

Mission and Capabilities

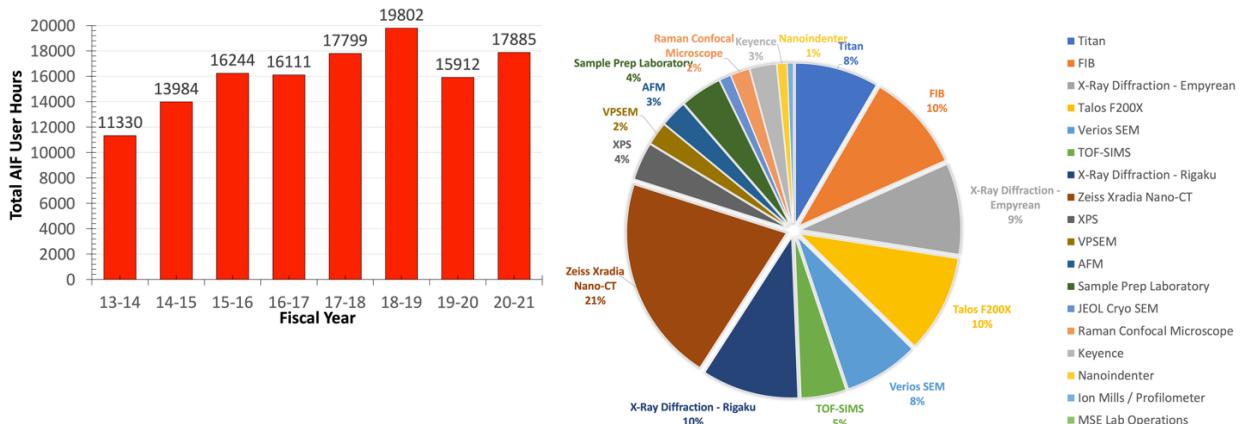
The AIF is NC State's primary shared facility for materials characterization with a mission to enable and lead state-of-the-art research through acquisition, development, maintenance, training, and access to major analytical and materials characterization instrumentation. Through the support of engaged faculty and experienced staff, the AIF supports state-of-the-art scanning and transmission electron microscopes, X-ray scattering and spectroscopy instruments, mass and electron spectrometry, scanning probe and Raman microscopy, laser scanning microscopy, nano-CT system, nanoindentation, freeze fracture system, high pressure freezer system and extensive sample preparation facilities. Some of the extraordinary capabilities of these instruments include chemically-sensitive atomic-scale imaging, extreme-resolution SEM of insulating and soft materials, *in situ* high temperature and electric-field-dependent X-ray diffraction, cryogenic SEM of biological and soft materials, low-temperature TEM and *in situ* microscopy during heating, electrical current, immersion in fluids, and in flowing gases (to name a few). The AIF is positioned within the College of Engineering and is named an NC State Core Facility by the Office of Research and Innovation (ORI).

