



*1st nanoMFG Node Workshop on
Data-Science Enabled Advances
In Nanomanufacturing
(DSEAN)*



Introduction to the NSF Nanomanufacturing Node

Kimani C. Toussaint, Jr.

*Department of Mechanical Science and Engineering,
and Department of Bioengineering*

*Affiliate, Dept. of Electrical & Computer Engineering, Beckman Institute for
Advanced Science and Technology, and the National Center for
Supercomputing Applications*

University of Illinois at Urbana-Champaign

*1st nanoMFG Node Workshop on Data-Science Enabled Advances In
Nanomanufacturing (DSEAN)*

February 26-27, 2019 (Urbana, IL)

<http://nanomfgnode.illinois.edu/>

nano**MFG**



OUTLINE



□ Nanomanufacturing node

- ✓ Team
- ✓ About the node
- ✓ Vision
- ✓ Tools

□ DSEAN Workshop

- ✓ Goals



nanoMFG NODE LEADERSHIP



**Kimani
Toussaint, Jr.**



**Placid
Ferreira**



**Hayden
Taylor**



**Elif
Ertekin**



**Narayana
Aluru**



Jay Roloff
Project Site Lead



Irfan Ahmad
Assoc. Director,
Education & Outreach



Ayesha Boyce
External
Evaluator



Dan Katz
Cyberinfrastructure
Lead

Darren Adams
Software
Programmer



Nahil Sobh
Consulting Project
Manager

Seid Koric
Technical Director
NCSA Industry Prog.





ABOUT nanoMFG NODE

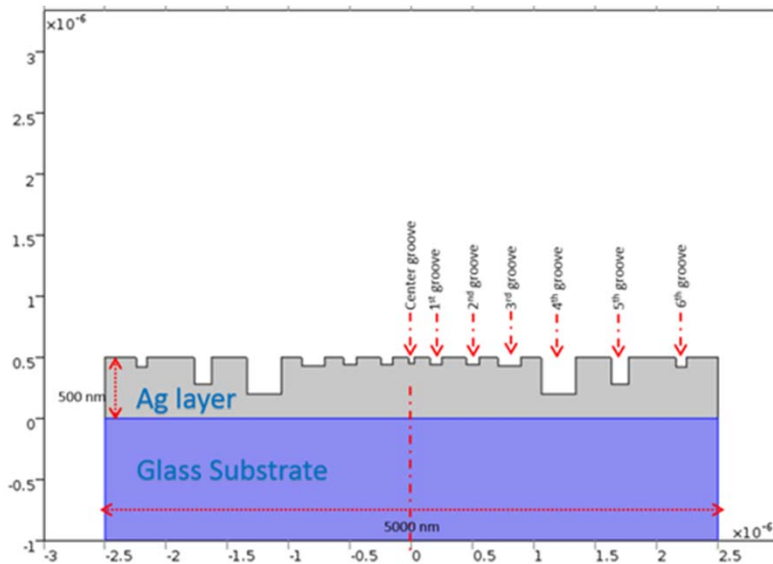


- Launched in 2017 (1st of its kind)
- \$4M, 5-year (infrastructure-development) effort by the NSF
- Develop software tools to facilitate nanomanufacturing
- Part of the Network for Computational Nanotechnology (NCN)
- Tools freely shared on nanoHUB cyberframework (@ Purdue)

