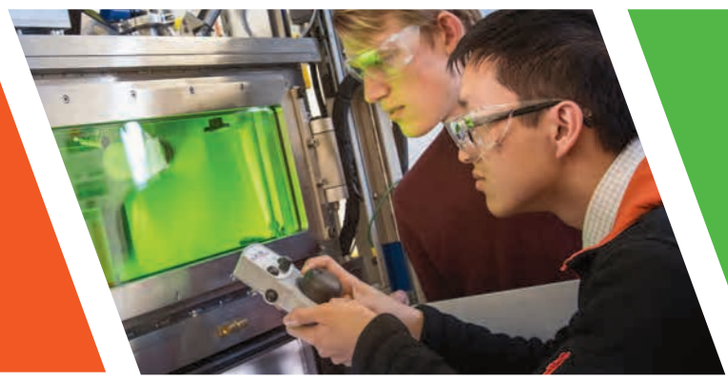
UCONN TECH PARK

ANNUAL REPORT 2018 - 2019



UCONN | SCHOOL OF ENGINEERING

UCONN | RESEARCH

CONTENTS

ANNUAL REPORT 2018 - 2019

WELCOME

From the Executive Director of UConn Tech Park

I am delighted to share with you the 2018-2019 Annual Report for **UConn Tech Park**, the University of Connecticut's premier center for cutting-edge research, state-of-the-art technology and industry collaboration and innovation. This remarkable research facility was made possible thanks to our strong industry partnerships, UConn's commitment to working with industry – particularly the UConn School of Engineering, and a significant investment from the state of Connecticut.

At Tech Park, our goal is to serve as a vital place for applied research in diverse areas of technical expertise. Our unique space is specifically designed for partnerships that bring together faculty experts with businesses of all sizes, from local startups to large global corporations. We collaborate with our partners to develop a research plan tailored to individual business needs and help companies reach their strategic objectives, be innovative, and excel in the development of new technologies.

Tech Park is an exciting venue that opens up new possibilities for our research partners, students and faculty, and the state of Connecticut. Our facility is an unparalleled resource that drives today's discoveries as we develop compelling technological solutions for the future. Creative, innovative thinking stimulates us as academic researchers, but also provides opportunities for a future generation of engineers and business leaders. The research centers located at the Innovation Partnership Building (IPB) are an educational gold mine where students gain hands-on experience, meet potential employers, and learn to be highly competitive, productive members, and eventually leaders, of Connecticut's workforce.

We first opened our doors in October 2017 with ten established research centers funded by local and global industry leaders across a broad spectrum of fields including additive manufacturing, materials testing, advanced characterization, systems engineering, process modeling, data sciences, cybersecurity, weather prediction, and more. Our instrumentation is some of the most sophisticated in the world and includes state-of-the-art characterization through partnerships with Thermo Fisher Scientific, Zeiss, DENSsolutions and Rigaku; fantastic facilities for metal and polymer additive manufacturing with two brand new testbed instruments designed by UConn faculty; and processing/simulation capabilities related to advanced manufacturing.

Now in its second year of operation, Tech Park has established a distinctive footprint of innovation and partnership that is illustrated by the exciting accomplishments described throughout this report.

Achievements

RIBBON-CUTTING EVENT & SYMPOSIUM

Tech Park celebrated its official opening with a ribbon-cutting ceremony in September 2018. UConn leadership, state legislators and representatives of science and technology companies kicked off the morning, describing the myriad opportunities the building brings.

> U.S. Rep. Joe Courtney: *"This building could not come at a better time with its cutting-edge research. Connecticut has to take advantage of the incredible opportunities out there. There is tremendous growth potential and opportunity before it."*

> U.S. Sen. Richard Blumenthal: *"What we are doing here is investing in the future of America, with real-world actions to make sure our country stays as the greatest nation in the world."*

An afternoon symposium followed, with compelling comments on Tech Park goals and future aspirations from UConn leaders, faculty, and industry representatives, and engrossing presentations of ongoing research collaborations. Thanks to gracious arrangements made by Dean of School of Fine Arts Anne D'Alleva, guests also enjoyed a demonstration of the awe-inspiring Spirio, Steinway's most technologically advanced player piano.

"As a major research university and state institution, it is our mission to serve our state, and the businesses that grow our economy, through collaborative research and technology development. Major initiatives like our recent Air Force Research Laboratory contract, which will create next generation manufacturing solutions, and the launch of our National Institute for Undersea Vehicle Technology, are helping to strengthen and grow some of our largest industries in the state —aerospace and naval."

– Kazem Kazerounian, Dean of School of Engineering

MAJOR FUNDING MILESTONES

- $6.0M pledged by Eversource for Eversource Energy Center research
- $5.4M contract with the Air Force Research Laboratory (AFRL) for aerospace research in advanced manufacturing
- $2.2M expansion of research for the Collins Aerospace Center for Advanced Materials

RESEARCH CENTERS NEWLY ESTABLISHED AT TECH PARK

- Air Force Research Laboratory– Research in Advanced Manufacturing (AFRL RAM), supported by a new Air Force contract – aerospace manufacturing processes and simulations
- UConn DENSsolutions Center for IN-siTu/Operando Electron Microscopy (InToEM) – structure and dynamics of energy materials
- Center for Science of Heterogeneous Additive Printing of 3D Materials (SHAP3D), an NSF-funded industry/university cooperative – heterogeneous additive printing of 3D materials
- Coming soon to Tech Park
  - » Center for Materials Processing Data (CMPD), a multi-university research center and consortium: materials data creation and validation for ICME and process design
  - » National Institute for Undersea Vehicle Technology (NIUVT), a university-industry partnership collaborating with the Navy: advancing new technologies to develop the capabilities of the next generation US undersea fleet

BUILDING DEVELOPMENT AND EXPANSION; NEW EQUIPMENT

- New offices and wet lab for Fraunhofer USA Center for Energy Innovation CEI
- Eversource Center expansion: research testbed for simulating and modeling the electric grid
- New seminar/workshop flex space and offices
- New equipment installations including metal and polymeric testbed 3D printers, robotics, machining center for rapid prototyping

I invite you to explore UConn Tech Park, our capabilities, and our achievements. Our future vision and strategy are for continued growth of our diverse culture and expansion of our capabilities and the ways we support industry around the state. Tech Park has the bandwidth and space to establish new partnerships. We look forward to providing more Connecticut businesses with new opportunities to take advantage of the unique possibilities and expertise available in this remarkable facility at the University of Connecticut.

"As the state's flagship public research university, we recognize that we play a critical role in economic and workforce development across the state and beyond. To achieve this, we work alongside our industry partners, and are responsive to their needs. Technology is advancing at a pace we have never before seen, and with UConn Tech Park, we are making leaps and bounds to keep up and get ahead."

– Radenka Maric, Vice President for Research and CT Clean Energy Fund Professor of Sustainable Energy

Tech Park Advisory Board

UConn Tech Park is delighted to announce its Advisory Board which will shape and guide the strategy of Tech Park in partnership with UConn leadership.

Executive Director Pamir Alpay states, "We're very fortunate to have such a well-balanced complement of accomplished professionals and leaders from diverse backgrounds including academia, business, engineering, and manufacturing. Their input and expertise will accelerate our programs, foster new partnerships and enable us to keep our finger on the pulse of innovation in research and development. This team will provide critical contributions to Tech Park's strategic direction and success."

SULIN BA
Associate Dean of Academic and Research Support, School of Business, University of Connecticut

KEVIN BOULEY
President & CEO
Nerac, Inc.

KENNETH BOWES
Vice President
ISO Policy, Siting and Compliance
Eversource

ISAAC COHEN
Executive Director
Collins Aerospace Program Office
United Technologies Research Center (UTRC)

BONNIE DEL CONTE
President/CEO
CONNSTEP

DAVID FOORD
Director of Marketing
Thermo Fisher Scientific

JESSICA INACIO
Business Development Associate
Connecticut Economic Resource Center (CERC)

LAURA JAWORSKI
State of CT Dept. of Economic and Community Development (DECD) Office of International and Domestic Business Development

JILL BRYANT MAYER
CEO
Bead Industries, Inc.

FRANCIS PRELI
Vice President
Propulsion & Materials Technologies
Pratt & Whitney

GLEB REZNIK
Deputy CISO
Synchrony

SONIA TULYANI
Senior Director
Materials Engineering
Collins Aerospace

VENKAT VEDULA
Executive Director
Additive Manufacturing
UnitedTechnologies Corp. (UTC)

Quick Facts

PEOPLE

Over **300 UConn faculty and students** benefit from Tech Park's Research Centers' sophisticated technology and educational programs, including research center members, collaborators and customers.

Affiliated Faculty:	135
Post-doctoral Fellows:	13
Graduate Students:	158
Undergraduate Students:	17
Staff:	11

STATE-OF-THE-ART EQUIPMENT

Specialty	# at UConn Tech Park
Electron microscopy	6
X-ray characterization	2
Focused ion beam milling	6
Reverse engineering	3
Optical and digital microscopy	2
3D printing	8
Materials testing	10
Manufacturing and materials processing	7
Robotics/automation	1

MICROSCOPY

Powerful electron microscopes provide

- A **10-nanometer level** of precision, or
  - » The width of **4 strands of DNA**
  - » **10,000 x** narrower than a strand of human hair.
- **>100 million x** magnification power
  - » Researchers can see **individual atoms**
- Myriad applications, from biomedicines to aerospace.
- Highest honors - **Nobel Prize in Chemistry** (2017) was awarded to cryo-electron microscopy researchers.

ENERGY

- Utility Companies
- Energy Storage
- Water Filtration
- Clean Energy
- Sustainability

CYBER

- Cybersecurity
- Hardware Assurance
- Cyber-physical Security
- Big Data
- Information Technology

MATERIALS

- Electron Microscopy
- X-Ray Tomography
- Custom Materials Design
- Aerospace Materials

CYBERSECURITY

Cyberthreats

- Your smart card can be hacked in ~30 seconds – **1,000 x faster** than seven years ago.
- Cybercrime-related damage is projected to hit **$6 trillion annually** by 2021.
- The average cost of a malware attack on a company is **$2.4 million**.
- In 2019, ransomware damage costs will rise to **$11.5 billion** and a business will fall victim to a **ransomware attack every 14 seconds**.
- In 2018, Under Armor reported that its "My Fitness Pal" was hacked, affecting **150 million users**.

WEATHER MODELING

UConn's Outage Prediction Model

- **1.8 million customers** benefit
- Models are generated by a **computer powerhouse** equivalent to
  - » **168 laptops** performing simultaneous calculations
  - » Storage space for **10.5 million hours** of music

MECHANICAL TESTING

The Gleeble **thermal-mechanical** simulator tests materials under extreme conditions

- Has **10 tons** of crushing power, or **100 x** the power of the **human bite**.
- Heats an object at **10,000 degrees centigrade per second**.

MANUFACTURING

- Aerospace
- Naval
- Supply Chain
- Manufacturing Simulations

DATA SCIENCE

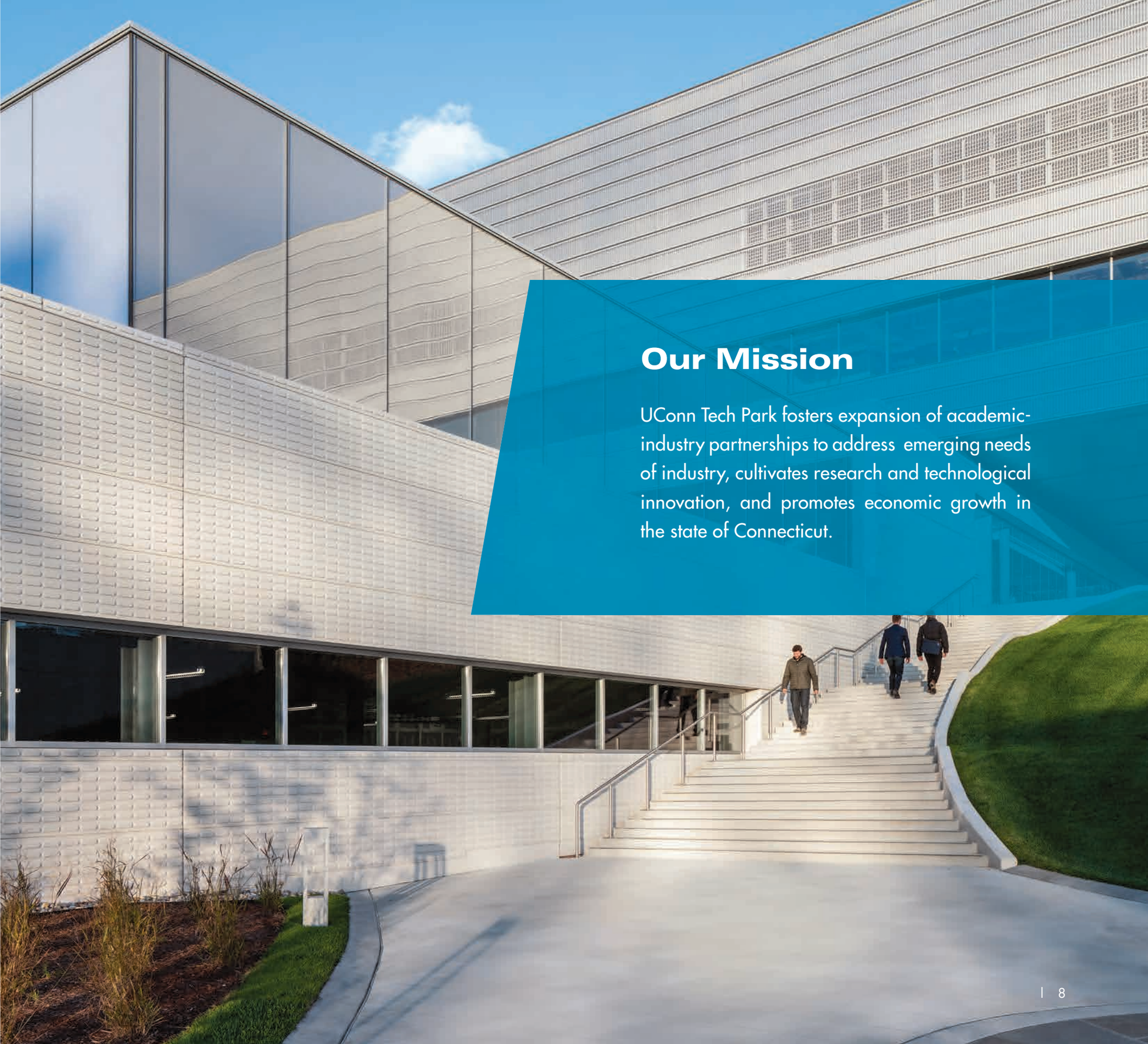
- Finance
- Insurance
- Engineering

ARTIFICIAL INTELLIGENCE AND ROBOTICS

- Artificial Intelligence
- Robots
- Machine Learning
- Industry 4.0

Orion Nanofab

Orion Nanofab is the only Helium and Neon Ion Microscope in the world with the best possible scanning and fabrication resolution (0.5m and sub 10nm respectively). Nanofab's applications vary from lithography to failure analysis and circuit editing for semiconductor industry. It is also a unique tool for imaging non-conductive samples without charging with applications in biomedical engineering, polymer engineering and shale analysis.



Our Mission

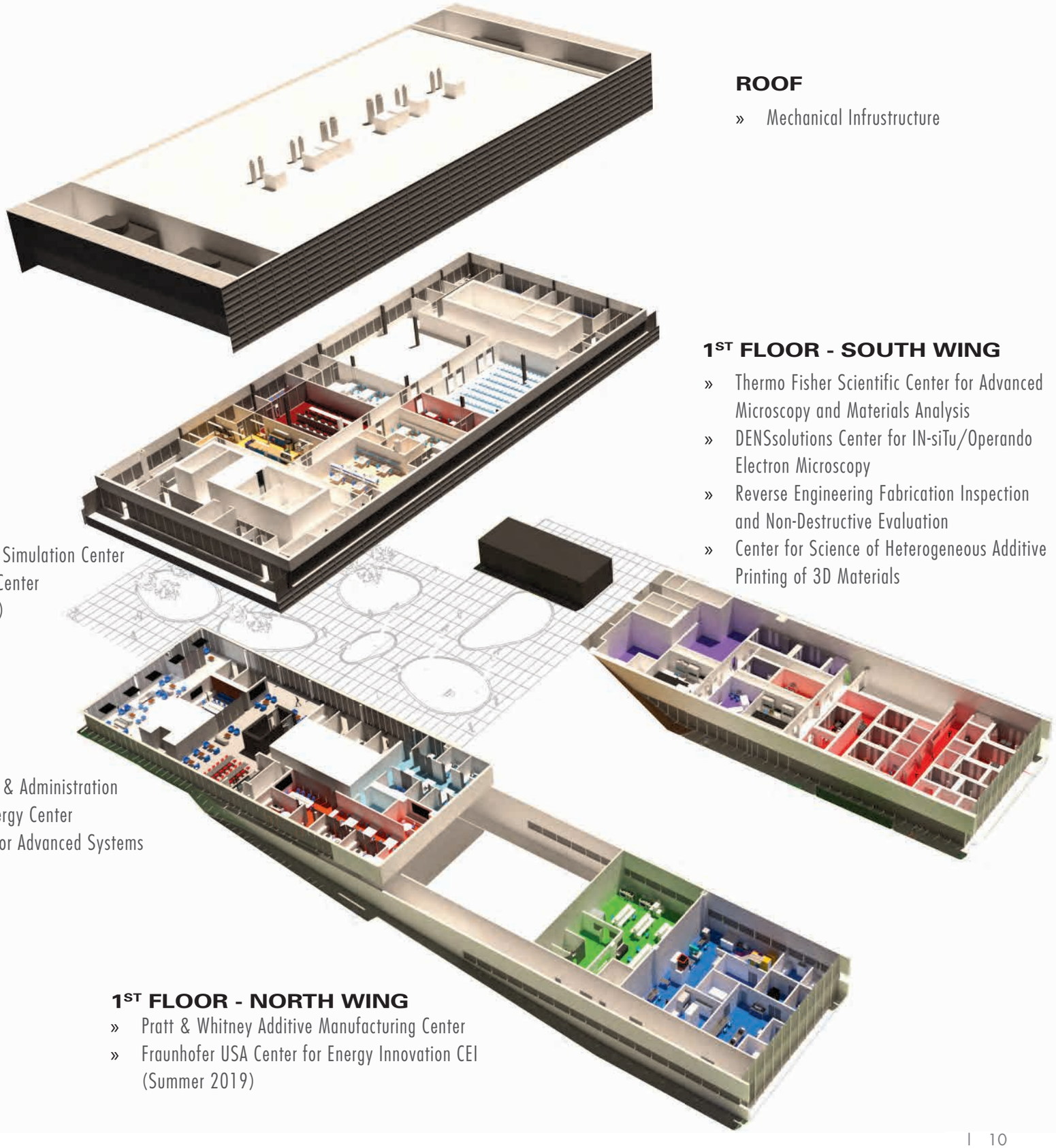
UConn Tech Park fosters expansion of academic-industry partnerships to address emerging needs of industry, cultivates research and technological innovation, and promotes economic growth in the state of Connecticut.