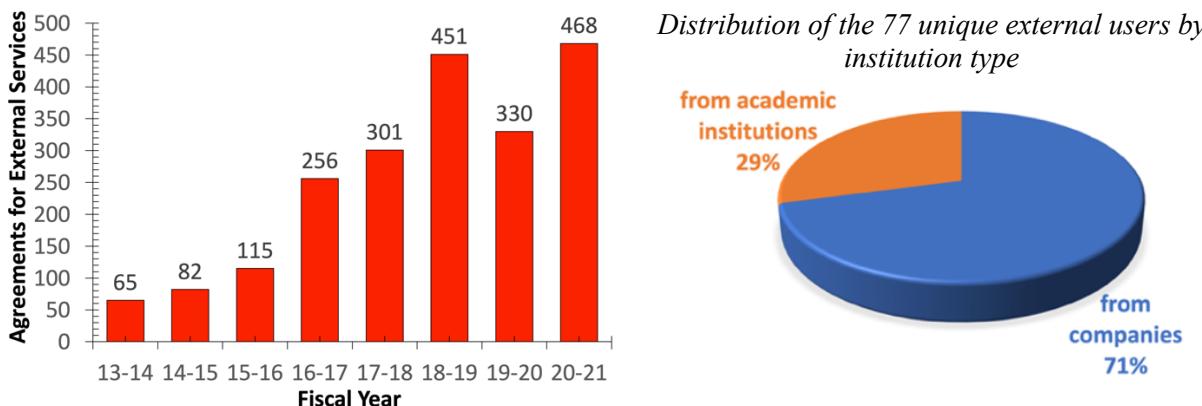


Usage

In FY21, the AIF was accessed by **135 NC State Principal Investigators (PIs)** at NC State and **312 users from those groups, who are mostly students and postdocs**. These individuals come from the **Colleges of Agriculture and Life Sciences, Natural Resources, Engineering, Sciences, Textiles, and Veterinary Medicine**. In addition, the AIF supported materials characterization services for **77 unique external government, industrial, and other academic researchers** through managing **468 active contracts** (330 contracts in FY20, 451 in FY19, 301 in FY18, and 256 in FY 17). Overall, the AIF provided **17,885 lab user hours** in FY21, and the increase due to the relaxation of the lab access restriction during the COVID-19 pandemic. ~20% of AIF users are external to the university, demonstrating our service to researchers from North Carolina and around the world.

Distribution of the 17885 hours across the AIF laboratories and instruments.





Education and Engagement

The AIF is heavily involved in student training/education and engagement with the community. During FY21, the AIF offered **56 virtual training**, demos, and short courses for learning on topics including SEM, FIB, TEM, XRD, surface analysis, and vacuum technology. AIF staff members helped to organize the annual Carolina Science Symposium in November of 2020, a virtual event that attracted over 106 researchers from around the Mid-Atlantic region. The event was comprised of four 90-120 min sessions spanning the 2 days with 4 live invited talks, 19 pre-recorded student oral presentations, 14 student posters complete with audio description of the posters, and an AVS short course on Atomic Layer Etching by Steve George the day before the symposium. In FY21, the AIF gave over **13 virtual tours** for visitors, industry researchers, and classrooms. Starting in March 2020 and throughout the stay-at-home orders during the COVID-19 pandemic, AIF launched several online introduction courses via Zoom video conferencing that were subsequently posted on the a newly created [AIF YouTube channel](#). New online videos were created in this channel including TEM, ToF-SIMS, SEM, AFM, FIB, and Nanoindentation Technique courses.

New Instrumentation and Upgrades

The AIF acquired several new instruments. In December 2020, a new ThermoFisher Helios Hydra Dual Beam Plasma-Focused Ion Beam (pFIB) was delivered. It was acquired through an NSF Major Research Instrumentation (MRI) award by Prof. Elizabeth Dickey (see article on this award [here](#)) from the Materials Science and Engineering Department. The instrument enables and supports a diverse range of research projects and programs, within academia and industry, that involve three-dimensional, multi-modal characterization and patterning of microstructures. Such three-dimensional analysis is particularly important for developing materials processing strategies for additive manufacturing and for understanding mechanisms leading to material degradation and failure. AIF also is home to a new Biological Transmission Electron Microscope (bio-TEM), Hitachi HT7800. It was acquired through a donation with additional support from the Office of Research and Innovation (ORI) and College of Engineering. Despite the pandemic, it was delivered in early April 2021. The HT7800 has many convenient features to aid in image acquisition, including a Dual-Mode objective lens that supports easy observation under low magnification, wide-field high contrast and high resolution. It also includes an advanced stage-navigation function that enables whole-grid searching and efficient image acquisition. Another new instrument was acquired in the June 2021, a Hitachi SU3900 Scanning electron microscope by Prof. Tasnim Hassan in Civil Engineering Department, using funds made available from Department of Energy (DOE).