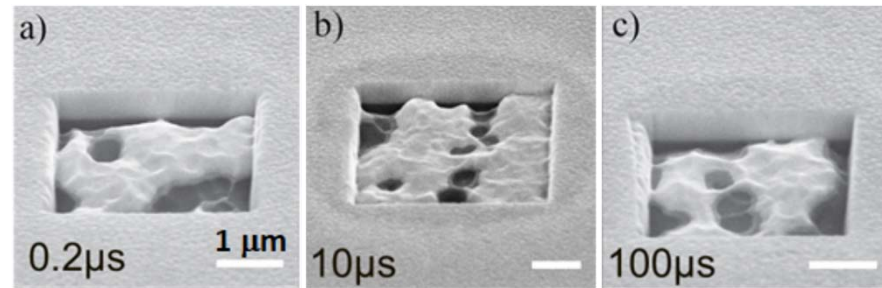
FIB milling: parameter exploration

Varying beam dwell time: 30keV, 30pA

Metasurface flat focusing optic

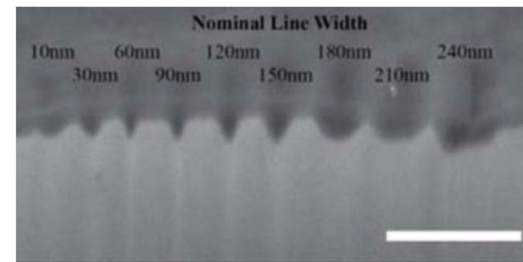
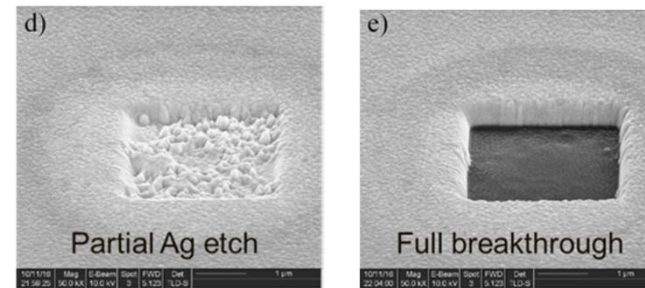


courtesy: K. Toussaint

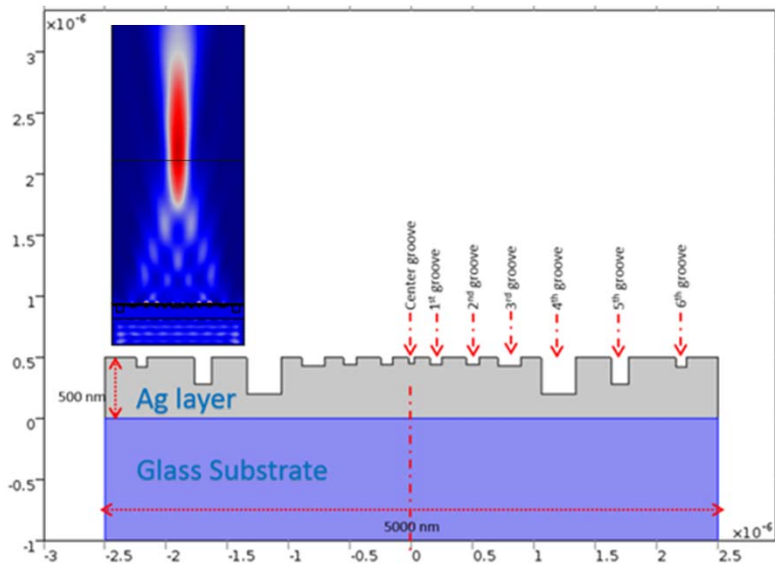


courtesy: K. Jacobs and P. Ferreira

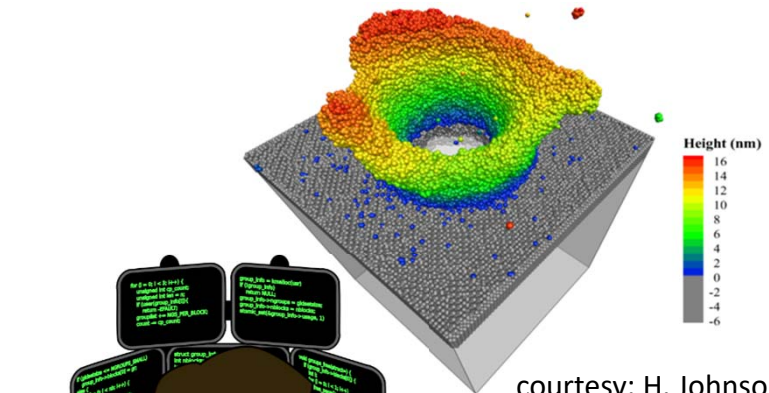
Lowering ion energy: 5keV, 20pA



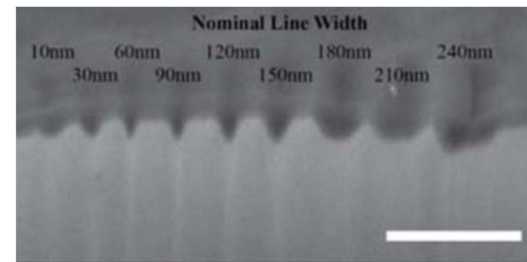
Metasurface flat focusing optic



MD simulation of focused Ga⁺ ion beam



courtesy: H. Johnson and J. Freund





NANOMFG PROCESSES



Directed Assembly

Electrostatic driven
Fluidic alignment

Deposition Processes

Atomic layer deposition
Chemical vapor deposition
Molecular beam epitaxy

Synthesis

Electron-beam evaporation
Plasma spray

Etching Processes

Deep reactive ion etching
Focused ion-beam

Self Assembly

Colloidal crystallization
Langmuir-Blodgett film transfer

Nanopatterning Lithography

Nanoimprint lithography
Electron-beam lithography
Direct laser writing

Printing and Coating

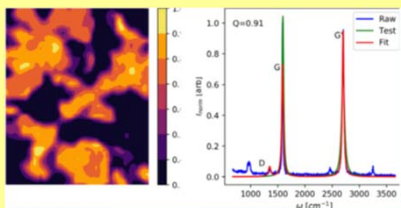
Embossing
Multilayer film process



nanoMFG TOOLS DEVELOPED

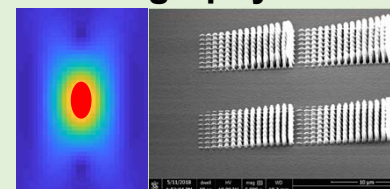


Graphene Raman Fitting Tool



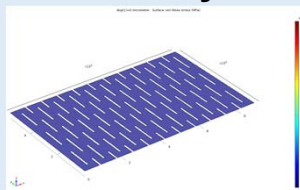
Analyzes Raman spectra from graphene

Two-Photon Lithography Tool



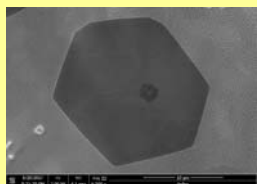
Calculates voxel dimensions for a two-photon lithography process

Kirigami Design and Analysis



Design and mechanical analysis of Kirigami structures

SEM Image Processing Tool



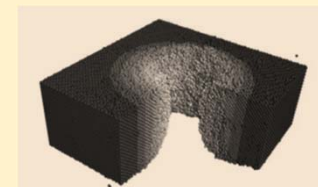
Analysis and feature detection in SEM images of graphene

Your Tool!!



