Texas Nanofabrication facility (TNF) Annual Report 2018

Sanjay K. Banerjee- Site Director

Dr. Sarmita Majumder- Site Coordinator

Prof. Lee Ann Kahlor- SEI Director

S.V. Sreenivasan- co-PI, NASCENT Director

R.Manthiram- co-PI, TMI Director

- ***Focus Areas/ Capabilities***
- ***User statistics***
- ***Impact and Network Activities***
- ***Education/ Outreach (Majumder)***
- ***SEI (Kahlor)***
- ***Plans***
- ***Advisory Board Additions*** *(Profs. Donna Nelson (Oklahoma); Rick Wise (Arkansas))*

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TNF User Data

Yearly User Data Comparison			
	Year 1	**Year 2**	**Year 3 (6 months)**
Total Users	653	696	442
Internal Users	500	529	334
External Users	153 (23%)	167 (24%)	108 (24%)
External Academic	46	55	19
External Industry	103	107	85
External Government	0	0	0
External Foreign	4	5	4
Total Hours	67,570	70,756	29,345
Internal Hours	53,485	45,951	21,006
External Hours	14084 (21%)	24,805 (35%)	8339 (28%)
Average Monthly Users	243	271	247
Average Ext. Monthly Users	45 (18%)	50 (18%)	55 (22%)
New Users Trained	99	97	42
New External Users Trained	48 (48%)	48 (49%)	16 (38%)

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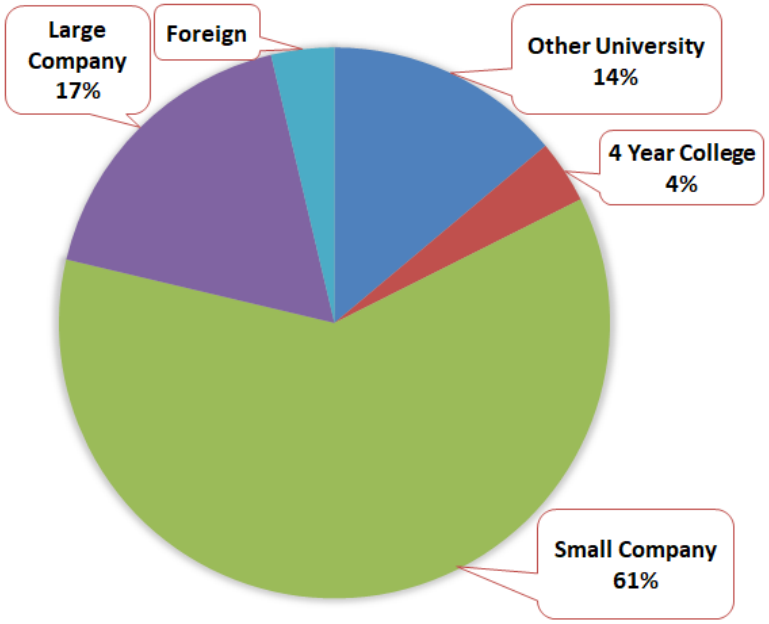
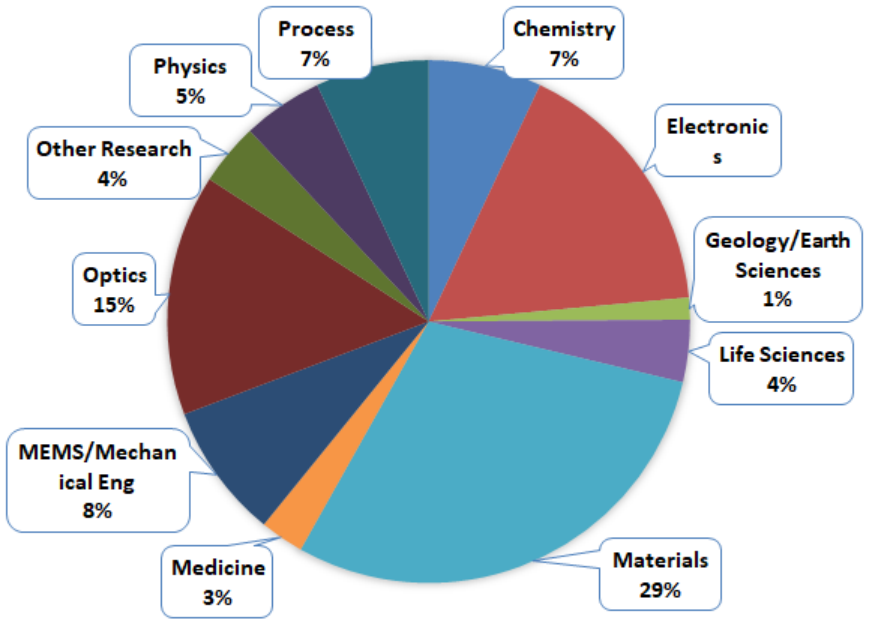
TNF User Data

