

Midwest Nano Infrastructure Corridor

Steven J. Koester, PI

Sarah Swisher, co-PI

James Marti, senior investigator

Greg Haugstad, senior investigator

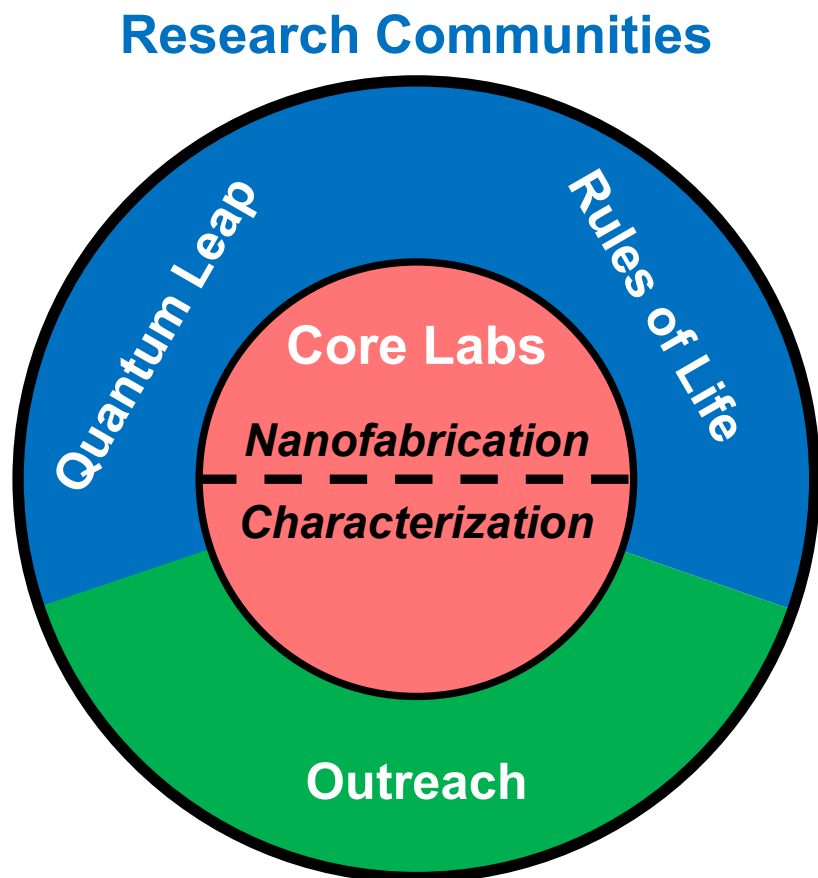
MINIC
Midwest Nano
Infrastructure Corridor



October 29, 2024



Overview: Node Structure and Leadership



Steve Koester
Node Director
Quantum Leap Lead



Kristina Pearson
MNC Admin



Nate Lynch
CharFac Admin



Javier Garcia Barriocanal
CharFac Outreach



Brian Olmsted
Nanofabrication Lead



Jim Marti
Rules of Life co-Lead
MNC Outreach



Greg Haugstad
Characterization Lead



Sarah Swisher
Rules of Life co-Lead



Theresa Reinecke has stepped down as co-PI and Rules of Life co-Lead.

Overview: Node Structure and Leadership

- **Jim will be retiring in early 2025. Thanks for your significant contributions to NNCI!!**

- **Jim Marti was awarded a 2024 UMN Research Technical Staff Award.**



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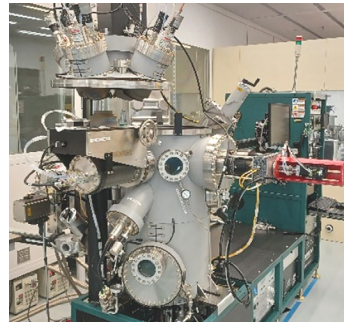
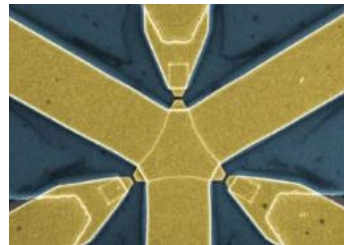
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MiNIC Focus Areas

- Two focus areas: Quantum Leap, Rules of Life. Focusing on establishing infrastructure and external user base in these two emerging areas.

