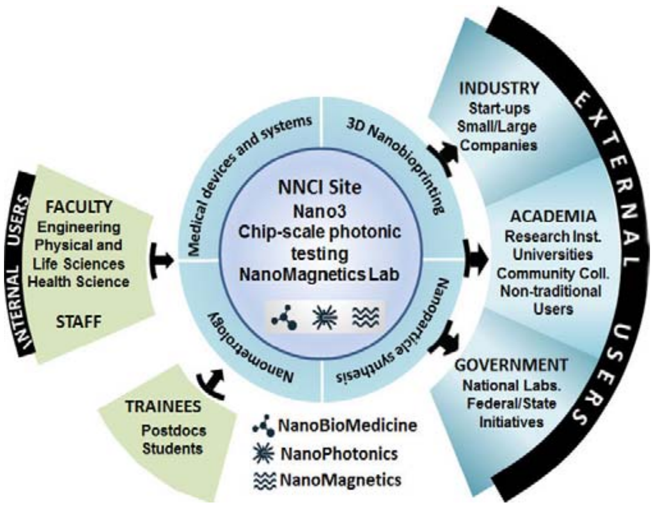
The San Diego Nanotechnology Infrastructure (SDNI)

- SDNI Builds upon UCSD's existing Nano3 (Nanoscience, Nanoengineering, Nanomedicine) user facility, established in 2006.
- SDNI leverages additional specialized resources and expertise at UCSD for **NanoBioMedicine, NanoPhotonics,** and **NanoMagnetics**.
- Provides researchers from academia, government, and companies large and small with access to university user facilities.
- Enables and accelerates cutting edge scientific research, proof-of-concept demonstration, device and system prototyping, product development, and technology translation.
- Renowned for nanobiomedical research, UCSD marshals world-class research and training in the life and physical sciences, medicine, and engineering to forge strong connections with the nearly ***700 biotechnology companies near campus***.

SDNI Year 1 Data:

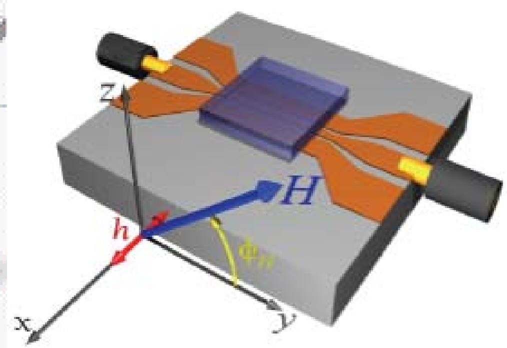
650 Cumulative Individual Users
290 Average Monthly Users
48000 Hours Lab Time
161 User Groups:
93 Local Academic; 35 Small Companies; 18 Large Companies; 9 Non-UCSD US Academic; 3 State/Federal; 3 International



Magnetic Characterization

1.7 – 1000 K and +/- 9 T magnetic field

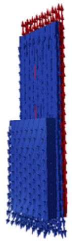
- Magnetization
- Magnetic susceptibility up to 6 GHz
- Ferromagnetic resonance up to 40 GHz
- Magnetic Force Microscopy
- Magneto-optical Kerr Microscopy
- Magneto-transport up to 12 GHz



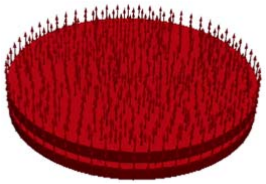
High-Performance Modeling of Magnetic Devices

- **Available tools**
  - Object Oriented Micromagnetic Framework (OOMMF) on GPUs
    - Finite difference based micromagnetic simulator
    - 20x-70x speed up as compared to the CPU version
    - Optimal for relatively simple structures
  - FastMag micromagnetic simulator on GPUs and CPUS
    - Finite element method based micromagnetic simulator
    - Highly flexible, efficient, multi-physics capabilities
- **Applications**
  - Magnetic memories, magnetic recording, microwave materials, permanent magnets, integrated inductors, coupling with SPICE solvers

