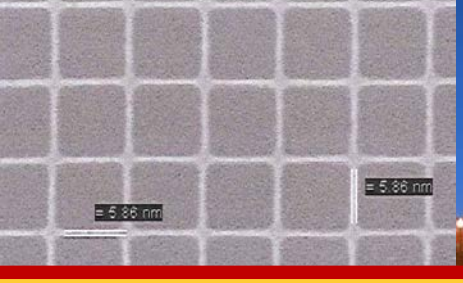




Minnesota Nano Center

NDSU Packaging Center

UNIVERSITY OF MINNESOTA
Driven to Discover℠

NDSU NORTH DAKOTA STATE UNIVERSITY

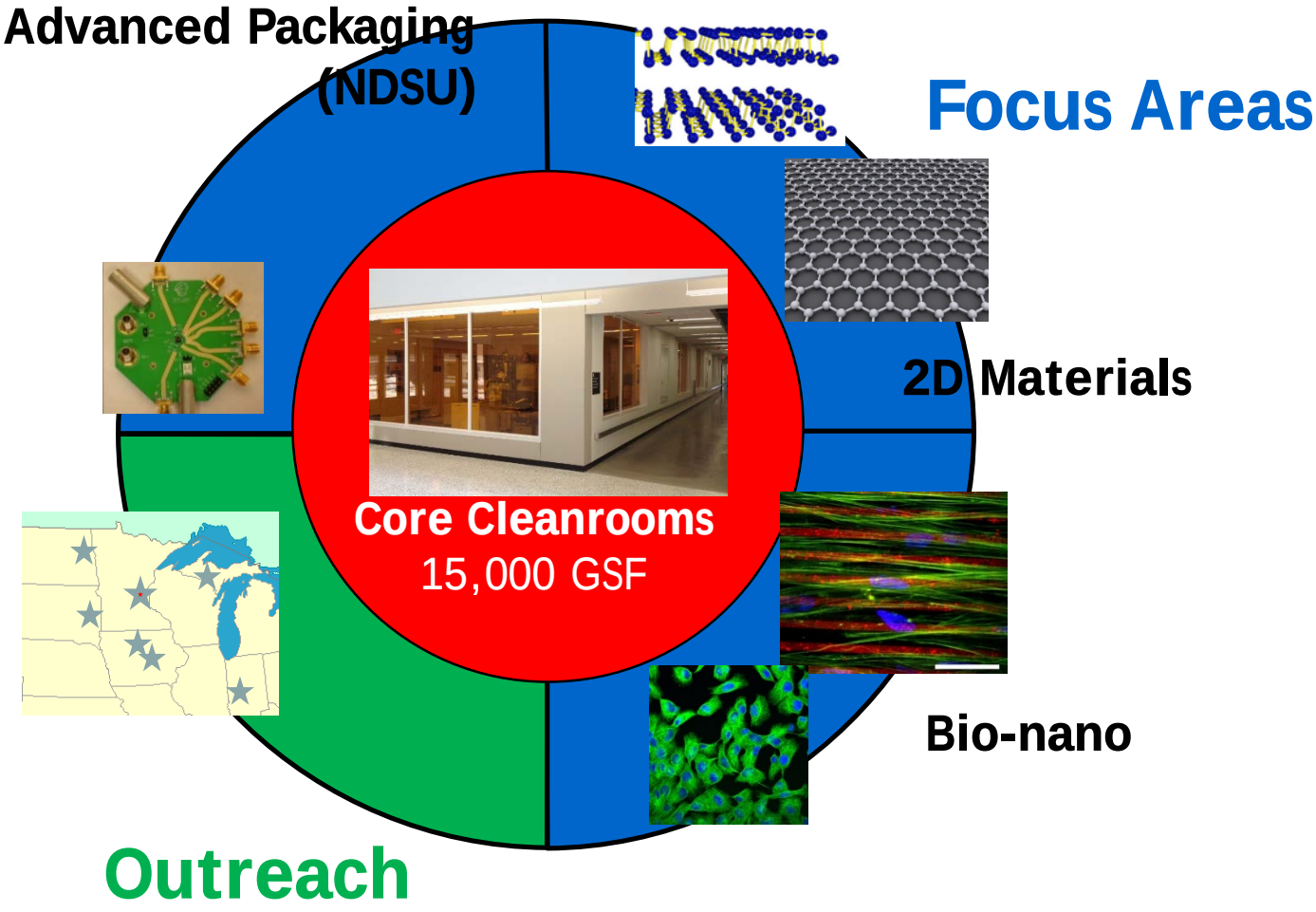
Midwest Nano Infrastructure Corridor

Steve Campbell, Greg Cibuzar, Jim Marti

University of Minnesota

September 13, 2018

Site Overview



National Nanotechnology Coordinated Infrastructure

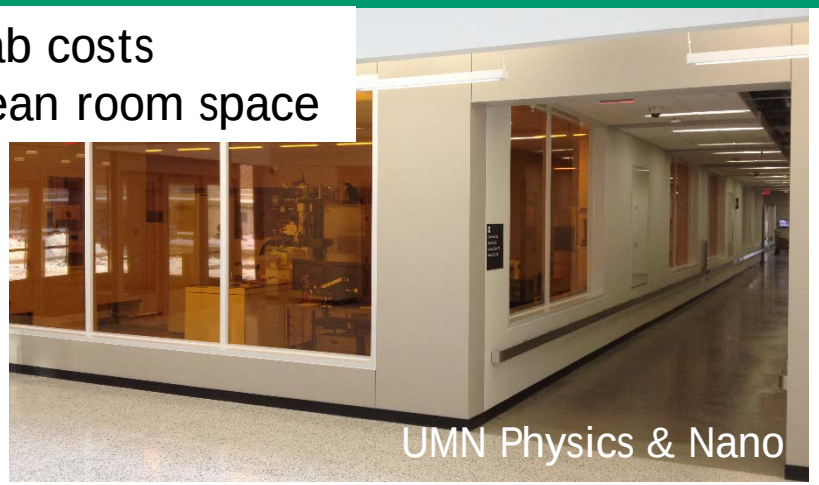
NSF

MiNiC

Minnesota Cleanroom Facilities

~40 M$ lab costs
15,000 GSF of clean room space


UMN Keller Hall


UMN Physics & Nano

6-nm e-beam lithography

i-line stepper

Direct write/mask maker (2)

Nanoimprint system

Three contact printers

High resolution FESEM

Ion mill

Deep silicon etcher

HDP-RIE system

Four RIE systems

Vapor etch system

PECVD and HDP-PECVD

Thermal ALD and PE-ALD

Three sputtering systems

Three evaporators

Three LPCVD tubes

Five tube furnaces

Rapid thermal system

Wafer scale AFMs (2), film thickness and stress systems

Conventional and confocal microscopes, SEM/EDX

Saws, bonders, etc.

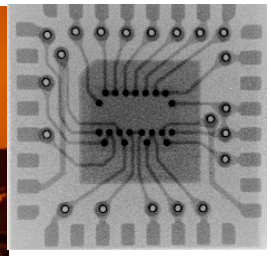
National Nanotechnology Coordinated Infrastructure

Advanced Packaging Capability Overview

Wafer Level Back End Processes

Die Bonders, Wirebonders, Dicing Saw, etc.

