



UGIM 2016 SYMPOSIUM
University of Utah
June 12-15, 2016

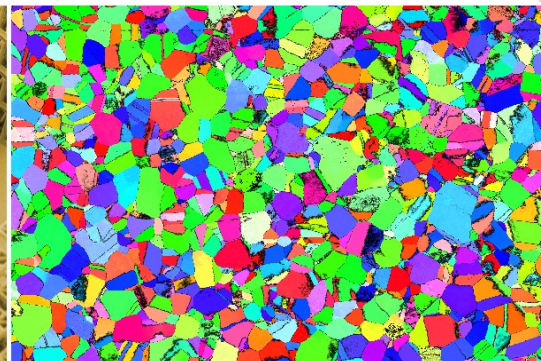
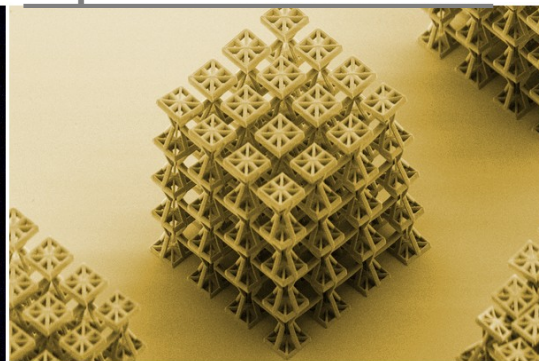
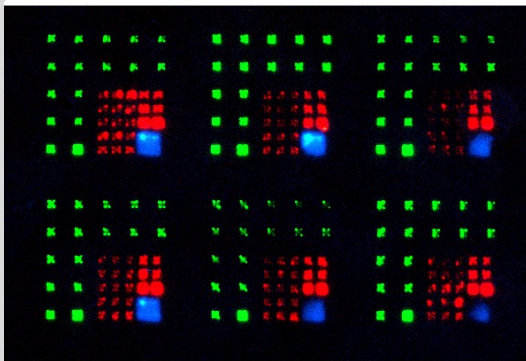
University
Government
Industry
Micro/Nano Technology

**International
Symposium on Research
Cleanroom Operations**

WELCOME

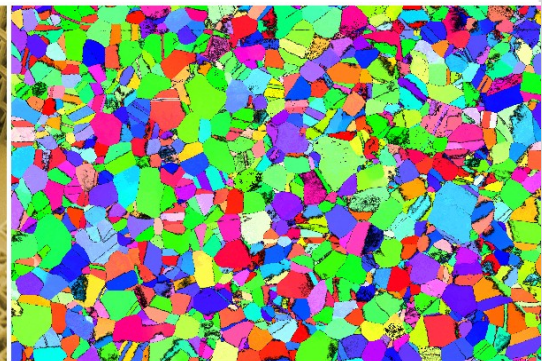
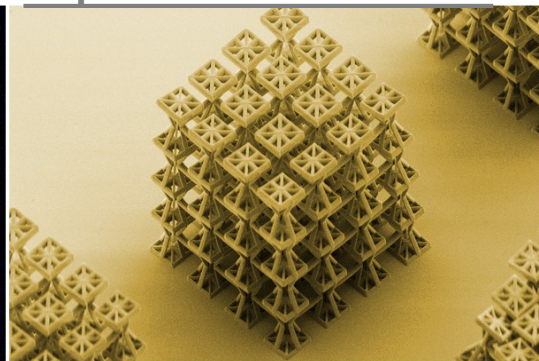
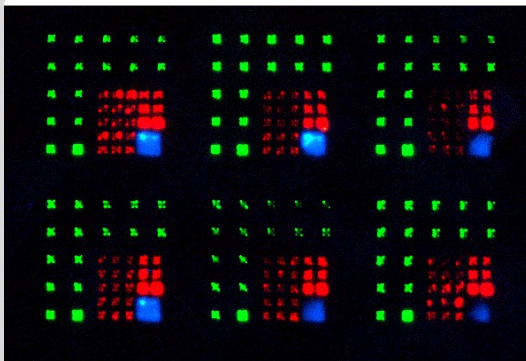
- **Open access large-scale user facility with a unique and dedicated set of micro and nanotechnologies to enable new research work**
- **Combines technologies and/or characterization methods in complex process chains to serve a broad range of user needs**
- **No fee access for peer reviewed proposals**
- **Located at the Karlsruhe Institute of Technology, Germany**

<http://www.knmf.kit.edu/>



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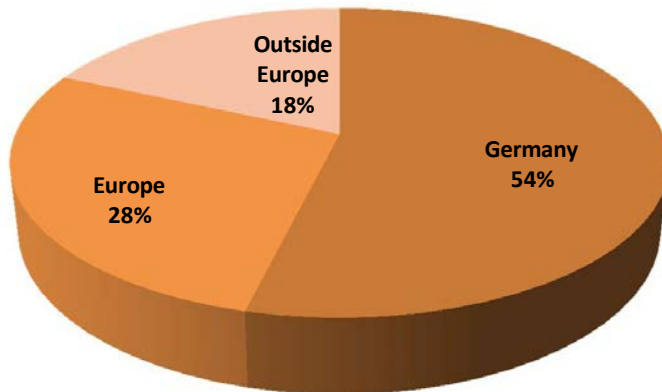


Performance Indicators KNMF (End of 2015)

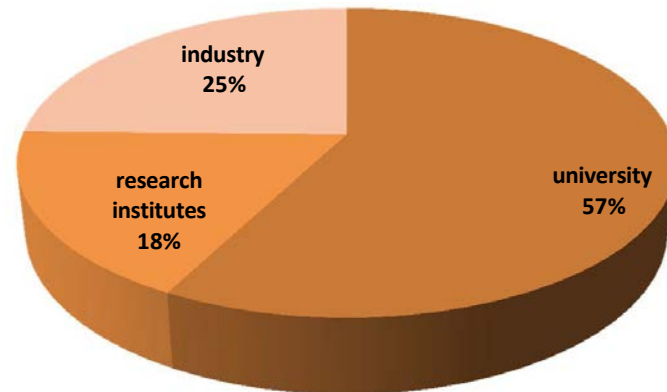
- In total 677 external projects (since 2011)
- 170 external projects in 2015

External users

User's country of origin



User's type of organisation



Joint School of Nanoscience and Nanoengineering (JSNN) Southeastern Nanotechnology Coordinated Infrastructure (SENIC)

- Member of the NSF National Nanotechnology Coordinated Infrastructure (NNCI); Located in Greensboro, North Carolina
- A 105K sq. feet, LEED® Gold certified interdisciplinary research facility dedicated to academic and industrial R&D activities
- An academic collaboration of North Carolina A&T State University and the University of North Carolina at Greensboro
 - Offers one of few graduate degree (MS and PhD) programs in Nanoscience and Nanoengineering
- Core Facilities
 - Nanoelectronics and Nanobioelectronics Cleanrooms
 - Electron and Ion-based Microscopy Suite incl. Helium Ion Microscope
 - Analytical and NMR Labs
 - Nanofabrication Facility, incl. nanoparticle synthesis and scale-up
 - Nanobioscience Labs incl. BSL-3, cell bio, genomics, MRI, wet chem.
 - 3D Visualization Suite and High Performance Computing Facility
 - Nanoenergy and Hydroponics Labs
- Conference facilities, partner office and lab spaces available



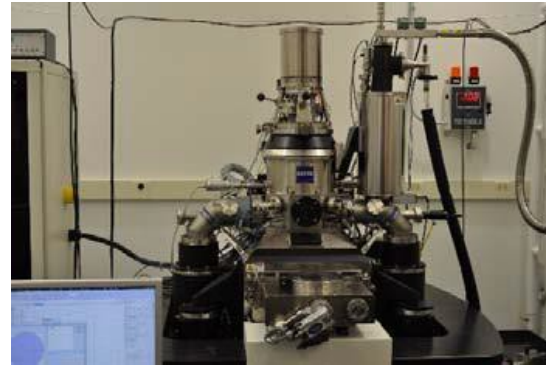
<http://jsnn.ncat.uncg.edu>

Core Facilities at JSNN

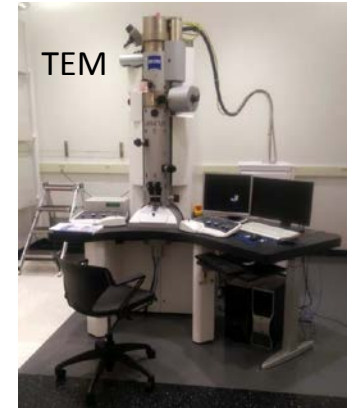
- Nanoelectronics and Nanobioelectronics Cleanrooms
- Electron and Ion-based Microscopy Suite incl. Helium Ion Microscope



200 mm fabrication tools



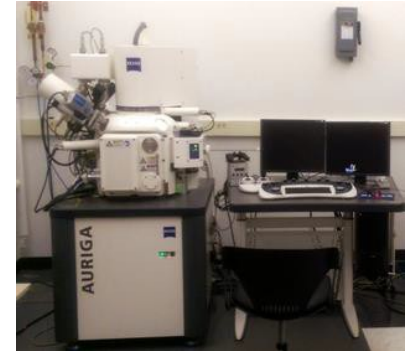
Helium Ion Microscope



TEM



Nanobio cleanroom



FIB/SEM

Core Facilities at JSNN

- Analytical and NMR Labs
- 3D Visualization Suite and High Performance Computing Facility
- Nanofabrication Facility, incl. nanoparticle synthesis and scale-up
- Nanobioscience Labs incl. BSL-3, cell bio, genomics, MRI, wet chem.
- Nanoenergy and Hydroponics Labs



Analytical tools

NMR



3D visualization suite



Nanobioscience Lab

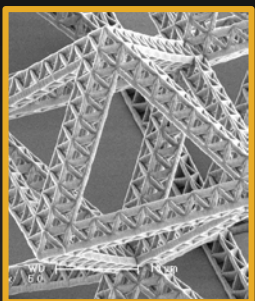
The Kavli Nanoscience Institute

California Institute of Technology

Pasadena, CA 91125 USA

The KNI is equipped for - and dedicated to - exploring the limits of nano fabrication. The KNI is a shared recharge user facility focused on fabrication and metrology, enabling researchers to engage in the rapid prototyping and rigorous characterization of nanodevices.

The lab is optimized to process up to 6" semiconductor wafers, and also supports microfluidic chip production with a multilayer soft lithography foundry.



Caltech

Contact: Guy DeRose, PhD
derose@caltech.edu

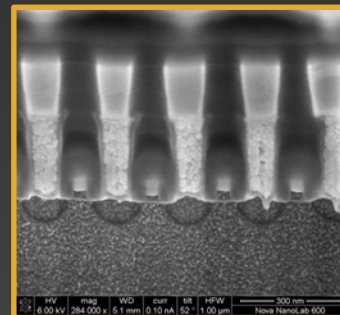
(626) 676-8529

(626) 395-3423



Pushing the limits of nanofabrication

- Lithography – writing a pattern
 - Optical
 - Electron / ion beam
- Deposition – adding functionality
 - Sputtering
 - Evaporation
- Etching – removing material precisely
 - Wet chemistry (isotropic)
 - Dry plasma (anisotropic)
- Microscopy – what do nanostructures look like?
 - Optical (light) microscopy
 - Electron microscopy



Who Uses the KNI Cleanroom?

Physics, Engineering and Materials Science

- Semiconductor fabrication and nanoelectronics and optics
- Mechanical properties of nanopillars
- Ultra-thin membranes
- MEMS/NEMS and Quantum transport in 2D materials

Biology and Chemistry

- Micro and nanofluidics for genomics and medical diagnostics

JPL / NASA / Companies

- New electronics for space systems
- Rapid prototyping for product development

Accessing the KNI Facilities

The KNI operates on a cost recovery basis

Academic and Government: Monthly base rate + hourly tool costs

Corporate: Annual flat rate

All charges include training and 24 x 7 access to facility

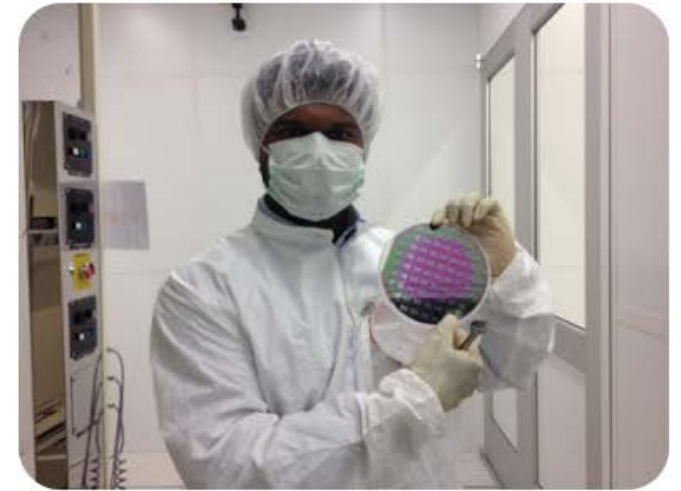
Email kni@caltech.edu or see <http://kni.caltech.edu/knilab> for more information

Masdar Institute Core/Shared Facilities

A “Substrate for Success”-Micro/Nano Fabrication Facility



- The most advanced research cleanroom in the UAE.
- Fit out of lab shell started in Summer 2010. First tools online mid 2012, official opening November 2013
- Numerous “firsts” for UAE (organic solar cell, Atomic Layer Deposition, Deep Reactive Ion Etch, Electron Beam Lithography, Graphene test device, etc.)
- Drives growth of regional and global partnerships.
- 4 bays, 3000 sqft total, class 100/1000/10k, >30 advanced processing and metrology tools available for use.
- High environmental standards of the Masdar Initiative are met utilizing best practices and commercially available equipment.



Masdar Institute Core/Shared Facilities

A "Substrate for Success"-Micro/Nano Fabrication Facility

- **Hazardous gas exhaust:** We use solid state scrubbers instead of burn boxes to handle hazardous exhaust from our tools.
- Cold water cooled solvent vapor trap instead of a carbon trap system for solvent vapor extract.
- Completely integrated TGMS and BMS system, with real time gas detection.
- All major equipment are on annual PM contracts.
- Advanced design to limit waste released to the environment.



- Operational model serves to secure continuous funding.
 - Separation between fixed cost/maintenance and operational (research) costs.
 - Operational costs provided from Institute “top line” budget.
- Experimental work is performed by trained users, utilizing their own recipes. We are coaches and mentors effectively multiplying capability by taking in fresh students and putting out well prepared researchers and innovators. Provides exponential growth capability as opposed to linear.
- Catalyst for transformation, forced the ecosystem to form around us and creating partnerships with local and international entities.
 - Had over 8000 billed equipment hours for 2015.
 - Half of all our users are female, and more than 20% of our users are local, Emirati students/researchers.

- Challenges

- DI water conservation: We are tooled down from 6”, and primarily work with small samples, bench top style.
- All research is carried out sustainably, with just a few samples per run and maximum allowable thicknesses on various deposition tools.
- Operational supply inventory levels have to be tracked carefully and ordered well in advance or we could have disruptions, i.e., Ultra-pure gasses.
 - MI & Air Liquide™ are in a Total Gas Management contract that handles all refill, hookup and emergency response.

Partnering to Achieve Innovation

iCenters are Interfaces for Collaboration

- Industry (and government) partnerships are essential for:
- Defining key UAE R&D needs and guiding translational and applied R&D
 - Providing employment for trained graduates

MI Industry and Government Research Partnerships 2015



Isle Royale National Park



Wolf population – 2 (2016)
Moose population – 1300 (2016)

Michigan Tech



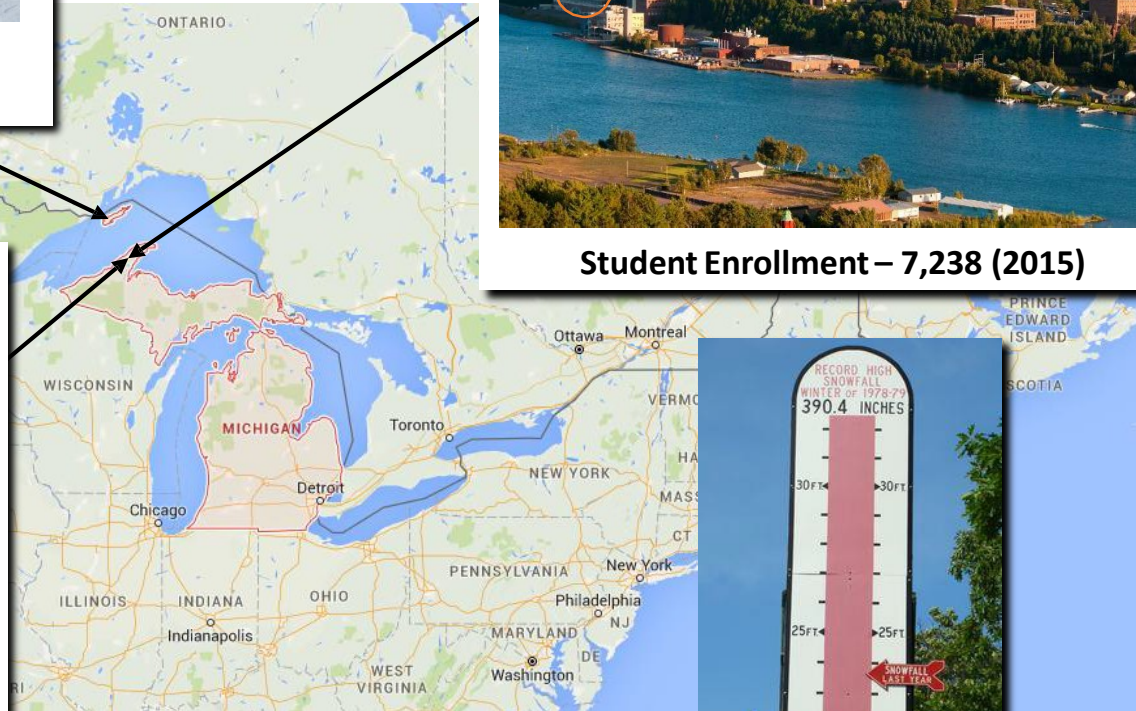
Student Enrollment – 7,238 (2015)