Overview

UConn Tech Park, located on UConn's North Campus in Storrs, Connecticut, is a $172M facility funded through the State of Connecticut to create a state-of-the-art research center that fosters expansion of academic-industry partnerships and promotes economic growth in the State of Connecticut.

The 113,700-square-foot space offers access to cutting-edge equipment, world-class faculty, and top-tier graduate and undergraduate students. Three floors provide a combination of flexible and functional office and laboratory space organized to meet the needs of research and education. A network of indoor and outdoor social areas establishes a feeling of community and cultivates multidisciplinary collaboration and innovative thinking.

Tech Park operates and maintains over $40 million of state-of-the-art instrumentation. The core lab spaces illustrated here and throughout this report were custom designed to create an optimal operating environment for this highly specialized equipment.



ROOF

» Mechanical Infrustructure

1ST FLOOR - SOUTH WING

» Thermo Fisher Scientific Center for Advanced Microscopy and Materials Analysis
» DENSsolutions Center for IN-siTu/Operando Electron Microscopy
» Reverse Engineering Fabrication Inspection and Non-Destructive Evaluation
» Center for Science of Heterogeneous Additive Printing of 3D Materials

3RD FLOOR

» Proof of Concept Center
» Connecticut Manufacturing Simulation Center
» Connecticut Cybersecurity Center
» Eversource Testbed (future)

2ND FLOOR

» Main Entrance & Administration
» Eversource Energy Center
» UTC Institute for Advanced Systems Engineering

1ST FLOOR - NORTH WING

» Pratt & Whitney Additive Manufacturing Center
» Fraunhofer USA Center for Energy Innovation CEI (Summer 2019)

Organization

Administrative Support and Marketing

PAMIR ALPAY
Executive Director Tech Park

RAELENE DEROBERTIS
Executive Administrative Assistant

MELANIE NOBLE
Executive Administrative Assistant

HEIKE BRUECKNER
Graphic & Website Design

Building Management & Safety

BEN ANACLETO
Laboratory Services Manager

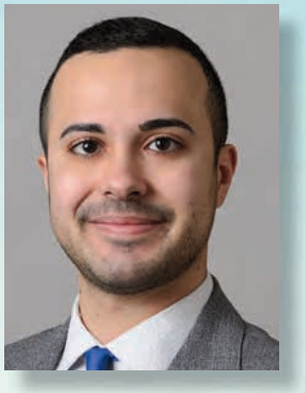
BRIAN CARDINAL
Building Manager

Small Business Support

DEB SANTY
SBIR/STTR Specialist

Scientific and Technical Support

MARK BIRON
Additive Manufacturing Center

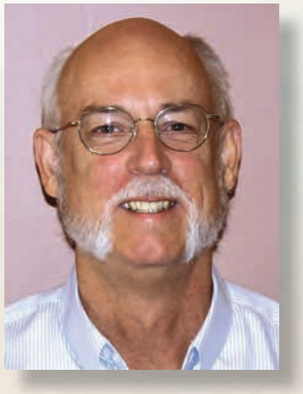


MIKE GANGI
Finite Element Technician
Connecticut Manufacturing
Simulation Center

JOSEPH LUCIANI
Proof of Concept Center (POCC)
Quiet Corner Innovation Cluster
(QCIC)

DANIELA MORALES
X-ray Laboratories

LUCAS PARENT
Electron Microscopy
Research Scientist



ROGER RISTAU
Lab Manager
CAMMA

HAIYAN TAN
Electron Microscopy
Research Scientist
CAMMA

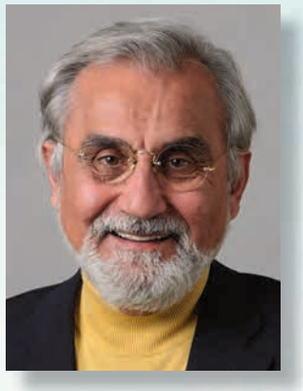
LICHUN ZHANG
Microscopy Specialist
CAMMA

Tech Park Center Directors

PAMIR ALPAY
Collins Aerospace Center
for Advanced Materials
AFRL Research in Advanced Manufacturing
Department of Materials Science
and Engineering

EMMANOUIL ANAGNOSTOU
Eversource Energy Center
Department of Civil and
Environmental Engineering

GEORGE BOLLAS
UTC Institute for Advanced
Systems Engineering
AFRL Research in Advanced Manufacturing
Department of Chemical
and Biomolecular Engineering



HADI BOZORGMANESH
Enterprise Solution Center
School of Engineering

JOHN CHANDY
Connecticut Cybersecurity Center
(CHEST, Comcast)
Department of Electrical and
Computer Engineering

RICHARD CHRISTENSON
National Institute for Undersea
Vehicle Technology
Department of Civil and
Environmental Engineering

LESLEY FRAME
Center for Materials Processing Data
Department of Materials Science
and Engineering

RAINER HEBERT
Pratt & Whitney Additive
Manufacturing Center
AFRL Research in Advanced Manufacturing
Department of Materials Science
and Engineering

JEONGHO KIM
Connecticut Manufacturing Simulation Center
Department of Civil and Environmental Engineering

JOSEPH LUCIANI
Proof of Concept Center
Quiet Corner Innovation Cluster

ANSON MA
Center for Science of Heterogeneous Additive Printing of 3D Materials
Department of Chemical and Biomolecular Engineering

JEFF MCCUTCHEON
Fraunhofer USA Center for Energy Innovation CEI
Department of Chemical and Biomolecular Engineering

LAURENT MICHEL
Connecticut Cybersecurity Center (Comcast, Synchrony)
Department of Computer Science and Engineering

SINA SHAHBAZMOHAMADI
Reverse Engineering Fabrication Inspection & Non-Destructive Evaluation
Department of Biomedical Engineering

STEVEN L. SUIB
UConn Thermo Fisher Scientific Center for Advanced Microscopy and Materials Analysis
Department of Chemistry

YUANYUAN ZHU
UConn DENSsolutions Center for IN-situ/Operando Electron Microscopy
Department of Materials Science and Engineering

COMING SOON TO TECH PARK

National Institute for Undersea Vehicle Technology (NIUVT)

The NIUVT is a partnership between UConn, the University of Rhode Island (URI), and General Dynamics Electric Boat (EB), with support provided by the Naval Undersea Warfare Center (NUWC) and the Undersea Warfighting Development Center (UWDC). The group accelerates innovation by bringing together partners in undersea vehicle technology for applied research, technology transition and workforce development, and it seeks to be a resource in the development of new capabilities and technologies to ensure naval dominance for the future fleet.

Accomplishments

NIUVT is committed to building relationships with the Navy enterprise while strengthening partnerships between all members. NIUVT members have joined partners at EB for technical meetings and participated in EB's Director's Forum and Technical Excellence Week. The NIUVT Industry Day in April 2019, brought together 130 participants from academics and the Navy enterprise to discuss research needs. Additional meetings have focused on the synergistic activities of NIUVT and NUWC to promote and advance excellence in the area of undersea vehicle technology as well as technical meetings with UWDC further strengthening communications between partners.

NIUVT received $3.5M in funding from ONR earlier this year, funding 11 applied research projects that collaborate closely with our Navy partners to address the needs in the undersea technology domain. NIUVT maintains a focus on Concept Development and Innovation through training programs and technology exploration workshops with Rite-Solutions.

NIUVT continues to prioritize workforce development by developing the personnel needed to accelerate critical research and enhance U.S. superiority in undersea vehicle technologies. Currently, more than 70 undergraduate students at UConn and URI are participating in the ONR-funded UConn/URI Navy STEM Program. Our students engage in real-world problem solving that develops critical skills for the next generation of engineers. This year alone, students completed 17 Senior Design projects with the naval sector in conjunction with sponsors NUWC, UWDC, EB, and Raytheon. Additional efforts aimed at advancing the workforce in this area of critical national need include Navy STEM professional development seminars offered in the fall 2018 and spring 2019 semesters.

RICHARD CHRISTENSON
Co-director NIUVT
Department of Civil and Environmental Engineering

ARUN SHUKLA
Co-director NIUVT
Department of Mechanical, Industrial and Systems Engineering
University of Rhode Island

Participating Faculty: 13
Graduate Students: 8
Undergraduate Students: 19

Center for Materials Processing Data (CMPD)

LESLEY FRAME
Director CMPD
Department of Materials Science
and Engineering

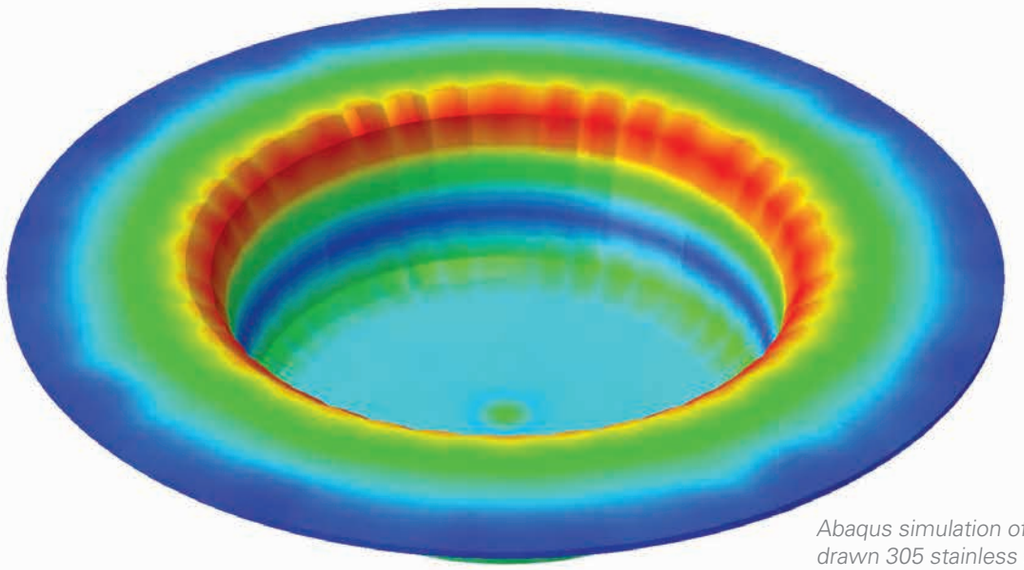
Center for Materials Processing Data (CMPD) is a multi-university research center and consortium dedicated to producing and curating pre-competitive transient material property data used in materials process simulations and process design. The center is member driven with portfolio projects proposed by member companies and carried out by the academic members – UConn, Worcester Polytechnic Institute (WPI), and University at Buffalo. The goals of the center include the development and dissemination of best practices for materials data management, data exchange, and integration with computational methods, and the center serves as a hub for accelerating the transition from knowledge discovery in materials science to implementation in manufacturing.

Accomplishments

Over the past year, the center has achieved the following:

- Established by-laws and forms for member agreement and project selection.
- Established a memorandum of understanding (MOU) among the founding members of the CMPD. The founding members include UConn, WPI, University at Buffalo, ASM International, and Pratt and Whitney.
- Created a list of potential companies to join the consortium.
- Identified a pilot project for the center that involves all academic members and a potential member company (Concurrent Technologies Corporation). The pilot project focuses on the digitization of the Atlas of Formability, supplemented with forming experiments carried out on the Gleeble by Rainer Hebert's research group at Tech Park.

UConn Faculty: 3
UConn Graduate Students: 1
WPI Faculty: 2
University at Buffalo Faculty: 1
ASM International: 3
Pratt & Whitney: 1



Abaqus simulation of deep drawn 305 stainless steel with Von Mises strain plotted.

RESEARCH CENTER NEW TO TECH PARK

Air Force Research Laboratory – Research in Advanced Manufacturing (AFRL RAM)

AFRL RAM is a new collaboration supported by a four-year $5.4M contract with the Air Force Research Laboratory awarded in August 2018. Industry partners currently include Pratt & Whitney, Aero Gear, GKN Aerospace and Collins Aerospace. The Center will help the U.S. Air Force and their contractors to further improve manufacturing technologies and maintain a position of strength in international defense.

AFRL RAM's objective is to reduce variations in key manufacturing technologies for aerospace applications—casting, machining, composite manufacturing, and additive manufacturing. Reduced variations and uncertainties in these technologies help AFRL, original equipment manufacturers (OEMs), and supply chain companies to reduce scrap rates, increase yield & performance, and cut down failures during the manufacturing processes. AFRL RAM will apply its highly specialized expertise in manufacturing simulation, extensive materials analysis, and process modeling to understand the main sources of process variations and failures.

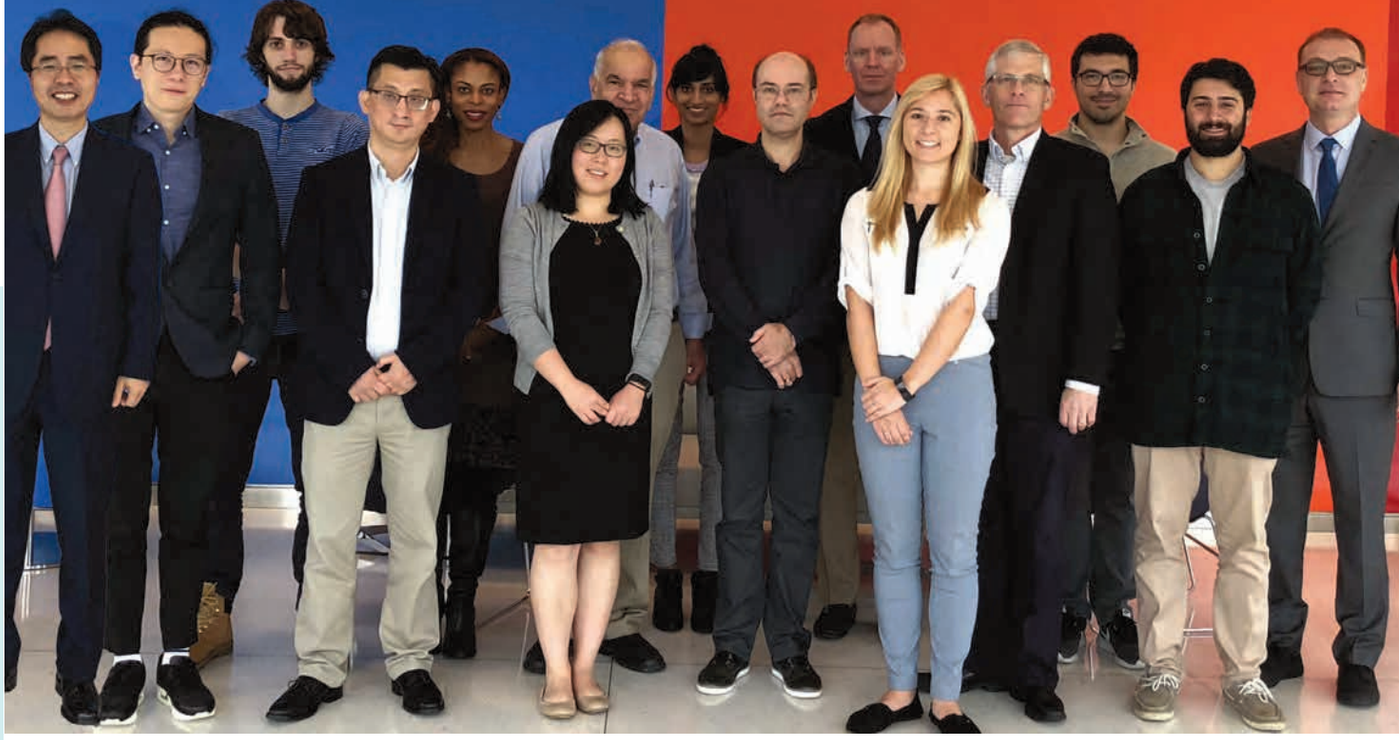
Graduate student Lakshmi Ravi Narayan uses the Gleeble Hydrawedge at the Additive Manufacturing Center in Tech Park. (Al Ferreira)

PAMIR ALPAY
Co-director AFRL RAM
Department of Materials Science and Engineering

GEORGE BOLLAS
Co-director AFRL RAM
Department of Chemical and Biomolecular Engineering

AFRL
THE AIR FORCE RESEARCH LABORATORY
LEAD | DISCOVER | DEVELOP | DELIVER

RAINER HEBERT
Co-director AFRL RAM
Department of Materials
Science and Engineering

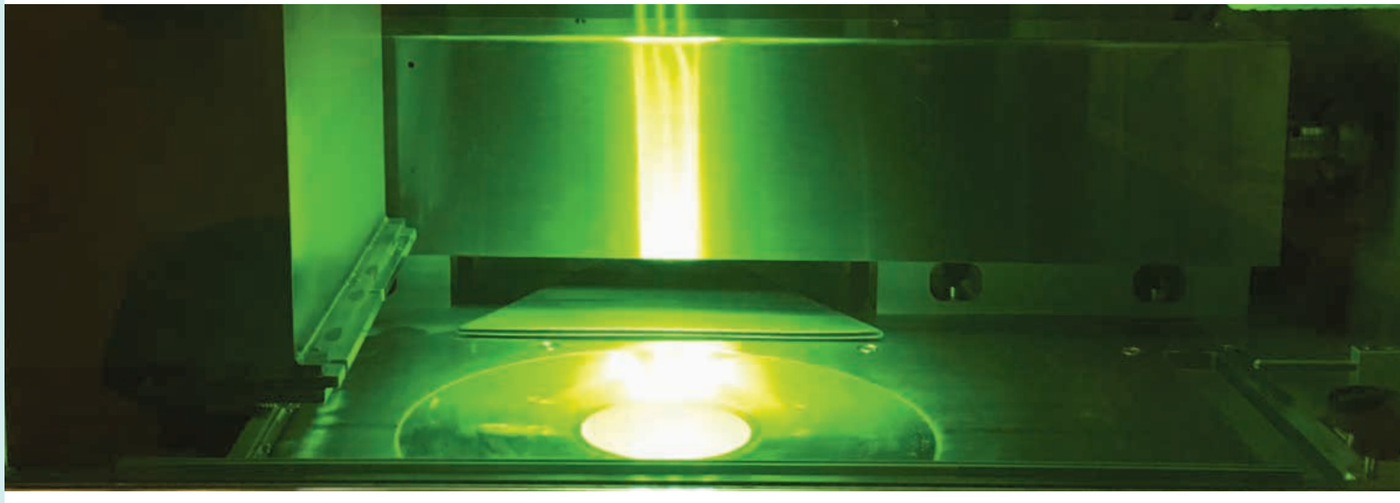


AFRL RAM center members, fall 2019

AFRL RAM's approach to combine commercial simulation codes, advanced materials modeling techniques, and laboratory-based manufacturing helps to reduce cost, to improve component and system quality, and to enhance industrial capabilities. The Center also trains a new generation of engineers who work in multi-disciplinary teams and in an integrated computational-experimental environment.