Environmental Testing



X-Ray Inspection System

Scanning Acoustic Microscope

National Nanotechnology Coordinated Infrastructure

NSF

MiNiC

MINIC User Data

Yearly User Data Comparison			
	Year 1	**Year 2**	**Year 3 (6 months)**
Total Users	384	415	314
Internal Users	271	275	232
External Users	113 (29%)	140 (34%)	82 (26%)
External Academic	60	62	32
External Industry	52	52	36
External Government	1	0	0
External Foreign	0	26	14
Total Hours	27,002	26,495	11,668
Internal Hours	20495	19,733	9,535
External Hours	6,507 (24%)	6,762 (26%)	2,133 (18%)
Average Monthly Users	156	156	160
Average Ext. Monthly Users	26 (17%)	33 (21%)	30 (19%)
New Users Trained	151	150	81
New External Users Trained	57 (38%)	59 (39%)	17 (21%)

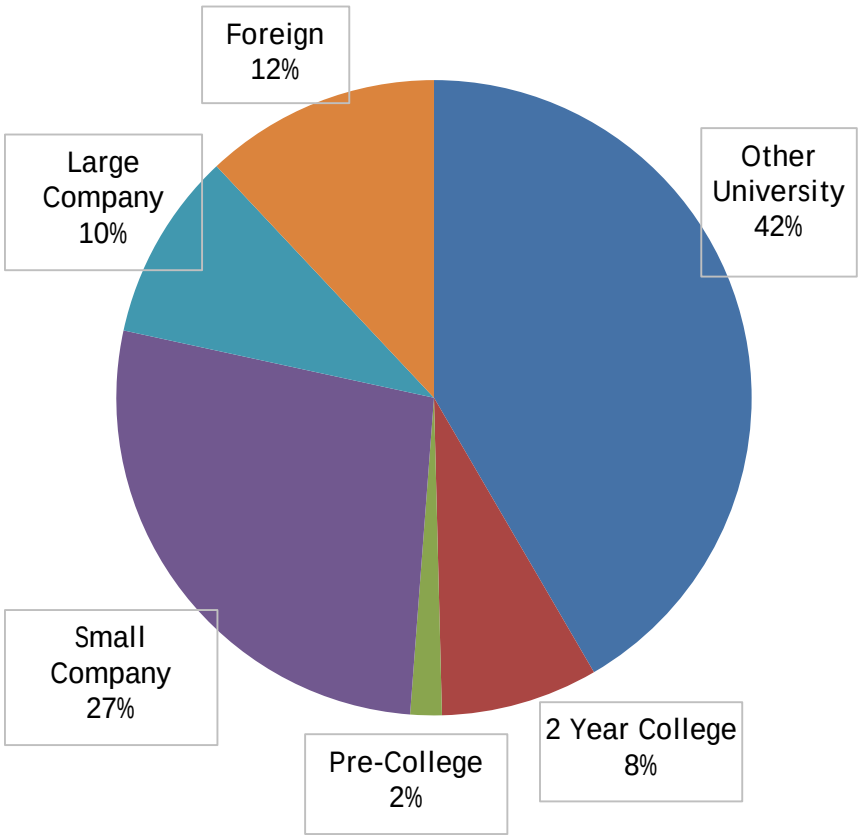
National Nanotechnology Coordinated Infrastructure

NSF

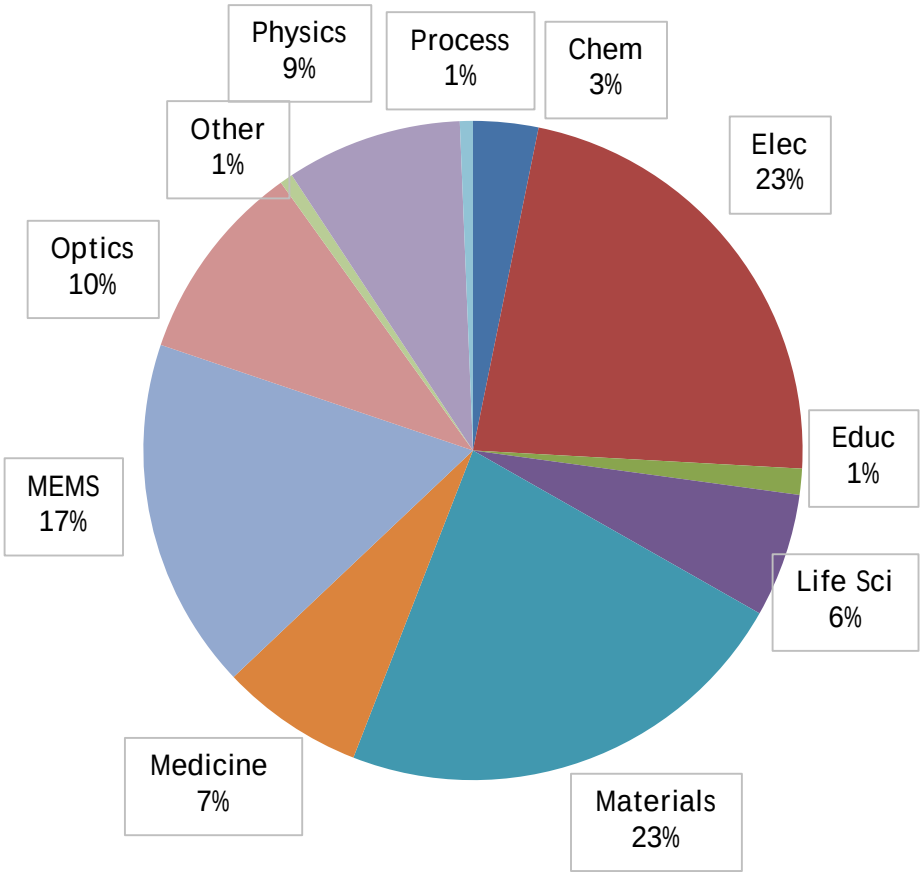
MiNiC

MINIC User Data

External User Affiliations



All User Disciplines

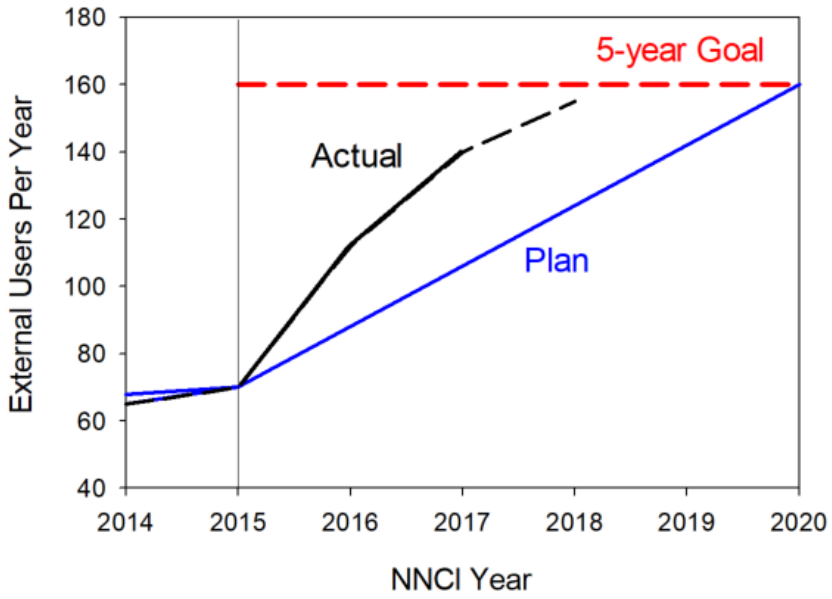


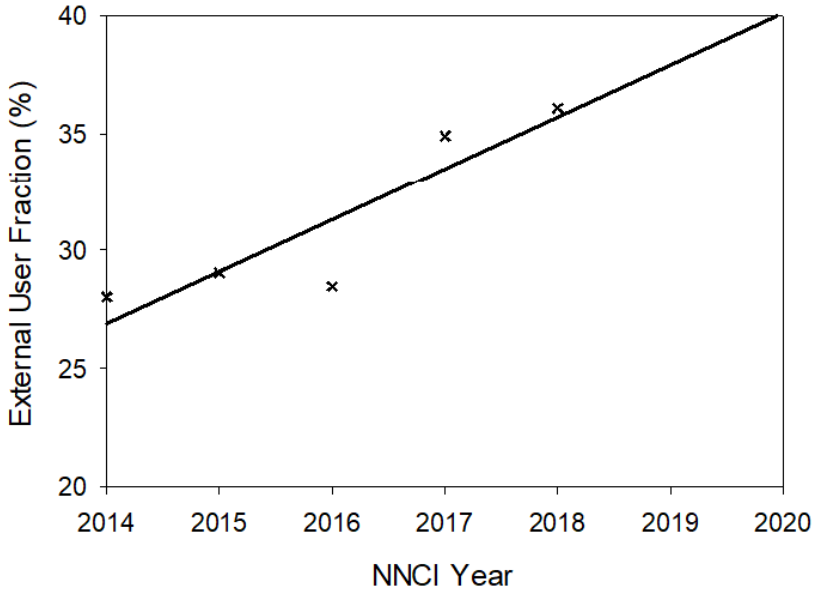
National Nanotechnology Coordinated Infrastructure

