

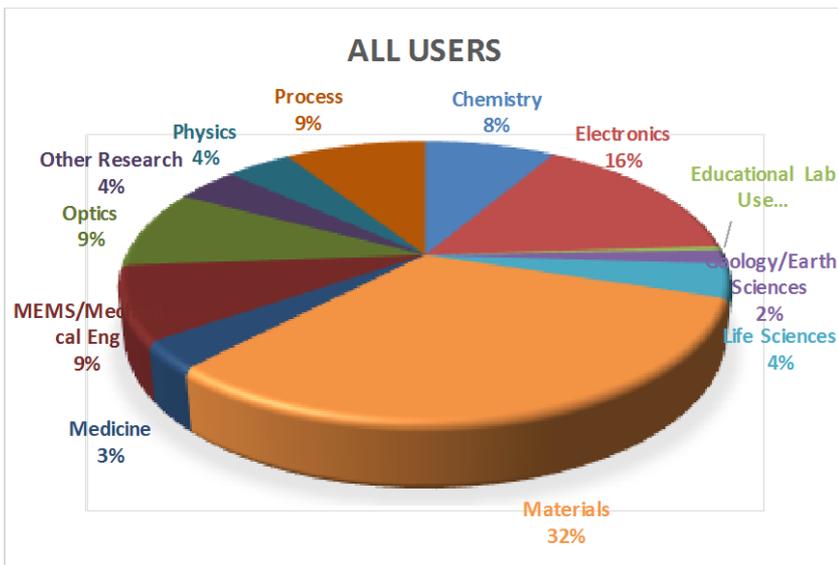
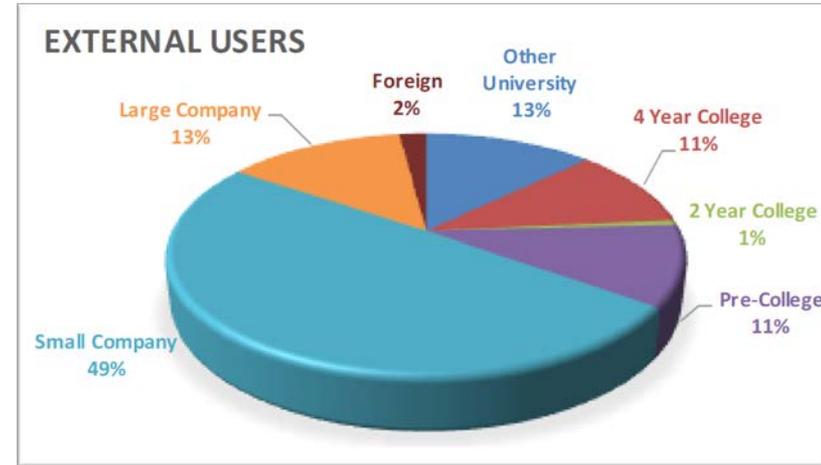
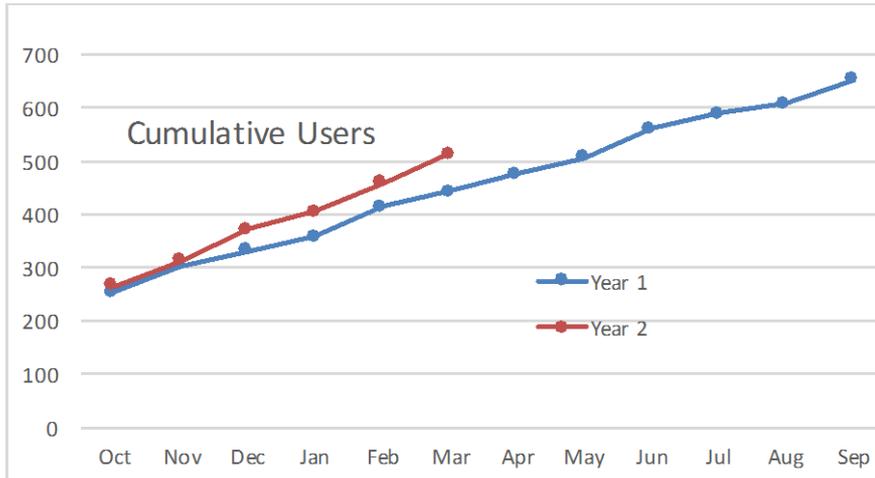
TNF Overview