AFRL RAM's innovative manufacturing solutions for the aerospace sector will ultimately reduce costs, improve component and system quality, and enhance industrial capability.

Faculty: 7
Post-doctoral Fellows: 2
Graduate Students: 10



Powder bed in the IPG Photonics custom-designed additive manufacturing machine.

RESEARCH CENTER NEW TO TECH PARK

Center for Science of Heterogeneous Additive Printing of 3D Materials (SHAP3D)

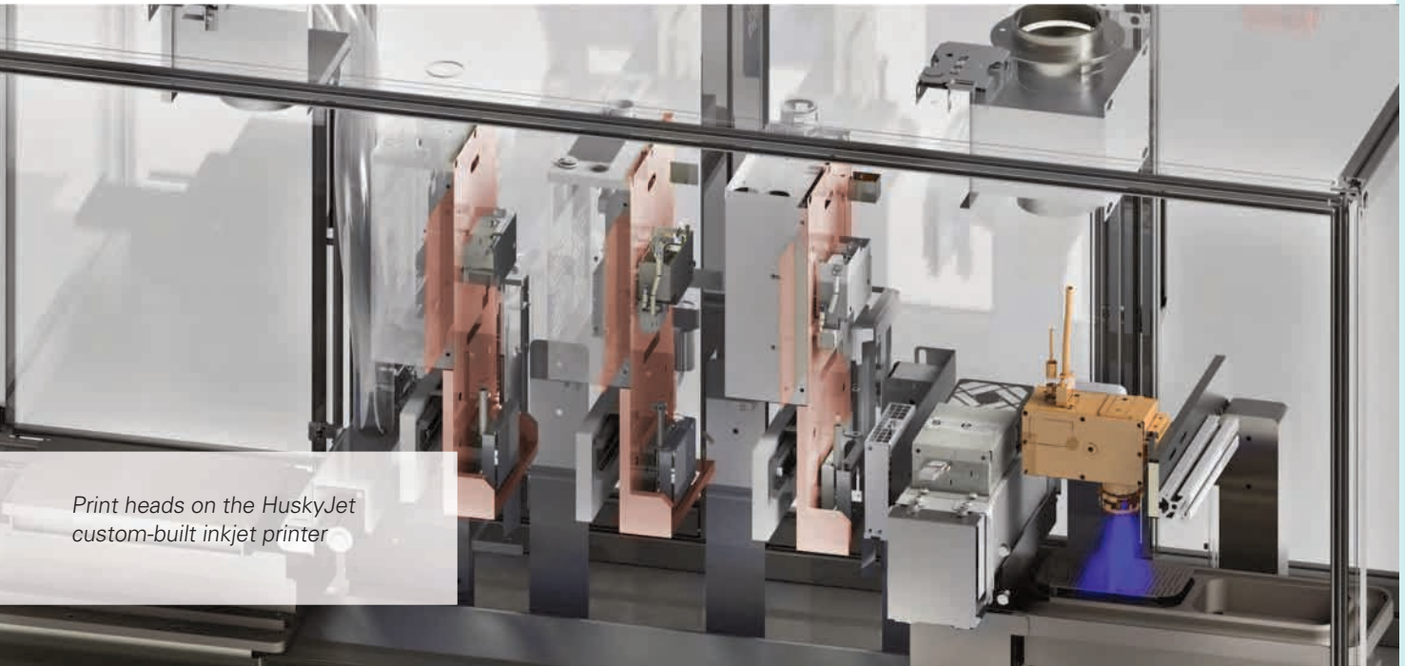
SHAP3D was established in July 2018 with funding from the National Science Foundation (NSF) and the founding industrial members. SHAP3D is a named NSF industry/university cooperative research center (I/UCRC) dedicated to the science of heterogeneous additive printing of 3D materials. A collaboration between UConn, UMass Lowell, and Georgia Tech and its members, the center aims to develop critical insight into the fundamental structure-processing-property relationships to predict and control the integration of diverse materials for 3D printing with a focus on polymer materials.

SHAP3D applies innovations from research universities to develop high-impact solutions to key challenges in additive manufacturing. It provides a platform in which companies and public agencies may cost-effectively collaborate on shared, pre-competitive research topics by leveraging R&D investment to access world class facilities, faculty and graduate students. SHAP3D's goal is to decrease cost and increase reliability at all stages of additive manufacturing for creating additively printed heterogeneous products that integrate multiple engineering materials with complex 3D structures and diverse functionality.

ANSON MA
Director SHAP3D
Department of Chemical
and Biomolecular Engineering

Accomplishments

Ten companies and federal agencies have joined the center as founding members. Current members include: The Boeing Co., United Technologies Research Corporation (UTRC), Hewlett-Packard (HP), Stratasys, Sandia National Laboratories, US Army Futures Command, Hutchison Aerospace and Industry, Integrity Industrial Ink Jet Integration, Midé, and Triton Systems. Twenty-four UConn faculty members are engaged with the center. The center reviewed twenty six proposals from faculty members in fall 2018 and funded seven projects with a total budget exceeding $360,000.



Print heads on the HuskyJet custom-built inkjet printer

Faculty: 24
Post-doctoral Fellows: 2
Graduate Students: 2
Staff: 1

UConn DENSsolutions Center for IN-siTu/ Operando Electron Microscopy (InToEM)

YUANYUAN ZHU
Director InToEM
Department of Materials Science
and Engineering

STEVEN L. SUIB
Co-director InToEM
Department of Chemistry

UConn DENSsolutions Center for IN-siTu/Operando Electron Microscopy (InToEM) is one of the latest additions to the Institute of Materials Science (IMS) and the IPB. In April 2019, the operation of the Climate MEMS-based Nano-Reactor TEM system heralded a new beginning for visualizing materials dynamics in operation, with simultaneous real-time mass spectrometry and calorimetry. This unique capability to probe (high temperature) gas-solid reactions at high spatial and temporal resolution opens up a world of opportunities for fundamental understanding of heterogeneous catalysis, fuel cells, corrosion, materials growth and transformation.

Climate G+ MEMS-based Nano-Reactor TEM System

Advanced Electron Microscopy Center Tackles Real World Challenges in Materials Science

With in-situ and/or operando transmission electron microscopy (TEM), scientists can study material reactions in the here and now. A new center at the UConn Tech Park aims to use this specialized technology to find innovative solutions for some of the most complex challenges facing society today.

The IN-siTu/Operando Electron Microscopy (InToEM) center represents a partnership between the UConn Tech Park and DENSsolutions, a firm based in the Netherlands that develops in-situ TEM technologies.

Yuanyuan Zhu, director of the InToEM center, works with the DENSsolution Climate system at UConn Tech Park. (UConn Photo)

InToEM will be the home of scientists and engineers with complementary expertise working at the frontier of materials dynamics.

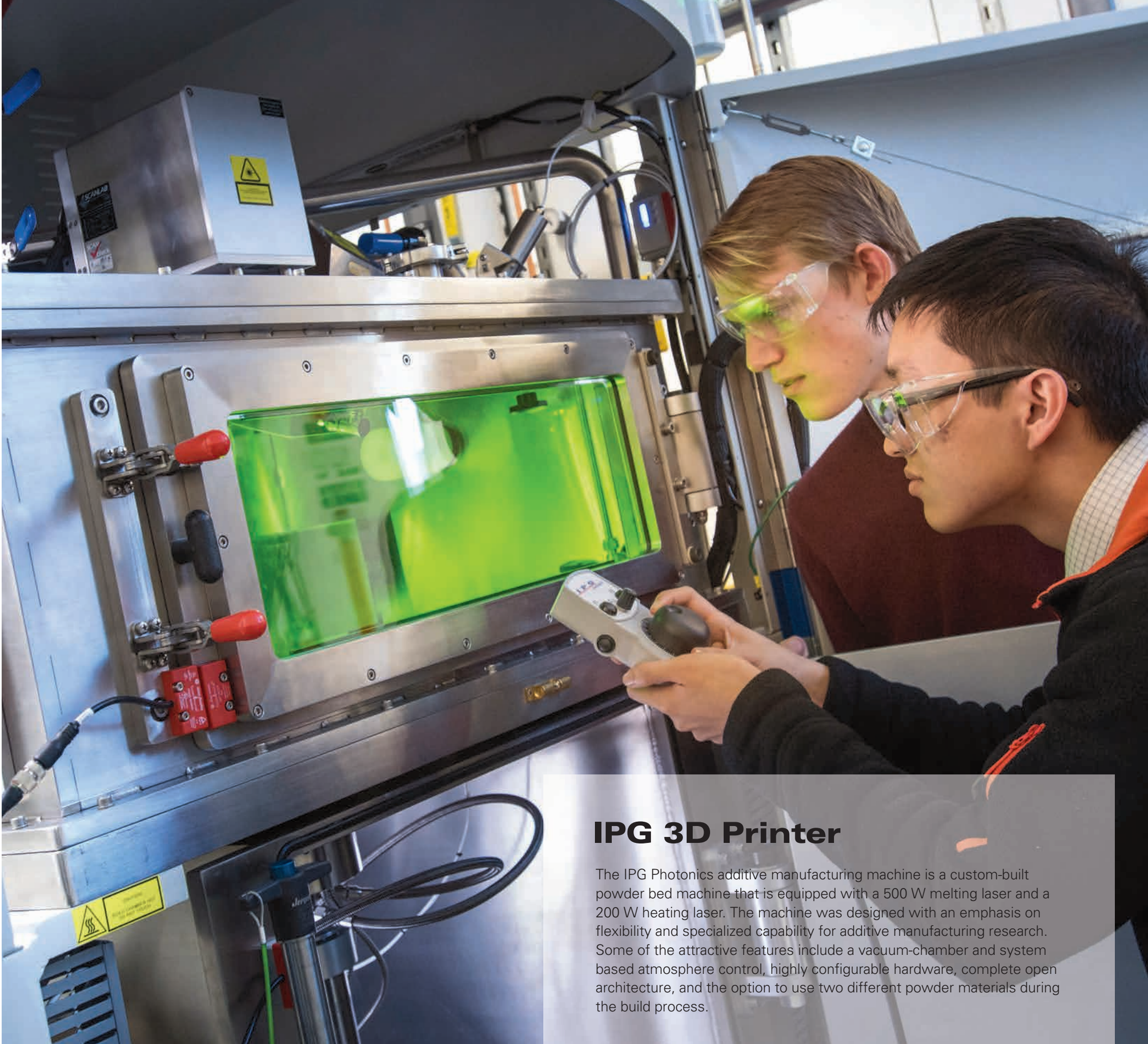
At the heart of the research center is the highly specialized Climate MEMS-based Nano-Reactor from DENSsolutions. The system is able to probe high-temperature gas-solid reactions with high spatial resolution under ambient pressure, in gaseous environments controlled by sophisticated dynamic gas mixing. The UConn scientists working in the center can monitor dynamic changes in local site-specific structural information of nanomaterials in real-time under realistic reaction conditions. This means they are able to gather more applicable information about what exactly is happening to the materials being tested, and can also conduct concurrent mass-spectrometry, calorimetry and chemical analysis while the material is in operation.

"Being able to study the behavior of materials in their native environment has been microscopists' dream since the birth of TEM," says Yuanyuan Zhu, director of the InToEM center. "I'm very excited about this collaboration, which will provide an optimal scientific 'sandbox' to explore microscopy as it should be." Zhu is also assistant professor in the Department of Materials Science and Engineering and Institute of Materials Science at UConn.

These new capabilities will provide unprecedented insight into the correlation between materials dynamics and temporal performance at the fundamental atomic-scale. The research team and partners at DENSsolutions have high hopes that the new center will open up a world of research opportunities in heterogeneous catalysis, fuel cells, corrosion, and materials growth and transformation.

"These new techniques connect microscopy more meaningfully with chemistry, materials research and nanotechnology," says Ben Bormans, CEO of DENSsolutions. "We are all very, very excited about being a partner in the InToEM center and with the world-class researchers at UConn."

- Jessica McBride - Office of the Vice President for Research



IPG 3D Printer

The IPG Photonics additive manufacturing machine is a custom-built powder bed machine that is equipped with a 500 W melting laser and a 200 W heating laser. The machine was designed with an emphasis on flexibility and specialized capability for additive manufacturing research. Some of the attractive features include a vacuum-chamber and system based atmosphere control, highly configurable hardware, complete open architecture, and the option to use two different powder materials during the build process.

RESEARCH CENTER

Pratt & Whitney Additive Manufacturing Center (PW AMC)

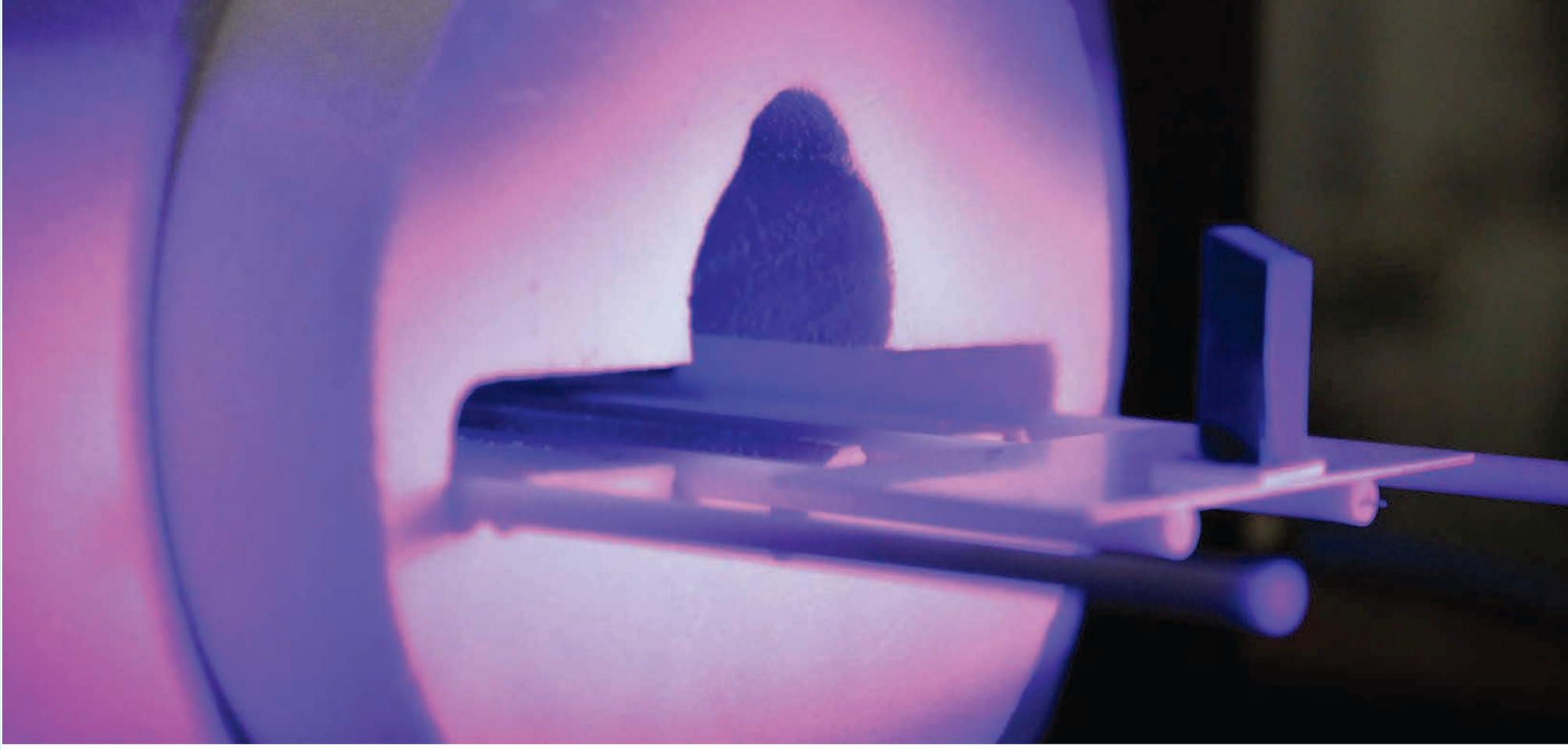
Pratt & Whitney Additive Manufacturing Center (PW AMC) is a premier facility for metal additive manufacturing. The range of equipment available includes electron beam melting and laser sintering technologies and a suite of thermophysical measurement instruments. PW AMC is focused on the underlying physics of additive manufacturing with emphasis on rapid solidification, powder spreading, and metal-atmosphere interactions. Experiments as well as ab-initio calculations are used to develop new insight into the additive manufacturing process. AMC furthermore addressed control theory with the goal to improve current machine technologies and supports the generation of data for manufacturing simulations.

Accomplishments

- PW AMC helped establish and will play a major role in a new consortium-based Center for Materials Processing Data (established 2018) with WPI, University of Buffalo, and ASM International.
- Fee for service work increased with the move into the IPB and the installation of thermophysical measurement equipment that supports manufacturing processes. Among the fee for service projects, Arcelor Mittal, the largest steel company in the world, has selected PW AMC as the first university-based research group in the US to assist with additive manufacturing work.
- Federal projects
  - » Tech Park received a $5.4M contract from the Air Force Research Laboratory in 2019 that includes a sub-project for PW AMC and funds two graduate students for four years.
  - » PW AMC was awarded a project from Office of Naval Research (ONR) ($400k/two years) to produce additively manufactured parts for high strain-rate testing at PW AMC and at the University of Rhode Island.
- PW AMC supported Capstone projects that help the sponsoring companies learn about metal additive manufacturing while training students on industry-relevant topics related to additive manufacturing. For 2018-19:
  - » (1) Stanadyne: "Additive Manufacturing of Gasoline Direct Injection Pump Parts", (2) Collins Aerospace: "Support structure optimization for ProX300 machine", (3) Pratt & Whitney: "Powder Rake studies".
- One of the center's recent Ph.D. graduates, Dr. Tulsi Patel (December 2018), was awarded a post-doctoral position at the Air Force Research Laboratory and has garnered a fellowship from the National Research Council.
- PW AMC participated in Thermo Fisher Scientific-organized webinars in 2018 during which Professors Hebert and Aindow and post-doctoral associate Dr. Sun highlighted characterization capabilities to over 600 webinar participants.