NSF

MiNiC

External User Site Data (through 30 months)





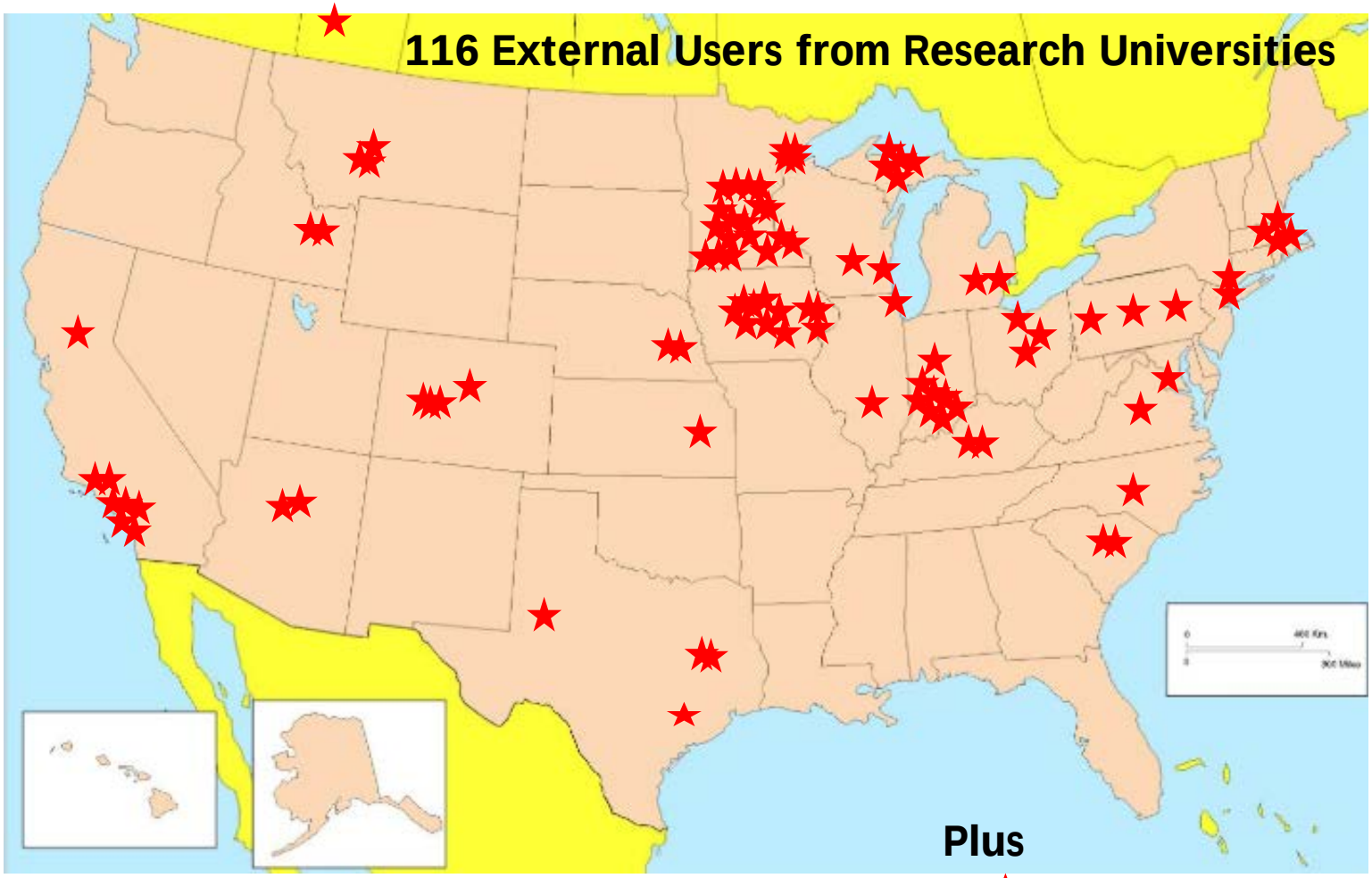
- Aggressive recruiting has dramatically increased external user count
- Expect to achieve close to 40% external usage

