



National Nanotechnology
Coordinated Infrastructure

SH₂NE

Soft and Hybrid Nanotechnology
Experimental Resource

2019 NNCI Annual Conference

ILLUMINATE YOUR RESEARCH



Northwestern
University

SHyNE Resource

Northwestern |  INTERNATIONAL INSTITUTE FOR NANOTECHNOLOGY

 THE UNIVERSITY OF CHICAGO

 PRITZKER SCHOOL OF MOLECULAR ENGINEERING



NU Center for
Nanofabrication
and Molecular Self-
Assembly



Simpson Querrey
Institute



Argonne National Laboratory
Center for Nanoscale Materials



Pritzker Nanofabrication Facility

Uniting over \$800 million in nanotechnology research,
education, infrastructure & facilities

Regional Coordination
Global Partnerships

Prof Vinayak P. Dravid (PI) – Northwestern

Prof Andrew Cleland (Co-PI) – U Chicago

*Chad Goeser
Business Manager*

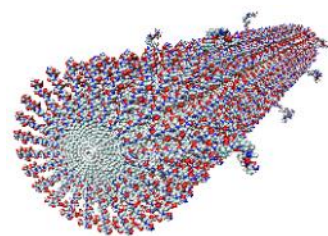
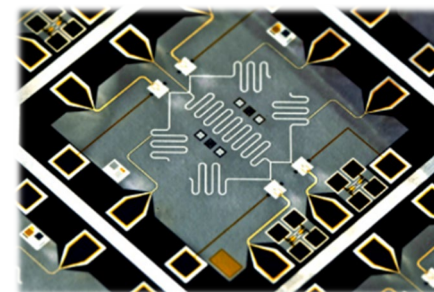
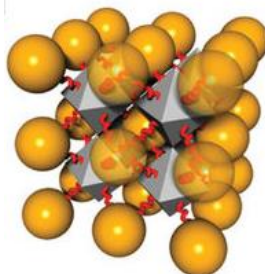
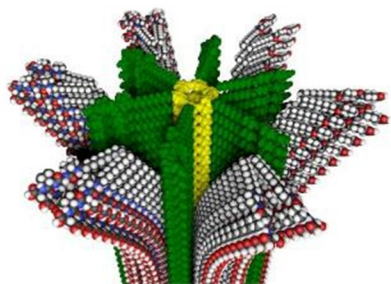
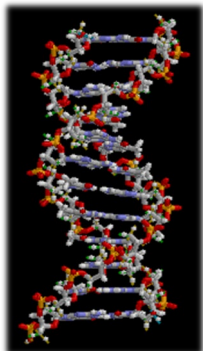
*Young Kasarski
Financial Administrator*

*Katy Dean
Outreach Coordinator*



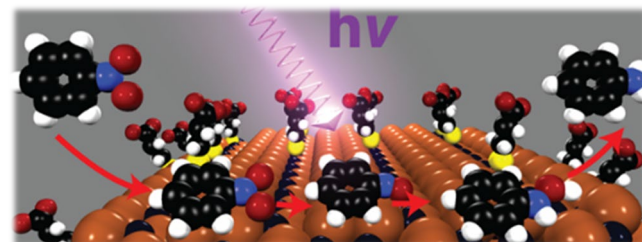
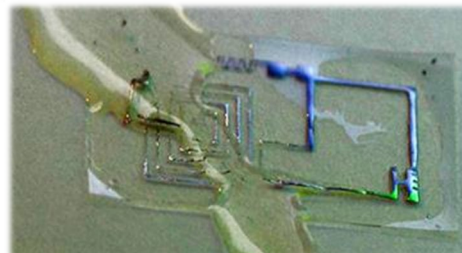
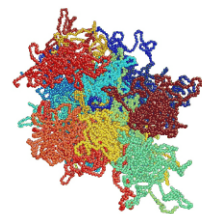
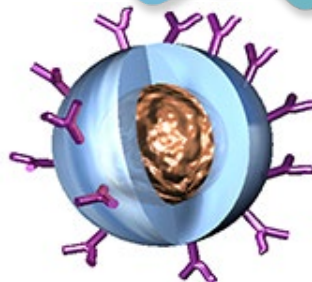
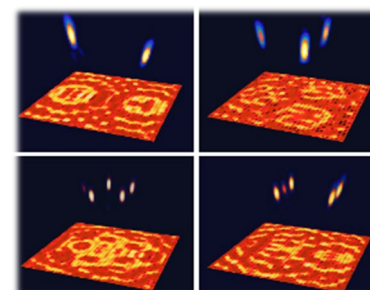
SHyNE | Soft Hybrid Nanotechnology
Experimental Resource

Focus on Soft & Hybrid Nanotechnology

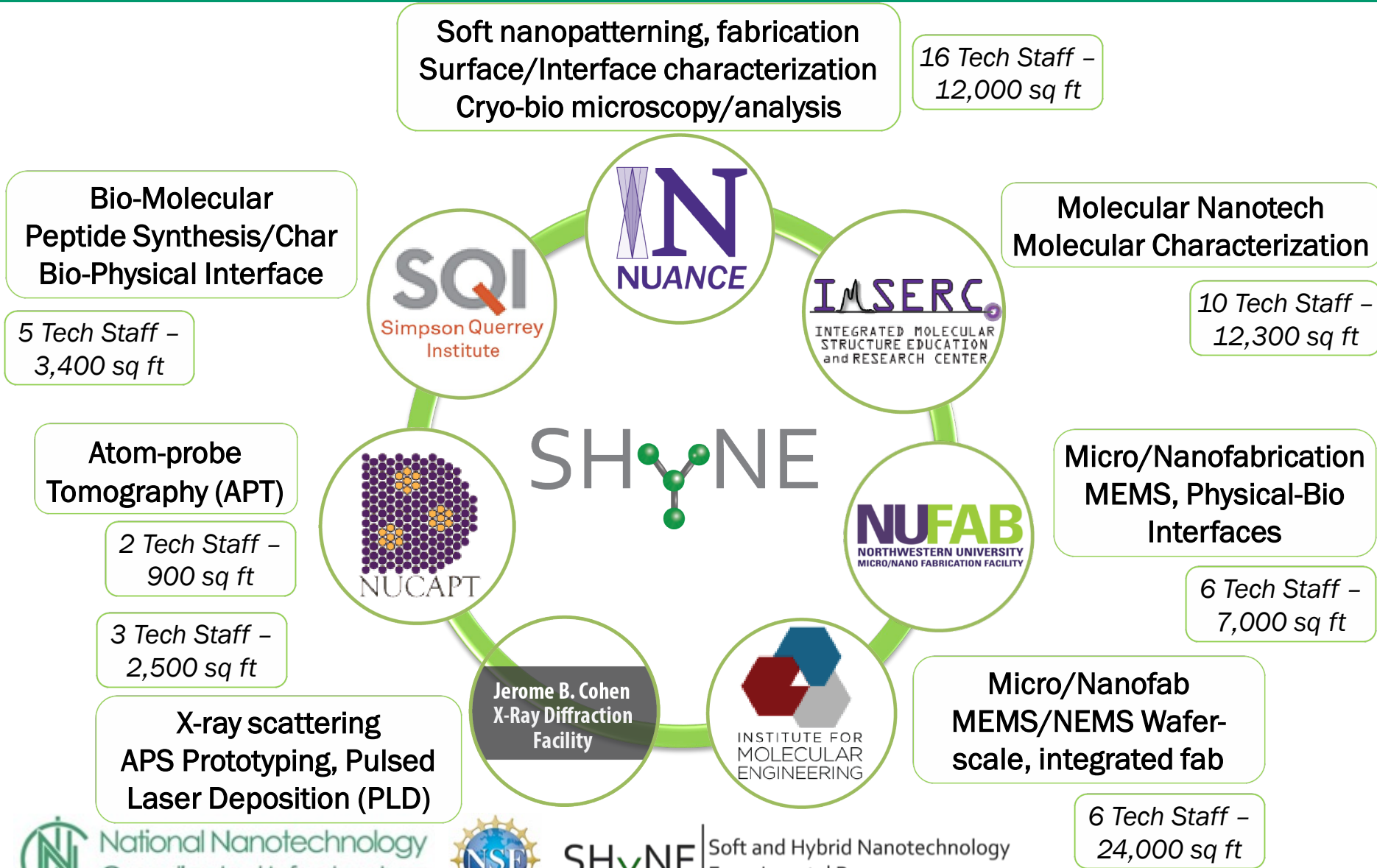


Soft

HARD

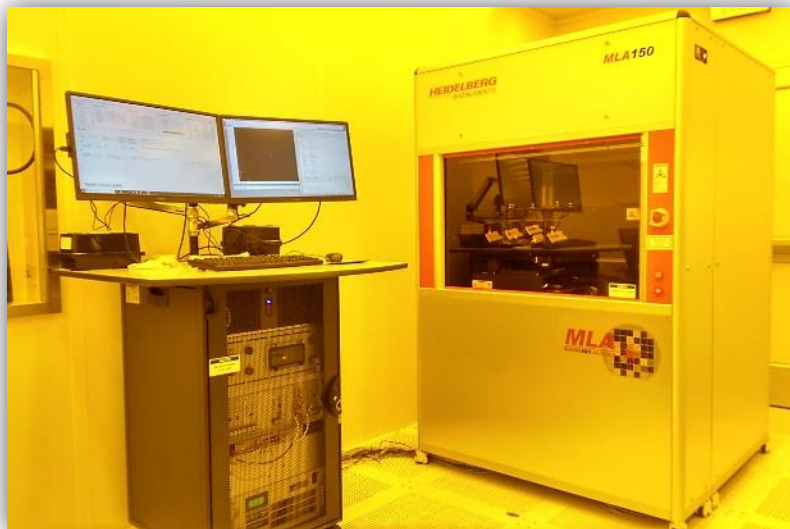


SH_YNE – Integrated Solution Approach



SHyNE: *Facilities & Tools*

- **Pulsed Laser Deposition Facility joins SHyNE**
 - *PVD PLD/MBE 2300*
 - *PVD nanoPLD 1000*
 - *Dr. Bruce Buchholz, Facility Manager*



- **SHyNE adds 3rd Direct Write Laser system**
 - *Heidelberg MLA150 in NUFAB*
 - *Joins another MLA150 at PNF and a uPG501 in NUFAB*

SHyNE: Facilities & Tools

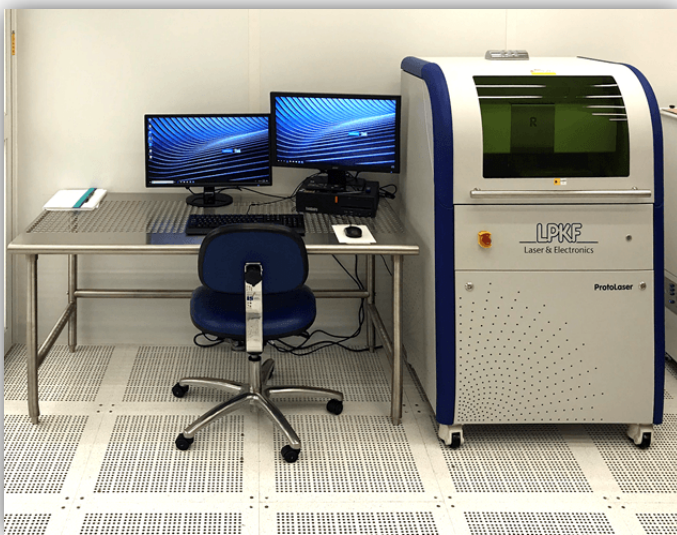
- **New NexDep Thermal/E-beam Evaporator**
 - *Wide range of different materials*
 - *High temp. ion-assisted evaporation*
 - *Joins existing evaporator in PNF*



- **SHyNE adds a new PlasmaTherm Apex SLR**
 - *Inductively coupled plasma etch*
 - *High density plasma with low temperature deposition*
 - *Joins existing SLR in the PNF*

SHyNE: Facilities & Tools

- **Two new direct electron detection cameras**
 - *Gatan K3-IS on JEOL ARM300*
 - *Beta site for in-situ IS system*
 - *Gatan K2-IS Summit on JEOL AC-S/TEM ARM200cf*



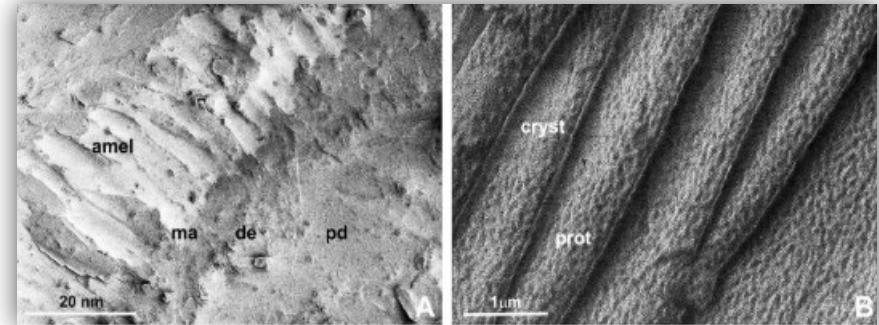
- **LPKF Protolaser R**
 - *Production-level CNC laser cutter*
 - *Cuts PCBs, Si, glass, metals, plastics*
 - *Picosecond laser for minimal heating*
 - *20 μm minimum cut width*

SHyNE: Research Highlights

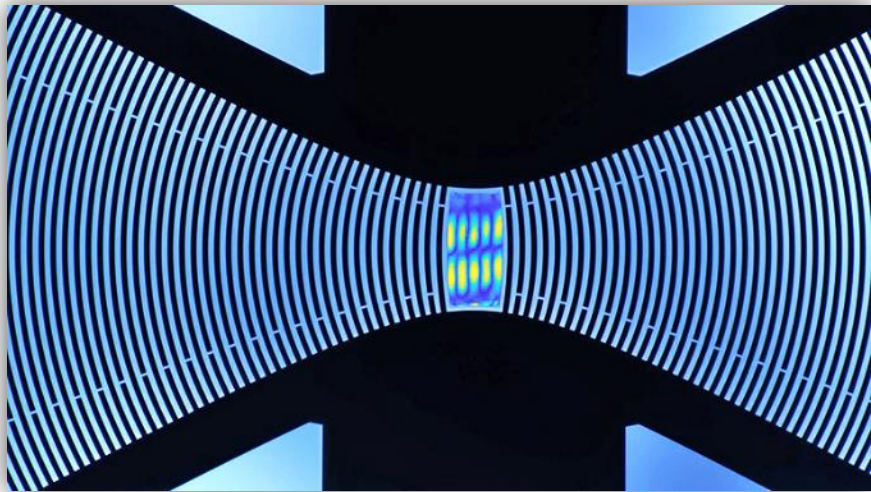
- **Structure & growth of enamel**

- Collaboration between Texas A&M and SHyNE staff
- Cryo-SEM investigation of dental enamel

Jokisaari, et al. ACS Nano (2019)



Cryo-SEM images showing the interface between ameloblasts, protein matrix, dentin and predentin (left) and the organic matrix and enamel crystals (right).



- **Breakthrough in advanced quantum sensors, computing and communication**

- Argonne National Lab with UChicago
- Demonstrate coupling of sound waves and electron spin

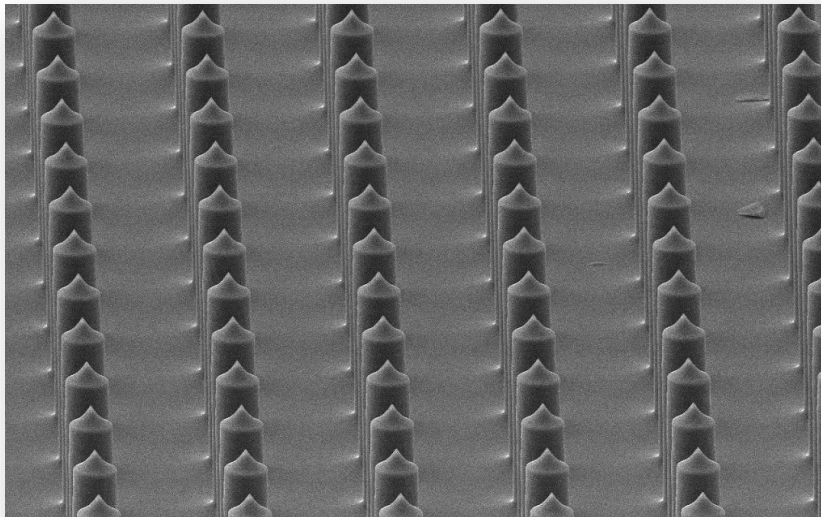
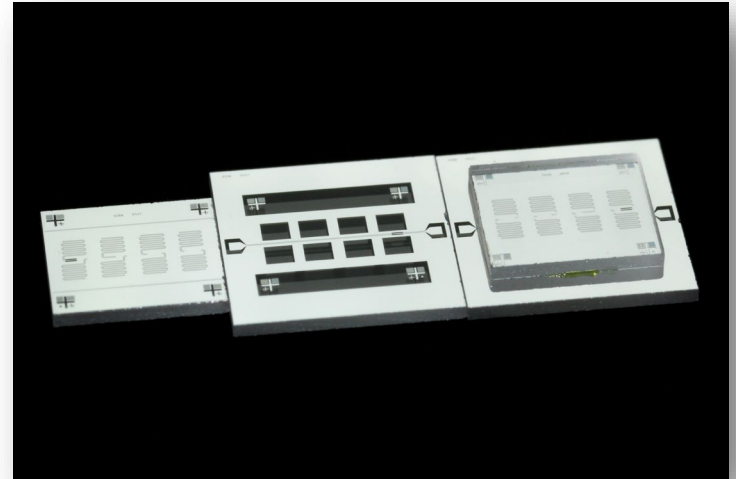
Whiteley, et al. Nature Physics (2019)

SHyNE: *Research Highlights:*

Major advance in hybrid quantum systems

- *Quantum control of individual phonons*
- *Tomography “photographs”- quantum states*
- *Collaboration between UChicago & ANL*

K. Satzinger et al., Nature (2018)

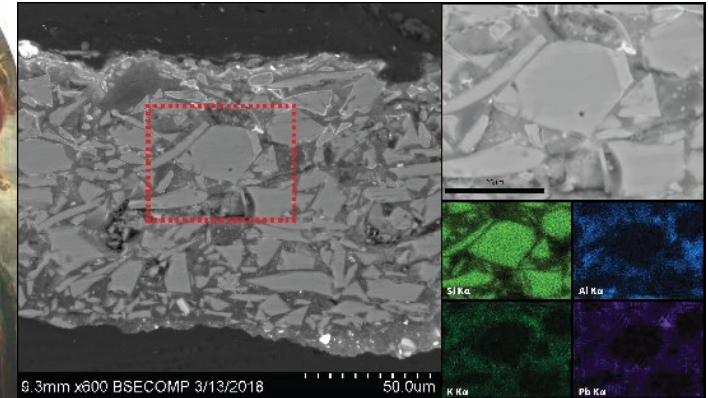


External user highlight: Microneedles for drug delivery

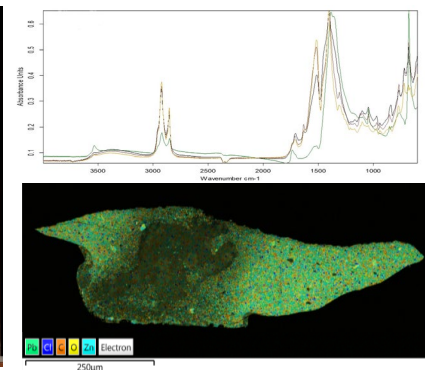
- *Microneedles transdermal drug delivery*
- *Collaboration across: PNF staff - Purdue University/University of Indiana*

Cultural Heritage Studies

- Kenneth Sutherland – Art Institute of Chicago, Annette Miranda and Marc Walton – NU-ACCESS
- Analysis of El Greco's *the Assumption of the Virgin* and Georgia O'Keefe's *Pedernal*
- Correlative optical spectroscopy and electron microscopy to probe provenance, degradation mechanisms, artist intent for conservation
- Publications in preparation



El Greco painting (left) and SEM-EDS results (right)

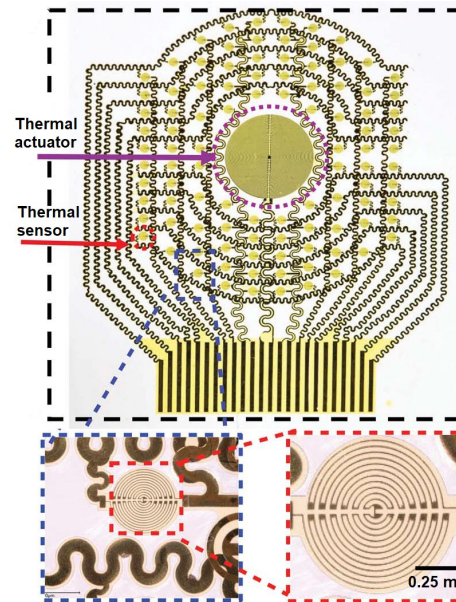


O'Keefe painting (left) with ATR-FTIR and SEM-EDS (right)