RAINER HEBERT
Director Pratt & Whitney
Additive Manufacturing Center
Co-director AFRL RAM
Department of Materials Science
and Engineering

Faculty: 5
Post-doctoral Fellows: 1
Graduate Students: 3
Undergraduate Students: 1
Staff: 3



TA Instruments ODP 868 is used for contact-less determination of thermal expansion.

Selected Publications

S. K. Nayak, C. J. Hung, R. J. Hebert, S. P. Alpay, "Atomistic origins of Guinier-Preston zone formation and morphology in Al-Cu and Al-Ag alloys from first principles," Scripta Mater. vol. 162, 235-240 (2019).

S. Sahoo, S. P. Alpay, R. J. Hebert, "Surface phase diagrams of titanium in Oxygen, Nitrogen and Hydrogen Environments: A first principles analysis," Surface Science, vol. 677, 18-25 (2018).

S. K. Nayak, C. J. Hung, V. Sharma, S. P. Alpay, A. M. Dongare, W. Brindley, R. J. Hebert, "Point defects in titanium: An ab-initio data mining analysis," npj Computational Materials, 4, Article number: 11 (2018), published online, March 16, 2018.

Y. Sun, R. J. Hebert, M. Aindow, "Non-metallic inclusions in 17-4PH stainless steel parts produced by selective laser melting," Materials and Design, vol. 140, 153-162 (2018).

Y. Sun, M. Aindow, R. J. Hebert, "Comparison of virgin Ti-6Al-4V powders for additive manufacturing," Additive Manufacturing vol. 21, 544-555 (2018).

Solving Problems in 3D

We've all watched videos, mesmerized, while a machine adds layer upon layer to 3D print anything from a model of the Eiffel Tower to a rubber duck. Aside from being really cool, this technology has tremendous implications for revolutionizing companies' manufacturing processes.

Under the leadership of Castleman Term Associate Professor in Engineering Innovation Rainer Hebert, the Pratt & Whitney Additive Manufacturing Center (PW AMC) at the UConn Tech Park is addressing the biggest problems currently faced by the aerospace industry in additive manufacturing.

Hebert has been a member of the UConn faculty since 2006. In 2012, when the University launched the first stage of its partnership with Pratt & Whitney to develop an additive manufacturing center, Hebert was at the helm. The center began with three machines in the Longley Building.

"The initial idea was really to support Pratt & Whitney, and at the same time train students here at UConn in the field of additive manufacturing," Hebert says. Hebert is astonished by how much growth the field and the center have experienced in that short time.

But that's not to say that any of this is a surprise to Hebert, an expert in materials science. Since his grad school days, Hebert has been interested in the rapid solidification of liquids to solid, amorphous metals, which is at the heart of additive manufacturing.

In powder bed additive manufacturing, lasers or electron beams move quickly over powder substances to melt and then rapidly solidify them at rates of about 100,000 degrees per second.

The Pratt & Whitney Additive Manufacturing Center does not typically create 3D printed parts; rather, the research team works on understanding the science behind the printers and how to make them perform better. The center provides its industry partners with answers to fundamental scientific questions about the process, allowing them to invest wisely in these cutting-edge technologies.

"The pace of industry and academia is different. At the PW AMC, we focus on the fundamental questions that help industry stay ahead right now and innovate for the future," says Hebert.

> *We focus on the fundamental questions that help industry stay ahead right now and innovate for the future.*
>
> — Rainer Hebert

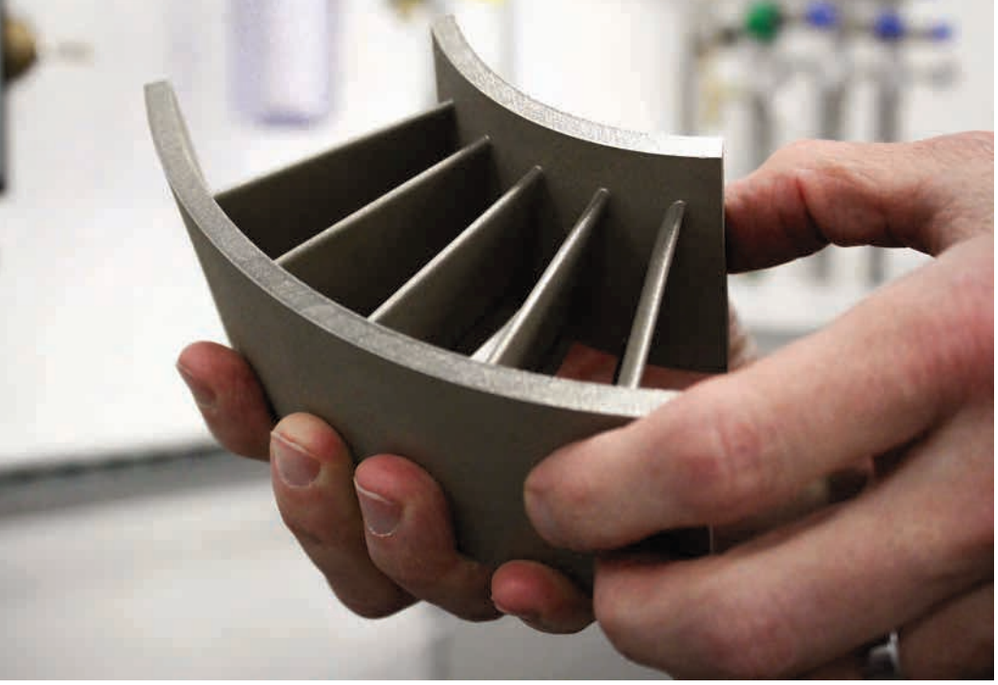
When the PW AMC moved into the IPB, the center was able to expand its floorspace and add new machines to its technological roster. UConn's hub for collaborative research between industry and academic researchers, the IPB is designed to house sensitive machines and minimize interference from external or environmental variables that can impact the accuracy of their results.

"The most exciting part is really the equipment," Hebert says. "It's not just that we have one or two specialized instruments. What sets us apart for this type of work is that we have a suite of equipment to find solutions for these unique challenges. I can say there is simply no other place nationally or internationally with our capabilities in this area of research."

One of the PW AMC's current efforts utilizes highly specialized technologies to characterize the thermophysical properties of materials used in additive manufacturing. With their sophisticated tools, UConn researchers and students can look at factors like the viscosity and thermal diffusivity of metals or powders and their thermal properties under extreme heating and cooling conditions. This data is critical to creating accurate simulations of additive manufacturing processes.

"These are all material properties that are needed for manufacturing simulations – be it additive manufacturing or more traditional manufacturing technologies – so it is applicable for many business in the state," Hebert says. "It is a relatively new area for us, but it's very important for industry to have that data available. We are doing what we can to provide that for them."

In fact, all of the center's projects try to respond directly to industry needs, often in new areas of R&D for the companies and the UConn engineers. From customized alloys specifically designed for additive manufacturing, strategies to prevent cracking and damage during the additive manufacturing process, or better understanding of how powders behave in additive manufacturing machines – research at the PW AMC doesn't exist in a bubble and always seeks real-world solutions for its industry partners.



Hebert holds additively manufactured samples for R&D that emulate real-world component designs.

Hebert works with equipment to determine melting points and other thermodynamic properties at temperatures up to about 3,000 degrees Fahrenheit.

"The value for us in working closely with Pratt & Whitney and other small to medium sized companies in the aerospace field is to understand what the actual application issues are, what the problems are that need to be addressed, so we can use our expertise and unparalleled facilities to find answers," Hebert says.

Hebert's center has worked closely with companies small, medium, and (very) large, ones that are close to home and others that are located across the globe. These companies include Pratt & Whitney, Collins Aerospace, aerospace supply chain companies, as well as firms from other sectors that specialize in raw materials and in the automotive industry.

PW AMC researchers have also been able to collaborate with some internal partners too, namely the Thermo Fisher Center for Advanced Microscopy and Materials Analysis at the Innovation Partnership Building (IPB) at UConn Tech Park. The two centers joined forces on a project that uses Thermo Fisher's sophisticated microscopy equipment to learn more about the additive manufacturing process. The project has allowed the Additive Manufacturing Center to develop a trove of microstructure data for understanding the additive manufacturing process they could not have collected otherwise.

As a dedicated educator, Hebert is also thrilled with the real-world experience these industry partnerships provide for his students. Student researchers have direct contact with industry partners, hear about their most pressing problems, and work with internationally recognized faculty researchers and the cutting-edge technology available at the IPB to tackle these challenges.

"By training undergraduate and graduate students to use this technology and showing them the industry-specific applications, we're helping create a talent pipeline that benefits the students, the companies, and the state. It's a win-win situation," Hebert says.

Moving forward, Hebert says he envisions the center maintaining its focus on solving fundamental challenges related to the additive manufacturing process and maximizing the new, highly specialized equipment at the IPB. He also expects a growing emphasis on improving manufacturing simulations.

"This really is a very large field and we are just at the beginning. We're all proud of how far we've come since the early days at the Longley Building, but I'm confident that the future holds many more advances, innovations, and solutions. That's what is truly exciting."

- Anna Zarra Aldrich '20 (CLAS), Office of the Vice President for Research

RESEARCH CENTER

UConn Thermo Fisher Scientific Center for Advanced Microscopy and Materials Analysis (CAMMA)

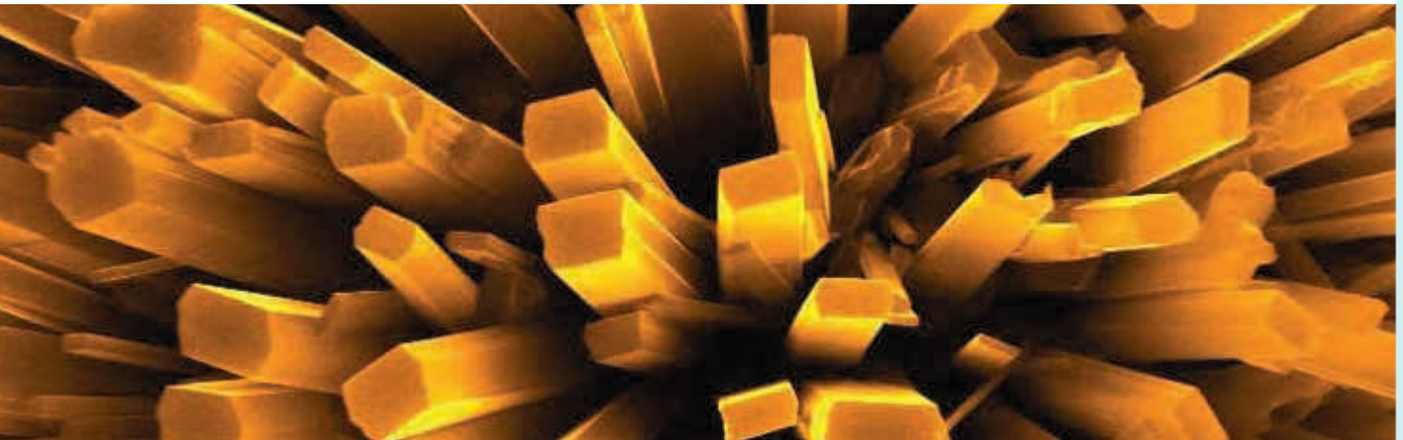
CAMMA is one of the world's foremost facilities for electron microscopy. Its microscopy instruments include the Titan Themis for imaging and analysis of materials down to the sub-angstrom level, and the Talos 200 S/TEM for high resolution imaging and quantitative energy dispersive spectroscopy to determine the chemical composition of materials.

This equipment is available for collaborative research with industry partners including applications for clean energy materials and the testing of additively-manufactured components such as those found in medical devices and polymeric materials for biomedical applications.

Accomplishments

- CAMMA obtained and installed seven new electron microscopes with capabilities of SEM, STEM, FIB, EELS, EDX, TEM, and others.
- During the first three months of 2019, CAMMA personnel trained 25 new users on the center's nine microscopes.
- The center currently serves over 150 graduate student users and 38 faculty users across 8 departments from the School of Engineering and the College of Liberal Arts and Sciences including biology, physics, environmental science, chemistry, pharmacy, biomaterials and materials science and engineering.
- The Titan Themis, one of the most advanced and complex electron microscopes in the world, was brought fully online after five months of qualification/certification of the space and instrument calibration, testing and additional adjustments.
- One new Ph.D. staff member was hired to manage the Titan Themis microscope.
- CAMMA's advanced capabilities played a key role in attracting three top academic materials science researchers who have a primary focus on use of electron microscopy methods in their research.
- In the past year, CAMMA fellowships were awarded to five IMS graduate students.
- The partnership with Thermo Fisher scientific has allowed new research projects to flourish in support of the IMS Industrial Affiliates Program and other academic/industrial interactions.

False colored bearns of a relatively fresh mineral discovery: "rudabanyait" from Hungary, Rudabanya. (Image courtesy of Thermo Fisher Scientific)



STEVEN L. SUIB
Director CAMMA
Department of Chemistry

Faculty: 38
Researchers: 5
Post-doctoral Fellows: 3
Graduate Students: 136
Staff: 3

Selected Publications

S. Vijayan, M. Aindow, "Temperature calibration of TEM specimen heating holders by isothermal sublimation of silver nanocubes," Ultramicroscopy, 196, 142–153 (2019).

Y Sun, R. J. Hebert; M. Aindow, "Non-metallic inclusions in 17-4PH stainless steel parts produced by selective laser melting," Mat. Design, 140, 153–162 (2018).

B. A. Bedard, T. J. Flanagan, A. T. Ernst, A. Nardi, A. M. Dongare, H. D. Brody, V. K. Champagne Jr., S. W. Lee, M. Aindow, "Microstructure and Micromechanical Response in Gas-Atomized Al 6061 Alloy Powder and Cold-Sprayed Splats," J. Therm. Spray Tech., 27, 1563–1578 (2018).

B. Dutta, Y. Wu, J. Chen, J. Wang, J. He, M. Sharafeldin, P. Kerns, L. Jin, A. Dongare, J. Rusling, S. L. Suib, "Partial Surface Selenization of Cobalt Sulfide Microspheres for Enhancing the Hydrogen Evolution Reaction," ACS Catalysis, 9, 456-465 (2018).

D. Vovchok, C. J. Guild, J. Llorca, R. M. Palomino, I. Waluyo, J. A. Rodriguez, S. L. Suib, S. D. Senanayake, "Structural and Chemical State of Doped and Impregnated Mesoporous Ni/CeO2 Catalysts for the Water-gas Shift," Appl.Catal. A, 567, 1-11 (2018).

Patents

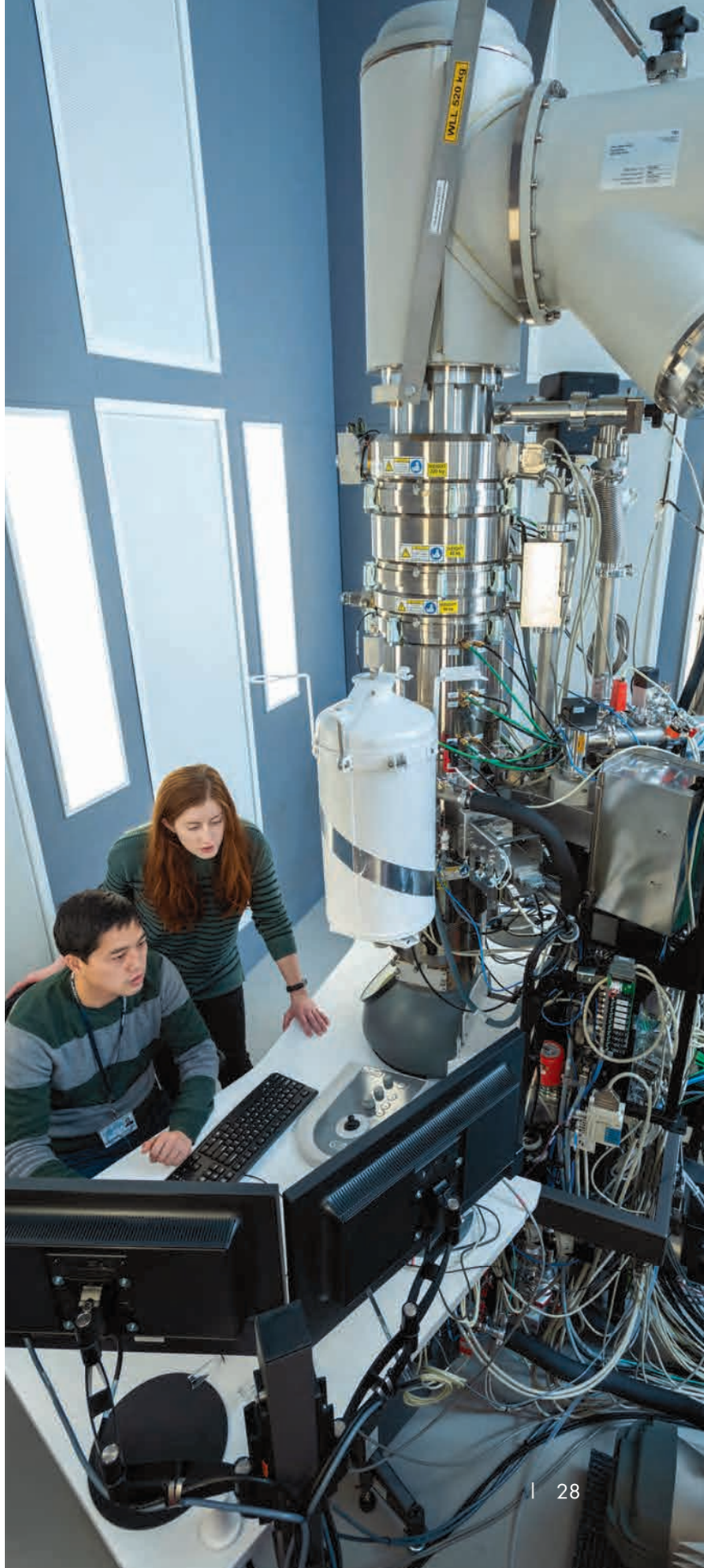
Suib, S. L.; Dharmarathna, D. A. S.; Pahalagedara, L., Method for Removing Soot from Exhaust Gas, US Patent 9869222, January 16, 2018.

Suib, S. L., Preceramic polymer for Ceramic Including Metal Boride, US Patent 9890088, February 13, 2018.