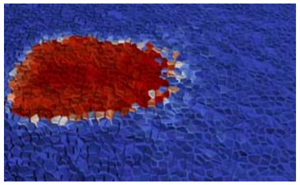
Write head



Read sensor



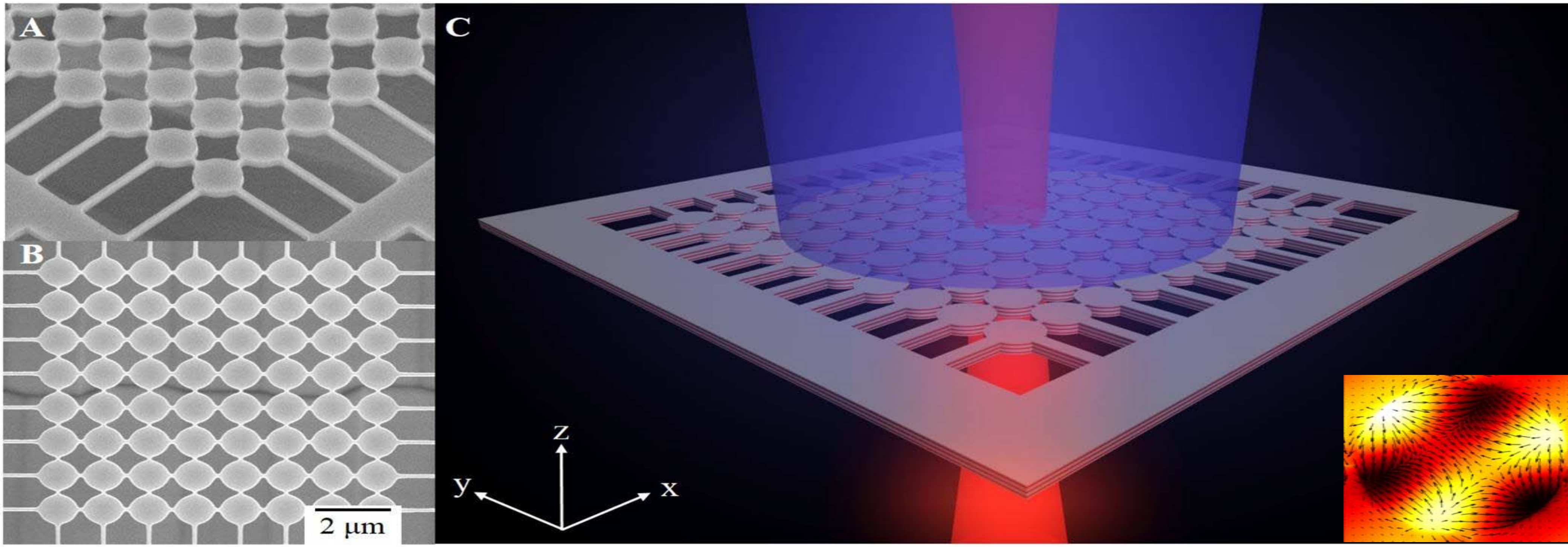
MRAM



Granular materials

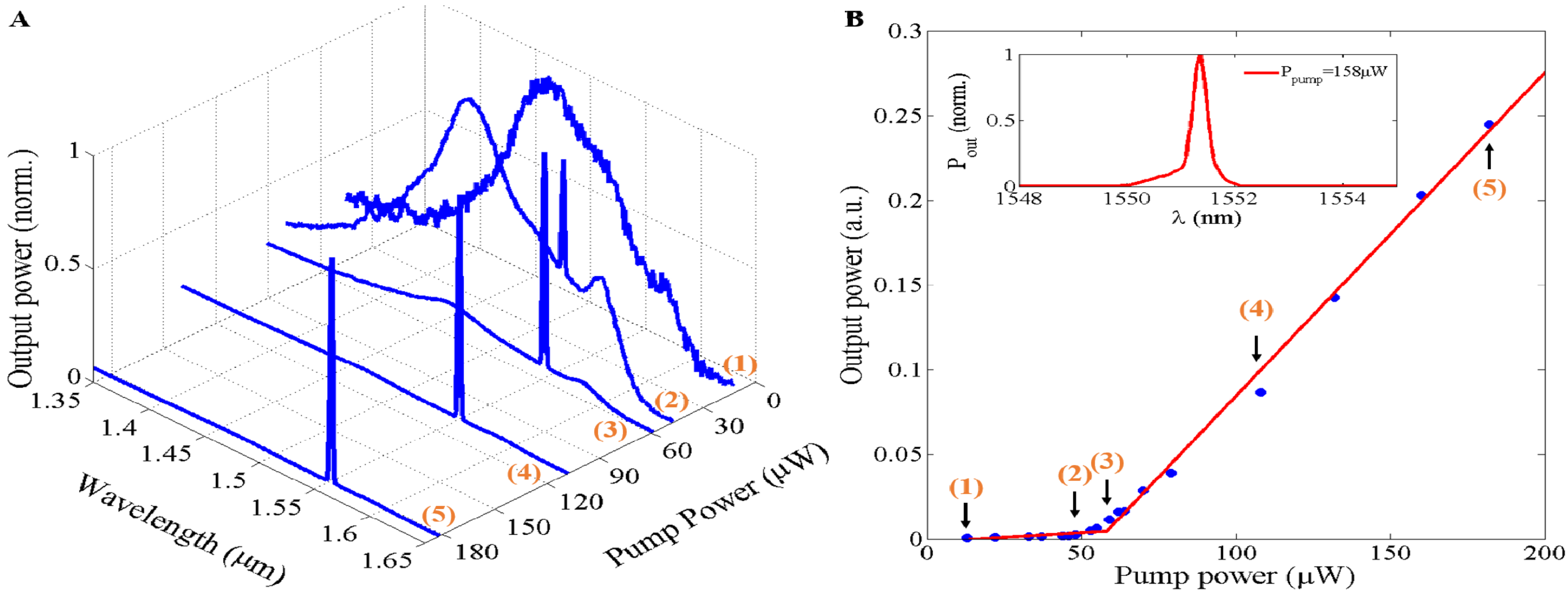
V. Uhlíř, J. A. Arregi and E. E. Fullerton, "Colossal magnetic phase transition asymmetry in mesoscale FeRh stripes", Nature Communications 7, 13113 (2016)