Contact nanoMFG node
<http://nanomfgnode.illinois.edu/>

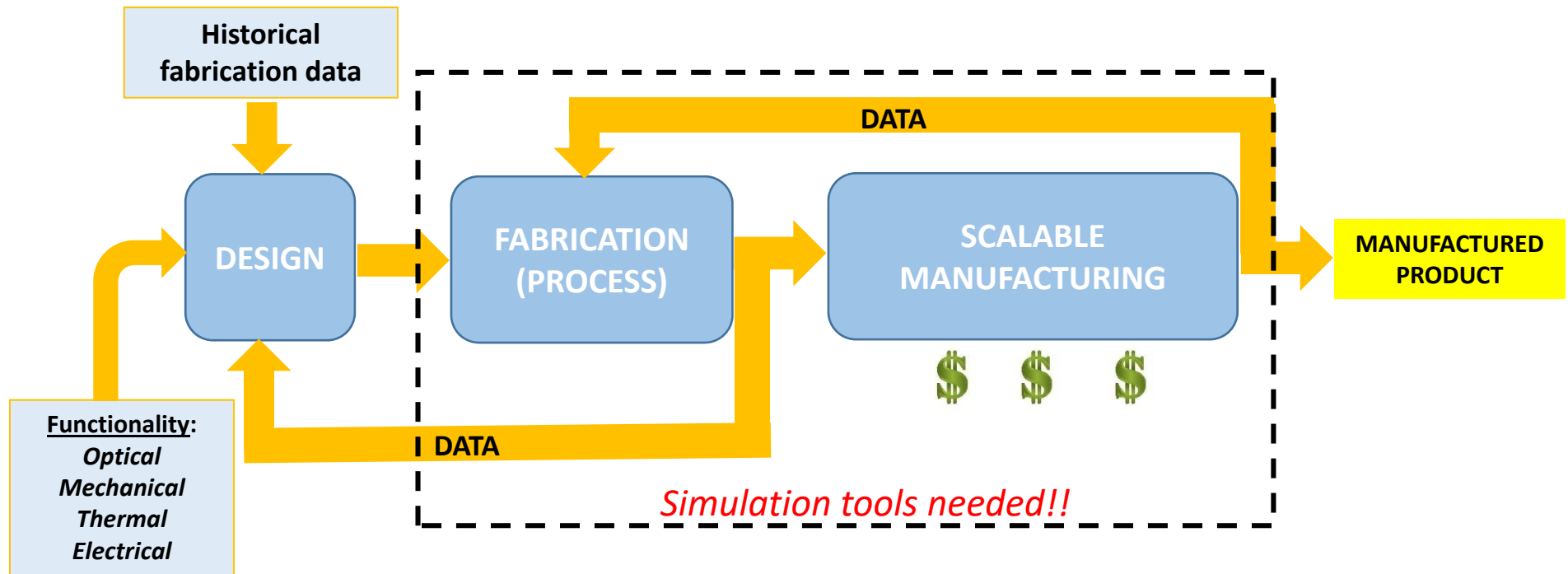
Focused Ion-Beam Tool



3-D molecular dynamics simulation of a Gallium FIB on silicon
Physics of Fluids 27, 052003 (2015)



nanoMFG WORKFLOW



- Data-driven uncertainty quantification will help refine models
- Each tool will be considered for scalability
- Incorporation of feedback is important at all stages

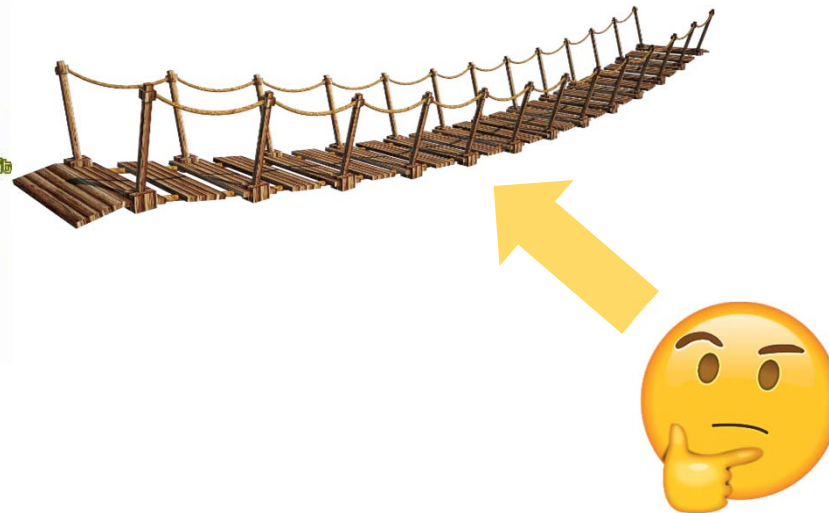
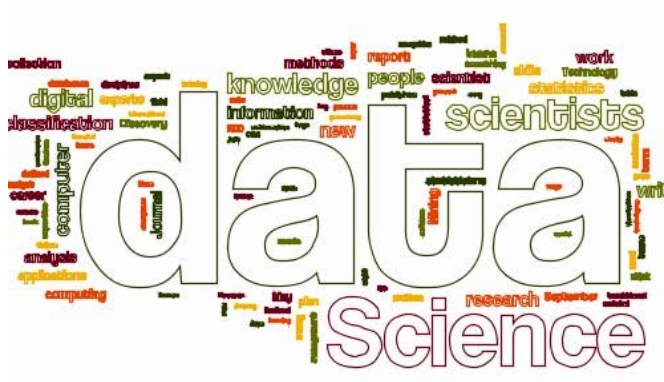


DSEAN WORKSHOP



Nanomanufacturing

Courtesy: K. Toussaint (Illinois)





WORKSHOP GOALS



Incentivized Data/Knowledge Sharing

Accelerate Discovery

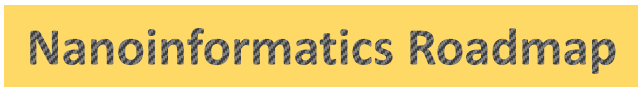
Data Science Tools



Reduce Cost



Data Readiness Level



Data Repositories

Effective Dissemination

Facilitate Collaboration



Reproducibility





WORKSHOP GOALS



NNI Signature Initiative: Nanotechnology Knowledge Infrastructure
May 14, 2012



NSTC COMMITTEE ON TECHNOLOGY
SUBCOMMITTEE ON NANOSCALE SCIENCE, ENGINEERING, AND TECHNOLOGY

Nanotechnology Signature Initiative

*Nanotechnology Knowledge Infrastructure:
Enabling National Leadership in Sustainable Design*