National Nanotechnology Coordinated Infrastructure

NSF

MiNiC

MINIC External Academic User Origin (To Date)



National Nanotechnology Coordinated Infrastructure

NSF

MiNiC

2018 Cleanroom Capability Upgrades

Brought up 2D (TMDC) deposition in cleanroom

National Nanotechnology Coordinated Infrastructure

NSF

MiNiC

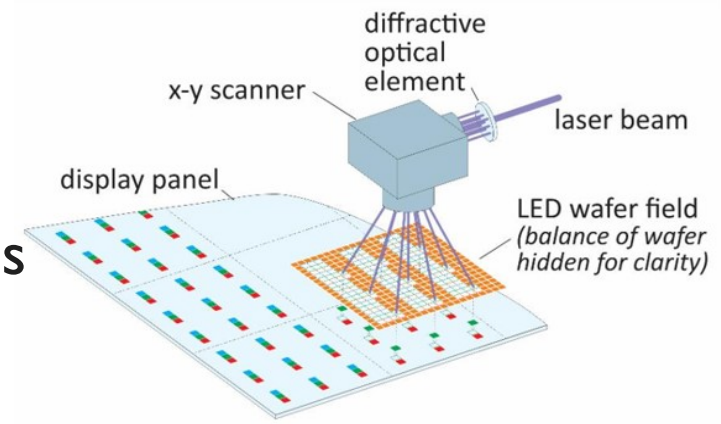
External User Highlights: Company One

Content Redacted

Advanced Packaging External Activity Highlights

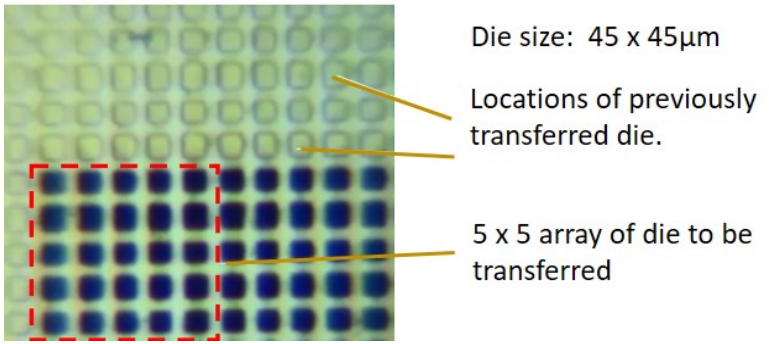
Uniqarta Inc.