World’s first Bound state In Continuum (BIC) laser



A. Kodigala, B. Kante *et al.*, Nature **541**, 196-199 (2017)

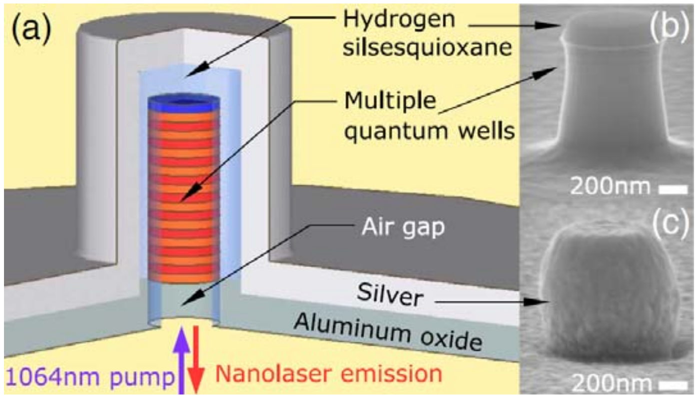
Characterization of the BIC Laser



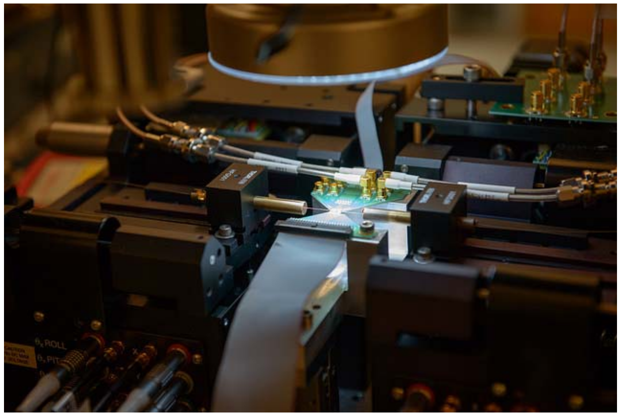
A. Kodigala, B. Kante *et al.*, Nature **541**, 196-199 (2017)