- 3 centers from UT: MRC (former NNIN site), TMI and NASCENT- ERC
- 130 major tools for silicon and III-V-based nano and microfabrication
 - Champion tools per hour of usage: Nanolithography equipment : Zeiss SEM/Raith EBL and JEOL 6000FSE (80hrs/week)
 - Most popular equipment: Zeiss SEM/Raith EBL (140 users)
- Workforce development: student workers
 - 9 hourly UT undergraduates since 2014. Three current workers
 - Paid with cleanroom usage fee
 - Participate in the Equipment Training effort (300 unique users/ year at MRC)
 - Increase the graduation rate in 4 years (51% in 2011, 66% in 2017%) by supporting the goal of the UT University Leadership Network (ULN).
 - Unparalleled work experience of 2-3 years: high employability either in the workforce or to join graduate school

| | | | |
|-----------------------|---|------------------------|--|
| ADRIAN VELEZ |  | ULN- training staff | Hourly training staff in 2016 |
| AALIYAH HUBBARD |  | ULN- training staff | Hourly training staff in 2016 |
| OFELIA TIJERINA |  | Technical Staff Asst I | Hourly training staff: Ellispometer, optical microscope, data managin. |
| MARIA O NIETO |  | Technical Staff Asst I | Hourly training staff in 2016: TA at UT |
| SAMUEL ETKIND |  | Technical Staff Asst I | Hourly training staff: MIT Grad school |
| ARGUELLO, NOEL R JR |  | Technical Staff Asst I | Hourly training staff: Graduated, Engineer in Austin |
| SANIA RAZZAK |  | Technical Staff Asst I | Hourly training staff: AFMs, Etchers, furnaces Cleanroom supply restock. |
| PHUOC HUYNH THINH NGO |  | Technical Staff Asst I | Hourly training staff: furnaces, Profilometer, Cleanroom supply restock. |

TNF User Data

| Yearly User Data Comparison | | |
|---------------------------------|-------------------|-------------------|
| | Year 1(12 months) | Year 2 (6 months) |
| Total Users | 653 | 513 |
| Internal Users | 500 | 430 |
| External Users | 153 (23%) | 83 (16%) |
| Total Hours | 67,570 | 30,239 |
| Internal Hours | 53,485 | 24,070 |
| External Hours | 14084 (21%) | 6,169 (20%) |
| Average Monthly Users | 243 | 271 |
| Average External Monthly | 45 (18%) | 45 (17%) |
| New Users | 99 | 122 |
| New External Users | 48 (48%) | 6 (5%) |



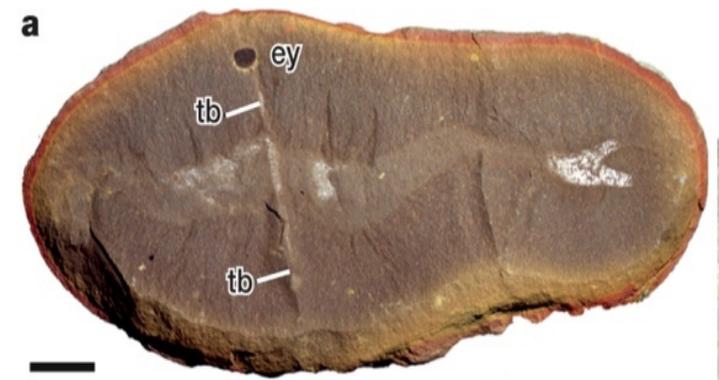
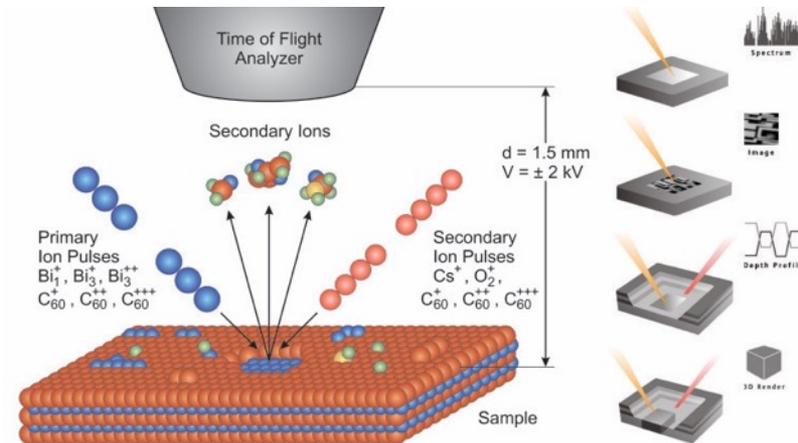
Facility Upgrades and New Tool Capabilities

Total capital investment in 2016-2017: \$2M

- Procurement of a new SEM/E-beam lithography system to upgrade the micro-nano fabrication at UT. Sponsored by UT (\$700k)
- Rigaku X-ray Diffraction System Smartlabs (\$350k). Funded by UT ECE. Facilitated in Aug 2017 at MRC. Training of new users on going.
- Replacement of the energy-dispersive X-ray spectrometer (EDS) on the SEM (\$34k- ECE funds): Bruker QUANTAX Compact to quantify light elements in materials at specific locations (Installed Sep 2017).
- NSF MRI Acquisition (\$785): Small Angle X-ray Scattering Instrument with *in situ* capabilities from SAXSLAB. To be installed in the new Engineering Education and Research Center (EERC) home of the UT Cockrell School of Electrical and Computer Engineering (ECE)
- Magnesium gas monitoring : To respond to a “near miss” incident by external user on ALD. Being a shared facility- push to higher standard of service and safety.
- Upgrade of the cleanroom management system to support and integrate the business operations of the three components of TNF:
 - \$10k spent to simplify the billing & invoicing, to track usage and compile quantitative data

Research Highlights (Example I)

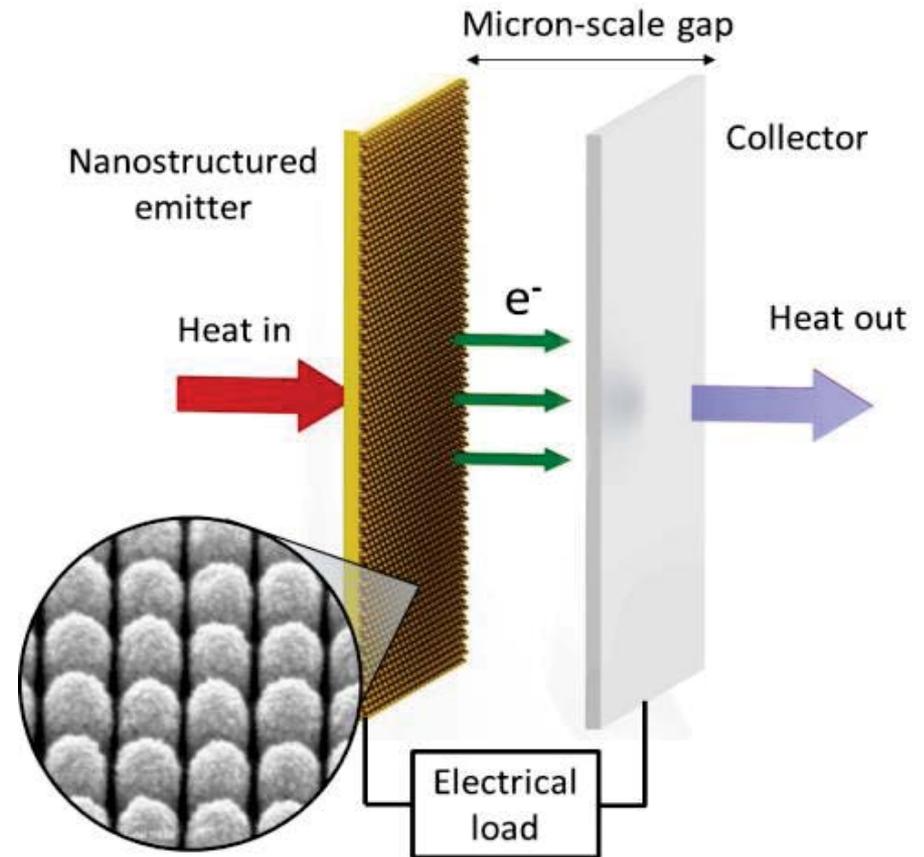
- **External User: University of Bristol UK, Time of Flight Secondary Ion Mass Spectrometer (TOF.SIMS 5)** is an Ultra-high resolution mass spectrometry (up to 0.001 a.m.u.). The TOF-SIMS is uniquely equipped to identify large, insoluble organic molecules such as C60 and melanin. In “The eyes of Tullimonstrum reveal a vertebrate affinity” paper Nature 532,500–503, TOF-SIMS and multivariate statistical analysis are utilized to determine the presence of fossilized melanin in the eye of a highly controversial fossil, Tullimonstrum, which proves the vertebrate origin of this ancient animal