External User Affiliations



All User Disciplines



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Key Capabilities Updates

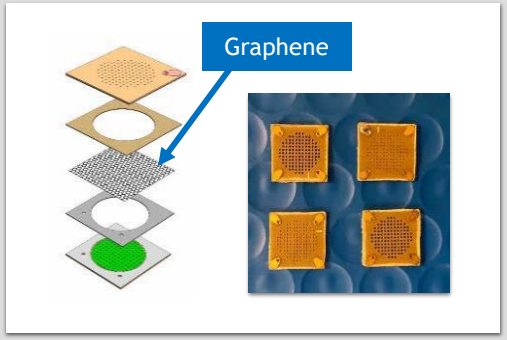
- **NSF MRI: Acquisition of a Small Angle X-ray Scattering Instrument with *In Situ* Capabilities.**
  - Installed in the new Engineering Education and Research Center on Sept. 2017
  - Managed and maintained by TMI
- **Raith e-beam lithography**
  - To handle load on Zeiss
  - $800k from UT to support TNF; delivered Feb. 2018.
- **Rigaku X-ray Diffraction System ($350k)**
  - Funded by UT to support TNF; delivered Aug. 2017
- **Upgrades of the cleanroom by UT**
  - Kurt Lesker evaporator ($290k)
  - Maskless litho system from Rave ($180k)

External Small Company User: GraphAudio

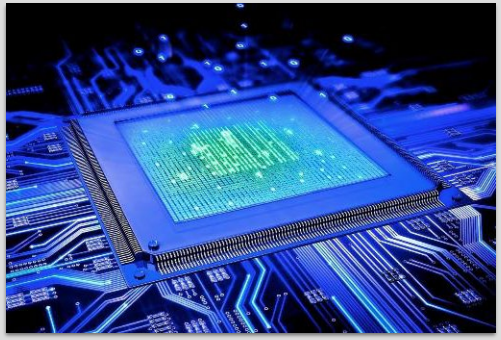
(Burt Fowler, Harry Chou, Yuanjun Fan, Jeff Maag, Mike Olla, Mike Klasco and Lorance Wilson)

Vision: Create an acoustic product platform of **Graphene** micro transducers, proprietary electronics and contextually aware voice operation software

Mission: Become the global leader in acoustic sensing, micro-speakers and microphones in mobile, consumer and enterprise electronics



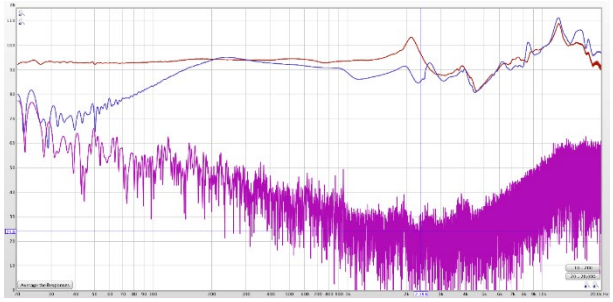
Transducers



Integrated Circuits

Software

- UC Berkeley (LBNL) technology commercialized in UT - Austin (MRC)
- Why Austin Team?
  - MRC cost effective development site with significant talent base
  - 2D synthesis work complementary and additive to UC Berkeley technology
    - First two engineering hires - UT Austin PhDs
- SPL: Graphene has significant low frequency improvement
- Fabricated and tested by TNF MRC team
- Team now translating results to robust and manufacturable process