Suib, S. L.; Poyraz, A. Mesoporous Metal oxides and Processes, US Patent 9908103, March 6, 2018.

Suib, S. L.; Poyraz, A. Mesoporous Metal oxides and Processes for Preparation thereof, US Patent 10046313, August 14, 2018.

Suib, S. L.; Pahalagedara, L. R.; Kuo, C. H., Adsorptive Desulfurization, U.S. Patent 10081006, September 25, 2018.



Researcher Haiyan Tan and graduate student Hannah Leonard use the Titan Themis ACEM. (Al Ferreira)

RESEARCH CENTER

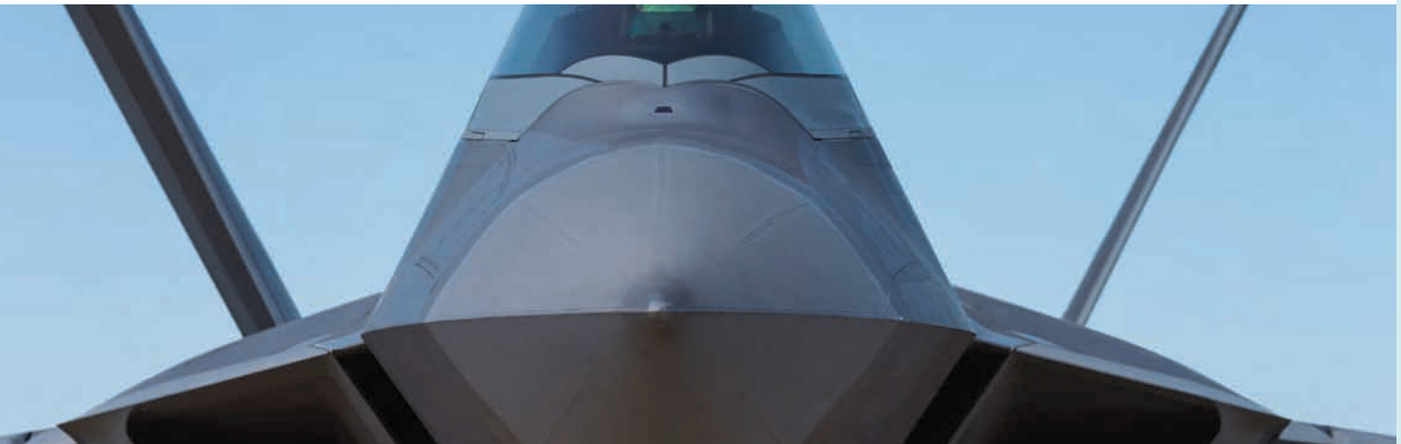
Collins Aerospace Center for Advanced Materials

The Collins Aerospace Center for Advanced Materials, established in 2016, is the result of the continuing collaboration between UConn and Collins Aerospace (previously UTC Aerospace Systems) for over two decades. The Center offers educational funding to graduate and undergraduate students as well as post-doctoral fellows in areas related to materials development and characterization. It provides an opportunity for firsthand interactions with an industrial partner whose focus is on advanced aerospace and defense products.

Collins Aerospace is one of the world's largest suppliers of technologically advanced aerospace and defense products. Collins designs, manufactures and services integrated systems and components for the aerospace and defense industries, supporting a global customer base with significant worldwide manufacturing and customer service facilities.

Accomplishments

- Developed computational framework to rationalize early phase precipitation in Al alloys
- Used computational framework and experiments to identify binary Al alloy with hardness comparable to Al6061
- Developed physical simulation of powder bed additive manufacturing with solid samples instead of powders
- Demonstrated feasibility of additive manufacturing of amorphous Al alloys
- Generation of oxide/oxide composites
- Establishment of in situ TGA CVD apparatus
- Generation of stable minicomposites
- Established the links between alloy composition, cooling rate in powder processing and l-phase morphological development in the Gen 2 alloys
- Determined the effects of alloy composition and post-consolidation processing on the tensile properties (yield strength, UTS, elongation and reduction in area) for Gen 2 alloys
- Acquired cyclic voltammetry data to identify open circuit, pitting and passivation potentials for as-consolidated and forged Gen2 alloys as a function of exposure time
- Constructed a modified apparatus for electrochemical impedance spectroscopy to measure the contributions of the various processes occurring to the total corrosion response



Collins Aerospace

PAMIR ALPAY
Director Collins Aerospace
Center for Advanced Materials
Co-director AFRL
Department of Materials Science
and Engineering

Principal Investigators: 4
Post-doctoral Fellows: 1
Graduate Students: 10
Undergraduate Students: 3

Selected Publications

S. K. Nayak, C. J. Hung, R. J. Hebert, and S. P. Alpay, "Atomistic origins of Guinier-Preston zone formation and morphology in Al-Cu and Al-Ag alloys from first principles," Scripta Materialia, 162, 235-239 (2019).

K. Petroski, S. Poges, C. Monteleone, J. Grady, R. Bhatt, and S. L. Suib, "Rapid Chemical Vapor Infiltration of Silicon Carbide Minicomposites at Atmospheric Pressure," ACS Appl. Mat. & Interf. 10, 4986-4992 (2018).

S. Poges, J. Jin, C. Guild, W. N. Li, M. Birnkrant, and S. L. Suib, "Preparation and Characterization of Aluminum Coatings via Electroless Plating Onto Nickel Nanowires Using Liquid Plating Solution," Mat. Chem. Phys. 207, 303-308 (2018).

S. Poges, C. Monteleone, K. Petroski, G. Richards, and S. L. Suib, "Preparation and Characterization of an Oxide-Oxide Continuous Fiber Reinforced Ceramic Matrix Composite with a Zinc Oxide Interphase," Cer. Int. 43, 17121-17127 (2017).

S. Vijayan, B. A. Bedard, M. A. Gleason, H. R. Leonard, D. L. Cote, M. Aindow, "Studies of thermally activated processes in gas-atomized Al alloy powders: in situ STEM heating experiments on FIB-cut cross-sections," J Mater Sci 54: accepted – in press (2019).

RESEARCH CENTER

UTC Institute for Advanced Systems Engineering (UTC-IASE)

The UTC Institute for Advanced Systems Engineering (UTC-IASE) produces, disseminates, and commercializes new science and technology in the field of cyber-physical systems engineering through transformative research, education, and workforce development. The Institute serves as a hub for world-class research, project-based learning by globally distributed teams of students, and industrial outreach activities focused on model-based systems engineering of complex systems that are built from and are dependent on the synergy of computational and physical components. Research applications are broad, and include smart buildings and cities, aerospace systems, manufacturing and energy industries, robotics, and cybersecurity.

Accomplishments

The UTC-IASE has built research and educational programs in the foundational scientific areas of (a) requirements formalization and systems engineering; (b) physics and data driven modeling; (c) advanced system control and optimization; (d) system diagnostics, prognostics and health management; (e) uncertainty and big data; and (f) systems engineering principles of cybersecurity. The UTC-IASE has become a world-class hub for research in three technology areas: (a) platform-based requirements formalization, (b) hybrid and heterogeneous acausal modeling of cyber and physical system components and systems; and (c) information & big data management and stewardship. With emphasis on the training of undergraduate and graduate students at UConn and professional engineers from around the world, the Institute has integrated research and training activities in the creation of a training and talent ecosystem in the area of cyber-physical systems engineering. The Institute's professional training program has trained more than 200 professionals to date, with over 40 in the 2018-2019 Academic Year. On the research and outreach fronts, significant accomplishments of the Institute in 2018-2019 include:

- 7 UTC-sponsored projects for a total funding over $800,000, engaging 19 UTC engineers/scientists and 15 students/fellows
- 25 peer-reviewed Journal & Conference papers, more than 15 conference presentations, and 20 invited talks by UTC-IASE core faculty
- 5 major extramural grants funded for total award of over $5,000,000, including projects sponsored by the NSF, the DoD-ARM Institute, the DoE CESMII, and NASA
- 29 industry outreach efforts, 2 distinguished lectures, and 4 seminars

Seven core participating faculty, and forty five affiliated faculty have helped the UTC-IASE to engage in these research, education and outreach activities.

United Technologies

GEORGE BOLLAS
Director UTC-IASE
Co-director AFRL RAM
Department of Chemical
and Biomolecular Engineering

Faculty: 7
Affiliated Faculty: 45
Graduate Students: 12
Staff: 1

Selected Publications

D. Zhang, P. B. Luh, J. Fan and S. Gupta, "Chiller plant operation optimization with minimum up/down time constraints," IEEE Robotics and Automation Letters, 3(1), pp.9-15 (2018).

D. Zhang, P.B. Luh, J. Fan, S. Gupta, "Chiller plant operation optimization: energy-efficient primary-only and primary-secondary systems," IEEE Transactions on Automation Science and Engineering, 15(1), pp.341-355 (2018).

D. Wang, X. Chen, "A spectral analysis of feedback regulation near and beyond Nyquist frequency" IEEE/ASME Transactions on Mechatronics, 23(2), pp.916-926 (2018).

W.T. Hale, M.E. Wilhelm, K.A. Palmer, M.D. Stuber, G.M. Bollas, "Semi-infinite programming for global guarantees of robust fault detection and isolation in safety-critical systems," Computers & Chemical Engineering, 126, pp.218-230 (2019).

K.A. Palmer, W.T. Hale, G.M. Bollas, "Active fault identification by optimization of test designs," IEEE Transactions on Control Systems Technology, (99), pp.1-15 (2018).

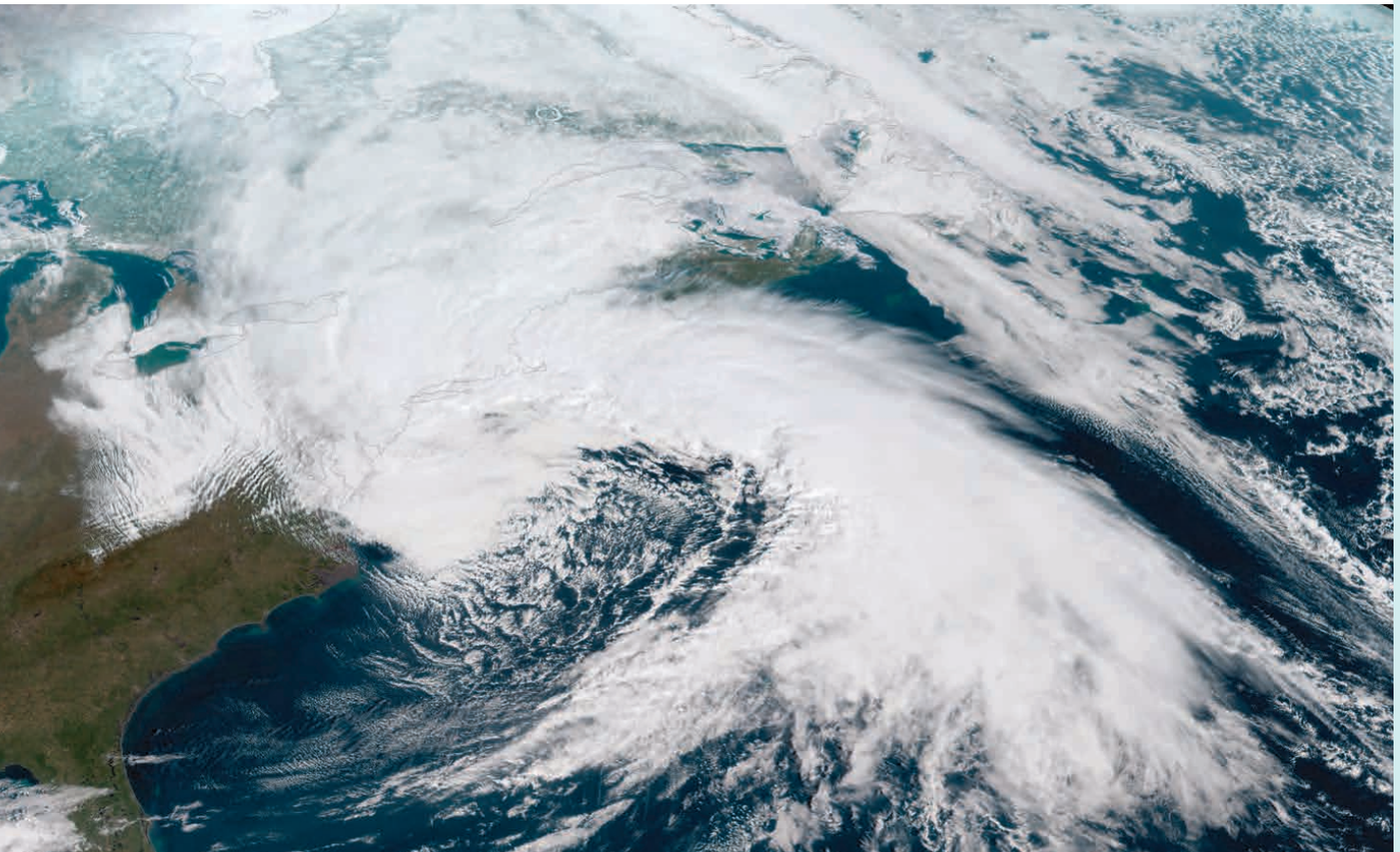
RESEARCH CENTER

Eversource Energy Center

The Eversource Energy Center leads the utility industry in innovating and developing new technologies and science-based solutions to ensure the delivery of reliable power and enhanced risk management associated with cyber and physical infrastructure security. Through research and teaching, the center is advancing the next generation of storm outage forecasting, best practices for healthy and storm-resistant forest design, and new technologies to proactively pinpoint electric grid operational efficiencies and storm resiliency improvements.

Accomplishments

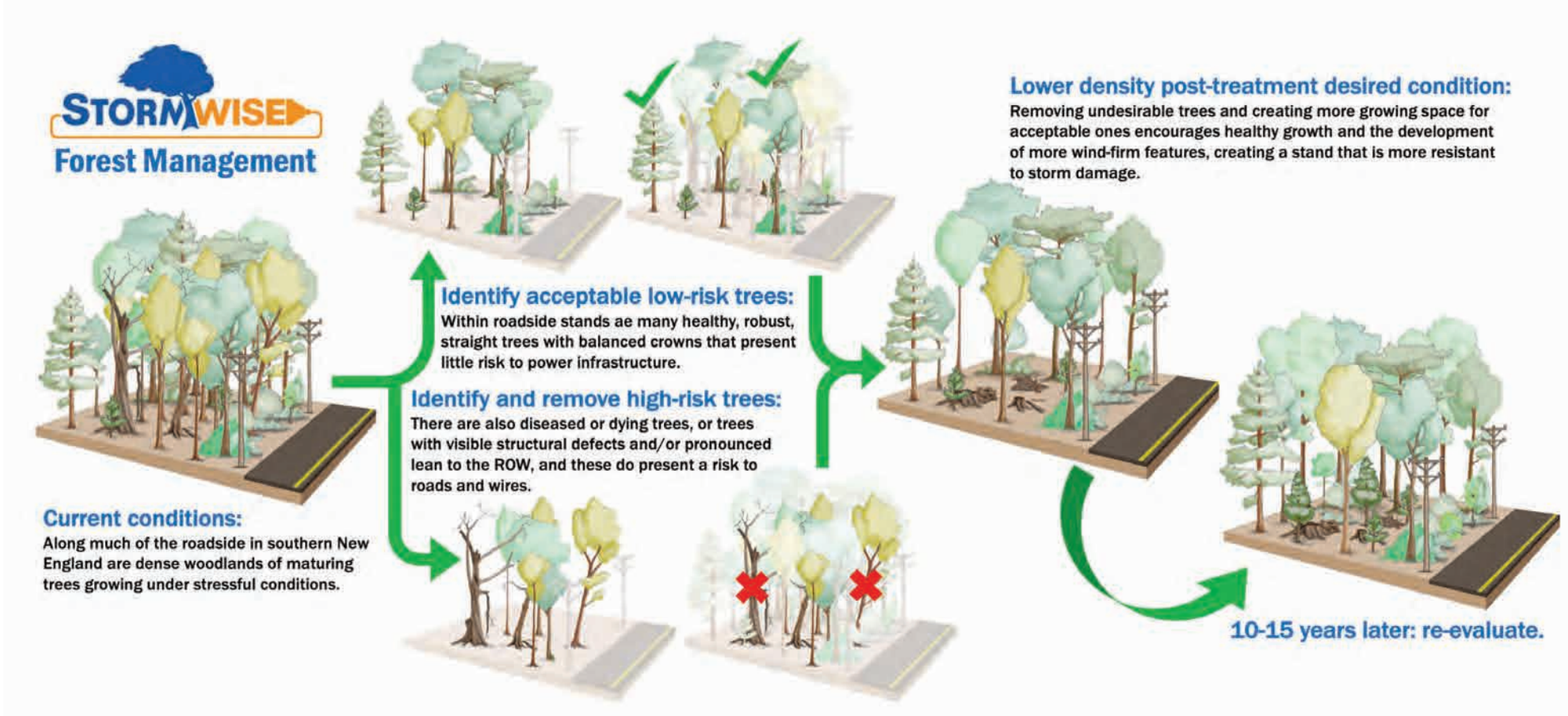
The Eversource Energy Center is establishing strategic partnerships nationally in the areas of grid resilience, security, and modernization. Its accomplishments include the center's Outage Prediction Model, which has been in operation since 2015, benefiting millions of people across New England. It has proved influential and valuable to Eversource Energy and is becoming a powerful tool to help researchers understand the complex interactions between the power grid infrastructure and the environment during extreme weather events. Another major accomplishment is the creation of Stormwise, an innovative forest management and public education project that focuses on reducing the risk of power outages and other damage caused by wind-related tree failure. Over fifteen research activities were carried out this year in the areas of power grid storm readiness, tree and forest management, grid vulnerability assessment, grid resilience and grid modernization. The center has published 45 peer-reviewed articles over the past three years.



EVERSOURCE

EMMANOUIL ANAGNOSTOU
Director Eversource Energy Center
Department of Civil and Environmental Engineering

Faculty: 26
Graduate Students: 25
Staff: 2



Selected Publications

A. Bunce, J.C. Volin, D.R. Miller, J. Parent, M. Rudnicki, "UCONN Tree Sway Biomechanics Project" (pre-thinning tree sway and weather data) (2018).

D. Cerrai, E.N. Anagnostou, et al., "Improving Predictability of Storm Power Outages by Evaluating a New Representation of Weather and Vegetation in Non-parametric Modeling," IEEE-Access (2019).