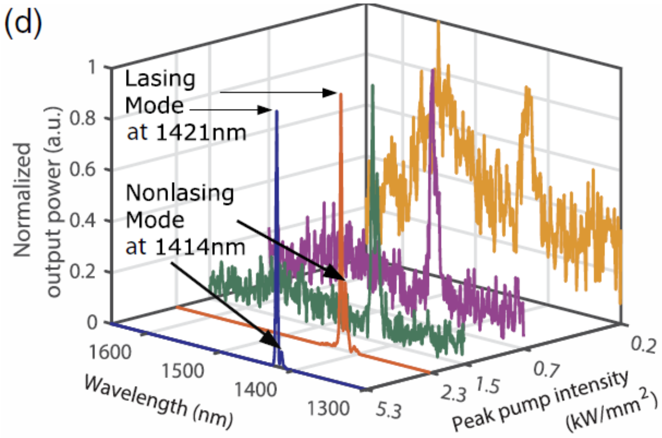
Nano Laser

- Conventional methods for characterizing lasing are not definitive in devices with high β factors
- We demonstrate that the transition from incoherent emission to lasing can be determined by examining the width of a second-order intensity correlation peak
- Additionally, we provide the first observation of dynamical hysteresis in a nanolaser



Metallo-dielectric nanolaser

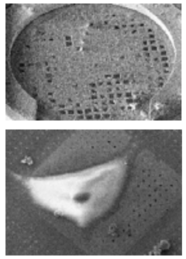




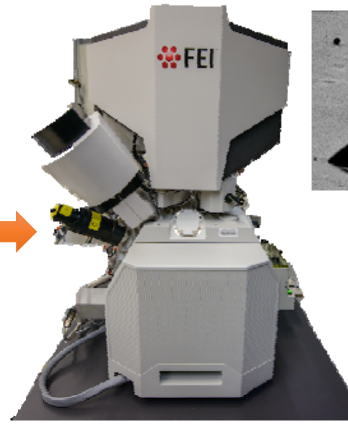
Nanolaser spectral evolution

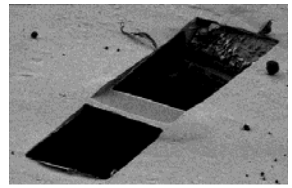
S. H. Pan, Y. Fainman, *et al.*, “Dynamic hysteresis in a coherent high-β nanolaser,” Optica, V. 3, pp. 1260-1265, 2016.

Revealing Protein Structure in the Cell

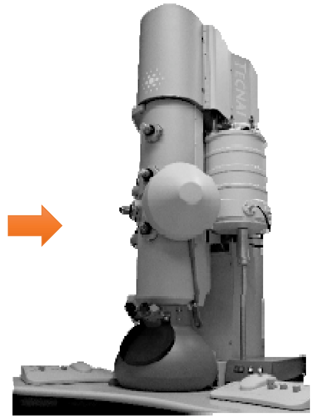


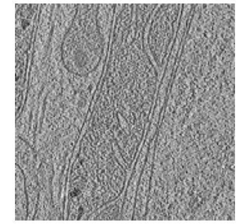
Cells are cultured on EM support grids and vitrified by plunging into liquid ethane



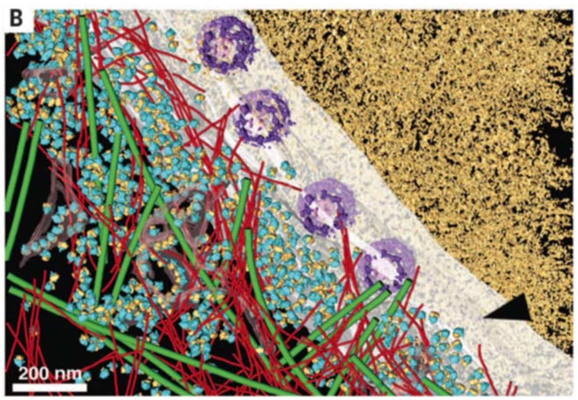


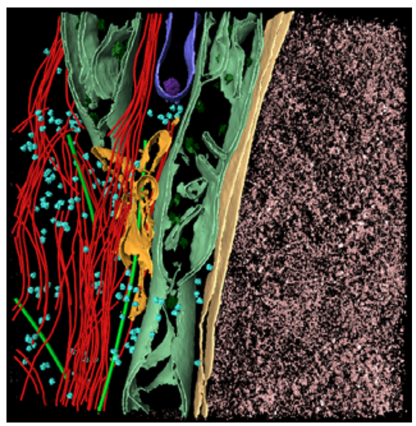
Top and bottom of the cells are removed by FIB milling, leaving a thin slice of the cell volume (80-200 nm)





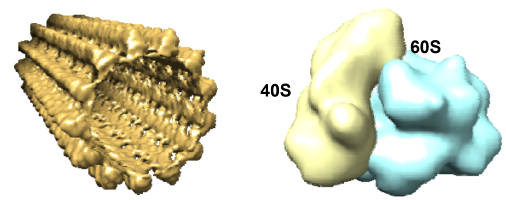
Volumes of interest from within the slice are visualized by electron cryo tomography





