

KY Multi-scale Manufacturing and Nano Integration Node (MMNIN)



NNCI Annual Conference
Boston, Mass
Oct, 2019

KY Multiscale - Visiting from our Site



Dr. Kevin Walsh
PI/Director KY MMNIN
Assoc. Dean of Research
[University of Louisville](#)
Walsh@Louisville.edu



Dr. Todd Hastings
Co-PI/Co-Director KY MMNIN
CENSE Director
[University of Kentucky](#)
Todd.Hastings@uky.edu



Ana Sanchez Galiano
KY MMNIN
Ky Multi-Scale Coordinator/
Program Manager
[University of Louisville](#)
Ana.Sanchez@Louisville.edu



Dr. Shamus McNamara
Co-PI KY MMNIN
Prof. of Electrical Engineering
[University of Louisville](#)
Shamus.McNamara@Louisville.edu



Dr. Chuang Qu
KY MMNIN
Post Doctoral Associate
[University of Louisville](#)
Chuang.Qu@Louisville.edu



Curt McKenna
KY MMNIN
Rsrch Engineer (MNTC)
[University of Louisville](#)
Curt.McKenna@Louisville.edu



Dr. Julia Aebersold
KY MMNIN
MNTC Manager
[University of Louisville](#)
Julia.aebersold@Louisville.edu



Dr. Dilan Ratnayake
KY MMNIN
Post Doctoral Associate
[University of Louisville](#)
Dilan.Ratnayake@Louisville.edu

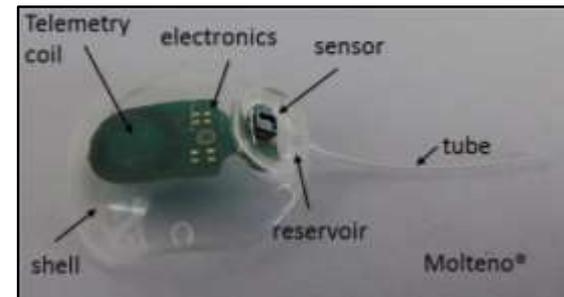
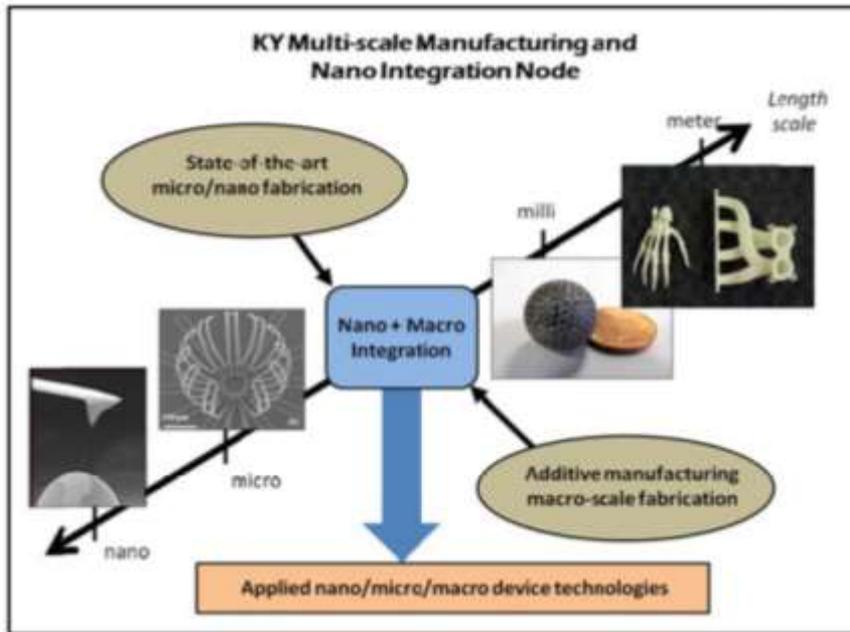


Dr. Jillian Cramer
KY MMNIN
Ky Multi-Scale UK Coordinator
[University of Kentucky](#)
jillian.cramer@uky.edu

KY Multiscale - Overview and Focus

KY MULTISCALE is a **new** NNCI site between UofL and UK that provides users the unique ability to perform research and build prototypes over various lengthscales and in a variety of materials. We offer core facilities and expertise for traditional microfabrication, MEMS technology, nanotechnology, imagining, and characterization, as well as various types of advanced manufacturing processes such as direct write, roll-to-roll, additive manufacturing, 3D printing, aerosol jet printing, fiber-weaving and 2-photon micro-assembly.

Our strength and focus is MULTISCALE MANUFACTURING.



Smart ocular shunt prototype

KY Multiscale – New Staff Additions



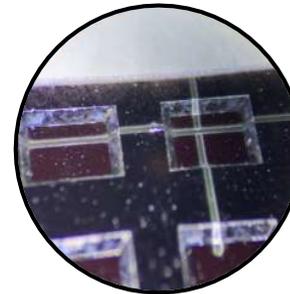
Dr. Jillian Cramer

Masters, University of Oregon
Chemistry (semiconductor processing)
UK KY Multiscale Coordinator
Training, Processing, Educational
Activities, and Outreach

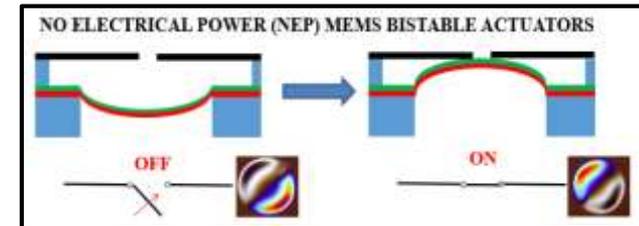


Dr. Dilan Ratnayake

PhD, University of Louisville
Electrical Engineering
UofL KY Multiscale Post Doc
Research, Training,
Educational Workshops