E. I. Nikolopoulos, E. Destro, A.E. Bhuiyan, M. Borga, and E.N. Anagnostou, "Evaluation of Predictive Models for Post-fire Debris Flows Occurrence in the Western United States," Nat. Hazards Earth Syst. Sci., 18, 2331-2343 (2018).

D. Wanik, E. N. Anagnostou, T. Layton, B. M. Hartman, "Estimated Time of Restoration (ETR) Guidance for Electric Distribution Networks," Journal of Homeland Security and Emergency Management (2018).

J. Yang, M. Astitha, L. Delle Monache, S. Alessandrini, "An Analog Technique to Improve Storm Wind Speed Prediction Using a Dual NWP Model Approach, Monthly Weather Review," (2018).

Patent

E.N. Anagnostou, D. Wanik, B. Hartman and J. He, Systems and Methods for Outage Prediction, US Patent Application No. 62/363,156, July 15, 2016.

Quantifying Chaos

Eversource Energy Center

> It's nice to be in an highly advanced, well-designed building where there's a lot of positive momentum and energy around you."
>
> — Emmanouil Anagnostou

Sitting glued to the evening news as a lively weatherperson displays colorful maps with patches of snow, ice and rain is a familiar pastime for anyone who has lived in New England. From blizzards and ice storms to hurricanes and tornadoes, extreme weather is a fact of life, and one of its worst side effects is power outages that can take out entire towns and cities for days or even weeks.

A lot of behind the scenes work goes into producing the weather maps local weather stations show viewers. They are built from valuable modeling data off-screen which researchers at the Eversource Energy Center mine and synthesize. The Eversource Energy Center is located at the UConn Tech Park.

The man behind the modeling is Emmanouil Anagnostou, director of the Eversource Energy Center and professor in UConn's department of civil and environmental engineering.

Originally from Athens, Greece, Anagnostou started his career as an engineering hydrologist using satellites to sense precipitation patterns on earth.

But about a decade ago, he moved to weather models for other purposes, specifically to make predictions about extreme weather events, which are the driving forces behind the hydrological problems he was studying.

Anagnostou does not develop weather prediction models, rather he uses some of the existing predictive tools to determine the impact of a weather system on the ground.

"I'm primarily a user of weather models, but a smart user," Anagnostou says. "That's where my research lies: on the interface between what we get from numerical weather prediction and using the data in impact modeling."

Anagnostou and his team at the Eversource Energy Center have developed an Outage Prediction model to process data about weather, infrastructure, and vegetation that correlate with power outages.

The model informs utility companies of vulnerabilities in their grid. This helps companies make more informed decisions about deploying crews to repair storm outages, and where they need to improve infrastructure or trim trees to prevent or mitigate the effects of storms on the power grid's resilience.

The Eversource Energy Center Outage Prediction Model already supports around half a dozen utility service territories in New England. Anagnostou and his team of students, other researchers, and industry collaborators are looking to expand services to other parts of the country.

Bringing together UConn researchers, experienced emergency response crews, and the artificial intelligence of the models has proven to be a winning combination.

"We know both from experience and from the literature that human expertise plus AI beats either the human or the AI alone, which is good news," Anagnostou says.

New Englanders need just to remember the winter 2017-'18 for proof. That year, New England was pummeled by snow storm after snow storm. For these events Eversource Energy had to bring in extra crews from southern states to help repair downed power lines. As the next storm loomed, they faced a dilemma–whether to keep the hired crews up north and continue paying them or send them back and hope the second storm wouldn't be that bad.

The Eversource Energy Center outage predictions indicated the storm was going to be as severe, if not worse than the last one, so officials decided to keep the crews. This turned out to be a wise choice as the storm was absolutely devastating for Eastern Massachusetts.

"That's a case where you can really see the value of prediction, because without much information about the impact of the next storm, they probably would have sent the crews back," Anagnostou says.

"The collaboration with Eversource has been a harmonious one," Anagnostou says.

"We've reached the point that this relationship is a true partnership," Anagnostou says. "It's not just about the funding, and that's what makes me firmly believe it will be a very long partnership."

Research With Global Impact

Anagnostou leads another team of faculty and graduate students from UConn and collaborating institutions worldwide who are funded by the National Science Foundation Partnership for International Research and Education (PIRE) for applications of their research to societal problems like food insecurity.

On the other side of the globe, the PIRE team is working with farmers in Ethiopia, where accurate prediction of the wet season's precipitation is essential to farmers' survival. The PIRE team's predictions can help these farmers make informed decisions about what kind of crops to plant and how much of the land to leave fallow.

Anagnostou is also looking for what the future could hold in terms of extreme weather, especially as man-made climate change exacerbates many of the conditions that cause dangerous storms.

Using data from the past decades, he and his collaborators are able to employ both dynamic and statistical models to predict how trends that appear in hydrological data may continue or change over time. These models can even work to quantify hydrological hazards and risks from severe weather events a century into the future, as disastrous weather events like hurricanes, droughts, and floods could become more severe or even more common given current climate change patterns.

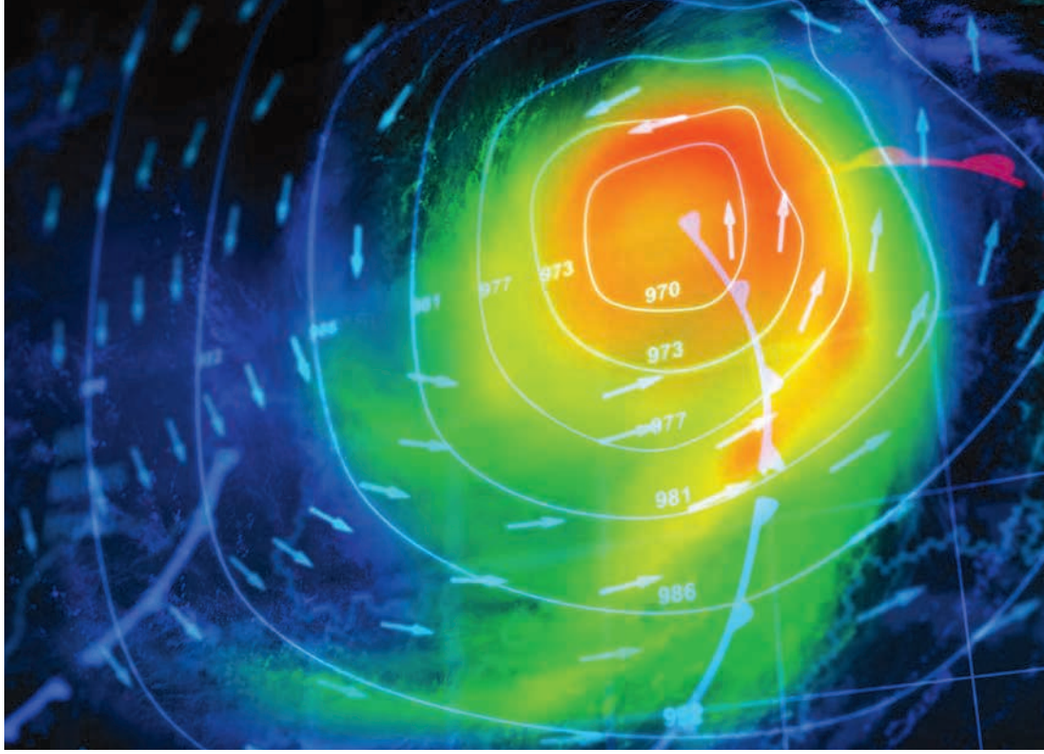
Great Minds Come Together

While their labs are filled with specialized computers instead of microscopes, Anagnostou, his research team, and collaborators draw inspiration from their space at the UConn Tech Park.

"It inspires the students," Anagnostou says. "They feel privileged to be here. It's nice to be in an highly advanced, well-designed building where there's a lot of positive momentum and energy around you."

The massive glass-encased Innovation Partnership Building (IPB) is home to ten diverse high-tech research centers that have the opportunity to work with each other on multi-faceted problems.

For example, the Eversource Energy Center teamed up last year with the United Technologies Institute for Advanced Systems Engineering on a research proposal to the Advanced Research Projects Agency-Energy (ARPA-E) designed to develop a way to incorporate renewable energy into the existing power grid, avoiding a large-scale overhaul of the existing infrastructure.



On another partnering project, Eversource Energy Center is tackling the issue of power grid vulnerability to cyber-attacks. Having so many homes and buildings attached to a single grid creates a significant risk for a large number of customers. Working with another Tech Park center, the Connecticut Cybersecurity Center, Anagnostou is developing a training program for utility industry workers about how to prevent and recover from a cyber-attack.

At the center of all these initiatives are around two dozen Ph.D. and graduate students. They have published nearly 40 papers in the course of three short years and many have gone on to promising careers in research or the private sector.

"The students get access to state-of-the-art facilities and data, which provides a tremendously valuable experience and opportunity. Data really is the key. Through our partnership, Eversource is giving us access to their data, very rich data, that allows us to pilot a number of ideas," Anagnostou says. "Data, to me, is the most valuable source for someone to do research."

Anagnostou's research combines powerful data with the kind of expertise and judgment only living, breathing humans can offer to predict and create better outcomes. The work at his center helps farmers in Africa and emergency response crews in Connecticut alike prepare for whatever the weather has in store, since when it rains, it could pour.

- Anna Zarra Aldrich '20 (CLAS), Office of the Vice President for Research

RESEARCH CENTER

Fraunhofer USA Center for Energy Innovation CEI

Fraunhofer USA Center for Energy Innovation CEI is dedicated to applied research in membrane technology. The CEI is part of Fraunhofer USA, Inc., a 501 (c) (3) not-for-profit organization that aims to close the innovation gap from the lab to the market and develop and validate technologies for industrial innovation in the United States. The CEI's focus on membrane technology allows it to provide R&D services across numerous industrial sectors.

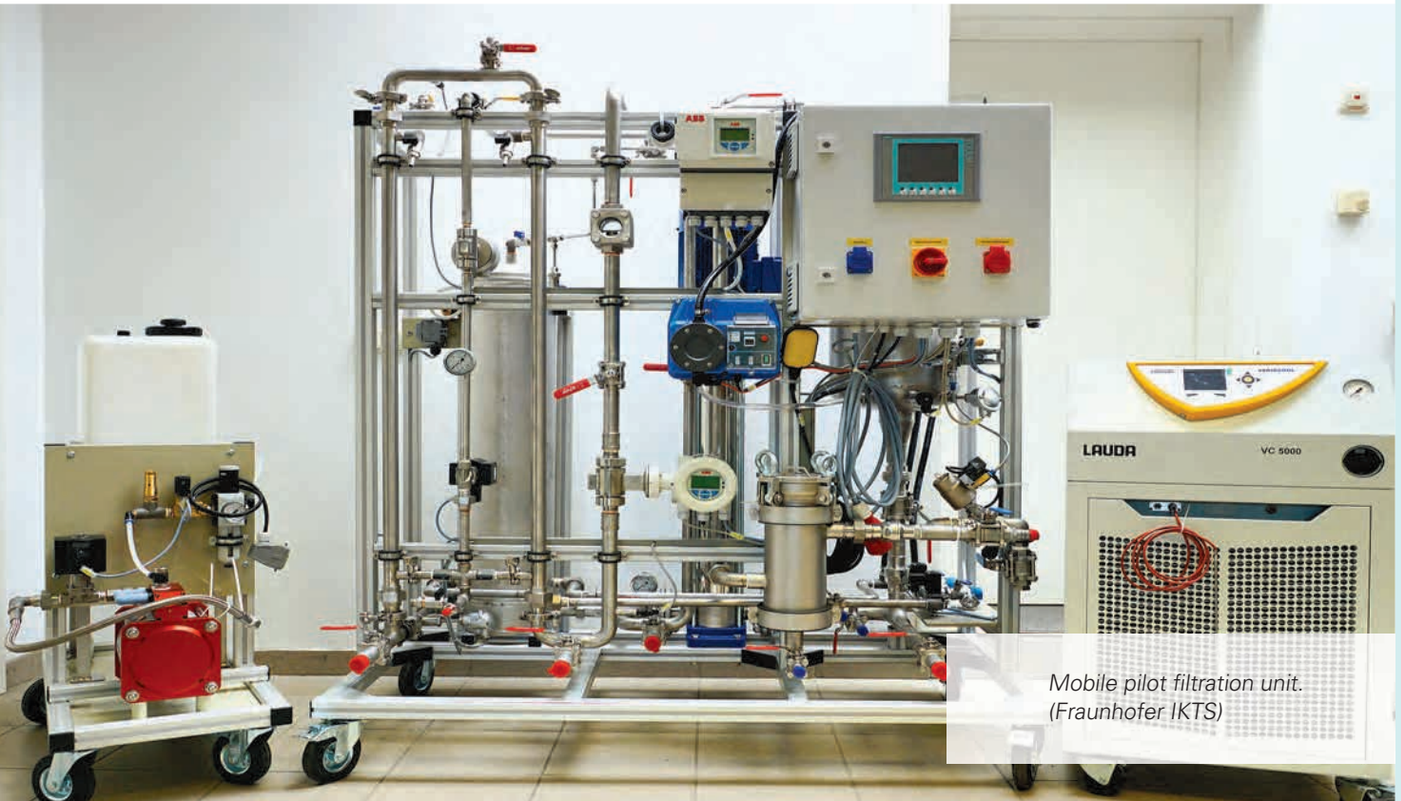
Our center is equipped with state-of-the-art membrane testing and characterization equipment. These include

Bench-scale:

- Reverse osmosis
- Nanofiltration
- Forward osmosis
- Direct contact membrane distillation
- Vacuum membrane distillation
- Pervaporation
- Vapor permeation
- Gas-liquid contactor
- Gas permeation (Fall 2019)

Element-scale:

- Reverse osmosis – spiral wound elements
- Forward osmosis – spiral wound, plate and frame, or hollow fiber elements
- Ultrafiltration and nanofiltration ceramic elements



Mobile pilot filtration unit. (Fraunhofer IKTS)

JEFF MCCUTCHEON
Fraunhofer USA Center for Energy Innovation CEI
Department of Chemical and Biomolecular Engineering

Faculty: 1
Graduate Students: 3
Staff: 4

Ceramic filtration membranes. (Fraunhofer IKTS)

Accomplishments

The Fraunhofer USA CEI completed a reorganization in 2017 that has seen it shift into a contract research services role associated with energy efficient separations technology. The reorganization has resulted in the construction of a new lab at the IPB and the execution of new contracts with Fraunhofer USA and the Connecticut Department of Economic and Community Development. The contracts and lab completion are enabling us to proceed with an aggressive hiring plan in technical staff and business development.

Since the reconfiguration of the center in 2017, we have raised $1.5M in project funding which includes approximately $200K in collaborative awards to UConn. We are currently managing a major DOE award out of the Concentrated Solar Program ($1.1M) and are starting a program with RAPID ($322K).

Additionally, our faculty and students have given multiple presentations as a center during the past year. One of our recently graduated doctoral students, Dr. Lingling Xia, won a poster award for her work at the International Conference on Inorganic Membranes in June 2018. She also published a paper in the Journal of Membrane Science in collaboration with our close partners the Fraunhofer Institute for Ceramic Technologies and Systems (IKTS) located in Germany.

Selected Publications

L. Xia, J. Ren, M. Weyd, J. R. McCutcheon, "Ceramic-supported thin film composite membrane for organic solvent nanofiltration," Journal of Membrane Science 563, 857-863 (2018).

Reverse Engineering Fabrication Inspection & Non-Destructive Evaluation (REFINE)

Reverse Engineering Fabrication Inspection & Non-Destructive Evaluation (REFINE) lab houses state-of-the-art light, X-ray, electron and ion microscopes. It was established in 2017 in partnership with Zeiss, a leading microscopy company, and is supported by a $5.5M donation from Zeiss in addition to $3.5M from UConn and $1M from Dorman Products, to advance circuit applications.

The lab focuses on "correlative microscopy" where information from multiple imaging modalities can be integrated in order to reach a much deeper understanding of imaged samples. REFINE lab's instruments can "talk" to each other, enabling researchers to gain a multi-dimensional, multi-resolution and multi-scale perspective about the studied sample. REFINE is working closely with industries in areas of electronics and hardware security, biomedical devices, batteries and energy storage, aerospace, advanced coatings, and additive manufacturing.

SINA SHAHBAZMOHAMADI
Director REFINE
Department of Biomedical Engineering

Accomplishments

- REFINE promotes shared use of UConn resources through collaborative research. We served:
  - 20 UConn faculty members across 8 departments
  - 22 companies (over 40 companies since its inception in 2017)
  - 3 universities
- REFINE submitted 6 proposals to corporations and federal agencies and contributed to 4 additional proposals.
  - Two large proposals ($2M and $5M) were developed in collaboration with industry and other universities
  - Industry collaborations have resulted in three awarded proposals and more than $200K in fee for service revenue (FY2017) and $200K to date in FY2018.
- REFINE promotes an increased industrial presence at UConn through its fee for service, joint projects and research endeavors. Our lab capabilities have generated significant interest, directly leading to an increase in member companies in the IMS Industrial Affiliates Program.
- Academic achievements include:
  - 10 proposals
  - 14 journal papers
  - 15 peer-reviewed conference proceedings
  - 1 best paper award
  - 1 patent

Faculty: 20
Post-doctoral Fellows: 1
Graduate Students: 18
Undergraduate Students: 5

Graduate students Bahar Ahmadi and Nicholas May use the Orion Nanofab. (Al Ferreira)

Selected Publications

- A. Bahar, P. Tavousi, J. Favata, P. Shahbeigi-Roodposhti, R. Pelapur, S. Shahbazmohamadi, "A novel crowdsourcing platform for microelectronics counterfeit defect detection," Microelectronics Reliability 88: 48-53 (2018).
- J. Favata, A. Bahar, A. Shahram, S. Shahbazmohamadi, "Correlative Workflow in the characterization of TiN coatings in cardiac rhythm management devices," Microscopy and Microanalysis 24, no. S1: 362-363 (2018).
- K. Ahi, S. Shahbazmohamadi, N. Asadizanjani, "Quality control and authentication of packaged integrated circuits using enhanced-spatial-resolution terahertz time-domain spectroscopy and imaging," Optics and Lasers in Engineering, Volume 104: 274-284 (2018).
- A. VahidMohammadi, A. Hadjikhani, S. Shahbazmohamadi, M. Beidaghi, "Two-dimensional vanadium carbide (MXene) as a high-capacity cathode material for rechargeable aluminum batteries," ACS nano 11, no. 11: 11135-11144 (2017).
- A. Hadjikhani, A. Rodzinski, P. Wang, A. Nagesetti, R. Guduru, P. Liang, C. Runowicz, S. Shahbazmohamadi, S. Khizroev, "Biodistribution and clearance of magnetoelectric nanoparticles for nanomedical applications using energy dispersive spectroscopy," Nanomedicine 12, no. 15: 1801-1822 (2017).