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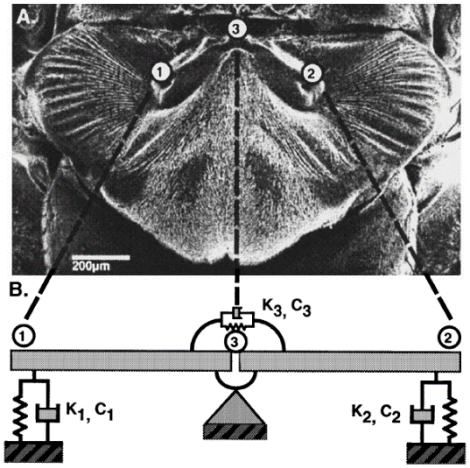
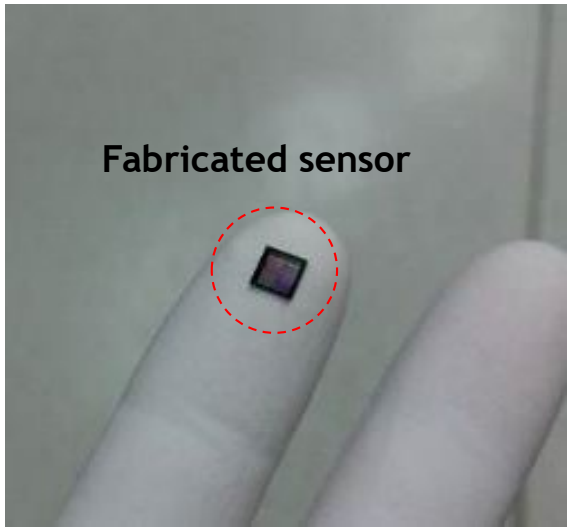
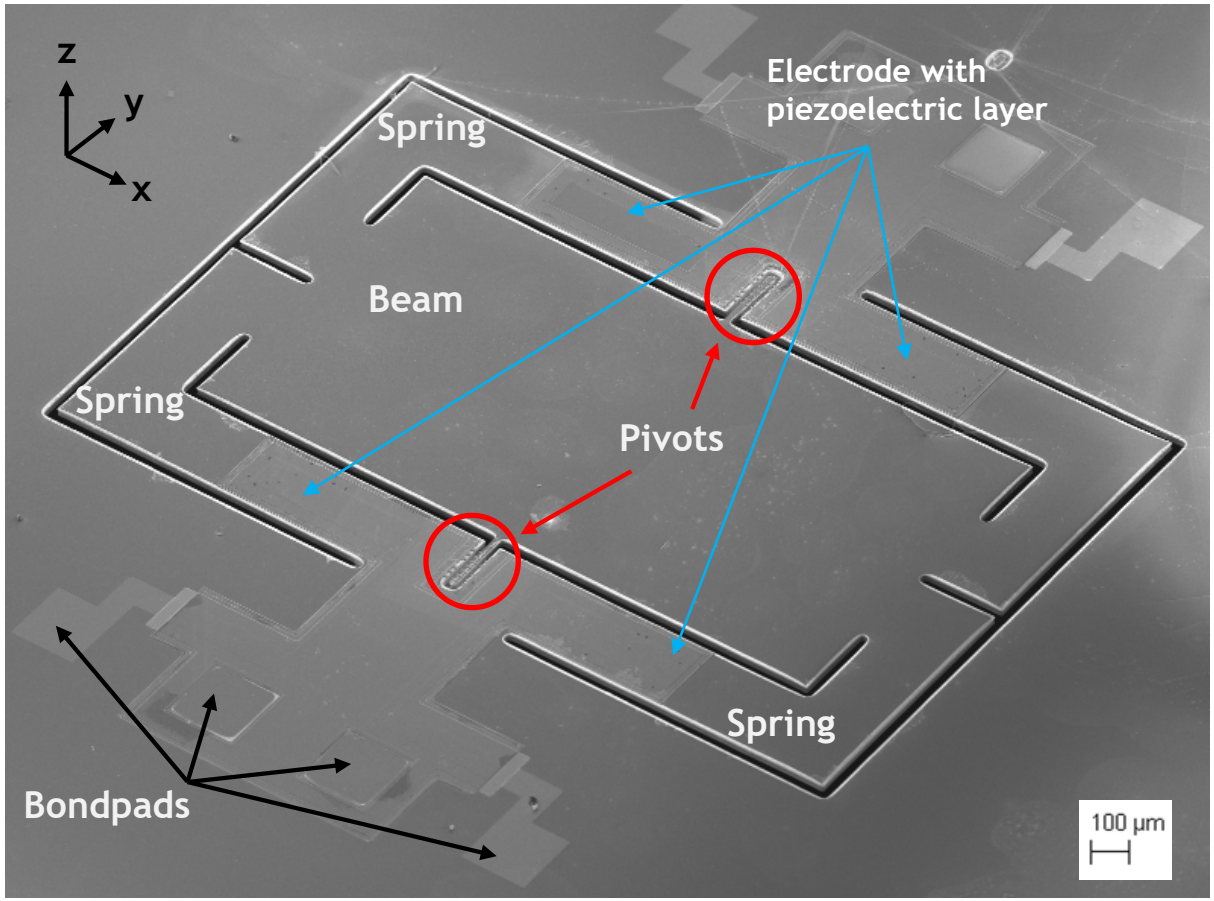
Academic/Small Company User: Silicon Audio
(Prof. Neal Hall)



Hearing mechanism of fly





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Education and Outreach Activity