Mahamid et al., Science (2016)

Segmentation reveals the architecture of the cell in 3D (left: HeLa cell, red: Actin & intermediate filaments, green: Microtubules, cyan: Ribosomes, purple: Nuclear Pore Complexes, gold: nuclear density; right: U2OS cell, colored as in left except: dark green: mitochondria, salmon: nuclear density, orange: ER, purple: endosome)



Subtomogram averaging reveals the structure of proteins and complexes in their native cellular environment (left: microtubule at ~30 Å, right: 80S ribosome at ~50 Å)

Wagner FR, Schampers R, Watanabe R, Persoon H, Schaffer M, Fruhstorfer P, Villa E. Preparing samples for cryo-electron tomography from whole cells using focused-ion-beam milling. Under revision at Nature Protocols.

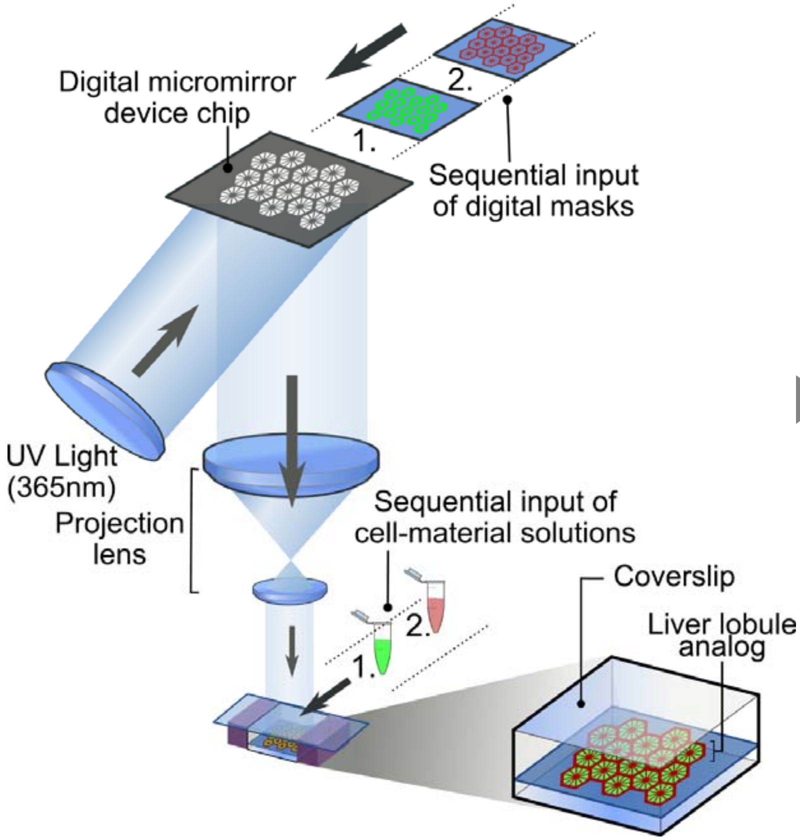
Villa E, Schaffer M, Plitzko JM, Baumeister W. Opening windows into the cell: focused-ion-beam milling for cryo-electron tomography. Curr. Opin. in Struct. Biol. 2013;23:771–777.

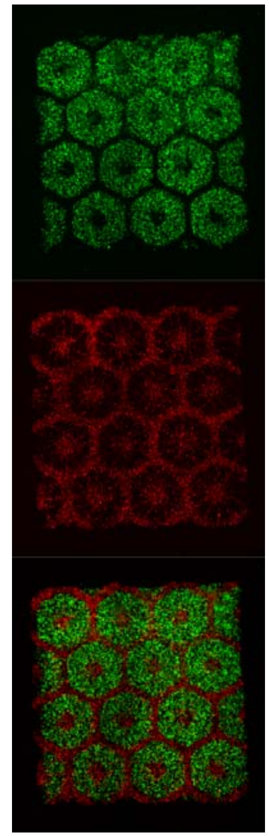
Mahamid J, Pfeffer S, Schaffer M, Villa E, Danev R, Cuellar LK, Forster F, Hyman AA, Plitzko JM, Baumeister W. Visualizing the molecular sociology at the HeLa cell nuclear periphery. Science. 2016;351(6276):969–972.

sdni

Rapid 3D Bioprinting of Human Liver Tissue

National Nanotechnology Coordinated Infrastructure





Green – Hepatic cells
Red – HUVAC cells

Liver Regeneration

Drug Screening

Liver disease modeling

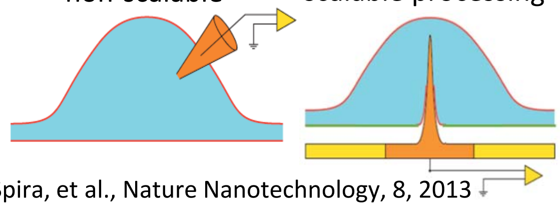
X. Ma, X. Qu, W. Zhu, YS Li, S Yuan, H Zhang, J Liu, P Wang, CSE Lai, F Zanella, GS Feng, F Sheikh, S Chien, and S Chen, “Deterministically patterned biomimetic human iPSC-derived hepatic model via rapid 3D bioprinting”, *PNAS* Vol. 113 (8), 2206-2211, 2016

Individually Addressable Nanowire Arrays

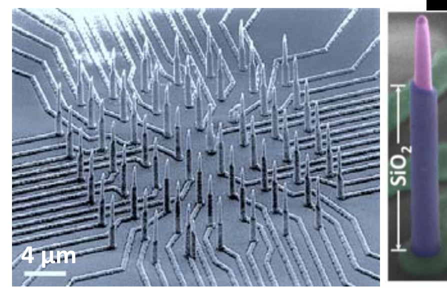
Drug Screening and Mapping Activity of Neuronal Networks

Patch clamp: destructive, serial, non-scalable

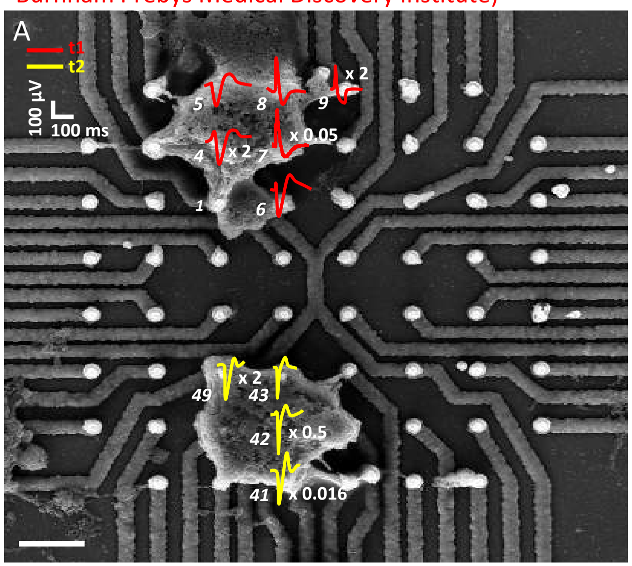
Single NW device: minimal invasive, scalable processing



Spira, et al., Nature Nanotechnology, 8, 2013

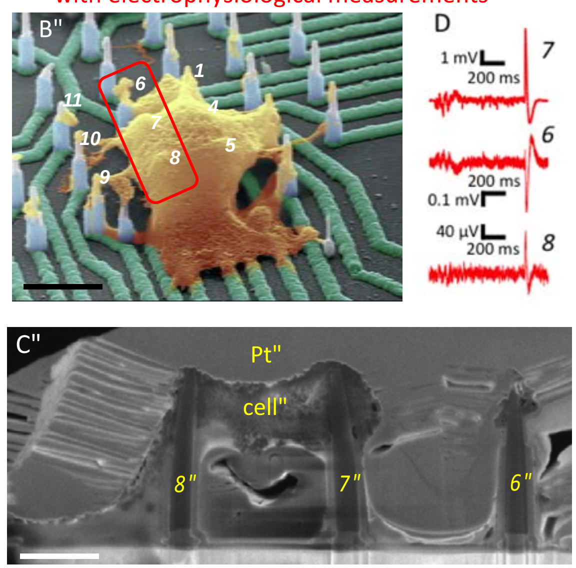


Mapping activity from human induced pluripotent stem cell neurons (in collaboration with Anne Bang, Sanford Burnham Prebys Medical Discovery Institute)