Patent

Sina Shahbazmohamadi, Robert S. Howe, Richard Bass, Methods and systems for non-destructive analysis of objects and production of replica objects, US Patent 9818383, November 14, 2017.

Meet REFINE's Director Sina Shahbazmohamadi

> If you think about it, what we really want to do in any engineering system, whether it's biological or mechanical, is see internal structures and understand what's happening.
>
> — Sina Shahbazmohamadi

Sina Shahbazmohamadi wears his long black hair in a ponytail pulled back from his bearded face and smiles eagerly as he begins to talk about his work at the Innovation Partnership Building (IPB) at UConn Tech Park.

A mechanical engineer by training, Shahbazmohamadi does advanced research in 3D imaging at the Reverse Engineering, Fabrication, Inspection and Non-Destructive Analysis (REFINE) lab, one of eight industry-sponsored research centers in the IPB. He uses a suite of state-of-the-art electron, X-ray, and optical microscopes to explore, deconstruct, and reconstruct materials more than ten thousand times smaller than the head of a pin.

During his Ph.D. work, Shahbazmohamadi inspected the failure of turbine blades in gas turbine engines with 3D X-ray tomography, the same technology used in medical CT scans. This technology can capture structural attributes of a material without physically damaging it, allowing researchers to "see inside" down to a 700-nanometer resolution – about the size of a red blood cell.

"I became fascinated by the technique and quickly realized it could be used in a lot of other applications," Shahbazmohamadi says. "So I began developing novel imaging methods that can be used to solve highly complex engineering questions."

As Shahbazmohamadi began looking at increasingly smaller units, X-ray technology was no longer sufficient, so he started exploring applications of scanning electron microscopes (SEM) and scanning helium ion microscopes (HIM). More than one thousand times more powerful, this specialized equipment brings a complex challenge for Shahbazmohamadi to tackle: making the machines talk to each other.

Different microscopes allow us to view a system on increasingly smaller scales. However, when we move to a smaller unit, we lose the context that is essential to understanding its function. When we move a sample from a SEM to a HIM, we are able to zoom in from 10 nanometers all the way down to 0.3 nanometers. Information isn't preserved from one instrument to another, so when we view the smaller field, we do not know where we are relative to the larger field of vision. By figuring out how to make his microscopes "communicate" with each other, Shahbazmohamadi will be able to move a sample from one microscope to the other, know precisely where he is, which all results in more precise data for his research.

Shahbazmohamadi's work on materials characteristics at a microscopic scale has many potential applications that impact consumers, industry, and the military.

One project focuses on better ways to detect counterfeit nano and microelectronics.

"As electronics are getting smaller and smaller, we need more sophisticated equipment with higher and higher resolution to be able to see inside the components," Shahbazmohamadi says.

His research is also making an impact on improving battery design for electric cars, cell phones, and laptops. In order to make better-performing products that are also lighter and less expensive, researchers need to be able to analyze and characterize the materials used to construct them

Shahbazmohamadi, who is also an assistant professor in the Department of Biomedical Engineering, is keenly aware that the world of engineering is changing and research in one field is no longer isolated from applications in another. He is eager to apply technology across fields and is using imaging techniques to look at biological samples like human tumors and the brain.

"If you think about it," Shahbazmohamadi says, "what we really want to do in any engineering system, whether it's biological or mechanical, is see internal structures and understand what's happening."

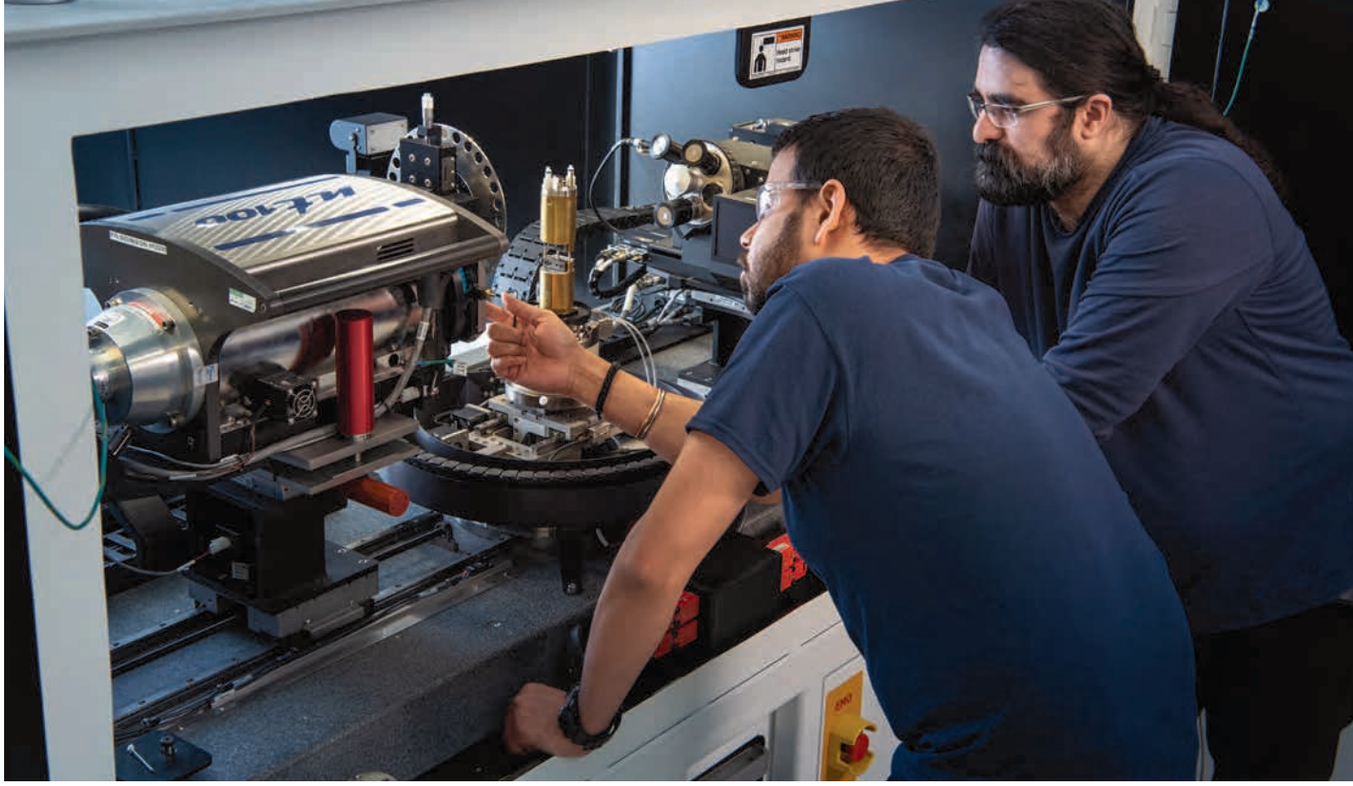
Shahbazmohamadi is a firm believer in the tremendous power of human collaboration. When an engineer discovers or develops something, it usually only addresses one part of a problem. When researchers don't or can't share their findings, scientific advancement as a whole is stalled. So Shahbazmohamadi is working on a project that pools the findings and expertise of researchers from around the globe to combat a particularly complex, multi-faceted problem using a collective power greater than any computer.

The project provides a global community of scientists with online access to a 3D image of a microchip along with related imaging data, research, and shared results. Academic researchers, industrial partners and

institutes have open access and can collectively contribute to finding possible defects that a single researcher might miss.

"People talk about using the computational power of high-performance computers, but, if you think about it, the greatest computational power is human beings," Shahbazmohamadi says. "My one-year-old son can more easily detect a cat in our backyard, for instance, than the greatest computer in the world."

Shahbazmohamadi sees this spirit of collaboration taking place every day at the IPB, which serves as a base camp for interdisciplinary collaboration as experts from different fields work only a few rooms away from one another.



Sina Shahbazmohamadi (right) and grad student, Utsav Awasthi, use the Xradia Versa 520. (Al Ferreira/UConn Photo)

"I can't answer every question related to microelectronics. I need help from my materials science and electrical engineering colleagues," Shahbazmohamadi says. "The IPB allows me ready access to their expertise, and is uniquely designed to house the state-of-the-art equipment that is required to make such interdisciplinary collaborations possible."

The microscopes Shahbazmohamadi uses in his research and collaborations certainly are state-of-the-art. In fact, the IPB is one of only a few facilities in the country housing so many specialized microscopes under the same roof. This equipment is extremely sensitive and any number of acoustic, electromagnetic, or vibratory disturbances can impact the reliability of the data. The IPB building is designed to allow such instruments to function optimally.

Shahbazmohamadi has a uniquely collaborative relationship with ZEISS Microscopy, the manufacturer of the microscopes in the REFINE lab. ZEISS has shared not only their resources but their research challenges with Shahbazmohamadi's lab.

"They invested in REFINE to take what we're doing to the next level," Shahbazmohamadi says. "Companies become part of us and we become part of them. It's a win-win for both parties."

Without this kind of connection to industry, Shahbazmohamadi says, the products and solutions developed by engineers may never make their way into the real world. He believes that this aspect of his work at REFINE has a critical impact on the numerous Ph.D. students and postdocs he works with at the IPB. He says being able to place a microchip in students' hands and tell them the Air Force needs them to fix it, for example, has a profound effect on how students view their work.

"When someone starts their Ph.D., they already love science and engineering," he says. "They want to do something great. Some of them want to change the world and it's important to encourage them. At the end of the day, students like to know that what they're doing is actually being used somewhere. It piques their interest and changes the level of education, plus the industry and the community benefit from the advances they're making."

Shahbazmohamadi's work spans multiple research fields and utilizes the technology available at REFINE in exciting and inventive ways. He shows enthusiastic dedication to his students and his research. He is an advocate for science and collaboration. His work is moving science and industry forward by constantly looking at the world from newer and closer angles, from the outside in.

- Anna Zarra Aldrich '20 (CLAS), Office of the Vice President for Research

RESEARCH CENTERS

Connecticut Cybersecurity Center (C3)

Connecticut Cybersecurity Center (C3) and its member centers, Comcast Center for Security Innovation (CSI), Center for Hardware and Embedded Systems Security and Trust (CHEST), Synchrony Financial Center of Excellence in Cybersecurity and Voter carry out research in cybersecurity and cryptography (Voter is housed on main campus). Their mission is to expand theoretical models and the boundary of cybersecurity technology to enable organizations to protect and safe keep the digital assets under their purview as well as enable safe, private, reliable and trustworthy computing in adversarial settings.

- CHEST is an industry-supported consortium tackling research issues in embedded systems and hardware security.
- CSI focuses on networking products deployed in businesses and homes.
- Synchrony Financial Center of Excellence in Cybersecurity addresses threats to financial organizations.

C3 leverages synergies across its component centers to investigate, develop, promote and nurture best practices in cybersecurity. Cybersecurity is a core competency that is now essential to the function and survival of public and commercial entities. A continuous stream of attacks and threats brings to the forefront the importance of addressing this challenge. The organization strives to create a powerful and integrated organization encompassing all aspects of cybersecurity: hardware, software, information management and ultimately, data privacy related public policy. Its scope reflects the need for trustworthy computing systems across all domains within our society.

COMCAST

synchrony BANK

Faculty: 10
Researchers: 1
Post-doctoral Fellows: 2
Graduate Students: 25
Undergraduate Students: 15

JOHN CHANDY
Co-director C3 (CHEST, Comcast)
Department of Electrical and
Computer Engineering

LAURENT MICHEL
Co-director C3 (Comcast, Synchrony)
Department of Computer Science
and Engineering

Accomplishments

In 2018-2019, the center received a $746,250 grant from the Department of Education to support Graduate Assistance in Areas of National Need (GAANN) fellowships for 5 students studying in the area of computer systems security. The center was also redesignated as a Center of Academic Excellence in Cyber Defense Research by the Department of Homeland Security and the National Security Agency.

The CHEST center submitted a phase I proposal to the NSF IUCRC program in December 2018, with approval expected early this summer. The center will receive over $300K in annual funding support from NSF, Honeywell, United Technologies, and MITRE. New industry funding secured from Comcast and Synchrony Financial reached a total of $881K spread across fellowships and five different grants on projects ranging from authentication, network defense, source code analysis, secure deployment and quantum communication protocols.

Selected Publications

C. Badertscher, P. Gaži, A. Kiayias, A. Russell, V. Zikas, "Ouroboros genesis: composable proof-of-stake blockchains with dynamic availability," proceedings of the 2018 ACM SIGSAC Conference on Computer and Communications Security (CCS), Ed. By D. Lie, M. Mannan, M. Backes, X. Wang, ACM, pp. 913–930 (2018).

F. Liu, W. Cruz, L. Michel, "A complete tolerant algebraic side-channel attack for AES with CP," in Principles and practice of constraint programming - 24th international conference, CP2018: 259-275 (2018).

R. Henry, A. Herzberg, A. Kate, "Blockchain access privacy: challenges and directions," IEEE Security & Privacy, 16(4):38-45 (2018).

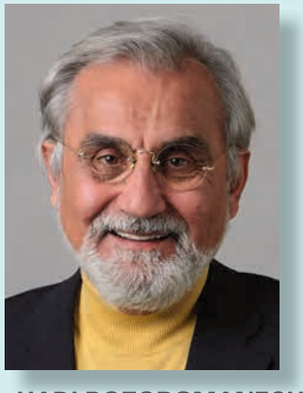
A. Alamélou, P.-E. Berthier, C. Cachet, S. Cauchie, B. Fuller, P. Gaborit, S. Simhadri, "Pseudoentropic isometries: A new framework for fuzzy extractor reusability" AsiaCCS (2018).

C. Jin, S. Valizadeh, M. van Dijk, "Snapshotter: Lightweight intrusion detection and prevention system for industrial control systems," 1st IEEE International Conference on Industrial Cyber-Physical Systems, ICPS (2018).

Enterprise Solution Center (ESC)

Enterprise Solution Center (ESC) is an innovation hub that connects small and medium manufacturing enterprises (SMMEs) to science and engineering resources at UConn and to major original equipment manufacturers (OEMs).

- **Proof of Concept Center (POCC)** offers state-of-the-art prototyping and fabrication equipment that facilitate new product development for a wide range of industries.
- **Quiet Corner Innovation Cluster (QCIC)** partners with SMMEs to promote business growth through innovation, enhanced R&D, and updated business capabilities.
- **Connecticut Manufacturing Simulation Center (CMSC)** provides SMMEs with affordable technical assistance for computer-based design, finite element modeling and simulation, testing, and validation, with capabilities in modeling a variety of manufacturing processes, including machining, forming, forging, and casting.



HADI BOZORGMANESH
Director ESC
School of Engineering

Accomplishments

ESC has enabled the following small and medium-sized manufacturers to grow and become more competitive through these QCIC funded projects:

- **Loos & Co**
  - » Develop a method for quantifying the luster of metal wires produced by Loos for use in the aerospace, commercial and military industries.
- **ACME Wire**
  - » Develop 3D printed replacement fixtures for production of wire components & fabricated wire products to reduce downtime, maximize production and reduce lead time.
- **CJMCO**
  - » Determine the root cause for harmonics during operation of a prototype and design a solution to reduce noise, improve operating life and increase efficiency over current drives.
- **Linemaster Switch Co**
  - » Leverage UConn's research expertise and advanced computational tools to analyze current manufacturing processes and redesign them to optimize efficiency and performance.
- **Control Station Inc.**
  - » Develop a software solution that can analyze industrial process data and determine relationships across the dataset, leading to a faster and more efficient semi-automated diagnosis.
- **Trans-Tek**
  - » Develop an add-on module that utilizes advanced signal processing to improve transducer functionality.
- **Wepco Plastics**
  - » Explore 3D printing of polymer-based tooling dies for plastic injection molding to reduce cost and lead time.
- **Aero Gear**
  - » Using 3D printing, focus on the development of production masking used in a heat treatment process for aerospace-quality gears to reduce lead time and overall cost of manufacturing.

JEONGHO KIM
Director CMSC
Department of Civil and Environmental Engineering

JOSEPH LUCIANI
Director POCC
Director QCIC

ESC
Faculty: 7

CMSC
Faculty: 7
Graduate Students:3
Staff: 1

POCC
Graduate Students: 1
Undergraduate Student: 1
Staff: 1

QCIC and **CMSC** named "Murphy's Monday Manufacturer" by U.S. Senator Chris Murphy.

> *Connecticut's Quiet Corner is anything but quiet – it's full of dedicated business owners and manufacturers, and QCIC is helping to bring out their potential."*
>
> *"CMSC is doing important work to build a pipeline of credentialed and dedicated young workers who are excited about manufacturing, and to set our manufacturing businesses up for success.*
>
> - Senator Chris Murphy

CMSC has performed a variety of manufacturing simulation projects with seven small and medium-sized manufacturing companies in Connecticut. These projects are focused on engineering analysis and design, and manufacturing modeling and simulations. By collaborating with an engineering team in each company, CMSC tackles real manufacturing problems and provides technical solutions and training. Our modeling and simulation capability and service to Connecticut manufacturers is promoting innovation and economic growth. CMSC has also offered a four-week training program since the fall semester of 2017 to Quinabaug Valley Community College students. CMSC has established partnerships with ANSYS and MSC Software for software usage and training. This partnership sponsors a team of UConn graduate and undergraduate students and professionals who will be trained to use modeling and simulation software tools. CMSC hosted MSC Software Workshop in 2018.

Since its opening in spring 2018, **POCC** has acquired a full suite of prototyping equipment and established a unique, innovative footprint at the Tech Park, collaborating with numerous university researchers and small business partners having diverse research interests and expertise.

POCC provided research and service based support to:

- 10 faculty research projects
- 2 UConn TIP projects
- 1 sponsored project
- 4 QCIC projects
- 2 Industrial Affiliates Program projects

Additionally, the following courses and projects were conducted and completed at the POCC lab:

- ENGR 3501 "Technology Innovation and Entrepreneurship II" course with 5 undergraduate students
- ENGR5300 "Special Topics in Engineering" course with 1 graduate student
- 2 Material Science & Engineering senior design projects
- 2 Mechanical Engineering senior design projects

Post-doctoral fellow Sanjubala Sahoo makes precision measurements of 3D printed materials at the POCC. (Al Ferreira)

Instrumentation

Advanced Characterization Lab

First Floor, South Wing

The Advanced Characterization Lab (ACL) is one of the foremost electron microscopy facilities in the United States, capable of analyzing materials on several scales. It houses state-of-the-art equipment including correlative multiscale workflows with X-ray, optical, ion and electron microscopy, with applications in electronics and hardware security, nanotechnology, clean energy, biomedicine, and more.