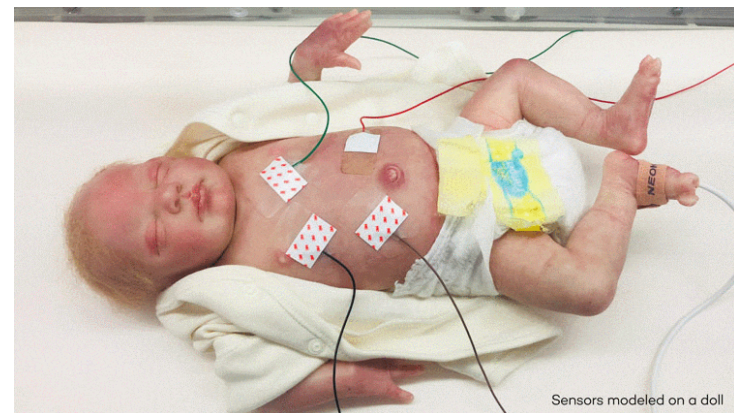
- <https://news.northwestern.edu/stories/2017/november/mummy-portrait-research-roman-egyptian/>

Flexible/Wearable Electronics: *Non-invasive Diagnostics*

- Rogers Lab at NU
- Epidermal electronics for ventricular shunt function assessment in patients with hydrocephalus
- Innovative fab processes on flexible substrates developed in SHyNE
- Non-invasive, wearable, wireless technology
- Krishnan, et al. Science Translational Medicine (2018)



Optical micrograph of epidermal electronic device with enlarged images showing stretchable interconnects (blue dashed line) and individual temperature sensors (red dashed line).



SHyNE: Education & Outreach

- **Facilities-focused REUs**
 - Four REU students embedded in SHyNE facilities
 - Projects included PLD, 2D materials, large-scale SEM imaging



- **iNANO 2019 - Quantum**

- Joint SHyNE-Argonne National Lab meeting
 - Sponsorship from NAISE and Chicago Quantum Exchange
- Keynote speakers included David Awschalom, Danna Freedman and Xuedan Ma

SHyNE: Education & Outreach

- **Nano-Journalism**

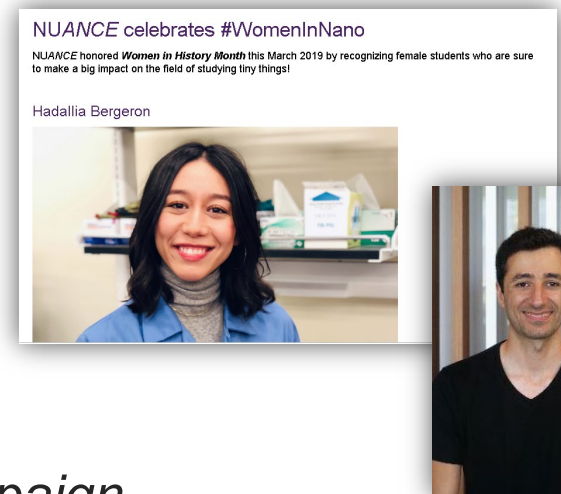
- Joint program with SHyNE and NU Medill School of Journalism; 2019/20 focus on video production
- Hired Mohammad Behroozian, International filmmaker, PhD student

- **Women in Nano**

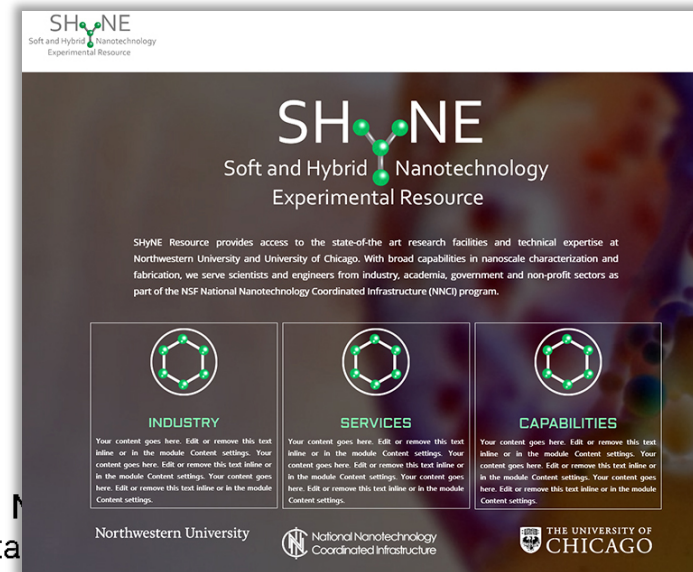
- Women's History Month social media campaign

- **SHyNE Web Portal, Tech Talks, NUANCE**

- **Outreach / Assessment**



Typical Questions	Out of 5
<i>Overall how would you rate this event?</i>	4.0
<i>How organized was the event?</i>	4.3
<i>Did you find the speaker / content engaging?</i>	4.0
<i>How helpful was the content presented at this event?</i>	4.2



Northwestern University



SHyNE: Impact

- **Publications**

- *Over 600 research products in 2018*
 - *331 research products specifically acknowledged NNCI award*

- **Patents**

- *85 Patents, applications and disclosures in 2018*

- **External Users**

- *22 external colleges and universities*
- *143 External Users in 1st 6 months of Year 4*

- **Regional Engagement, Testimonials**

- *iNANO*
- *Interaction with cultural institutions (AIC, Field Museum, etc.)*
- *K-12 outreach*
- *Support local startup ecosystem (SEED program)*
- *SMEs and Large Corp.*

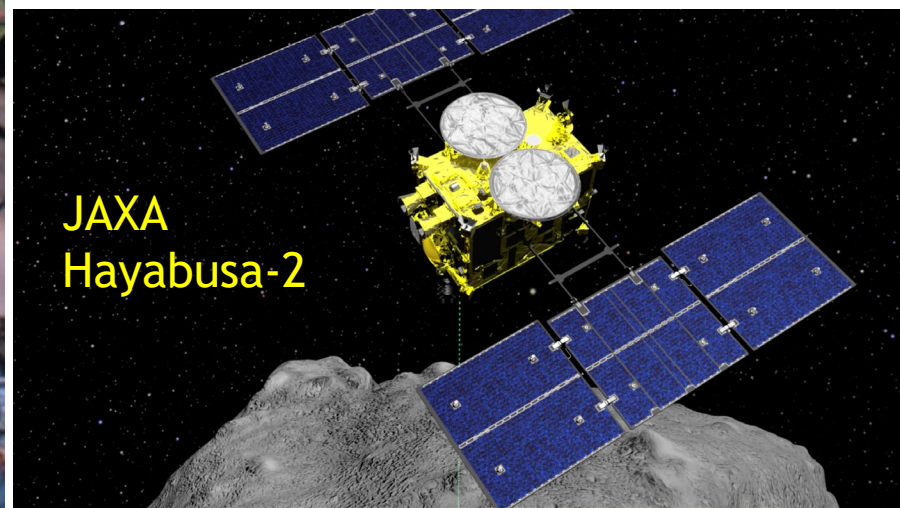


STRATEGIC INVESTMENTS IN INSTRUMENTATION
AND FACILITIES FOR EXTRATERRESTRIAL
SAMPLE CURATION AND ANALYSIS

NASA-National Academies (NA)
Report: 2019

To Infinity...
and beyond!

*Prep'ing SHyNE
for
Extra-Terrestrial
Materials Analysis!*



SHyNE: Network Collaboration

- **Network Collaboration**

- **Staff exchange program**

- SHyNE leading “staff-exchange” program
- Effort to cross-train & develop staff skills
- Online database; professional developments
- Travel support to attend & engage across NNCI



- **NNCI RET proposal**

- SHyNE participated in RET proposal (led by SENIC)
- Hosting 5 teachers per year, over 3 years
- Aligns with long-standing MRSEC RET program
- Connects teachers, grads, mentors across 4 sites



SHyNE: Panel Discussion

- **Panel Discussion Topic:**
Collaborations Beyond NNCI
 - ***Collaborations among DoD, DOE, and NSF: Quantum Leap initiatives:***
 - NNCI-supported fabrication and characterization
 - Parallel efforts in the simulation, fabrication and characterization communities.
 - ***Advanced packaging; with NNCI-supported fabrication technology***
 - Technology development and technique sharing to strongly impact development and deployment of technologies.
 - IC integration with device fabrication, flip-chip bonding, optical fiber integration with fabricated chips, etc.