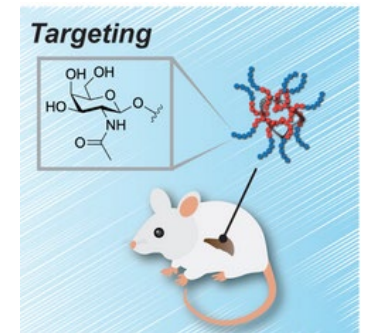
Quantum Leap

- Process knowledge for quantum materials and devices.
- Tools to support qubit fabrication.
- Community building and educational programs.



Rules of Life

- Facilities for bio-sensor fabrication and bio-material characterization
- Biosafety level 2 cell culture lab
- Research support for small companies and projects



Key MiNIC Capabilities: Core Laboratories

- **Minnesota Nano Center (MNC):**

- Two cleanrooms + Nano-Bio & Nano-Materials labs.
- More than 100 tools including EBL, stepper, direct laser writer, 3 ALD, HD-PECVD, RIE, sputter, UHV dep and 2D materials.
- 5 process + 5 maintenance staff with > 200 years experience.



MNC cleanrooms (in PAN and Keller Hall) and Nano-Bio / Nano-Materials labs.

- **Characterization Facility (CharFac):**

- Four facilities for hard, soft, and bio materials located in related buildings.
- More than 70 tools include Titan STEM, cryo SEM and TEM, dual beam FIB, XPS/UPS, IBA, XRD, and AFM.
- Staff include 10 FTE (11 PhD, 1 MS); >200 years experience.



CharFac instruments, including Titan STEM, XPS/UPS, Cryo-STM, and ion-beam analysis

Key MiNIC Capabilities: Key New Equipment

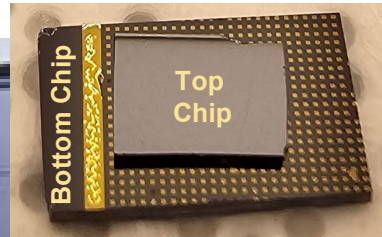
- Important new equipment additions:

Operational



Finetech *FinePlacer Sigma* Die Bonder

Supports 3D heterogeneous integration
200-mm compatible



Ordered



ThermoFisher *Glacios 2* Cryo-TEM

High-throughput soft matter imaging
Cryo-FIB capability also included



Delivered

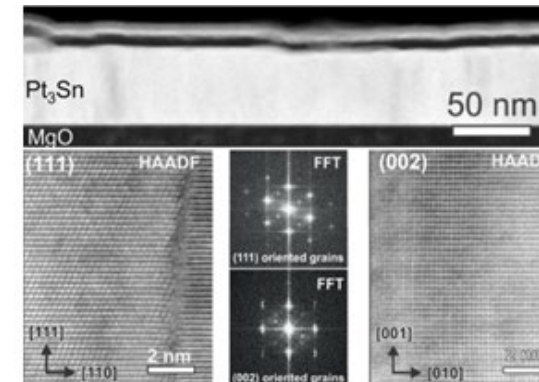
Raith *Picomaster DWL* Lithography

Dual laser sources (375 nm, 405 nm)
0.3 μm resolution, grey-scale compatible
200-mm compatible

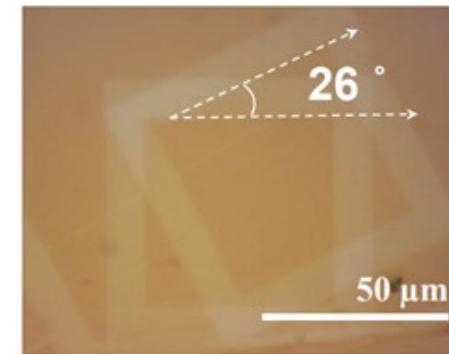
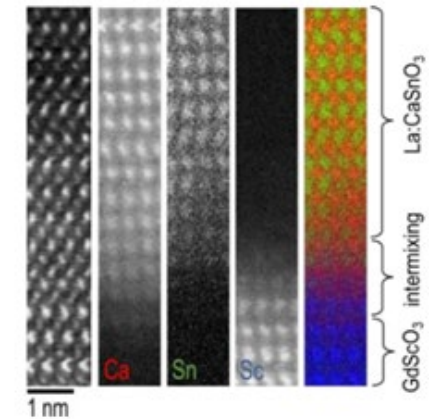
Impact Overview

- **Summary of CY 2023 publications:**
 - 175 journal papers:
 - Nature Communications = 8
 - Nature Nanotechnology = 1
 - High-impact ACS Journals = 8
 - Proc. Nat. Acad. of Sciences = 5
 - Science Advances = 1
 - 94 conference papers
- **In FY 2023, MiNIC supported \$138M+ in externally funded projects.**