The labs feature:

- Perfect vibration isolation
- Perfect EMI isolation
- Acoustic noise mitigating wall panels
- Regular exhaust and corrosive exhaust in equipment chase
- Secure key card access doors
- 60-inch monitor screens

THERMO FISHER SCIENTIFIC CAMMA

Electron Microscopy

- Titan Themis ACEM
- Talos F200X S/TEM
- Verios 460L SEM
- Teneo SEM
- Aspex
- Tecnai T-12 TEM

Focused Ion Beam Milling

- Helios PFIB Dual Beam
- Helios 460F1 Dual Beam
- Strata 400S Dual Beam

SHAP3D

3D Printing

- Pilot-Scale HuskyJet 3D Printer
- 3D Systems ProJet CJP 660Pro

REFINE

Focused Ion Beam Milling

- Zeiss Crossbeam 340 w/ Laser
- Zeiss Orion Nanofab
- FEI Micrion Vectra 986+

Reverse Engineering

- Zeiss Xradia Versa 520
- Zeiss Xradia MicroCT 400
- Zeiss Smart Proof
- Zeiss Smart Zoom

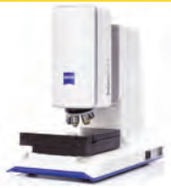
X-Ray

- Rigaku SmartLab X-ray Diffraction System
- Rigaku ZSX Primus IV XRF Spectrometer

Xradia MicroCT 400

ProJet CJP 660Pro

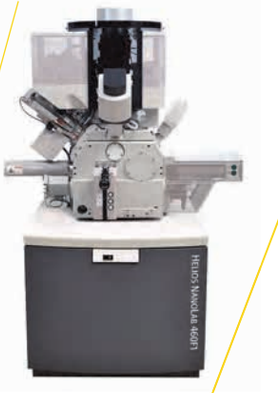
Smartzoom 5



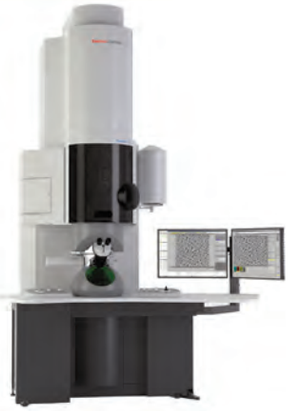
Orion Nanofab

Crossbeam 340 w/Laser

Helios 460F1 Dual Beam



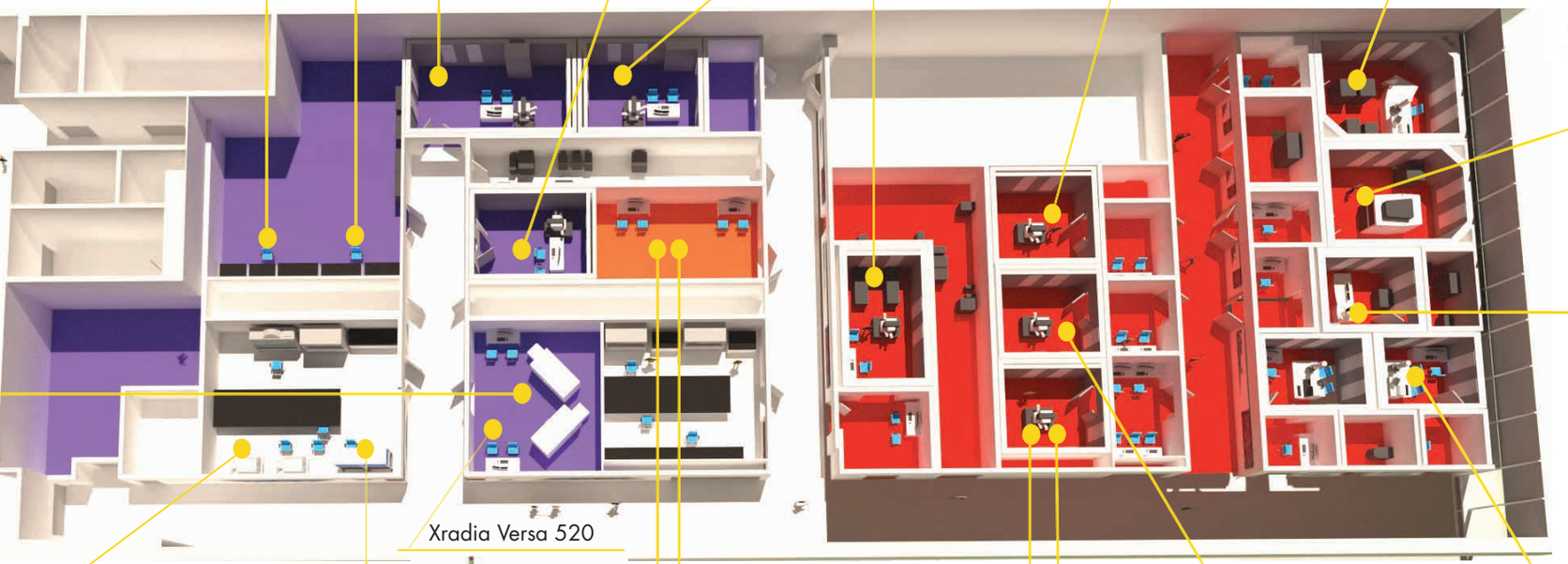
Titan Themis ACEM



Smartproof

Vectra 986+

Strata 400S Dual Beam



Talos F200X S/TEM

Tecnai T-12 TEM

Xradia Versa 520

ZSX Primus IV XRF Spectrometer

Aspex Explorer VP

Teneo SEM

HuskyJet 3D Printer

SmartLab X-ray Diffraction System

Verios 460L SEM

Helios PFIB Dual Beam

Instrumentation

Advanced Manufacturing Center

First Floor, North Wing

The Pratt & Whitney Additive Manufacturing Center (PW AMC) primarily addresses materials-related, fundamental challenges of metal additive manufacturing. Combining commercial and custom-built powder bed additive manufacturing machines as well as highly specialized characterization equipment, the center advances the knowledge of powder raking, melting, and solidification. The fundamental research of these topics is applied to alloy development, verification and validation of additive manufacturing simulation software. On a more applied side the center supports the private and public sector with help in qualifying the additive manufacturing process.

PW AMC EQUIPMENT

Materials Testing

- Gleeble 3500 (thermo-mechanical simulation system)
- Retsch Camsizer XT (Powder Size Distribution Analyzer)
- TA Instruments EM 1600 (Laser Flash)
- TA Instruments EM 2800 (Laser Flash)
- TA Instruments ODP 868 Optical Dilatometry Platform
- LECO ONH 836 (Oxygen-Nitrogen-Hydrogen Analyzer)
- LECO CS 844 (Carbon Sulfur Analyzer)
- Anton Paar Furnace Rheometer System FRS 1800
- Agilent ICP 7700
- Netzsch Pegasus DSC 404 F1
- Mettler-Toledo Flash DSC 2+

3D Printing

- Arcam A2X
- EOS M270
- 3DSystems ProX300
- IPG Photonics metal powder bed test bed machine

Manufacturing and Materials Processing

- MRF Arc Melter
- Agie Charmilles Wire EDM

Anton Paar Furnace Rheometer System 1800
(Image courtesy of Anton Paar)

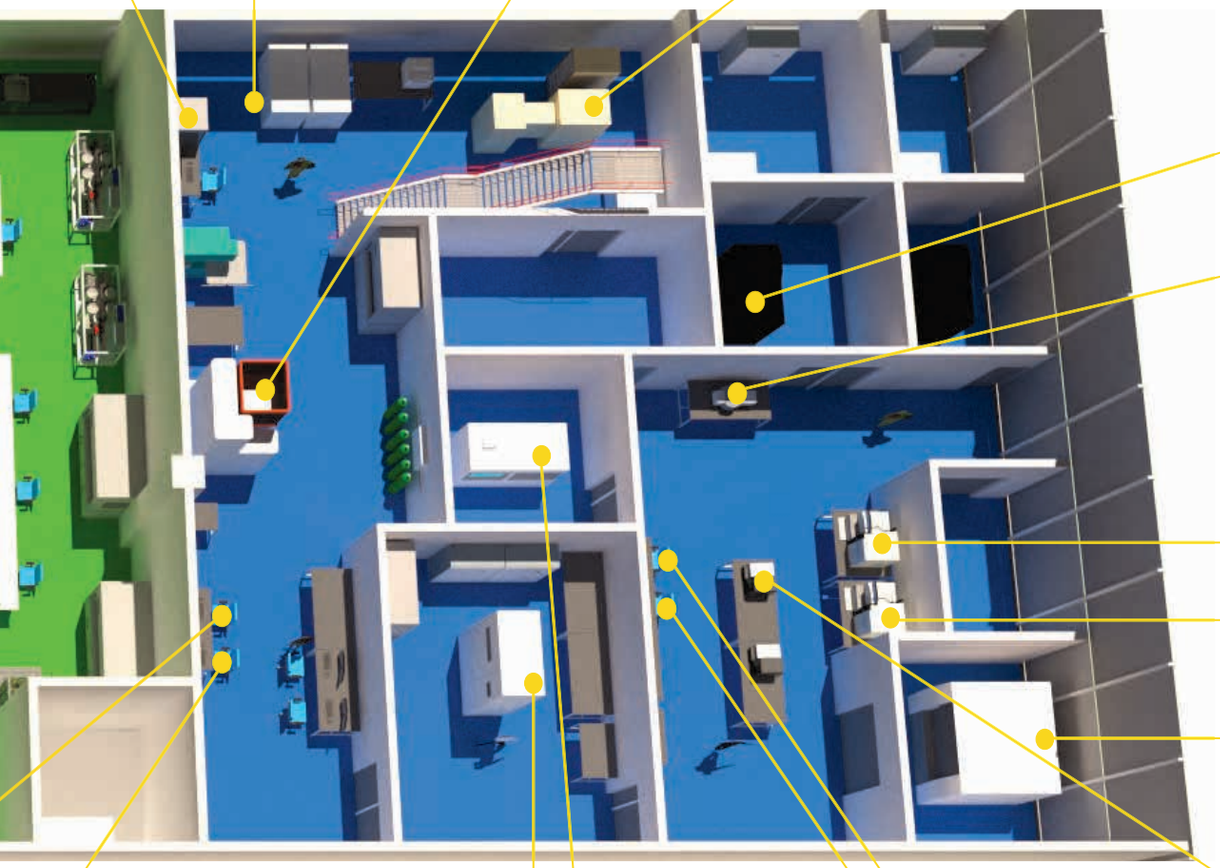
TA Instruments EM 2800
(Laser Flash)

TA Instruments EM 1600
(Laser Flash)

MRF Arc Melter

Wire EDM

Gleeble 3500 (Welding Simulation System)



Arcam A2X

Camsizer XT (Analyzer)

LECO ONH 836
(Oxygen-Nitrogen-Hydrogen Analyzer)

LECO CS 844 (Carbon Sulfur Analyzer)

3DSystems ProX300 (ProX 3D Printer)

ODP 868

Agilent IPC 770

Pegasus DSC

IPG Photonics Metal Powder Bed
Test Bed Machine

EOS M270

Instrumentation

Proof of Concept Center & Connecticut Manufacturing Simulation Center

3rd Floor

The Proof of Concept Center and Connecticut Manufacturing Simulation Center house state-of-the-art simulation, prototyping and fabrication equipment that facilitate design and development of fully functional prototypes for a wide range of industries.

POCC EQUIPMENT

3D Printing

- Stratasys Connex350
- Stratasys Design F370
- Formlabs Form 2

Manufacturing and Materials Processing

- Universal Laser Systems ILS 12.150D
- ICONIC CNC Router
- Haas CNC Mill
- Haas CNC Lathe
- OMAX Protomax Waterjet

Robotics/Automation

- Universal Robot

Reverse Engineering

- Faro Quantum 3D Scanner/Arm

CMSC EQUIPMENT

- 12 Dell Precision Workstations with 10-core Xeon processors/64GB of ram with priority access to 14 nodes, i.e. 504 cores, on UConn's high performance computing (HPC) cluster
- Modeling and simulation software suites include ANSYS, Solidworks, and ABAQUS
- MSC Software Suite
  - » Adams
  - » MSC Apex
  - » MSC Nastran
  - » Simufact Additive
  - » Simufact Forming
  - » Simufact Welding

Haas CNC Mill

Haas CNC Lathe

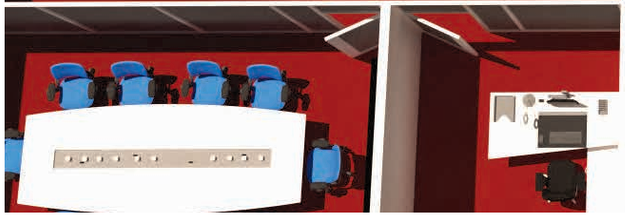
ICONIC CNC Router

Universal Laser Sytems ILS 12.150D

Stratasys Connex350

OMAX Protomax Waterjet

Formlabs Form 2



Stratasys Design F370

Universal Robot

3D Scanner and portable CMM Probe

Tech Park Visitors To Date

Tech Park is an active, vibrant community whose advanced capabilities and sophisticated resources draw interest from a truly diverse cohort. Our visitors have included international delegations, regional and international organizations, universities, and businesses, legislators and congressional delegations, government funding agencies, and more. Guests are eager to meet with faculty, tour our high tech facility, and explore the remarkable opportunities Tech Park provides.

Just off of main campus on Discovery Drive, our facility is an integral part of the university community, drawing interest from across UConn departments, schools and divisions. We regularly host a wide range of events including workshops, symposia, student poster sessions, departmental retreats, retirement celebrations and even a fashion show. In the spirit of interdisciplinary collaborations, we are excited to be partnering with the School of Fine Arts (SFA) department, offering unique opportunities for Digital Media and Design graduate students to develop their skills and creativity in a highly distinctive setting.

ACADEMIA

- Ashesi University, Ghana
- Clemson University
- ETH Zurich, Switzerland
- Georgia Tech
- Indian Higher Education Knowledge Delegation
- Massachusetts Institute of Technology
- Purdue University
- Southern Connecticut State University
- Technion - Israel Institute of Technology
- Tokyo University of Science
- Université Fédérale Toulouse Midi-Pyrénées
- University of California, Los Angeles
- University of Colorado
- University of Florida
- University of Maryland
- University of Massachusetts Amherst
- University of Massachusetts Lowell
- University of Rhode Island
- University of Virginia
- Worcester Polytechnic Institute
- Yale Entrepreneurial Institute
- Yale Office of Cooperative Research & YEI Innovation Fund
- Yale University

GOVERNMENT AGENCIES AND LEGISLATORS

- US Senator Richard Blumenthal
- US Senator Chris Murphy
- US Congressman Joe Courtney
- US Senator Richard Blumenthal Senior Policy Advisor and Staff
- US Senator Chris Murphy Lead Staff Delegation
- US Congressman Joe Courtney Military Legislative Assistant
- US Congressman Ralph Abraham Legislative Assistant
- US Senator Deb Fischer Defense Team
- CT Senator Cathy Osten
- US Small Business Administration
- Air Force Research Laboratory (AFRL)
- Army Research Laboratory Northeast
- Army Research Laboratory
- Department of Economic and Community Development (DECD)
- Department of Energy
- Department of Navy SBIR STTR
- German Delegation from Boston Consulate
- NAVAIR
- Naval Surface Warfare Center - Crane Division
- Naval Undersea Warfare Defense Center (UWDC)

US Congressman Joe Courtney with Tech Park Executive Director Pamir Alpay (center) and POCC Director Joe Luciani (left)

- NAVSEA Warfare Centers
- Navy Research Laboratory
- Southeastern CT Legislative Delegation
- Town of Berlin
- US Army Futures Command
- US Army Natick
- US Commissioner for Patents

German delegates representing Ministry of Science, Research and the Arts of Baden-Württemberg, Germany visit UConn Tech Park.

INDUSTRY

- 3M
- ABB
- Acme Wire Products Co, Inc.
- AddUp Solutions
- Advanced Manufacturing LLC
- Advanced Robot Solutions
- Aero Gear Inc.
- Altek Electronics Inc
- Amastan Technologies
- Amazon Lab126
- Anton Paar
- ARsome Technology Group
- Associated Spring
- AVANGRID
- Bead Industries
- Boehringer Ingelheim Inc
- Boeing
- Brainstorm
- Cabot Corporation
- Cadenza Innovation
- Campbell Soup Company
- Carlyle Johnson Machine Co, LLC
- Chasm Technologies
- Cigna
- CMT Materials
- Cognizant
- CohnReznick LLP
- Connecticut Innovations
- Convergent Mission Solutions
- Crimson Rook LLC
- Crunch Technologies
- Cyient
- Dante Solutions, Inc
- Disruptive
- Dive Technologies
- Dynamic Systems Inc. (Gleeble)
- ELDOR Group
- Enviro Power LLC
- Fraunhofer USA
- GE Appliances
- General Dynamics Electric Boat
- Gerber Technology
- Giner, Inc
- GKN Aerospace
- Godman Energy
- H2Sonics
- Hampford Research
- Health eSense
- Henkel
- Honeywell
- Imcorp
- InCHIP
- Infosys
- Jonal Laboratories, Inc.
- Kaman
- Kurimoto, LTD (Japan)
- KX Technologies LLC
- Line Master Switch
- Lite Sheet
- Loos & Co, Inc.
- M Cubed

The Indian Higher Education Knowledge Delegation visits UConn Tech Park during their trip to the US. The delegation included 30 technology leaders from top Indian universities and representatives from the Indian government and research organizations.

- Macroscopic Solutions
- Marmon
- Marmon Water
- Mastercam
- Medigate
- MetLife
- Metro Hartford Alliance
- Microsemi
- Mistras Group
- Moore Engineering
- Morgan Stanley
- MSC Software
- MSC Software /ACMT
- N&N Manufacturing
- NERAC
- NGK-NTK
- Northrop Grumman
- Nustreem
- NY & New England SCORE
- OutSecure
- Parrillo Consulting LLC
- Physical Electronics
- Platinum Equity
- Pratt & Whitney
- Precision Combustion, Inc.
- Qualitech Systems, Inc. (QSI)
- Queralt
- QUEST
- RC-Film Co.,Ltd.
- Revision Military
- Rite Solutions
- Schwerdtle
- Science of Heterogeneous Additive Printing of 3D Materials (SHAP3D)
- Shipman & Goodwin LLP
- Siemens
- Sikorsky Lockheed-Martin
- Simsbury Bank
- Skyre
- