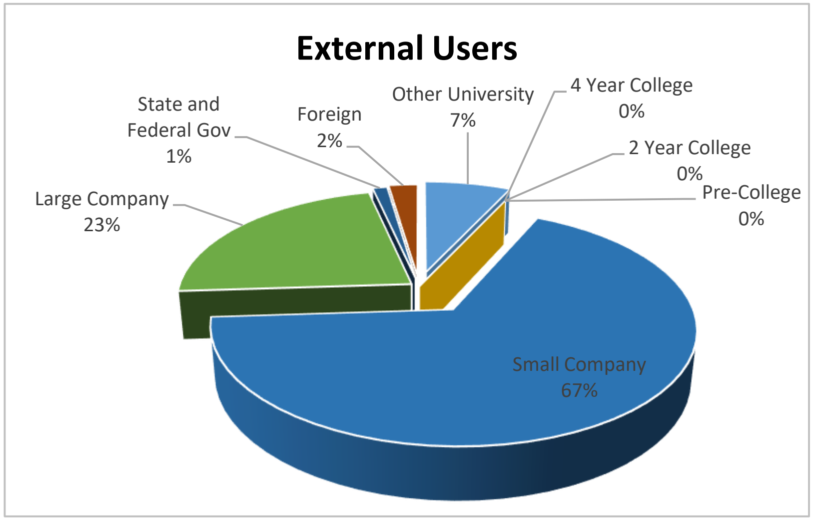
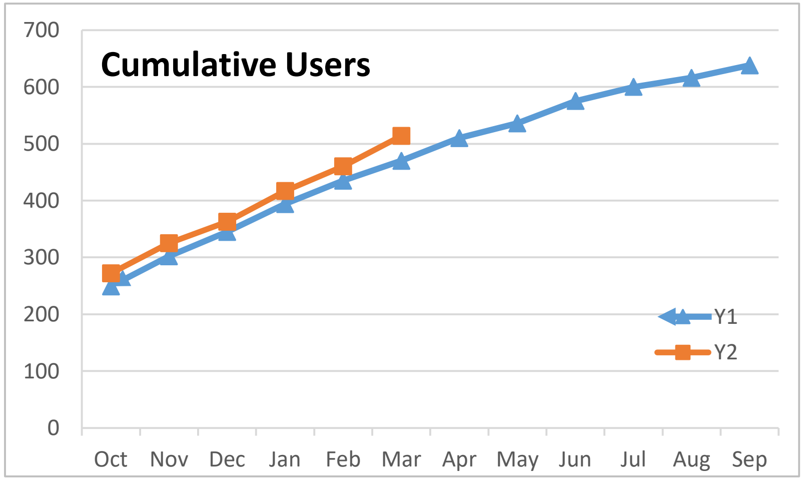
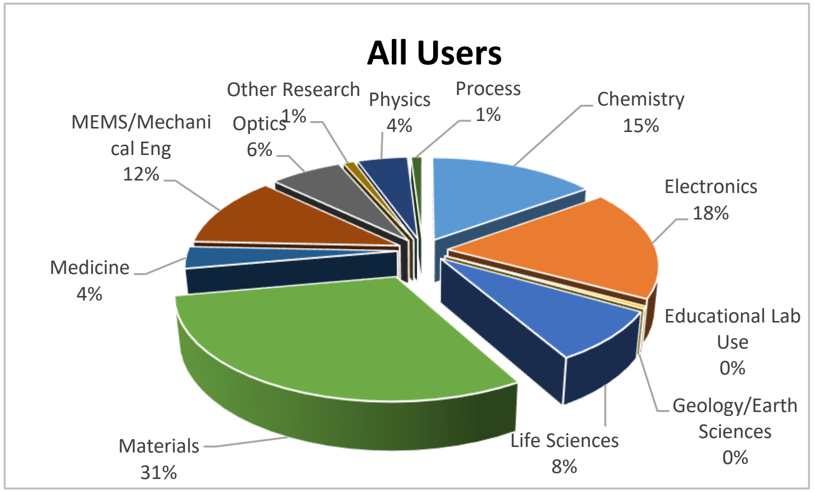
W
UNIVERSITY of WASHINGTON
OSU
Oregon State UNIVERSITY

NNI Site User Data

Yearly User Data Comparison		
	Year 1(12 months)	**Year 2 (6 months)**
Total Users	638	514
Internal Users	396	341
External Users	242 (38%)	173 (34%)
Total Hours	38,350	21,950
Internal Hours	21,822	13,588
External Hours	16,528 (43%)	8,362 (38%)
Average Monthly Users	267	272
Average External Monthly Users	103 (39%)	101 (37%)
New Users	126	83
New External Users	41 (33%)	26 (31%)







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Facility Upgrades (UW)