Collaborating Agencies:¹ CPSC, DOD, DOE, EPA, FDA, NASA, NIH, NIOSH, NIST, NSF, OSHA

4 thrust areas:

- 1. A diverse collaborative community of scientists, engineers, and technical staff to support research, development, and applications of nanotechnology to meet national challenges*
- 2. An agile modeling network for multidisciplinary intellectual collaboration that effectively couples experimental basic research, modeling, and applications development*
- 3. A sustainable cyber-toolbox to enable effective application of models and knowledge to nanomaterials design*
- 4. A robust digital nanotechnology data and information infrastructure to support effective data sharing, collaboration, and innovation across disciplines and applications*



WORKSHOP GOALS



- To identify the goals, opportunities, and challenges in applying data science to nanomanufacturing
- To understand the nanomanufacturing data ecosystem
- To identify the available resources for a nanomanufacturing data infrastructure
- Produce a position paper



TODAY'S AGENDA



Khershed Cooper (NSF)

[8:20am] “NSF’s Advanced Manufacturing Program and Research in Nanomanufacturing”



Placid Ferreira (U. Illinois)

[9:00am] “Manufacturing at the Nanoscale: Challenges and Opportunities”



Jianjun Shi (G. Tech)

[9:30am] “Engineering-driven data analytics for in-situ process monitoring of nanomanufacturing”



[10:10am]



Santanu Chaudhuri (UIC)

[10:25am] “Role of Computing and In situ Measurements in Scalable Manufacturing of Nanoscale Materials and Interfaces”



Joel W. Ager III (LBNL & Berkeley)

[11:05am] “Nanomanufacturing with 2D materials informed by machine learning”



Melissa Cragin (U. Illinois)

[11:45am] “Midwest Big Data Hub: Partnerships and projects to advance the data ecosystem”



TODAY'S AGENDA



[12:00pm]

Group Photo!!



shutterstock · 161123954



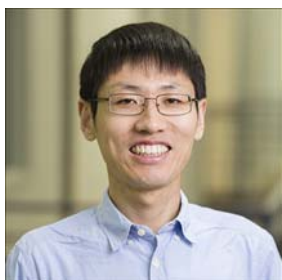
SungWoo Nam (U. Illinois)

[1:30pm] “Mechanically-driven nano-manufacturing of atomically-thin origami and kirigami structures”



Ian Foster (ANL & UChicago)

[2:00pm] “Infrastructure for data-driven discovery: Materials Data Facility and DLHub”



Chenhui Shao (U. Illinois)

[2:55pm] “Discussion (breakout) sessions”

Theme 1



Theme 2

Theme 3





TODAY'S AGENDA



Theme 1: Goals, opportunities, and challenges of DSEAN [Room 1040]



Theme 2: Nanomanufacturing data ecosystem [Room 3000]



Theme 3: Resources and data infrastructure [Room 3100]



TODAY'S AGENDA



Your Badge Labels

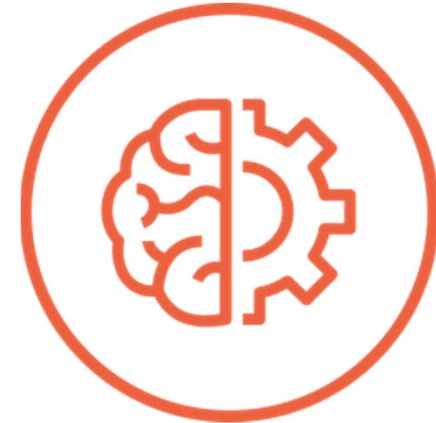
nanoMFG Process



Data Infrastructure



Machine Intelligence





TODAY'S AGENDA



Kimani Toussaint (U. Illinois)

[4:55pm] "Plan for day 2"

Networking Break!!

[5:00pm]



[5:30-7:30pm]

Reception



Poster Session