Thermofisher Helios Hydra Plasma Focused Ion Beam (pFIB)



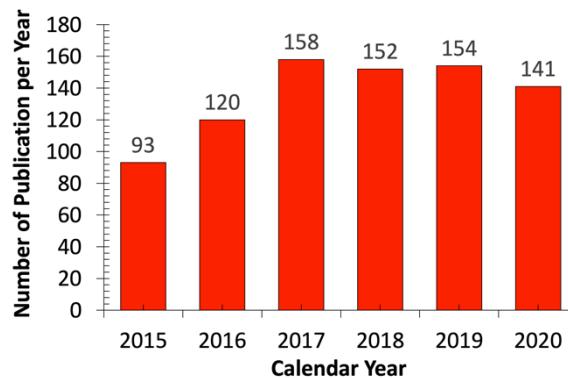
Hitachi Bio transmission electron microscope HT7800

Organizational Innovation

Each month, AIF features a “[User Spotlight](#),” where selected users’ backgrounds and projects are introduced and primary instrument(s) they are using for the research are discussed. In FY2021, [Jacob Smith](#) (PhD student in Materials Science and Engineering, working under Prof. Wenpei Gao), [Ahmed Darwish](#) (PhD students in Nuclear Engineering, working under Profs Jacob Eapen and KL Murty), [Milad Shamsi](#) (PhD student in Chemical and Biomolecular Engineering, working under Dr. Michael D. Dickey and Dr. Richard J. Spontak), [Michael Spencer](#) and [Ishita Kamboj](#) (PhD students in Materials Science and Engineering, working under Prof. Veronica Augustyn), [Stacy Schkoda](#) (PhD student in Biological Sciences Department, working under Prof. Heather Patisaul), [Evyn Routh](#) (PhD student in Materials Science and Engineering, working under Dr. Nadia El-Masry, and Dr. Salah Bedair), [Brendan Roess](#) (a student in Biological Sciences Department, working under Dr. Nascone-Yoder), [Samaher Salem](#) (PhD student in Department of Forest Biomaterials, working under Dr. Lokendra Pal and Dr. Lucian Lucia), and [Manik Chandra Biswas](#) (PhD student at Wilson College of Textiles, working under Dr. Ericka Ford) were featured. These individuals were from diverse disciplinary backgrounds and career trajectories and are brought together through utilizing instruments at AIF.

Research Outputs and Impact

The AIF was authorized to work on **189 unique 5-account projects** in FY21, representing >\$299M in research awards on campus. Users of the AIF published over **>141 peer-reviewed technical publications** (full list [here](#)) in the calendar year 2020 (virtually consistent with 154 in 2019, 152 in 2018, 158 in 2017, up from 120 in 2016, and 93 in 2015, 68 in 2015, and 44 in 2014). Many of these publications receive national attention through news media or recognition in scientific communities. The AIF holds a contest each year for the best papers written by



students. The 8th Annual [Best Paper Award](#) Winners were Shelby Boyd from the group of Professor Veronica Augustyn (MSE) for a publication in Frontiers in Chemistry on “[High Power Energy Storage via Electrochemically Expanded and Hydrated Manganese-Rich Oxides](#)” and Aurore Canoville from the group of Professor Lindsay Zanno (BIO) for a publication in Philosophical Transactions of the Royal Society B on “[Identifying medullary bone in extinct avemetatarsalians: challenges, implications and perspectives](#). ” The AIF identifies diverse “Cool Science” regularly, such as [Understanding How Materials Behave in Extreme Environments](#). [Professor Djamel Kaoumi](#), along with collaborators, looked at thin iron films and how ion irradiation damaged these films. They used the FIB and TEM in the AIF to prepare and characterize the defect structures within these iron thin film samples before and after ion irradiation.