Aerosol Jet Printing

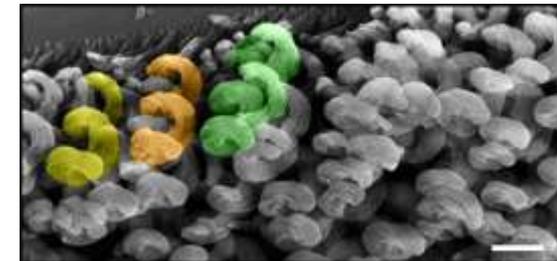


No-power Bistable MEMS Devices



Dr. Chuang Qu ⁴

PhD, University of Missouri S&T
Mechanical Engineering
UofL KY Multiscale Post Doc
Research and Training



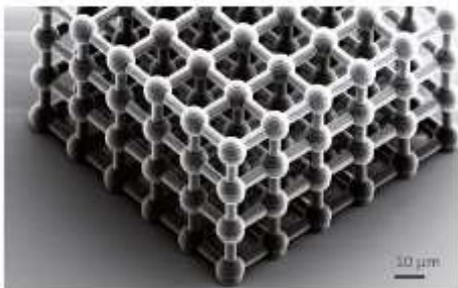
GLancing Angle Deposition (GLAD) Nano-springs

KY Multiscale - New Capability

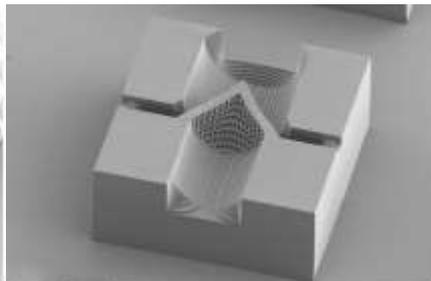


Nanoscribe GT System

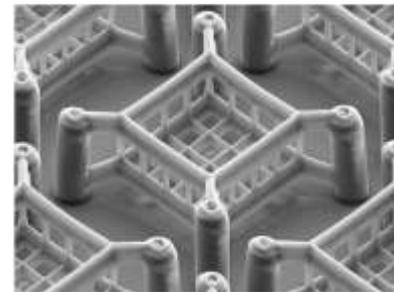
- \$500K acquisition, housed at UK
- Two photon lithography technology
- 3D printing with < 200 nm features
- Convert to functional materials using ALD, CVD, electro- and electroless deposition, or melt infiltration
- Bridges nm-scale electron- and ion-beam induced processes to 10 micron scale aerosol jet printing



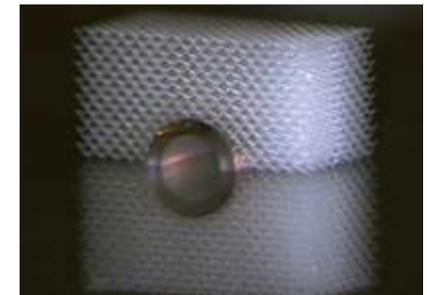
Photonics



Microfluidics



Cell scaffolds

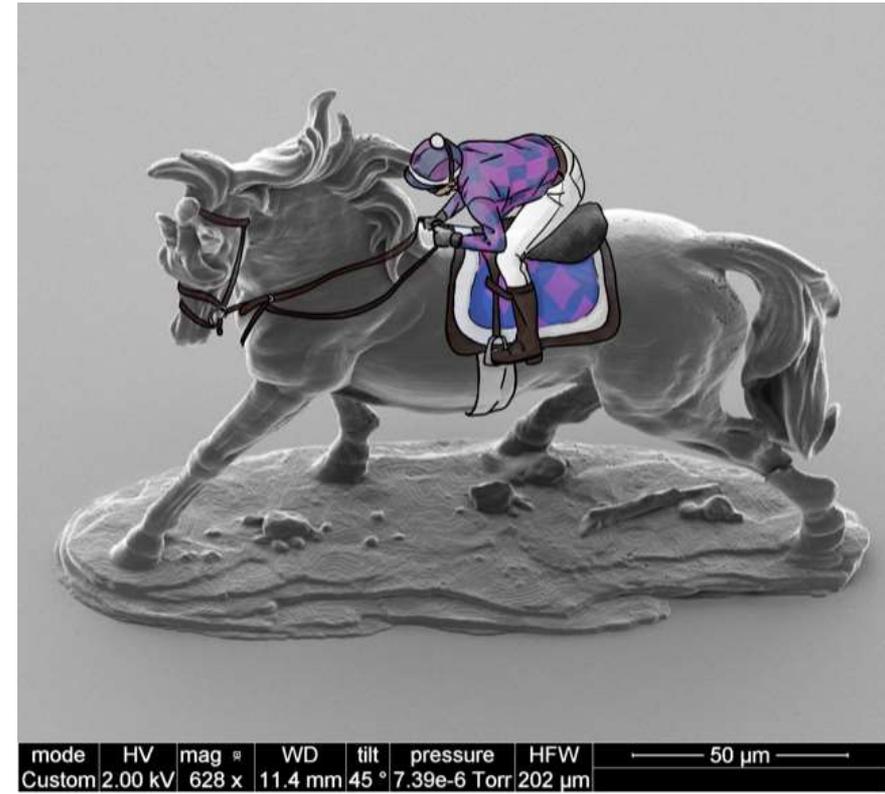


Mechanical metamaterials

KY Multiscale - New Capability



Left samples of this during our visit to Congress

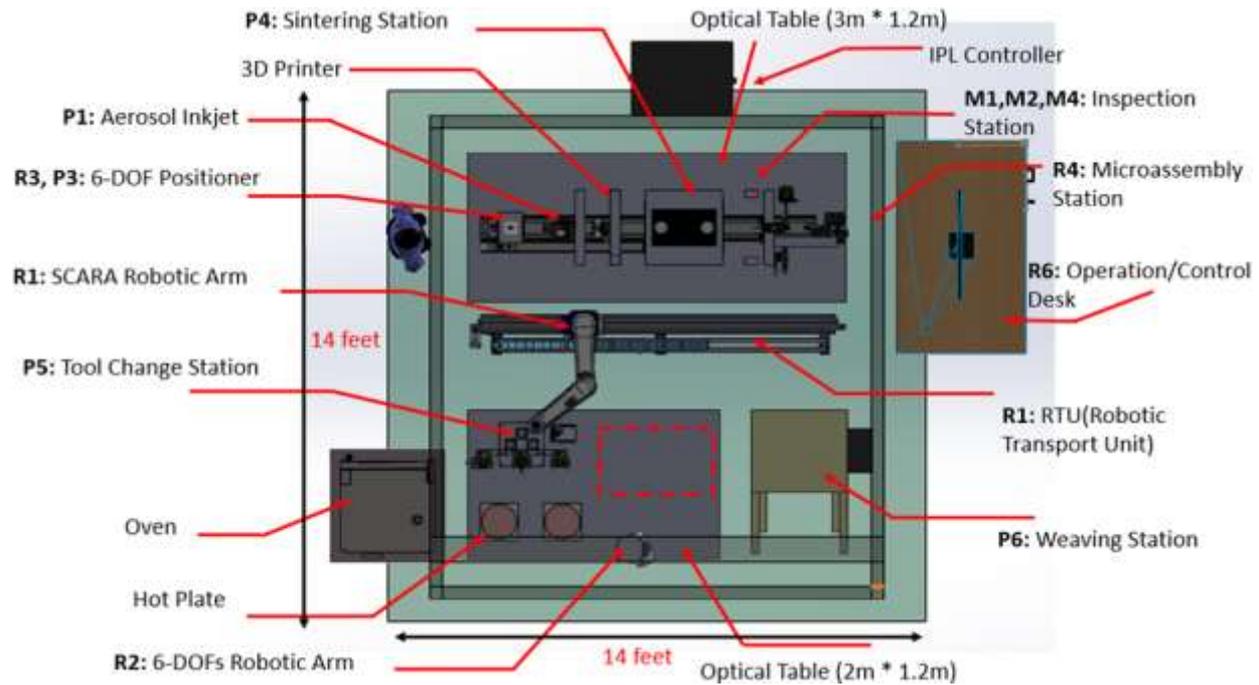
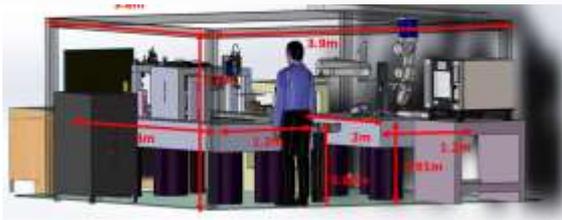
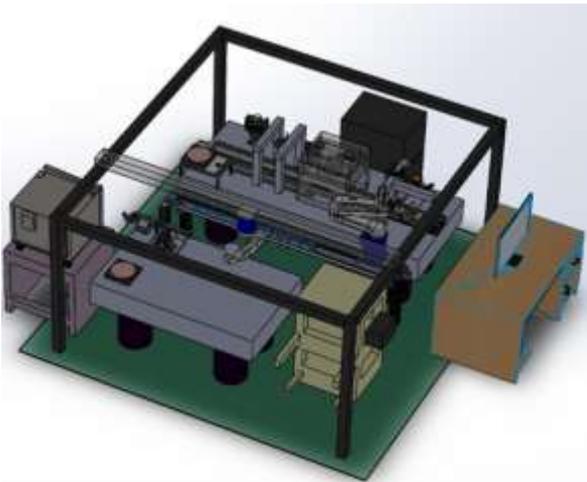


Entered into the NNCI Plenty of Beauty at the Bottom Competition

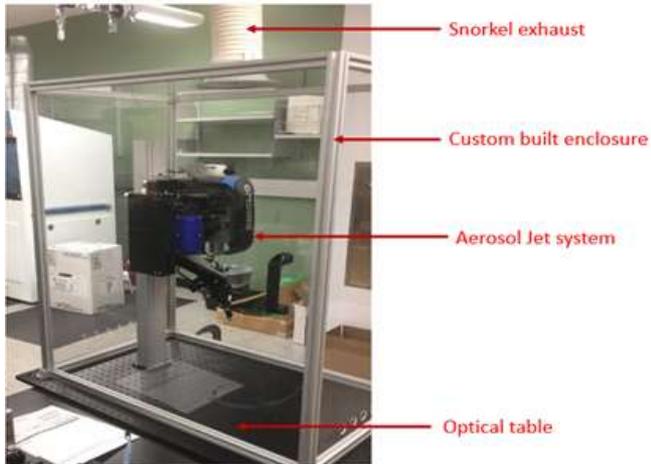
KY Multiscale - New Capability

\$1.5M NSF MRI award - “*Multiscale Additive Manufacturing Instrument with Integrated 3D Printing and Robotic Assembly*” by Prof. Dan Popa (ECE), et al.

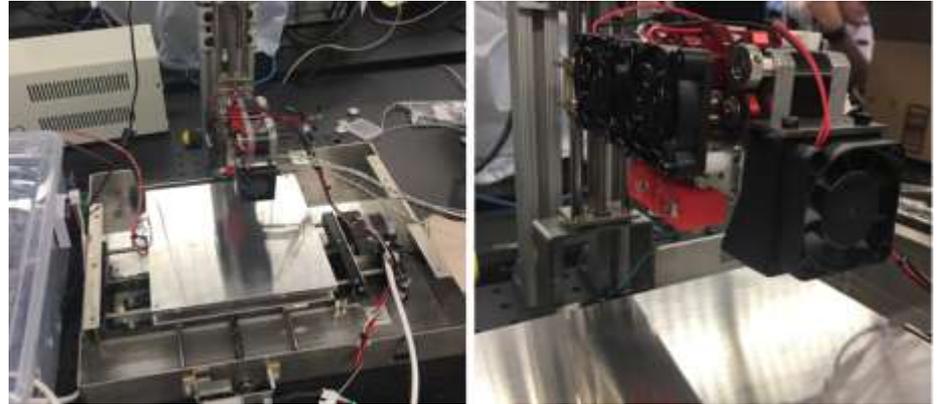
Combines 3D printing, aerosol jet printing, inkjet printing, auger dispensing, fiber weaving, intense pulse light annealing, pick and place, and optical/electrical inspection in a single automated system (NEXUS). Housed in the KY Multiscale core facilities.



KY Multiscale - New Capability



Optomec Aerosol Jet Printing Station



Fused Deposition Module (FDM) Printing Station



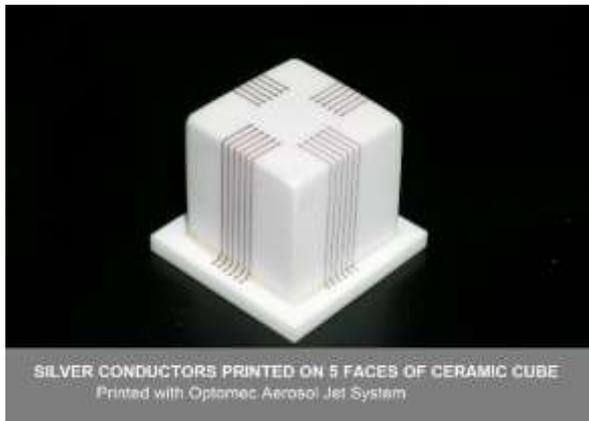
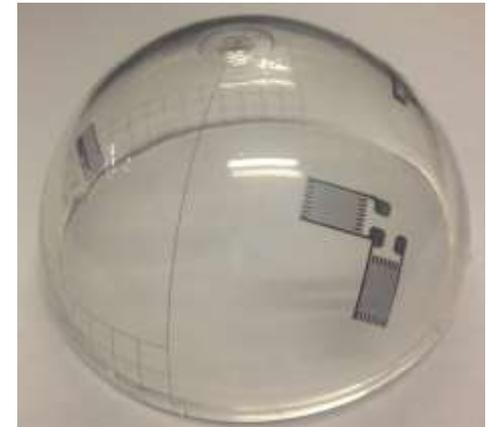
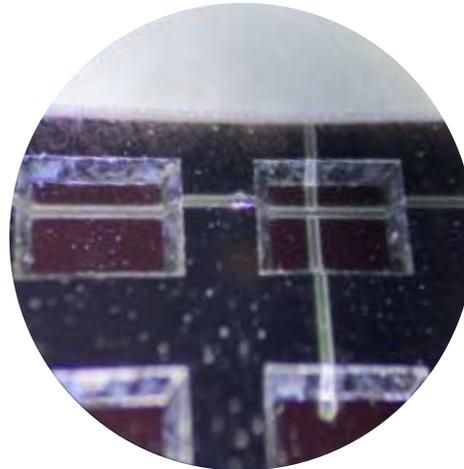
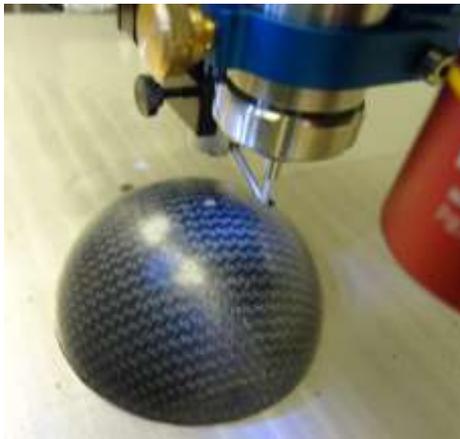
**Intense Pulse
Light (IPL)
Curing Station**



Fiber Loom Station (fiber weaving)

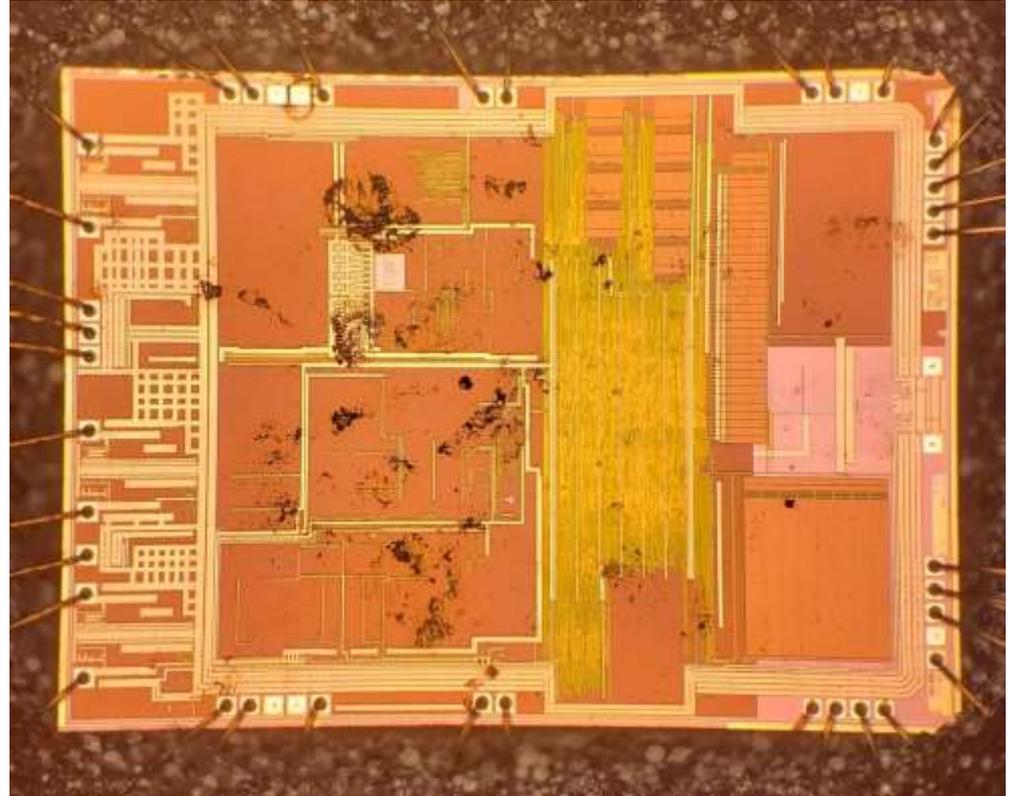
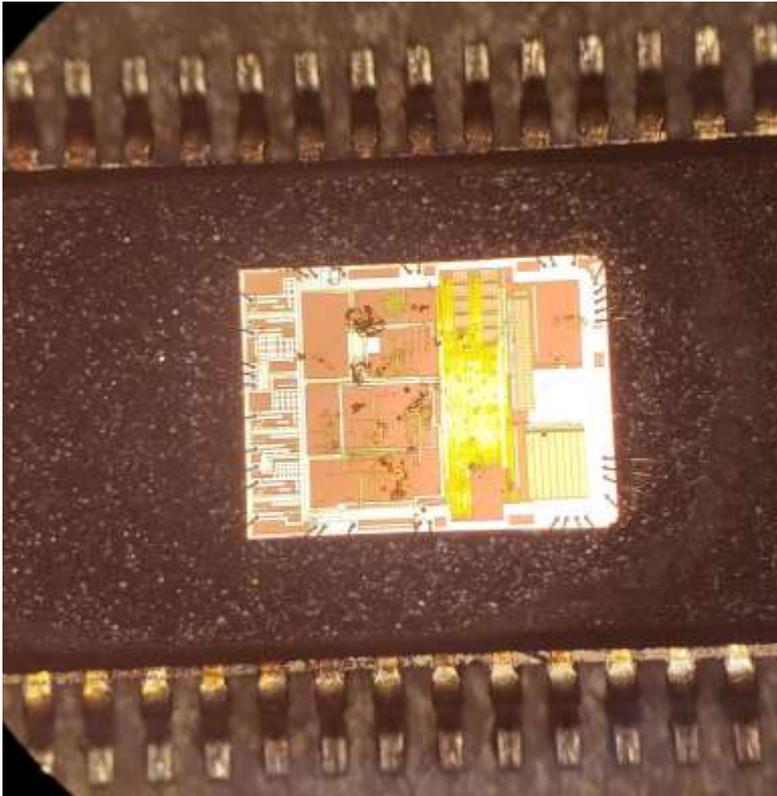
KY Multiscale - New Capability

Optomec Aerosol Jet Printing Station – ability to print conductors, insulators, and semiconductors on non-planar surfaces. Minimum resolution of 10 microns.



KY Multiscale - New Capability

IC Package Decapsulation

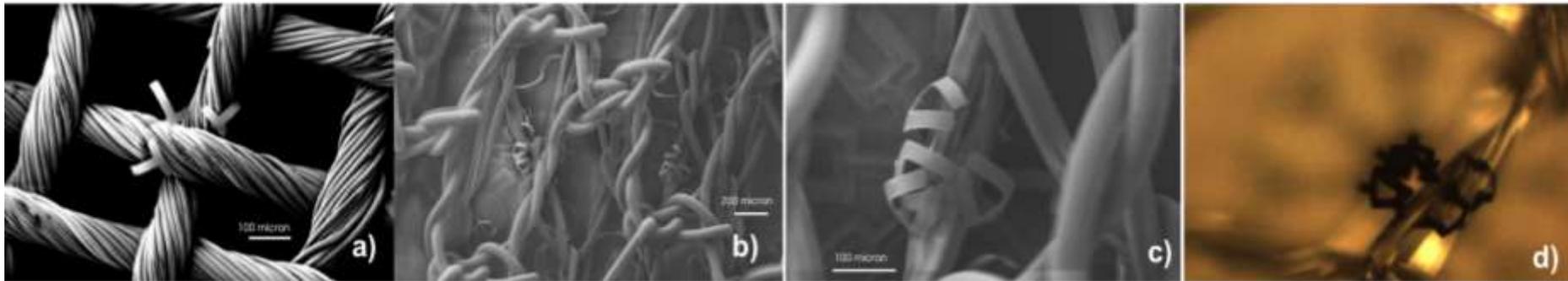
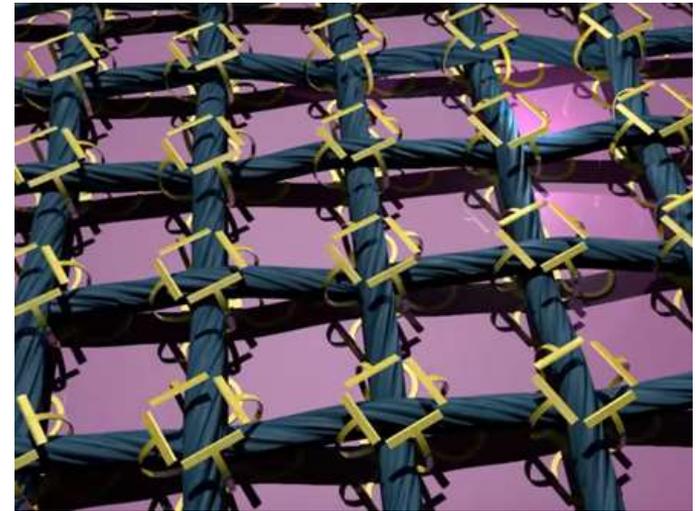