- Complete renovation of Fluke Hall ($37.5M) with 15,000 sqft WNF cleanroom
  - Ribbon cutting on October 24, 2017

- New: NanoES – Institute for Nano-engineered Systems
  - 35,000 sqft of offices and labs, including very low vibration/EMI space
  - New building ($87.8M)
  - Director Karl Böhringer
    Deputy Director Jevne Micheau-Cunningham
  - Neighbors: Molecular Engineering & Sciences Institute, Institute for Protein Design, Clean Energy Institute (CEI)
    - CEI Training Testbed: interdisciplinary lab lets students understand driving factors in energy that span from molecules to miles
  - Ribbon cutting on December 4, 2017

Facility Upgrades (OSU)

- New Johnson Hall ($40M) with 19,000 sqft of research space for chemical, biological and environmental engineering

- Phased renovation of ATAMI ($12.8M), almost doubling lab and office space to 80,000 sqft

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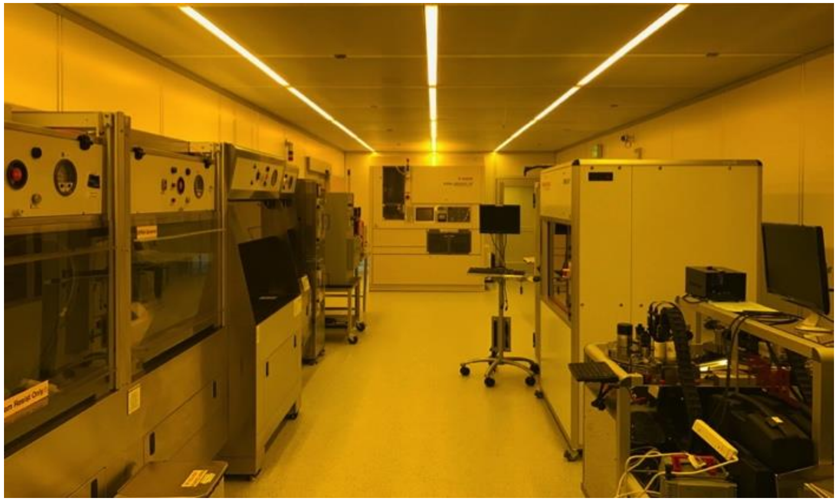
New Capabilities (WNF)

- WNF expanded to 15,000 sqft, bay-and-chase architecture, ISO certified class 5, 6, 7
- New staff engineer Mark Brunson
- Heidelberg DWL66+ mask writer
- Coat/develop track for 100, 150, and 200 mm
- Contact aligner
- Vision 320 RIE
- Nanoscribe 3D printer (NSF MRI)
- Coming soon:
  - HF and XeF_2 vapor etchers



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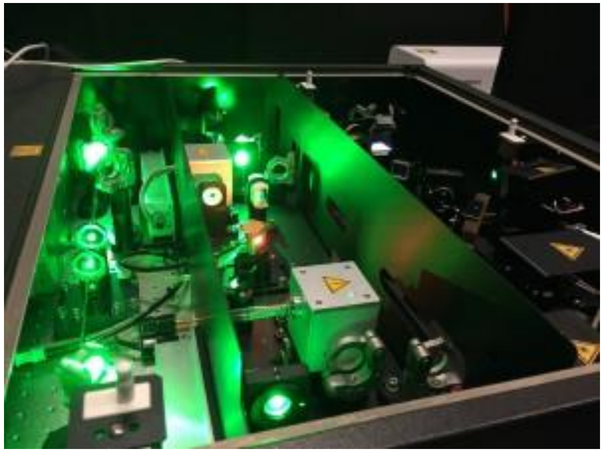
New Capabilities (MAF)

- Cypher AFM
- X-ray absorption near edge spectroscopy (XANES)
- Liquid TEM holder (collaboration with Hummingbird Inc.)
- New XRD Bruker D8 Discover with microfocus
- UTAP (Ultrafast Transient Absorption and Photoluminescence) laser system
- Coming soon:
  - EVOS FL Auto Imaging System
  - New consolidated Beckman/Murdock Microscopy Center: FEI Titan Krios, FEI Arctica, 2 Technai TEMs

- Incorporated the Analytical Biology Core (ABC) and staff scientist Dr. John Sumida



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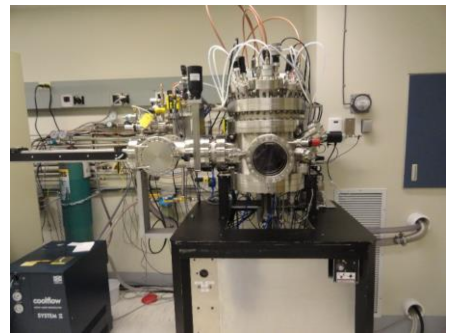
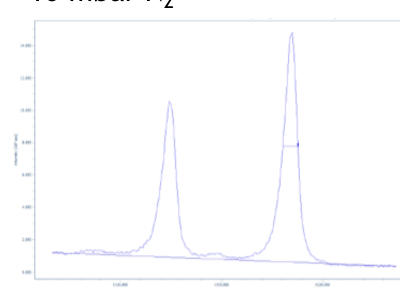
New Capabilities (OSU)