Personnel

A total of 13 technical and business staff members and postdocs staff the facility with two tenured faculty members serving in director-level leadership roles and undergraduate students working as research assistants. The technical staff are experienced, collaborative, energetic, and student/training focused. Dr. [Ruksana Baby](#) joined AIF in 2021 as a postdoc with responsibility for the X-ray computed tomography facilities. Dr. Ruksana Baby received her M.S. in Textile Engineering in 2017 and Ph.D. in Fiber and Polymer Science program from Wilson College of Textiles in 2021, both at NC State University. Ruksana uses the Zeiss Xradia 510 Versa 3D X-ray Tomography System for investigating skin-textiles interface at micro-scale for friction analysis. [Dr. Jennifer Forrester](#) also joined the AIF in 2021 as the XRD Lab Manager. Dr. Forrester earned her Ph.D. in Materials Engineering in 2003 at the University of Newcastle. She has worked in several research positions in Australia, the U.K. and the U.S., all of which heavily utilized X-ray diffraction tools and analysis approaches. AIF’s Director, Dr. Jacob Jones, received the prestigious [2020 R. J. Reynolds Tobacco Company Award](#) for Excellence in Teaching, Research, and Extension. Dr. Jones is recognized as a leading researcher in the areas of oxide materials and materials characterization and a passionate, dedicated educator. He plays a key leadership role both at NC State and the larger Research Triangle area of North Carolina in furthering research and education in analytical and materials characterization, nanotechnology and STEM education. After the virtual awards ceremony, Dr. Jones delivered the 2020 R. J. Reynolds Tobacco Company Award Distinguished Lecture, titled “[Embracing Convergence Research: The Journey from Ferroelectric Materials to Nanotechnology, Bayesian Statistics, and Water-Food Systems](#).” Surface Science Lab Manager Fred Stevie was named [ASM’s 2021 Class of Fellow](#). ASM established the Fellow of the Society honor to provide recognition to members for their distinguished contributions to materials science and engineering and to develop a broadly based forum of technical and professional leaders to serve as advisors to the society. Professor Wenpei Gao received the [2021 Albert Crewe Award](#) from the Microscopy Society of America. The Albert Crewe Award was initiated to recognize distinguished contributions to the field of microscopy and microanalysis in the physical sciences of an early career scientist. [Anna Lumpkin received the College of Engineering Award of Excellence](#). She is one of only two winners in the SHRA employee classification. The NC State University Awards for Excellence recognize the meritorious accomplishments and contributions of individual employees, notable contributions that are above and beyond an employee’s normal job responsibilities, and are so singularly outstanding that special recognition is justified. Anna’s award is in the category of Customer Service, which recognizes an employee who provides/provided exceptional service that leaves the customer fully satisfied with their experience. [Dr. Maude Cuchiara won the 2020 Outstanding Extension Award from the College of Engineering](#) and was inducted into the NC State Academy of Outstanding Faculty in Extension and Engagement.

Finances and Business

The AIF operates as a cost-recovery center, managing ~\$1.46M in annual expenditures across 23 different university accounts. The largest fraction of expenses is recovered from user fees (\$748k, or 51%), with support also provided by the College of Engineering and ORI. Note that these numbers do not include support for equipment acquisitions. ***Operational support from the university is critical*** to maintain a state-of-the-art facility, enable quality training of students and researchers, and offer competitive user rates for research activities. ***Service contracts for the instruments*** constitute a major portion of the annual expenditures (approximately \$580k), and this number will grow as new instruments come online and the factory warranty periods of newly commissioned instruments terminate. Though large, this is a necessary expense to minimize downtime of instruments critical to the research enterprise and minimize the volatility of maintenance costs. As these expenses grow, we aim to grow facility usage concurrently (by both internal and external researchers) in order to maintain our competitive user rates.

Outlook

We learned a lot through the shutdown and stay-at-home phase of the COVID-19 pandemic. Most importantly, it reinforced to us the importance of our facilities to our customers. As we move forward among many uncertainties, training and enabling student users is an important activity that will take a priority in our planning for subsequent phases of reopening. In May 2021, AIF initiated the [50-in-50 Challenge](#) to train over 50 new independent lab users in 50 days. While the NC State community becomes largely vaccinated, AIF staff resumed their priorities on training new users who can and will operate AIF equipment independently. All training is conducted within the current laboratory and classroom restrictions at NC State, meaning it is still slower than pre-pandemic days when we could have high occupancy in small spaces. The challenge was achieved within only 43 days!! Moreover, the creativity and adaptability that our staff demonstrated during the shutdown and stay-at-home phase of the pandemic provides a high level of confidence that we will find solutions to the challenges that lie ahead. Ultimately, it is the ingenuity, care, and determination of our entire AIF community, including all users and stakeholders, that will help us move forward in a manner that provides quality research and education training and support in a safe and effective environment.

Visit us or contact us at: <http://www.aif.ncsu.edu>, <https://www.linkedin.com/in/aif-nc-state-university/>
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