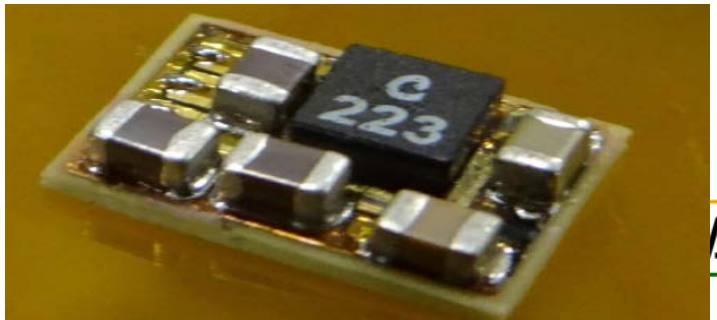
- Develops innovative package manufacturing technology for placing small, ultra-thin die onto substrates.
- Developing technology to place millions of die for micro-LED based displays.
- New SBIR awarded December 2017.



CrossFire Technologies

- First joint UMN/NDSU user
- High density interconnect technology
- Recently hired part-time staff member in Fargo to work with NDSU





Uniqarta Technology for Laser Based Die Transfer

Impact of Education & Outreach Activities

Summary of E&O programs presented by Minnesota Nano Center and North Dakota State University, with examples.

K-12 Programs	**358**	**25%**
Intro to Nano hands-on class		
Intro to Photolithography class		
Facility and cleanroom tours		
Programs for Grads/Faculty/Professionals	**162**	**11%**
Nanomedicine Short Course		
2-D Materials Short Course		
Outreach to K-12 Teachers	**350**	**24%**
MN Conference on Science Education		
General Public Events	**321**	**22%**
NanoDay at Science Museum of MN		
Public open houses		
Iron Range Science and Eng. Festival		
Industry Outreach	**268**	**18%**
Site visits, facility open houses		
Invited talk at medical device conference		
Conference exhibitors		
Total MINIC	**1459**	

Activities which were evaluated in 2018 are in green.

Assessment Data

MINIC is increasing E&O program evaluation.

2018 Nano hands-on classes:

N = 51	No	Slightly	Moderately	A lot
Increased my knowledge of nano	2%	2%	27%	69%
Increased my interest in science & engineering	4%	35%	35%	25%
Helped me understand how nano relates to real world	0%	6%	39%	55%
Increased my interest in studying STEM in college	10%	10%	45%	35%

2018 Grad Short Courses

N = 35	Strong Disagree	Disagree	Neutral	Agree	Strong Agree
Interesting material			6%	43%	51%
Would recommend			3%	33%	64%
Expand time				43%	57%

NNCI Cooperative Network Activities

Network-Wide

- Three attendees at NSF for reverse site visit and at NNCI conference
- Steve Campbell led the Metrics subgroup.
- James Marti was the chair of the network-wide working group on K-12 Teachers and RET programs, expanded last year to include programs for K-12 students and community outreach
- Tony Whipple is on the safety subcommittee.
- James Marti participated in Nano Day activities, offering Science Museum visitors close up views of micro devices and microfabrication.

Multi-Site

- James Marti worked with counterparts (NCI-SW, SENIC, MINIC, KY MMNIN, NNF) to submit a grant proposal for a multi-site Research Experience for Teachers
- Greg Cibuzar consults with multiple nodes on the suitability of the lab operating software i-Lab, for NNCI node operation, and on upgrades to the Badger software.
- Tony Whipple participated in DRIE upgrade telecom for the NNCI Etch Group meeting

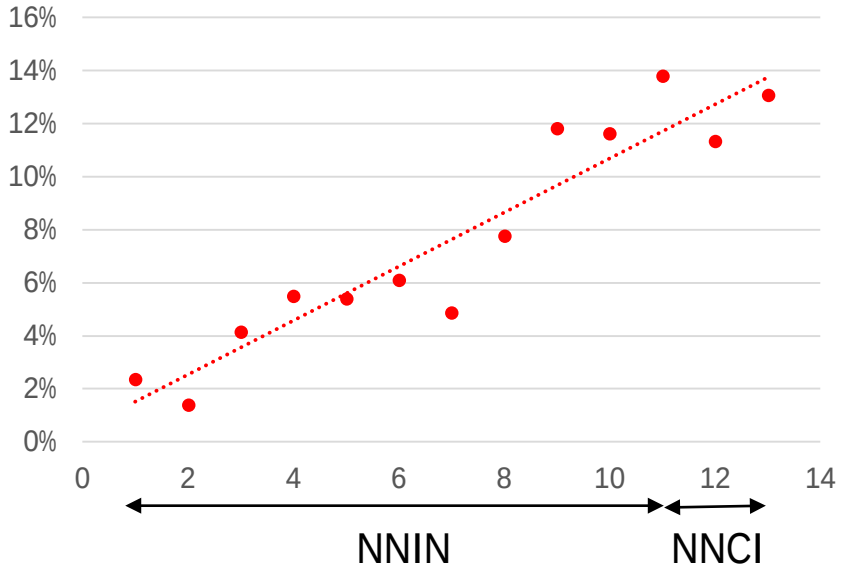
National Nanotechnology Coordinated Infrastructure

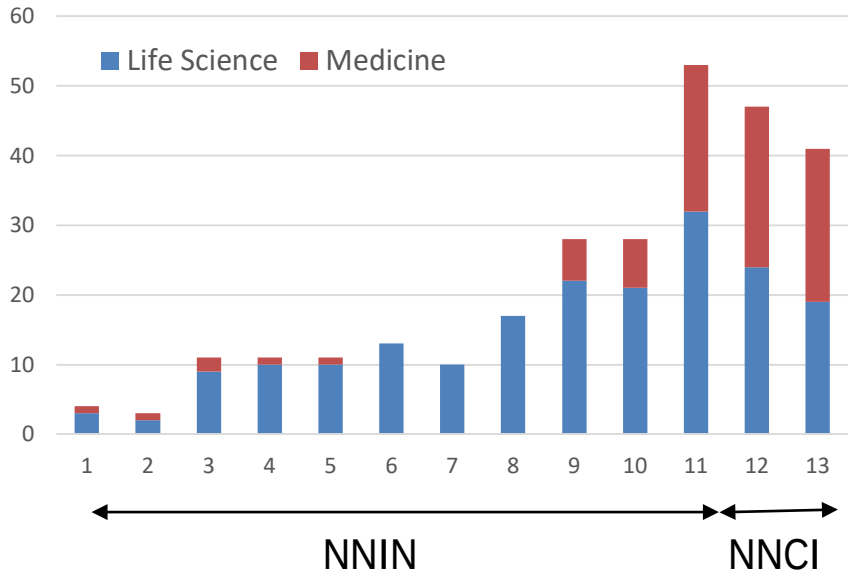
NSF

MiNiC

Panel Discussion Topic: Research Directions

- Bionano Users (Life Sciences and Medicine)





- Many come from traditional disciplines, but work with researchers from non traditional disciplines
- Nucleating cooperation; creating direct usage

National Nanotechnology Coordinated Infrastructure

NSF

MiNiC

Summary

- MINIC has exceptional capabilities, and is having a real impact, especially in the upper Midwest
- External usage is close to the 5-year goal after three years
  - We expect to continue growing and improving
- E+O activities are having an impact. E+O evaluation is expanding as regular feedback is routinely obtained
- MINIC sees continued growth in bio / lifesciences and more recently in medicine

National Nanotechnology Coordinated Infrastructure

NSF

MiNiC