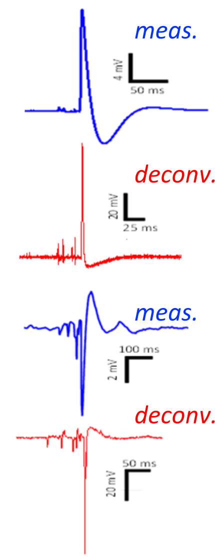


R Liu, SA Dayeh, et al., submitted 2016

FIB on cells to correlate interface nature with electrophysiological measurements



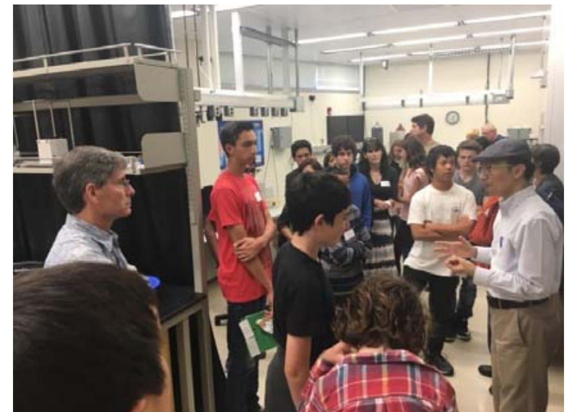
Very high SNR for intracellular and extracellular measurements



Education and Outreach

Introduced nanotechnologies to K-12, minorities, and STEM activities (in 2016) (Reach over 1000 K-12 students)

Envision Outreach (Feb 2016)
UCSD Enspire Middle School Outreach (Feb 2016)
Comienza Con un Sueno (STEM for Hispanic Families) (April 2016)
COSMOS (July, 2016)
Talented Youth Program with Johns Hopkins (Oct, 2016)
Community Event at Barrio Logan (Oct, 2016)

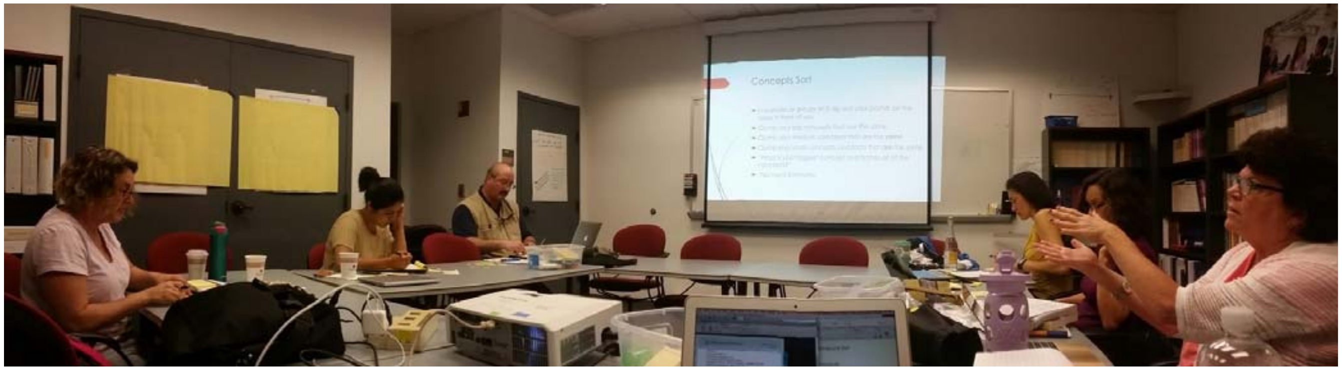


2016 Research Experiences for Undergraduates (REU)

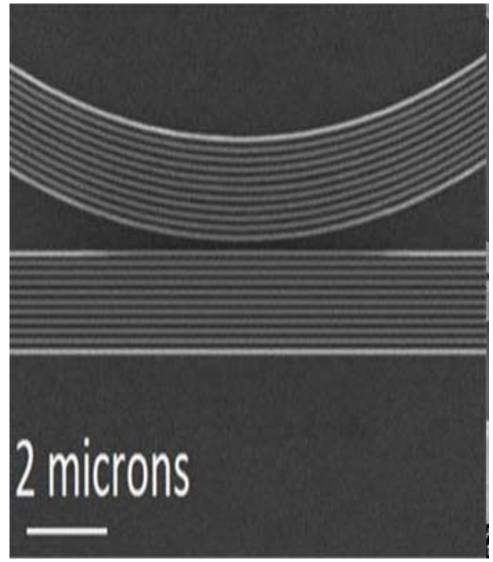
Supported 11 REU students (70% women and minority) from 9 universities to conduct 10 week nanotechnology research mentored by professors and graduate students.