The ultrastructural details of the eyes of *Tullimonstrum gregarium* from the Mazon Creek Lagerstätte : eye (ey) and transverse bar (tb).

Research Highlights (Example 2)

- **External User: Nanohmics Inc.,** local company, NNCI user since 2004, with currently over 15 SBIR projects worth \$6.5M. Nanohmics is developing high efficiency of Thermionic Thermal-to-Electric Converter product by employing nanostructured low-work-function emitters capable of high current thermionic electron emission. Innovative nanostructured emitters, fabricated at TNF using **E-Beam Lithography, Atomic Layer Deposition, ICP and RIE etchers,** demonstrate 2-3x the current density of their planar counterparts, enabling a pathway to >25% efficiency thermionic systems.



Nanohmics: LaB₆ coated sapphire TTEC emitter. An etch hardmask defined through an EBL liftoff regime (patterning extendable to NIL) is transferred to the substrate (Al₂O₃) by performing an RIE/ICP dry etch. Sputter coating of LaB₆ performed after stripping the dry etch hardmask.

Education and Outreach Activity: REU

- UT REU program since 2004 through NSF NNIN – over 100 undergraduates hosted.
- Targeted audience: NASCENT: Texas or neighboring State campuses with focus on colleges with under-represented minorities (UTRGV, UT Dallas, U of Dallas, UT El Paso, U of Arkansas,). NNCI: across the Nation (U at Albany, Stony Brook U, North Carolina State U).
Contact directly known faculty members in Texas colleges. Program posted on NSF REU and NNCI websites. 273 hits on the Qualtrics' application website, 20% complete application received.
- Longitudinal studies: 50% of the REU interns attend graduate school

Two NSF funded programs (NNCI & NASCENT-ERC) since 2012

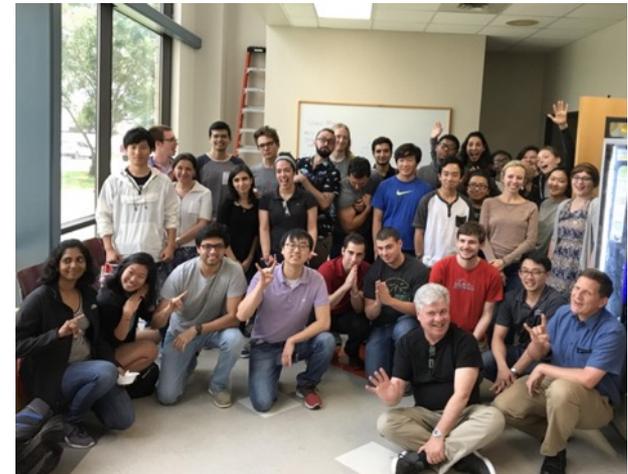
- Year long effort (advertisement, PI solicitation, mentor training, application review and selection)
- 9 weeks research
- Deliverables: Biweekly Meeting, Poster Session, Extended Abstract, Convocation at Georgia Tech to network with peer REUs
- Pre/Post survey by NASCENT Program evaluator D Yañez