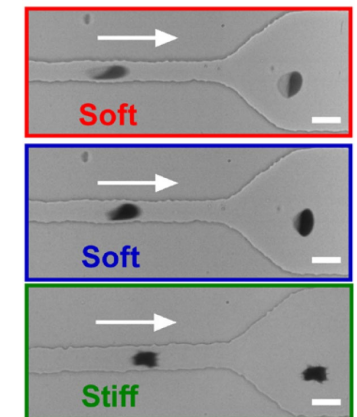
Spintronics



Smart Materials



Optics



Med Tech

Network Activities: The Northern NanoLab Alliance (NNLA)

- NNLA: The first NNCI regional network of university fabrication facilities:



Mission: Assist members to improve their facility operations and support of academic research in applied nanotechnology.

Activities: Met in January 2024, laid out objectives for coming year:

- University of Minnesota
- Michigan Technological University
- Rose Hulman Institute of Technology
- University of Iowa
- South Dakota State University
- Iowa State University
- North Dakota State University
- Minnesota State Mankato
- University of Wisconsin-Madison
- University of Colorado-Boulder

- Cooperate on supply purchases, pricing,
- Build knowledge base for safety, training,
- Standardize user and lab management software (Bookit, NEMO),
- Develop and share knowledge base for tool maintenance, repair specialists in region.



NNLA lab managers meeting at MNC, January 2024.

Education & Outreach – Internship Program

- **MiNIC’s laboratory internship program offers students from two-year colleges the chance to work in a nanoscience lab:**



- Four students supported from Fall 2023 to Spring 2024.
- Projects studied included:
 - Synthesis of quantum dot nanoparticles,
 - Genetically modifying cells.
- The students used our NanoBio labs and tools to characterize nanoparticle dispersions and culture human cell lines.
- Each intern’s work yielded a written report and a set of lab protocols useful for future work in this area.



Education & Outreach – Industry Workforce Development

- **Microfabrication Technology Short Course (MTSC):**
Responding to the need to support workforce development in the microelectronics industry
 - Developed a certificate program for new and incumbent workers in microelectronics and MEMS manufacturing,
 - Supported development of ten online training modules,
 - Provided hands-on lab training experience for 60 students from partner companies,
 - Supported by industry (Honeywell, Polar Semiconductor, Collins Aerospace) MN Dept. of Employment and Economic Development.
 - Started second training cohort in Fall 2024 with additional partners.