- New staff engineer Joe Bergevin
  - Reactive RF sputter
  - PlasmaPro System 100 dry etch



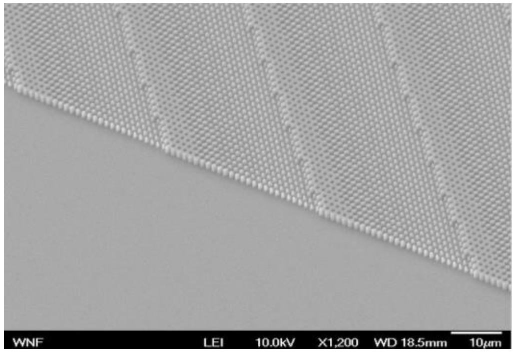
- New staff engineer Igor Lyubinetsky
  - Ambient pressure x-ray photoelectron and scanning tunneling microscopy (AP-XPS/STM)

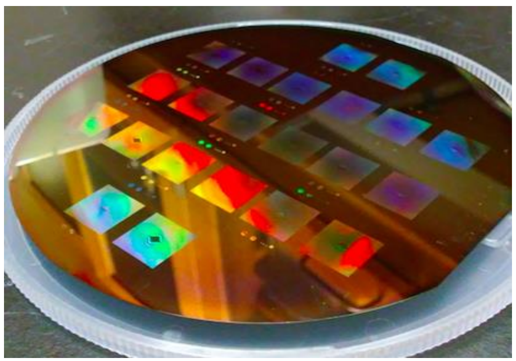
Site Acceptance Test Data
XPS, Ag 3d, Al Kα
10 mbar N_2



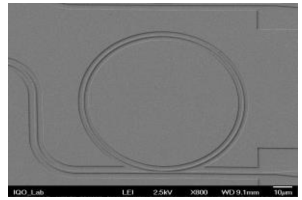
Nano-optoelectronic Integrated System Engineering

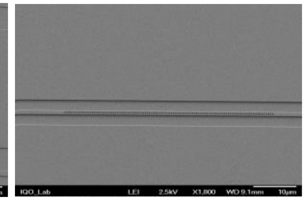
PI: Arka Majumdar (EE, Physics)

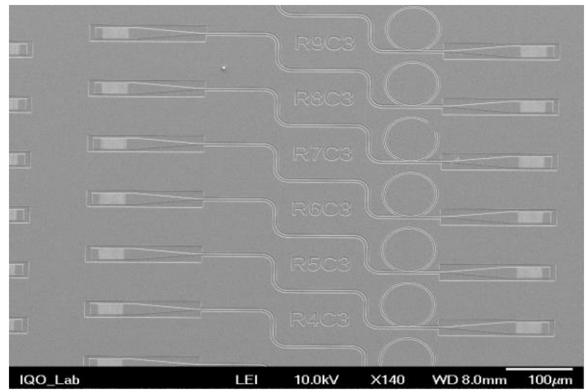




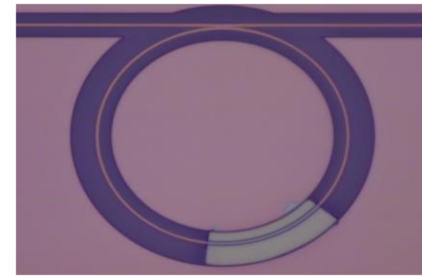
Large area sub-wavelength diffractive optics, also known as metasurfaces can revolutionize the current state of optical imaging.

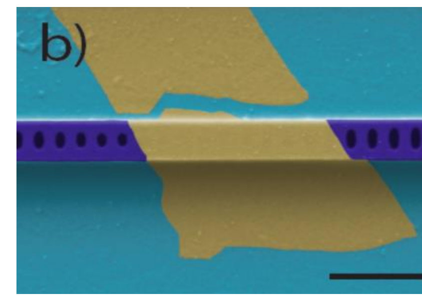






Heterogeneous integration of different nano-cavities on the same silicon nitride platform.





Integrate new 2D materials and phase change materials with integrated silicon nitride devices.