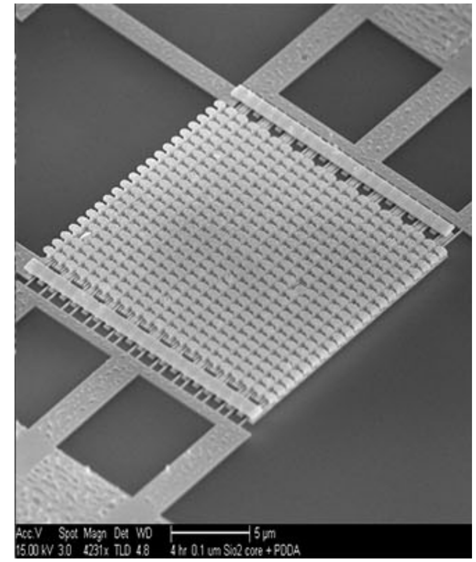
2016 Research Experiences for Teachers (RET)

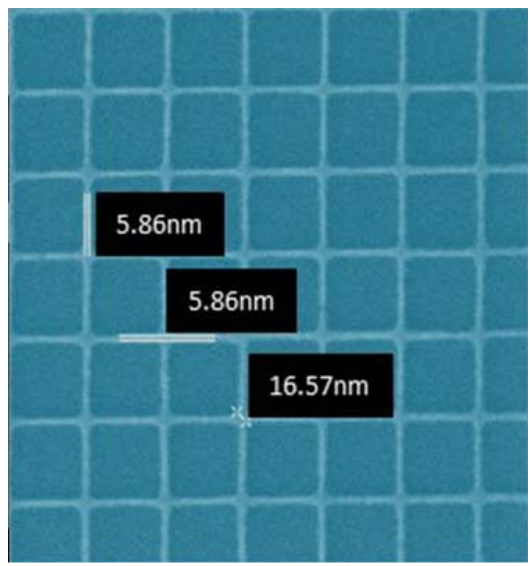
Supported 3 high school science teachers to develop science curricula and hands-on labs. The developed curricula meet the Next Generation Science Standards (NGSS) and will be delivered to thousands of high school students.



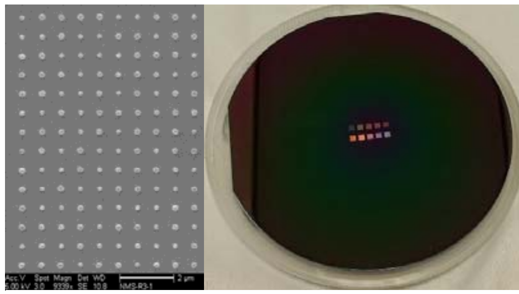

Vistec EBPG5


2 microns

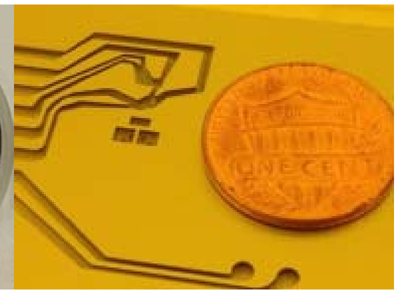

Acc.V Spot Magn Det WD
5 μm
15.00 kV 3.0 4231x TLD 4.8
4 hr 0.1 um Sio2 core + PDDA


5.86nm
5.86nm
16.57nm

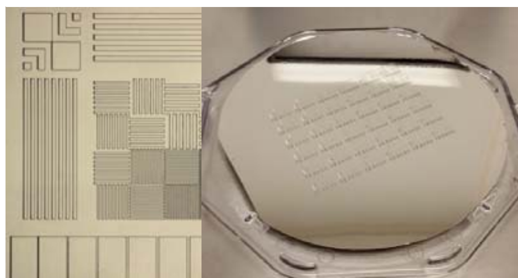
Biomedical Device Fabrication Facility



4” electroformed Ni mold, 200nm features



Si shadow mask (10 um)



6” electroformed Ni mold, 12 um features

4-layer, multi-valve PDMS device