2 females: Paola Perez, Luisa Espinosa. **9 males:** David Lonstein, Thomas Leonard, Michael D'Agati, Peter Chang, Yuki Nakashima, Reid Goins, Julio Trevino, Tobias Dwyer, Joshua Acosta

Education and Outreach Activity

- **TNF Technical Workshops: one day lecture and tool demo**
 - AFM- Park System (Oct 2016): long term demo agreement on NX10 AFM system (~\$200k)
 - LitesizerTM 500 dynamic light scattering (DLS) by Anton Paar (Nov 2016)
 - Polymer Pen Lithography (PPL)- TERA-print, (Dec 2016)
 - MRC Woollam Ellipsometer M-2000DI: Case studies on user samples (Aug 2017)
- **Mini-course on TEM**
 - Part of the Practical Electron Microscopy – ME 387R course
- **NASCENT Pre-College Summer Program** (one week camp - Jun 2017):
 - Fifteen 10-12th graders learned about cutting edge nanofabrication techniques, nanomaterials, & nano-enabled devices in electronics, healthcare, energy sectors.
 - Lectures: “Nanotechnology and Energy”
Dr. Larry Dunn;
“Demonstration of Inductive Heating of Magnetic Nanoparticles” Dr. Oved Abed;
“Nanoelectronics” Prof. Sanjay Banerjee



Ice cream social NASCENT summer '17

Network Activity

- NNCI *Metrics* Subcommittee (S. Banerjee)
- NNCI *REU* Working group (M. Palard)
- NNCI *Equipment Maintenance* Working group (J. James)
- ALD technical workshop organized by Stanford (Apr 2017)
- Participated in the REU convocation at Georgia Tech (Aug 2017)
- ASU –TNF Electron-Beam Lithography JEOL6000FSE troubleshooting.

SEI- TNF NNCI PI Prof. Lee-Ann Kahlor



- Recipient of The University of Texas System 2017 Regents' Outstanding Teaching Award. Board of Regents' highest honor, with a monetary award of \$25,000
- Plan to integrate the SEI pilot training module into the TNF-MRC safety / orientation training session:
 - Video with pre and post survey
- GRA student to continue work on SEI and Nano done by graduate Jacy N. Jones (MA thesis 2017)
- Future Conferences
 - Co-moderating with Fred Kronz, NSF/SBE, "Nanotechnology and Converging Technologies - Societal Aspects" (Dec 13, 2017)
 - Presenting at 6th Annual Winter School on Responsible Innovation and Social Studies of Emerging Technologies (NNCI - January 3-10, 2018 in AZ)

Resource Allocation and New Equipment Acquisition

- How do new and well-established user facilities plan for long-term replacement and for new acquisitions?
 - Grant proposal (MRI, DURIP,...). Mainly characterization equipment, for less than \$500k granted in the past.
 - No success with work horse equipment (E-beam writer) close to \$1M. Broader impact like high school education difficult to address with such complex tool demanding hours of training.
 - Crisis in failing to hire new nanotech faculty and low faculty retention incited the ECE Department to make a case to the University for new equipment procurement. This one time investment of (~ \$1M) will enable state-of-the-art EBL capability for the next 8-10 years.
 - The Department and the University expect the shared facility to be self sufficient for daily operations like maintenance, consumable (\$800k/year absorbed by user fee), staff salaries (covered by NNCI), capital equipment renewal (source to be identified).