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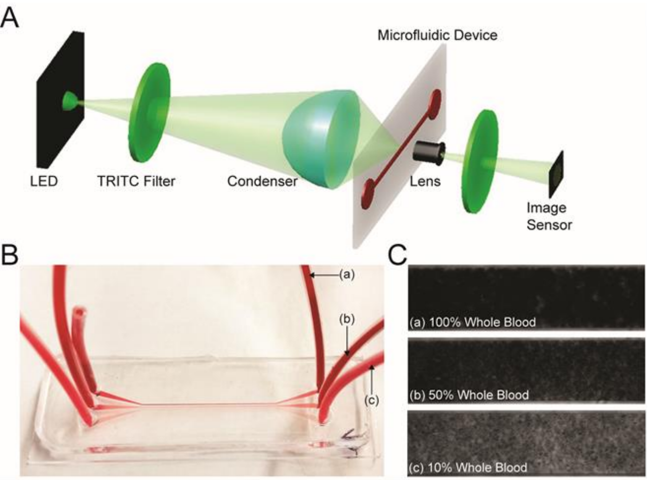
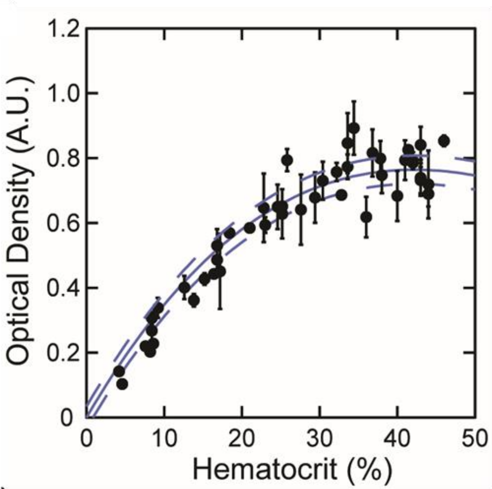
Hemoglobin Detection in Whole Blood Using Microfluidics

Nikita Taparia, PI: Nathan Sniadecki, ME, UW





Anemia Severity	Range (g/dL)	Bias (g/dL)	Limits (g/dL)
Severe	0-8	0.425	±1.005
Moderate	8-10	1.336	±3.394
Mild	10-12	0.962	±5.509
Normal	>12	0.023	±6.444

- Through a PDMS microfluidic channel, hemoglobin concentration in whole blood is determined based on the optical absorption of green light.
- A nonlinear fit that accounts for the light absorption and scattering properties of whole blood was fit to the data.
- Based on the fit, this device can detect moderate and severe anemia accurately.
- This method for detection can be incorporated into current microfluidic based blood diagnostic devices.
- News stories about the paper can be found at the following outlets:

360Dx UPI Microfluidics from TECHNOLOGY NETWORKS Novus Light Technologies Today SciDevNet

N. Taparia, et al. AIP Advances **7**, 105102 (2017)

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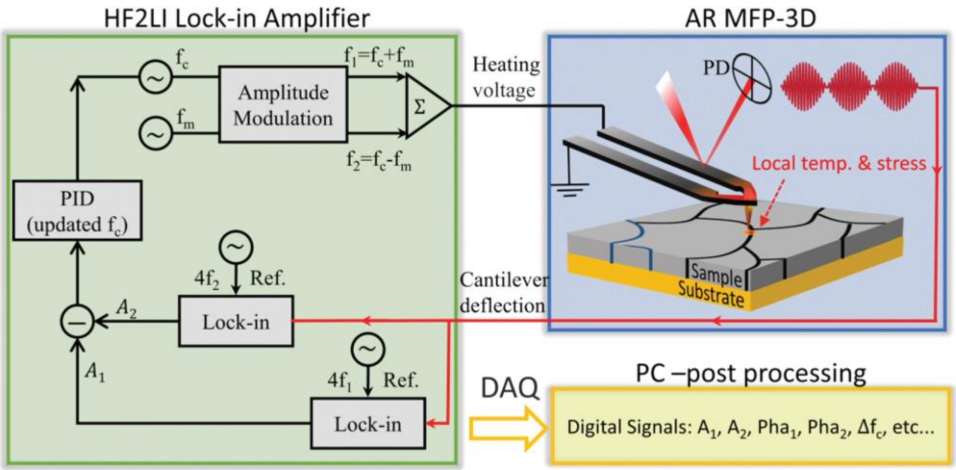
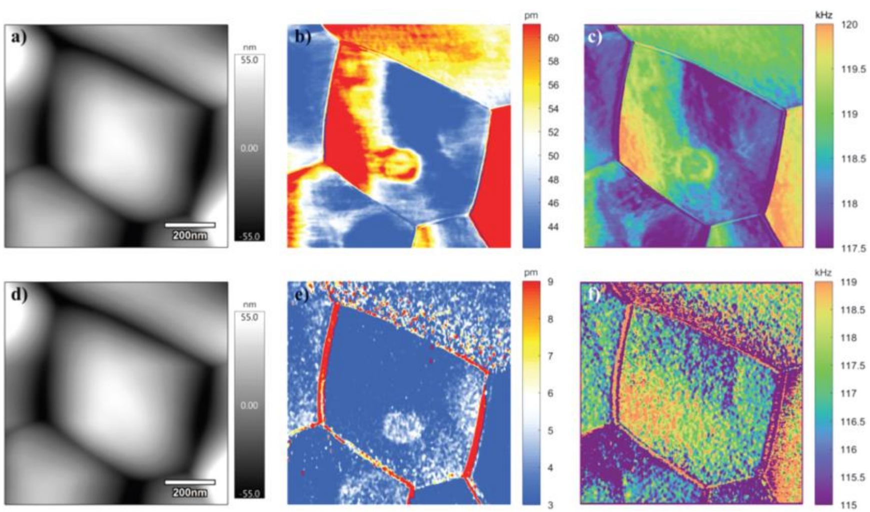
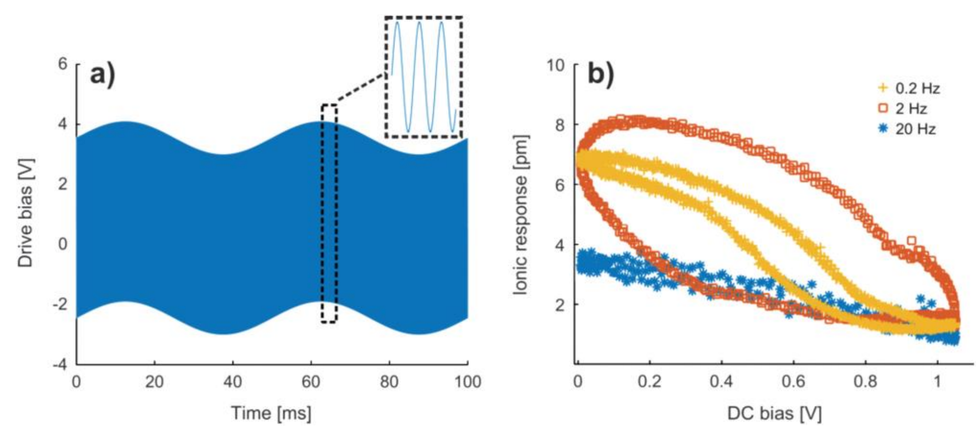
Scanning Thermo-ionic Microscopy
Jiangyu Li, ME, UW



2017 Microscopy TODAY INNOVATION AWARDS

Scanning thermo-ionic microscopy reveals local electrochemistry at the nanoscale.
Jiangyu Li et al., Microscopy Today (2018)





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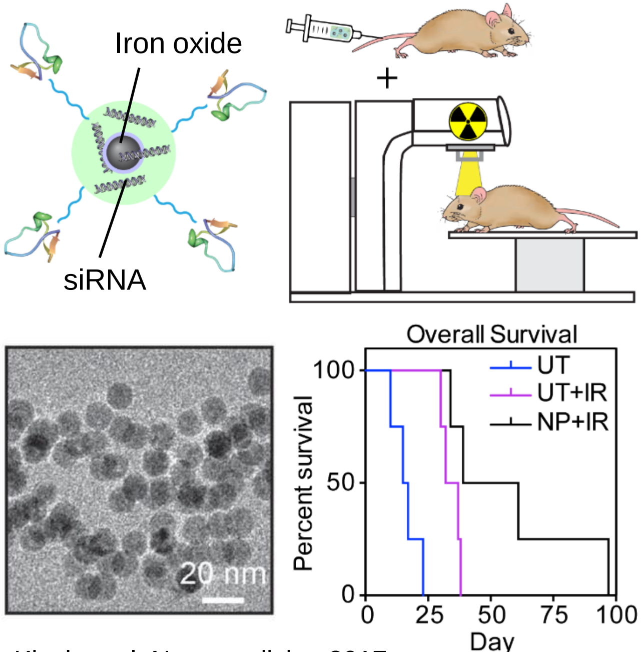
Nanomaterials for Tumor Diagnosis and Treatment: From Materials Development to Translation

Prof. Miqin Zhang, Materials Science & Engineering, UW

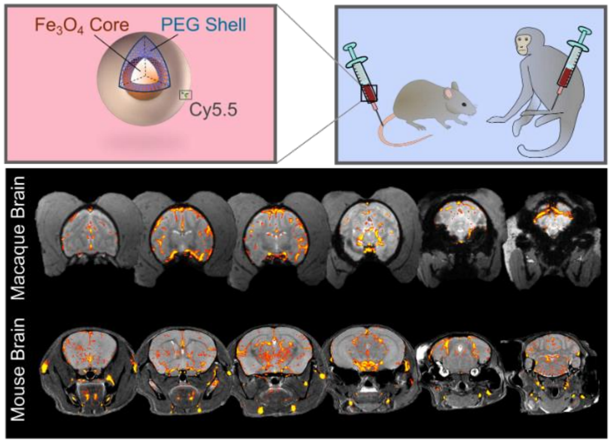
Nanoparticles for combined gene/radiation therapy for glioma



Kievit et al, Nanomedicine 2017

- Delivery of siRNA to glioma using iron oxide based transfection agent
- Remarkable knockdown of therapeutic genes
- A combined gene delivery and radiation therapy (NP+IR) significantly extends the survival as demonstrated in a genetic mouse model of glioma

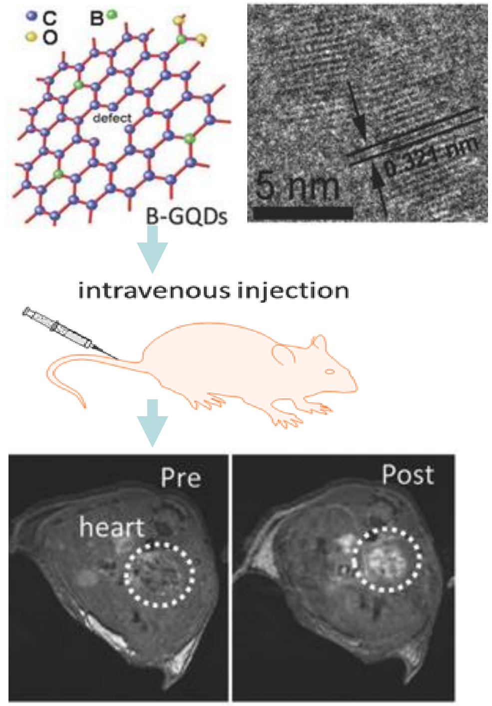
Nanoparticle (NP) biokinetics in nonhuman primates



Chiarelli et al, ACS Nano 2017

- Translation of iron oxide NPs in large animal model (primate)
- NP tracked by MRI in a large number of organ systems
- PK is similar between mice and macaque in blood, liver, spleen, and muscle, but different in kidneys, brain, and bone marrow
- No acute toxicity observed in primates

Safe graphene quantum dot-based T1 contrast agent for MR imaging



Wang et al, Adv. Mater. 2017

- Boron-doped graphene quantum dots exhibit paramagnetic properties
- Provide both excitation wave-length tunable photoluminescence and T1 contrast
- Exhibit long-term photostability

Cell Infiltration and Tissue Differentiation in Sponge-like Implant Materials

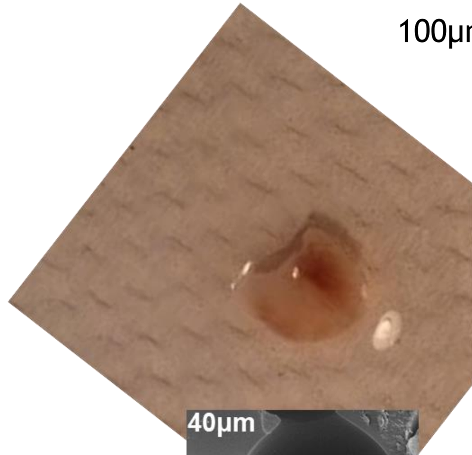
Neal Beeman, PI: Jame Bryers, Bioengineering, UW

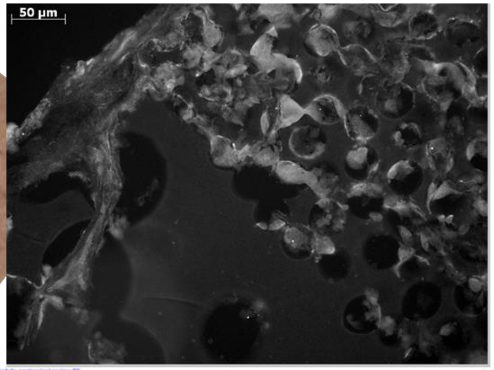
- Project 1 – Defining the fundamental differences in macrophage phenotypes in hydrogels of different porosity and topography.
- Project 2 – Defining the signaling pathways critical in mediating macrophage differentiation in different hydrogels.
- Project 3 – Showing the succession/differentiation of invading cells during wound healing and biointegration and alternatively showing the succession/differentiation of invading cells during foreign body response and fibrous encapsulation in different versions of our porous hydrogels.

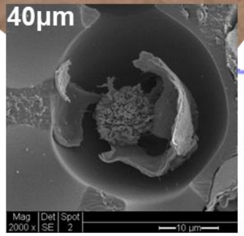
Significance:

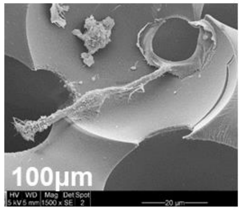
- ➢ This work will serve to reduce implant rejection and joint/implant loosening.
- ➢ Drug delivery and monitoring devices will be improved with improved biointegration.

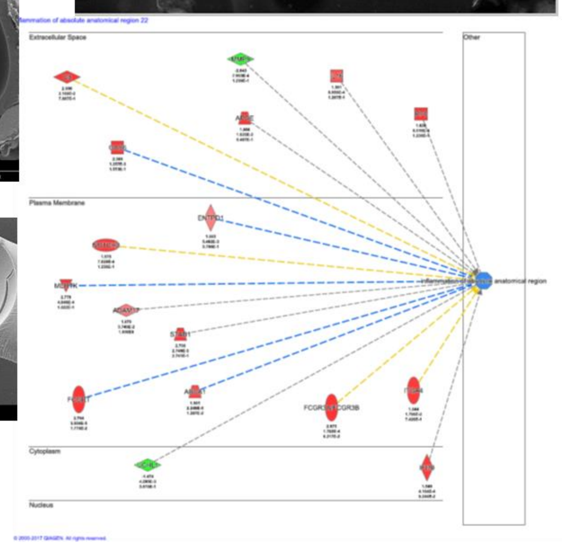
100µm\40µm porous hydrogel explanted from mouse after 28 days











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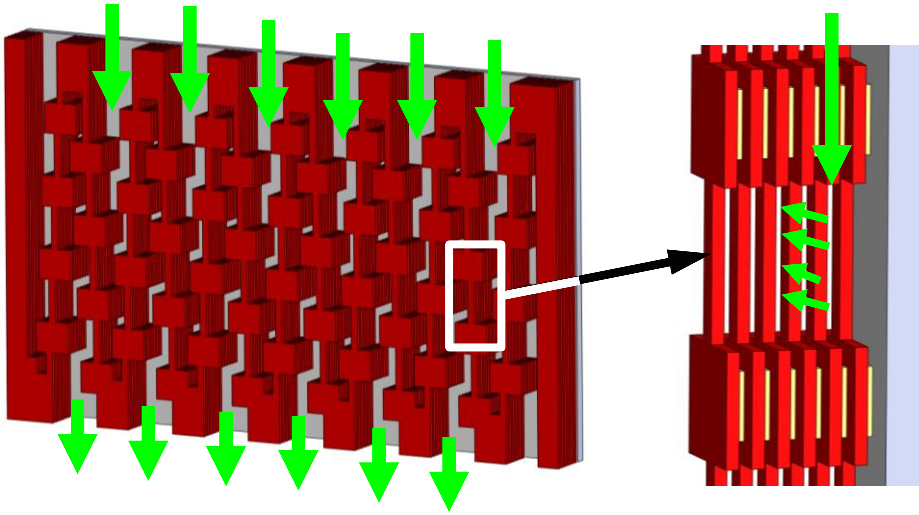
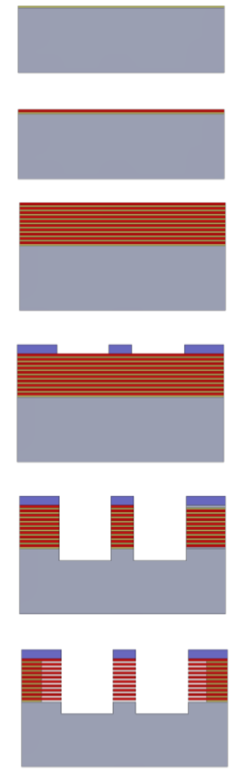
Multilayer Nanofiltration

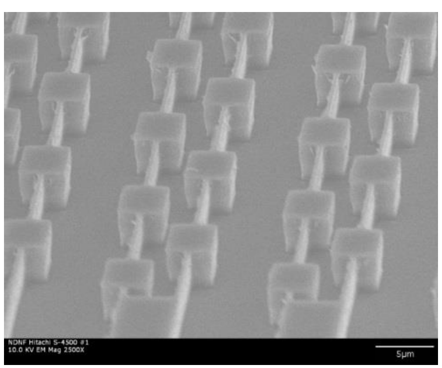
Brian Richardson, Imagine TF LLC

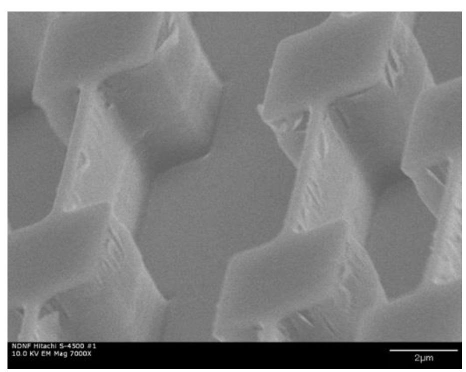


Layers of structural and sacrificial materials are used to create pores for filtration, separation and chromatography



Process Steps





60 layers of 18nm pores

NNCI labs at UW and Stanford have fabricated structures of this type for industry partners

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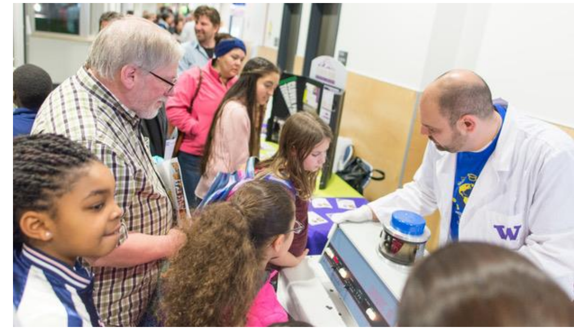
Education and Outreach

- Ambient Pressure XPS/STM Workshop (9/6/2017)
  http://cbee.oregonstate.edu/xps-workshop

- NNI E&O activities are reaching 10,000 local school children annually (K-12)
- Launched Inaugural Nanotechnology Day event at Pacific Science Center (Partnered with Nano.gov)
- NNI-affiliated Clean Energy Bridge to Research REU launches June 2017
- UG summer research symposium
- Inaugural "Introduce a Girl to Nano" event
- Workforce Development and First Nation partnership
  - Continuous employment of 17-26 student interns
    - Paid by user fees
  - 2 Puyallup tribal member interns
- Continuing to grow membership in Educators-in-Residence Network
  - Serving rural, urban, and tribal student populations



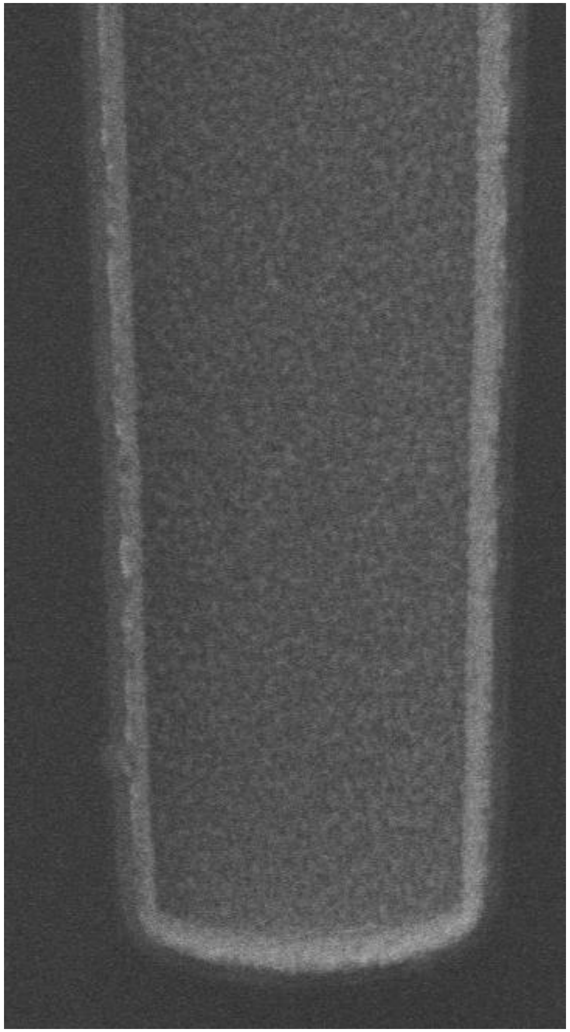
National Nanotechnology Day

Nano.gov

- Launched partnership with the Pacific Science Center
  - 8 booths and over 12 hands-on demonstrations
  - 55 NNCI volunteers
  - Hundreds of local families participated (census ongoing)

Network Activities:
UW-led Multi-site Project – TSV ALD Barrier/Seed

- Goal: coat high density Through Silicon Via (TSV) arrays with barrier and electroplating seed for Cu
- Analyzing differing deposition techniques (ALD, pulsed-CVD, ionized PVD) and ALD systems
- NNCI Partner Sites
  - SDNI (UCSD) – TiN coating
  - SNSF (Stanford) - XRR analysis
  - OSU – Ru coating
  - IEN (GaTech) – TiN/Pt coating
- External Companies
  - Kobus
  - Picosun
  - Arradiance
  - SPTS
  - Lesker



Announcement

3rd Annual NNCI Conference
Seattle, Washington, September 13-14, 2018

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Panel Topic: Future Research Directions

What new directions are on the horizon that may bring a future generation of "Traditional Users" to our laboratories and how do we accommodate them?

- Nothing we do is "traditional." We intend to keep it that way.
- Key to our future growth: Offer engineering and design assistance that accelerates and improves productivity of our evolving user base.