KY Multiscale - Research

Transferring MEMS Devices to Breathable Fabric Carriers with Strain-Engineered Grippers

NSF REU student (URM female student accepted directly into the PhD Program at Wash U St Louis)

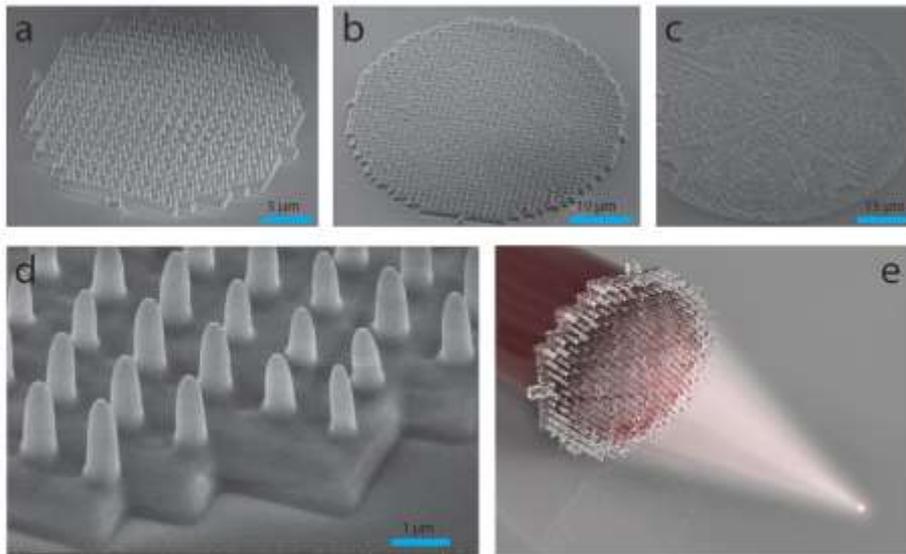
Sushmita Challa, Canisha Ternival, Shafquatul Islam, Jasmin Beharic, and Prof. Cindy Harnett (ECE)



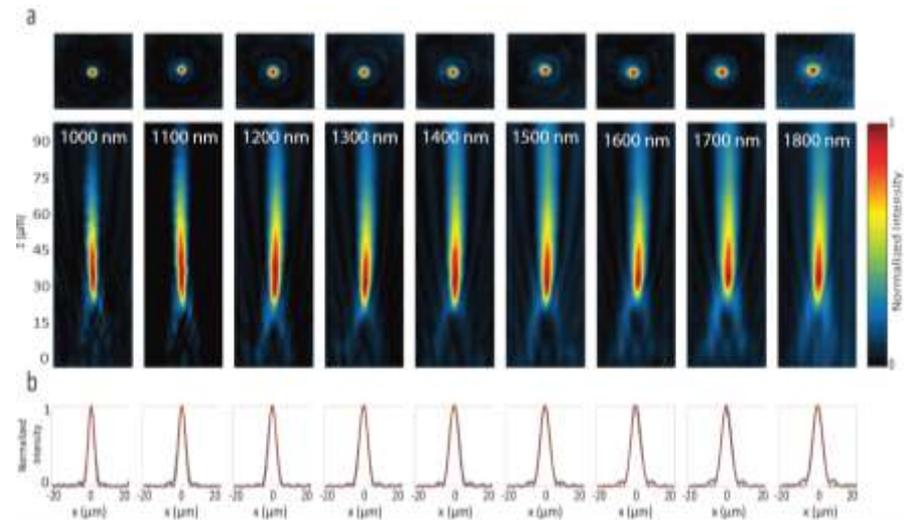
MRS Advances, February 2019, 1–8. <https://doi.org/10.1557/adv.2019.6>.

KY Multiscale - Research

Hybrid Achromatic Metalens (HAML)



HAMLs: phase plate + metalens →
quasi-flat, achromatic lens



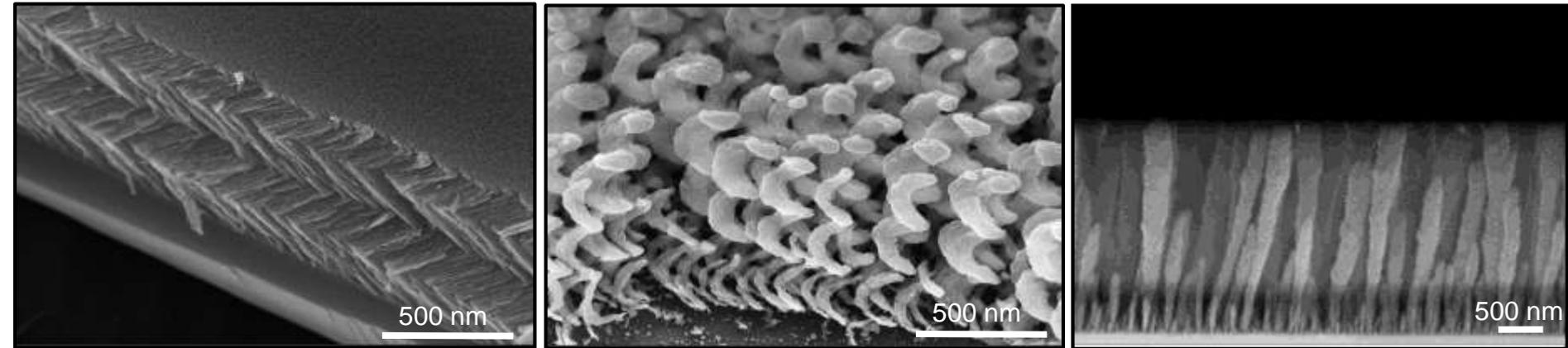
Near infrared HAMLs from KY Multiscale:
highest focusing efficiency and broadest
diffraction limited bandwidth reported to date

F. Balli, M. Sultan, S. Lami, and J. T. Hastings, submitted, preprint at <https://arxiv.org/abs/1909.07941>.

Research supported by Intel Corporation.

KY Multiscale - Research

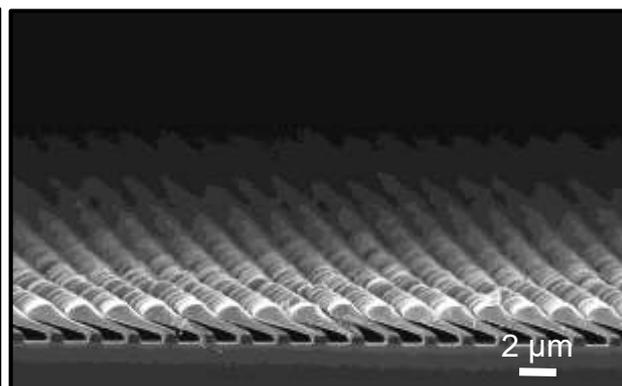
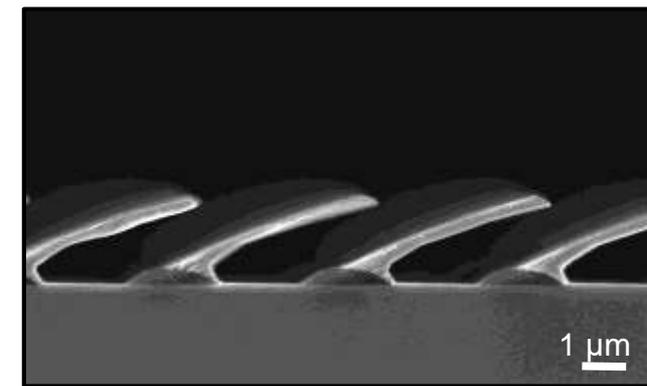
Enabling Technology - Nano 3D Structures by GLAD



By Dr. Chuang Qu (integration engineer)

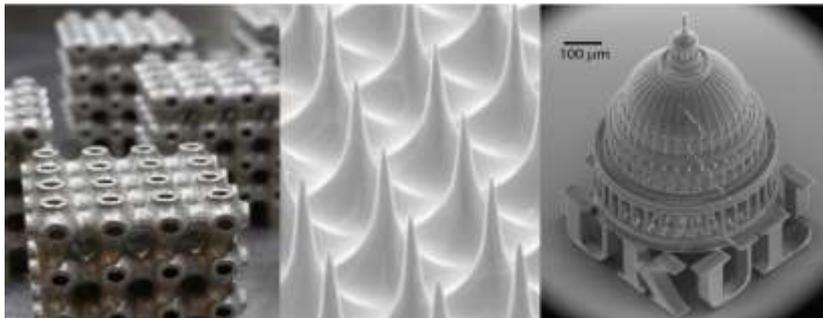
Proposed Applications

- Optical coatings
- Chiral filters
- Photonic crystals
- LCDs
- Mechanical and electrical sensors
- Catalysis
- Energy
- Microfluidics
- Packaging



KY Multiscale – Education and Outreach

2018 and 2019 KY Nano+AM Symposia



Survey Results (~50 respondents)

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Need for this Symposium	60%	40%			
Was High Quality	36%	50%	11%	3%	
Well Organized	63%	35%	2%		
Likely to recommend	60%	30%	10%		

- **Micro/nano plus Additive Manufacturing theme**
- **Annual event starting in 2018**
- **2019 – 4 National Keynote Speakers, 54 Technical Talks, 23 Posters, and 2 Expert Panel Sessions**
- **Over 150 attendees each year**
- **Mayor, University President and Invited Keynote Speakers**
- **Advisory Board Breakout Session**

KY Multiscale - Impact

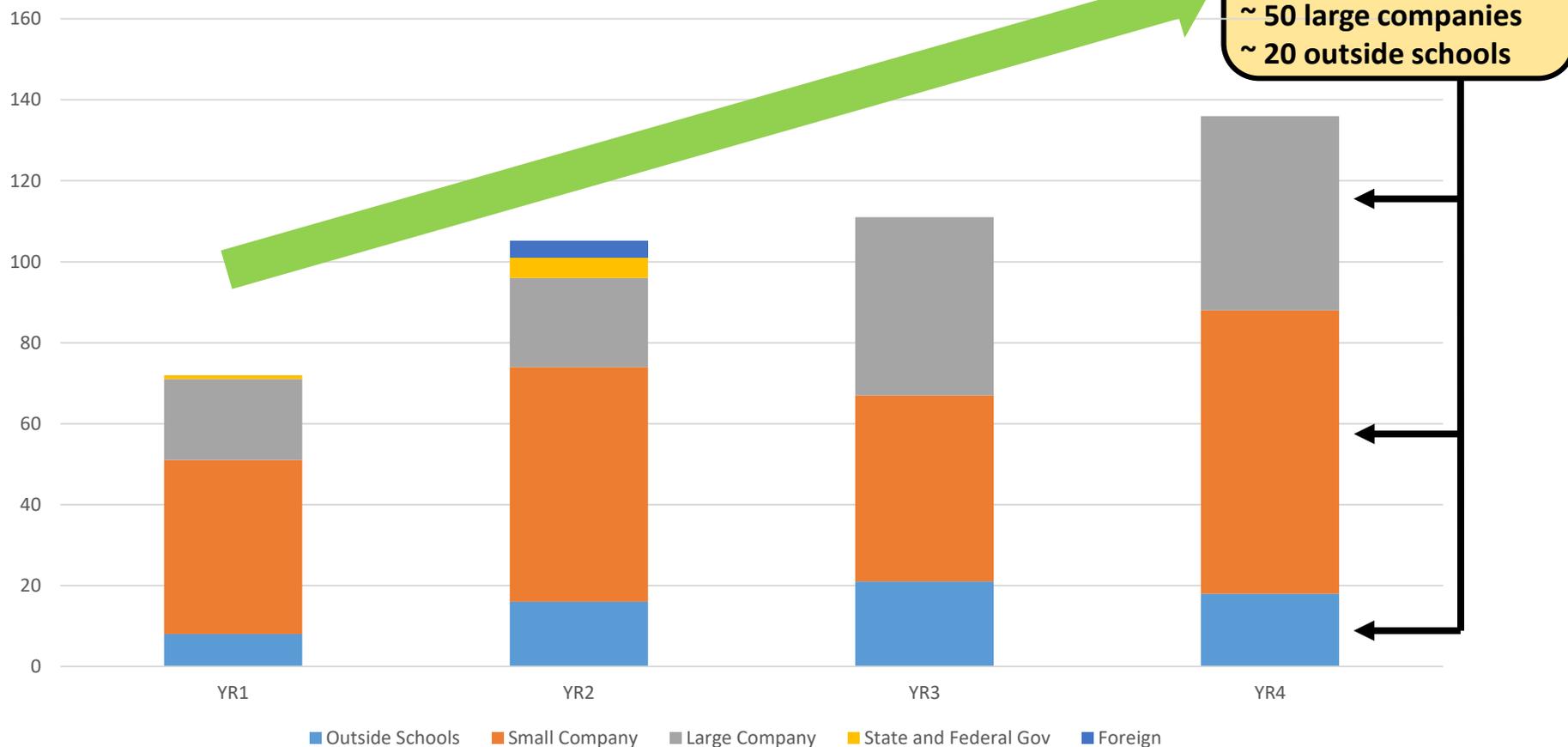
USER FEES – INTERNAL VS EXTERNAL



Positive impact that the NSF NNCI has had on our site!

KY Multiscale - Impact

Increase of External Users



KY Multiscale - Impact

New KY Multiscale Faculty and Staff Hires

Name	University	Department	Research Area
Dr. Kevin Chou	University of Louisville	Industrial Engineering	3D Printing and Additive Manufacturing
Dr. Martha E. Grady	University of Kentucky	Mechanical Engineering	Thin Film Mechanics for biological and biomedical applications
Dr. Keng Hsu	University of Louisville	Mechanical Engineering	Physics-based advanced Manuf.
Dr. Lee Thompson	University of Louisville	Chemistry	Materials for energy systems, including heterogeneous catalysts and photoactive materials.
Dr. Ishan Thakkar	University of Kentucky	Electrical & Computer Eng.	On-chip photonics for network-memory communications and phase change memory systems.
Dr. Ahmad Salehi	University of Kentucky	Electrical & Computer Eng.	DNA computing and hardware cyber security.
Dr. Rudolf Buchheit	University of Kentucky	Engineering, Dean's Office	Materials sciences
Dr. Bikram Bhatia	University of Louisville	Mechanical Engineering	Advanced manufacturing; pyroelectric research
Dr. Himanshu Thalpliyal	University of Kentucky	Electrical & Computer Eng.	Hardware assisted cybersecurity, circuits for quantum computing, magnetic nanocomputing circuits, smart health and IoT
Dr. Kenneth Graham	University of Kentucky	Chemistry	Solar energy, interface science, organic electronics, and thermoelectrics

KY Multiscale - Impact

New KY Multiscale Faculty and Staff Hires

Name	University	Department	Research Area
Dr. Paul Rottman	University of Kentucky	Materials Science & Engineering	MSE, additive manufacturing of metals
Dr. Edward Wang	University of Kentucky	Electrical and Computer Engineering	Machine learning for smart manufacturing
Dr. Bill Gannon	University of Kentucky	Physics	Quantum and low-dimensional magnetism
Dr. Dan Popa	University of Louisville	Electrical & Computer Eng.	Micro/Nano Sensors and Robotics
Dr. Sundar Atre	University of Louisville	Mechanical Engineering	3D Printing and development of new materials.
Dr. Michael Johnson	University of Kentucky	Electrical & Computer Eng.	Biomedical sensors
Michael Martin	University of Louisville	Micro Nano Technology Center	MEMS, microfabrication & micromilling.
Dr. Chuang Qu	University of Louisville	Electrical & Computer Eng.	Nanomanufacturing, Additive Manuf., and heat transfer.
Dr. Dilan Ratnayake	University of Louisville	Electrical & Computer Eng.	MEMS, semiconductor microfabrication, and microelectronics.
Jillian Cramer	University of Kentucky	CeNSE and EMC, UK Eng.	Semiconductor and Photovoltaic device processing.

KY Multiscale – Network Activities

Report from the NNCI New Equipment and Research Subcommittee

NNCI Equipment Acquisitions During Time Period 2 (YRS 3&4)

KY Multiscale – Network Activities

COMMITTEE MEMBERS

- Kevin Walsh (KY MMNIN/Louisville) - Chair
- Jacob Jones (RTNN/NCSU)
- Yu-Hwa Lo (UCSD)
- Mark Allen (Penn)
- Stephen Campbell (Minn)
- David Dickensheets (Mont State)
- Karl Bohringer (Wash)
- Vinayak Dravid (NW)
- Oliver Brand (CO)

KY Multiscale – Network Activities

METHOD

- Sent equipment survey to all 16 sites
- All 16 sites responded (100% participation!)
- Survey consisted of an Excel Template
- Data from Period 1 (Yrs 1&2 of NNCI award) were provided to minimize duplicate entries
- Respondents were asked to list all new equipment acquisitions for Period 2 (Yrs 3&4 of NNCI award)
- Various categories were provided
 - Cost and Description
 - Fab/Processing vs Metrology/Testing
 - Types of funding Sources
- Data were compiled and graphs/tables were created
- Prof Yu-Hwa Lo (SDNI) performed further analysis

KY Multiscale – Network Activities

**To be continued during
the Panel Discussion...**

END