- **Distinguished lectures for TNF users (10 in 2017-2018)**
  - MRC distinguished lecture series
    e.g. Jeffrey Bokor Professor, University of California at Berkeley
    Fabrication of Transistors Using Bottom-up Synthesized Graphene Nanoribbon Channels
- **Tours (**to various K-gray groups during the year)

- **On-Line Classes for industry certificate program**
  - Banerjee taught modules on Nanoelectronic devices and memory with NASCENT- TNF

- **TNF hosted NNCI Research Experience for undergraduates (REU) program (June 4th to Aug 5th ,2018)**

- **TNF Technical Workshops: one day lecture and tool demo**
  - Nanotechnology workshop at TMI, Nov 15th 2017

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Impact of Education & Outreach Activities

Pre-Evaluation of the Education and Outreach Activities

- Designing my own research
- Working as a member of a research team
- Presenting results of my data
- Writing scientific reports
- Preparing a scientific poster
- Managing my time
- Problem solving in the lab

Additional post-Evaluation of the Education and Outreach Activities

- I feel like a scientist
- I am a networker
- I anticipate problems
- Graduate school is a goal for me

Participants in the REU (NASCENT, NNCI, and MRSEC) summer 2018

The activities highlighted green are evaluated:

Activity	Visitors
Lectures/seminer	155
Lab Tour & workshop	60
Job fair	30
Annual Review	35
K-12 activities	20
Summer Research program (REU)	10

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Undergrad Internship program

Undergraduate Technical Support:

Employees Name & Title	Function
Kaustav Lahiri Lab Technical Assistant I	To help our senior lab engineers troubleshooting the tool inside and outside cleanroom
Ryan C. Cole Lab Technical Assistant I	To help our senior lab engineers troubleshooting the tool inside and outside cleanroom
Megan Renshaw Lab Technical Assistant I	Training tools (Acid and solvent hood, Furnaces, Metrology tools)
Brandon Pham Lab Technical Assistant I	Training tools (Acid and solvent hood, Furnaces, Metrology tools)
Anjali Sridharan Lab Technical Assistant I	Training tools (RIE and ICP Etching and atomic layer deposition tools)
Ahir Chatterjee Lab Technical Assistant I	Training tools (Acid and solvent hood, Furnaces, Metrology tools)

- 6 hourly UT undergraduates
- Paid with cleanroom usage fee
- Participate in the Equipment Training effort (400 unique users/ year at MRC)

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NNCI Cooperative Network Activities

Network-Wide

- NNCI *Metrics* Subcommittee (S. Banerjee)
- NNCI *REU* Working group (M. Palard/S.Majumder)
- NNCI *Equipment Maintenance* Working group (J. James)

Multi-Site

- ALD technical workshop organized by Stanford (2017)
- Participated in the REU convocation at Georgia Tech (Aug 2017)
- ASU –TNF Electron-Beam Lithography JEOL troubleshooting.

On Behalf of the Network

- Hosted Japanese NIMS student in collaboration with Cornell.

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The latest evaluation of the SEI module

- In April 2018, Kahlor's team piloted a revised training module as part of the required MRC user training program.
- The pilot module is embedded in an online survey that allows pre- and post-training data collection.
- The SEI training (video module and survey) takes about 30 minutes to complete.
- Our current analysis of that user data (detailed next) is based on a sample size of 45 trainees who completed the SEI training online in the last month.

SEI Results

- Open-ended (short answer) data suggests trainees had a fairly accurate working definition of SEI going into the training. After viewing the video, respondents were able to summarize their understanding more concisely but also invoke specific words that were mentioned in the video.
- Closed-ended data suggests significant, positive change (pre and post training) in level of agreement with the statement "There is a need for implementing the consideration of nanoethics into my routine practices."

Plans for Year 4:

NASCENT's ***nm-Fab***: Bringing NNCI Key Capabilities

NASCENT nanodevice manufacturability Fab (***nm*-Fab**):

- Flex wafer scale nanomanufacturing systems
- Roll-to-roll nanomanufacturing systems/processes
- Above systems comprising:
  - Tools and processes
  - Metrology and yield enhancement
  - Multiscale process modeling and simulation

NASCENT KEY ASSET

Gateway to nanotech commercialization: Enable small, mid-size and large companies to address risk of scalability in the areas such as photonics, magnetics, electronics, and optoelectronic devices.

•NASCENT: "Nanomanufacturing Systems for Mobile Computing and Mobile Energy Technologies," NSF ERC funded in September 2012.

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Commercialization

Metrics

- # of small company users
- # of users from startups
- Intensity of use (hours, $$)

Best Practices

- Provide office space
- Prioritize tool access for external/remote users
- Allow staff to consult for small companies