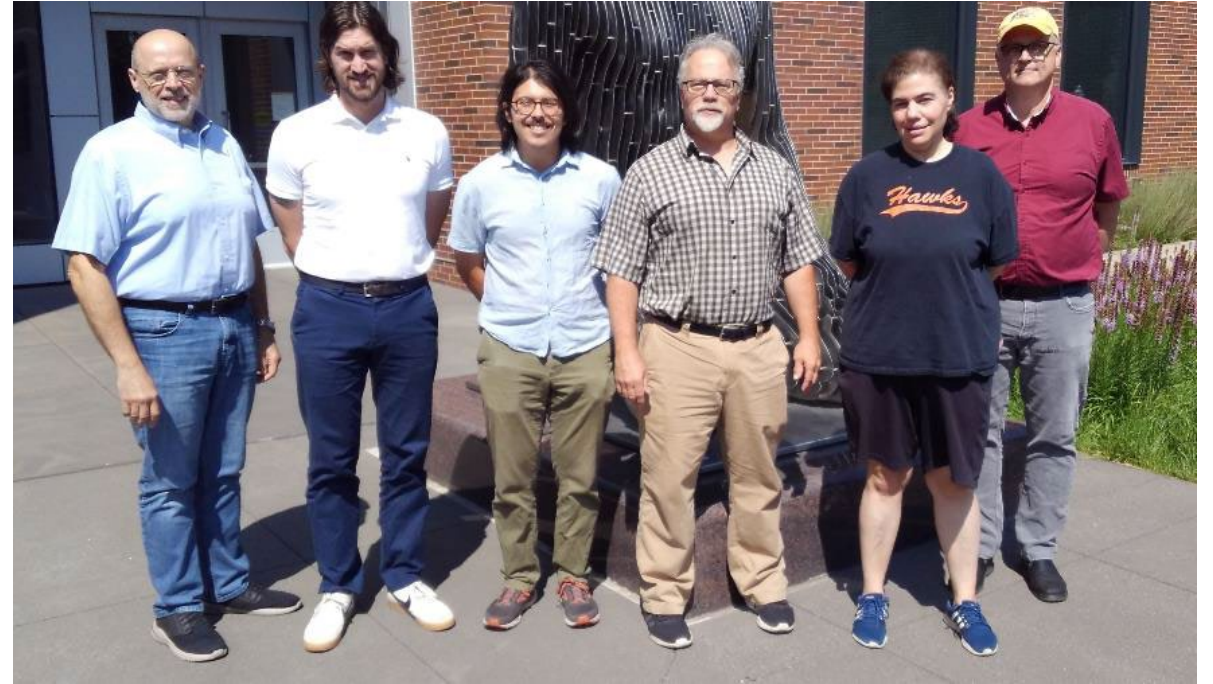
College of Science and Engineering

Technological Leadership Institute



Research Experience for Teachers (RET)

- MiNIC completed a three-year **RET Across the Network** project, with SHyNE (Northwestern), NNF (U Nebraska-Lincoln) and SENIC (Georgia Tech).
- RET teachers spent 6 weeks in summer working with faculty research groups. The participants:
 - Develop a classroom activity related to nanoscience or STEM.
 - Attend annual meeting of the National Science Teachers Association (NSTA).



MiNIC RET teachers, 2023-24, from a variety of urban and suburban school districts.

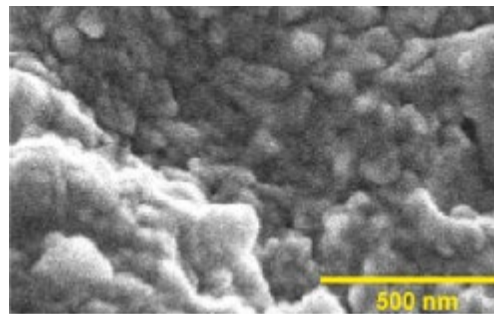


- **Were recently awarded a new collaborative grant to continue program into 2027!!**

Focus Area Activities in Year 9: Rules of Life

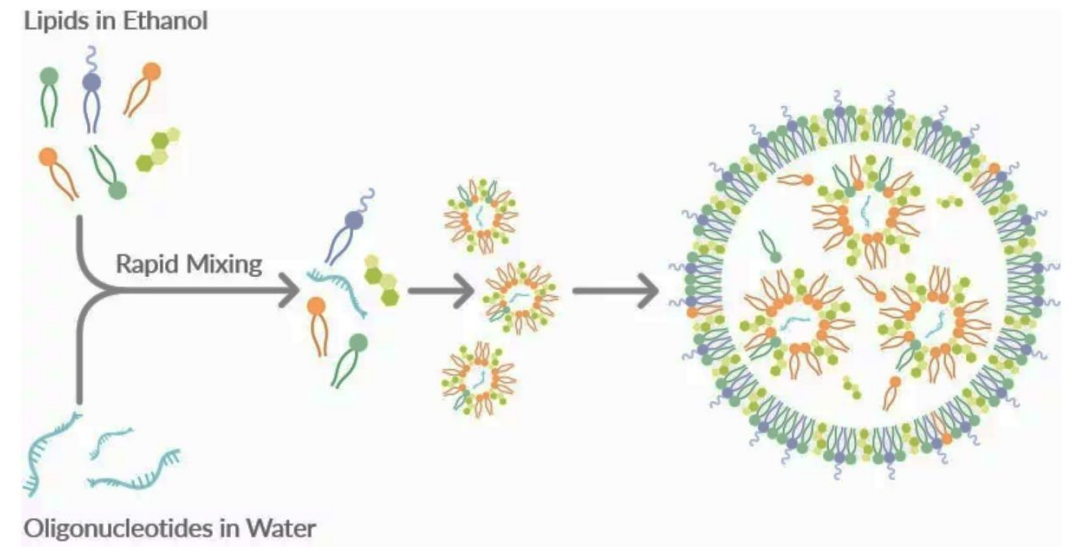
Industrial partnerships:

- Successful Phase 1 SBIR project with Superior Nano LLC to develop lipid nanoparticles (LNPs) for drug delivery.
- Oral LNPs demonstrated excellent drug bioavailability on mouse models.
- Phase 2 proposal, in preparation, is targeted to oral insulin formulation.



New lab capabilities:

- Formulating lipid nanoparticles as platform for vaccine delivery.
- Developing swine vaccine with UMN Veterinary Medicine Department.



Focus Area Activities in Year 9: Quantum Leap

Exchange Programs:

- NSF AccelNet program that links networks nano- and quantum technologies.
- Ran 3rd year of international exchange programs to Japan and Germany in 2024.