Portage Canal Bridge



Heaviest aerial lift bridge in the world

Hancock population – 4,596 (2013)
Houghton population – 7,650 (2013)



Other Interesting Facts:

Snow Averages	Days	Place	Inches	Centimetres
	90.5	Houghton	207.7	527.6

- Upper Peninsula aka Copper Country (11 billion pounds of copper extracted)
- Birthplace of professional ice hockey
- Home of Michigan Technological University and Finlandia University
- Eastern standard time

Michigan Technological University – Microfabrication Facility



- **Managing Director**
- Dr. Chito Kendrick (ECE)
- cekendri@mtu.edu



- **Faculty Advisor**
- Prof. Paul Bergstrom (ECE)
- paulb@mtu.edu

User base:

Electrical and Computer Engineering (3 Faculty, 5 Users)

Waveguides, Photonics, Photovoltaic materials

Physics Department (3 Faculty, 5 Users)

Magneto-optics, Super luminescence

Chemistry and Chemical Engineering (3 Faculty, 6 Users)

Lab-on-a-chip

Material Science and Engineering (2 Faculty, 6 Users)

Photovoltaic - Plasmonics

Biomedical Engineering (2 Faculty, 5 Users)

Lab-on-a-chip, MEMs

1000 ft² soft wall cleanroom

Laurell Polymer Spinner

Nikon Optical Microscope

EVG620 – Mask aligner

RCA Wet Bench

Etching and characterization

Ion Beam Etcher

J.A. Woollam VASE Ellipsometer

TRION RIE

Thin film deposition

Denton DV-502A – E-beam deposition

8" Perkin Elmer Sputtering System

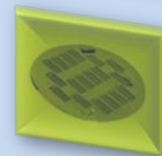
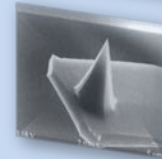
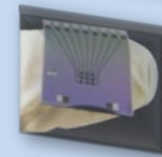
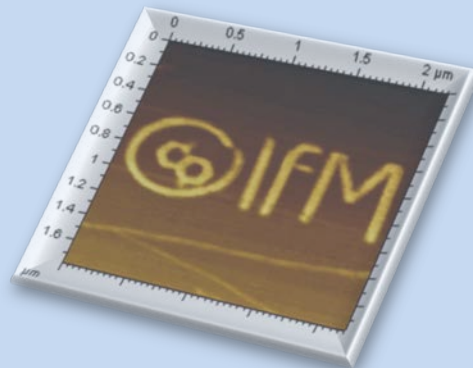
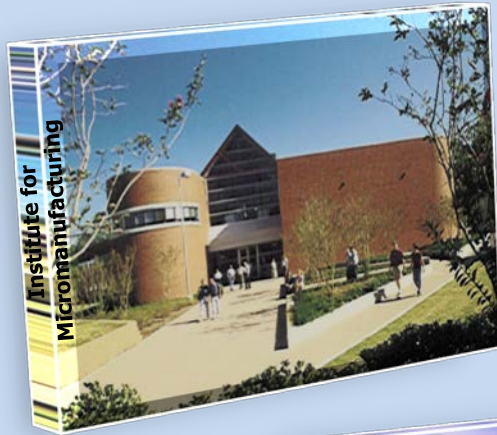
Parylene Coater

6" Perkin Elmer Sputtering System

A ex-industry atomic layer deposition system is being installed 2016-2017



Microfabrication Cleanroom with class 100 bay and 3 class 1000 bays
Metrology & Characterization Labs
Instructional Labs
Machine Shop



Australian National Fabrication Facility Ltd.