Germany 2024 summer
IRTE students



Japan 2024 summer
IRTE students

<https://www.globalquantumleap.org/irte-program>

Workshops and Bootcamps:



<https://www.globalquantumleap.org/wqei2>

- Hosted the 2nd Workshop on Quantum Engineering Infrastructure (WQEI2) in March, 2024.
- Goal was to address the critical needs for research fabrication infrastructure in quantum technology.



- 10 day bootcamp for early undergraduates to introduce key topics in quantum.
- 48 students from Korea & US.



<https://sites.google.com/umn.edu/quantum/home>

Prompt Question

Question: What are examples of programs and activities developed under NNCI that will be sustainable, independent of any continued NSF renewal funding, and what strategies or sources will be used to support them?

- Microfabrication Technology Short Course (MTSC) through the Technological Leadership Institute (TLI) → NNCI was instrumental in getting this started, through participant support. However, with state support and a fee-based model established by TLI, this has good potential to continue independent of NNCI.
- Nano-bio activities in MiNIC → NNCI staff support critical for expanding cryo-TEM infrastructure and user base. Ongoing support for nano-bio infrastructure is strong through UMN Medical School, International Inst. for Biosensing, Hormel Institute, etc..
- Northern Nanolab Alliance (NNLA) → NNCI provided motivation for setting this up. Success is driven by inherent benefit of knowledge sharing and mutual benefits of regional collaboration.

Summary + Outlook → The Future is Bright for MiNIC!!

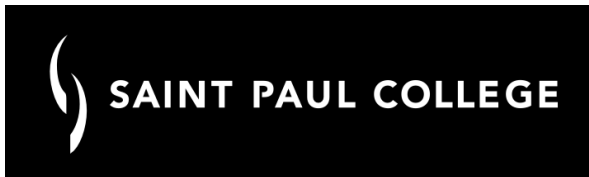
- MiNIC has been extremely productive over the past year, supporting basic research, tech translation, education and workforce development.
- As we move into Year 10, we are focusing on:
 - Supporting CHIPS Act research and development, particularly in partnership with Polar Semiconductor. Expanding infrastructure and workforce development through the Minnesota Forward Fund.
 - Expanding training activities as a new partner in the Scalable Asymmetric Lifecycle Engagement (SCALE) program (in partnership with University of St. Thomas and Metro State University). Focus is on creating a “clearable” workforce for DoD employment.
 - Continuing to expand our user base and quantum / bio focus areas in preparation for the new infrastructure network competition.

PANEL DISCUSSION PROMPT:

What role do **community/technical colleges play in your education and workforce development strategy and what role should they play in a future infrastructure network?**

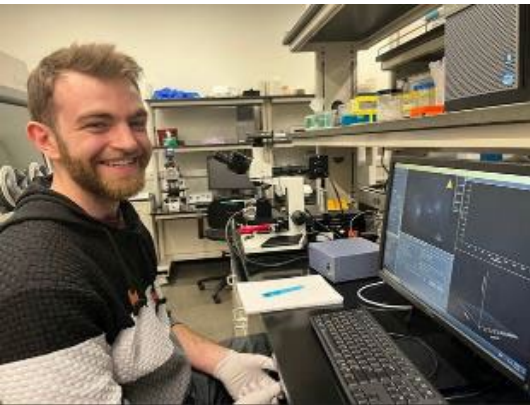
Panel Prompt

Question: What role do community/technical colleges play in your education and workforce development strategy...



Internship program:

- St Paul Community College
- Bio-nano and microelectronics semester-long projects
- Hands-on experience with nanoparticle synthesis and cell manipulation



Past capstone projects:

- Dakota County Technical College
- MNC provided capstone fabrication project during final semester of 2-yr degree
- Job placements in microelectronics (Cypress Semi.) and materials engineering (3M)
- Discontinued when DCTC enrollments declined, but could be restarted with other TCs using existing materials

Panel Prompt

Question: What role do community/technical colleges play in your education and workforce development strategy...and...what role should they play in a future infrastructure network?

- “Finishing touches” to CC/TC preparation
 - Experiential & hands-on learning, capstone projects
 - Build mentoring network, support pathways into 4-yr degrees or to industry
- Train CC instructors in RET to amplify impact
- Leverage MN Workforce Development Coalition
- Expand/export internship program:
 - Normandale Vacuum Technology Program: regional leader training microelectronics technicians
 - Learn from pilot projects, then replicate these programs in MN and elsewhere



Minnesota's extensive CC/TC network