What is ANFF?

- 19 universities and CSIRO in a national network of open-access laboratories
- 99 FTE ANFF staff
- >500 tools across Australia

How?

- \$139 m Federal Government
- \$33 m State Governments
- \$45 m participating institutions
- Leveraging \$89 m in-kind

Total investment >\$300 m

Providing nano and micro-fabrication facilities for Australia's researchers



A fully equipped 150mm micro- nanofabrication facility

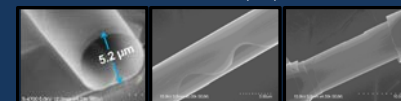
Highlights:

- 3000 sqf class 100, 1000
- 5 full time staff
- 40 tools
- 150mm compatibility
- more than 100 users/projects per year
- average of 700h/month of machine usage

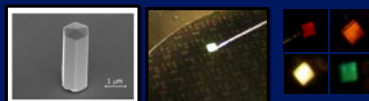
Glass/Si Microfluidics – In-chamber electrical paths



Self-assembled InGaAs/GaAs quantum dot microtubes on GaAs and Si. Mi (ECE)



InN Nanowire LEDs. Mi (ECE)



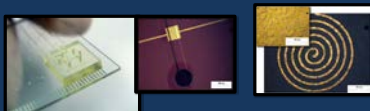
SiN cantilevers for muscles cells study. Rassier (Physiology)



SIC RF MEMS. El-Gamal (ECE)



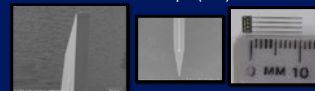
Electrostatic microvalves. Juncker (Biomed. Eng.)



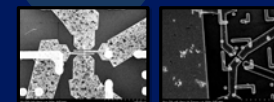
Graphene conduction study with EBL-defined leads. Szkopek (ECE)



Ultra-long silicon neural probes. Chodavarapu (ECE)



Intrinsic InAs and InN nanowires SNS junctions. Gervais (Physics)



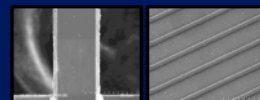
Heart cells stimulated by capacitive electrodes. Shrier (Physiology)



PDMS Microfluidics. Juncker (Biomed. Eng.)

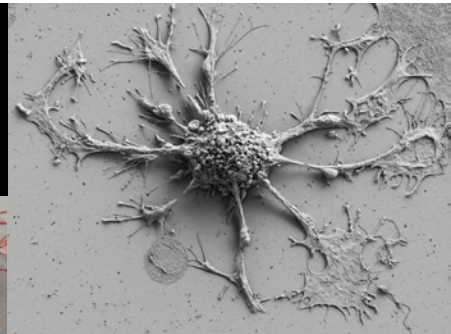
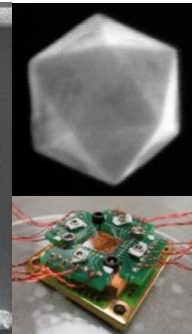


200nm metallic lines on cantilever. Vengallatore (Mech. Eng.)

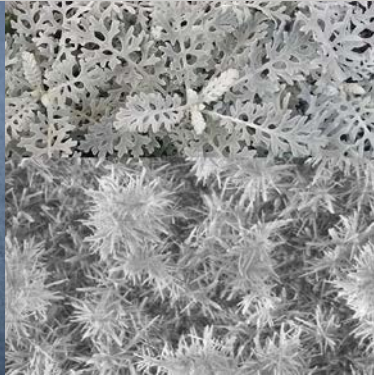
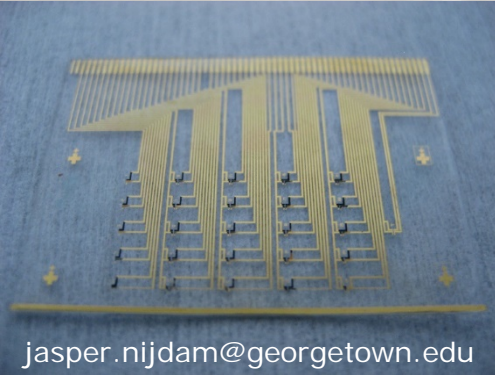


Automated CO2 dissolution platform, Guenther, UoT





Georgetown Nanoscience and Microtechnology Laboratory



jasper.nijdam@georgetown.edu

NTNU

NanoLab

NTNU
Norwegian University of
Science and Technology



- Norway's largest open access facility
- 300 users from universities and industry
- Graduate students and researchers side by side
- Nanofabrication, synthesis and characterization
- Part of NNN – Nordic Nano Network
- 700 m² of ISO 5-7 (7.500 sq.ft. of class 100-10.000)



Lurie Nanofabrication Facility at the University of Michigan



LNF.umich.edu
info@LNF.umich.edu

The mission of the LNF is to provide effective, efficient, safe, and socially responsible access to advanced nanofabrication equipment and expertise thereby promoting, enabling, and encouraging cutting-edge education, research and business development from materials and individual process steps to entire systems.

LNF by the numbers

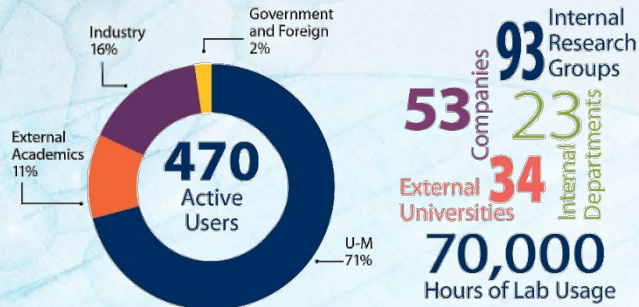
- 13,500 SF under filter / 18,000 GSF
- Class 10 / 100 / 1,000 / 10,000 areas + BSL2
- State-of-the-art infrastructure
- 140 Major tools
- 20 Professional support staff
- \$3.7M Annual operating budget

Capabilities and Expertise

- Pieces to 6" wafer processing
- Si, compound semiconductors, polymers and others
- MEMS, microfluidics, integrated microsystems, nanophotonics, optoelectronics

Processes and Technologies

- Deposition and growth
- Lithography, direct writing and mask making
- Etching
- Thermal processing
- Chemical processing
- Metrology and characterization
- Packaging and mechanical finishing (BEOL)



SABANCI UNIVERSITY NANOTECHNOLOGY RESEARCH AND APPLICATION CENTER (SUNUM)

- Dedicated 7.500 m² green research building
- LEED (Gold) and BREEAM (very good) certified
- Laboratories equipped with state-of-the-art equipment among the best in Eastern Europe
- Class 100 (ISO 2) clean room for depositing organic and/or inorganic, conductive, insulating, and semi-conductive materials and etching (wet and dry) in controlled dimensions
- Fabrication of structures with dimensions from a few nanometers, to hundreds of micrometers on single or multi-level functional structures
- Whole genome sequencing of all kind of organisms for health, medicine, agriculture and energy fields.
- Efficient membranes for energy (fuel cells) and filtration (cleaning up the environment, water purification) applications
- Integrated circuits and systems for X-BAND, Phase Shifter RADAR applications
- Fabrication of multi-functional and active nano/micro-structures to shape and manipulate cells for the development of 3D artificial tissues
- 13 researcher + 18 postdoc +7 staff
- 2 Million USD operation budget
- 1.5 Million USD income
- 451 users-90.000 hours of use
- No charge for faculty !!!
- 89 research papers+7 patents
- 2 Million USD new Project start every year
- Total research fund : 8.1 Million USD

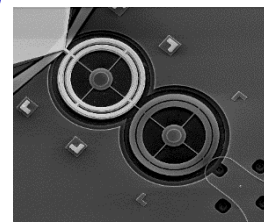
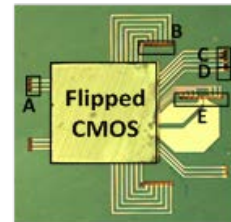
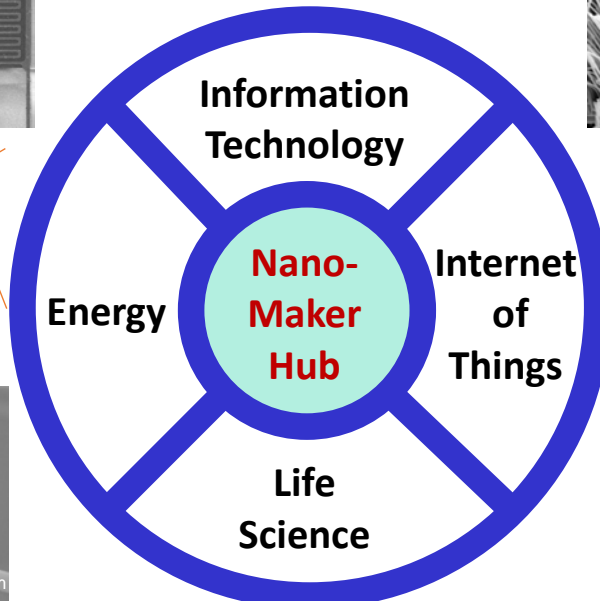
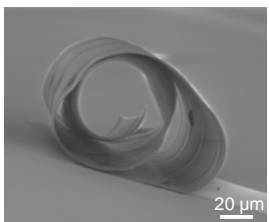
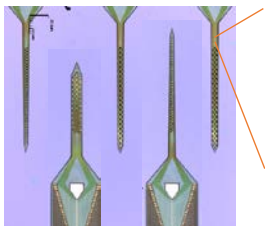
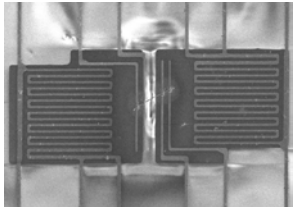
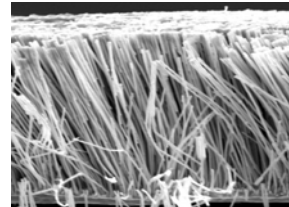
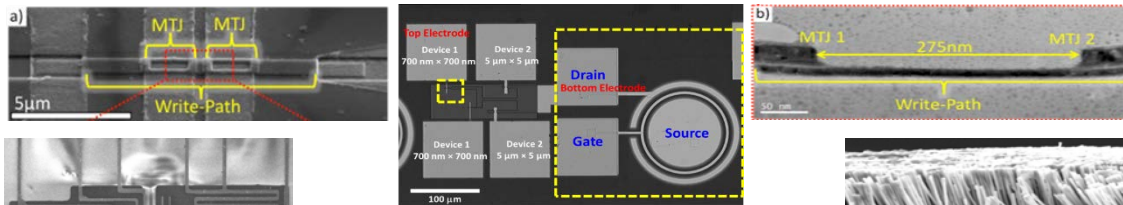


Carnegie Mellon University

Nanofabrication Facility

➤ The 11,000 sqft facility is part of the Claire and John Bertucci Nanotechnology Laboratory

➤ Includes an 8,500 sqft cleanroom made possible by Eden Hall Foundation



Tool Highlights

LITHOGRAPHY: 3 e-beam writers, i-line stepper, suite of mask aligners

ETCHING: Suite of ICP, RIE, and plasma tools, ion mills, VHF, XeF₂, etc.

DEPOSITION: Suite of 14 PVD systems, ALD, CVD, PECVD, etc.

POST-PROCESS and METROLOGY: Electroplating, CMP, stress analysis, SEMs, profilers, RTA, annealing furnaces, etc.

2016 UGIM SYMPOSIUM

SALT LAKE CITY, UTAH-JUNE 12-15, 2016

IEEST



UTAH NANOFAB

VINSE Nanofabrication and Characterization Facilities in the new Engineering and Science Building at Vanderbilt University

Anthony B. Hmelo, Joe Morgan, Bill Wilson,
Abbie Gregg, Sean Brice, Keith Loiseau, Jason
Valentine, Sharon M. Weiss, Sandra J. Rosenthal,
and Philippe M. Fauchet

Key Features of VINSE Facilities in the Engineering and Science Building (ESB)

Building (ESB)

Consolidation of all existing VINSE capabilities in the ESB

- Occupancy commences during the Fall of 2016
- VINSE Cleanroom and Nanocrystal Laboratories on the Ground Level
 - Bay and chase design ISO 5/6 (100/1000)
 - eBeam Lithography enclosure capabilities down to NC 25 sound attenuation
- Eventual nano-bio capabilities (Future expansion)
- VINSE Imaging Suite in the Basement Level
 - Imaging suites feature EMI shielding and vibration criteria down to VC-G.
- Visit us at <http://www.vanderbilt.edu/vinse/>



V_iNSE

V_iNSE Vanderbilt Institute of Nanoscale Science and Engineering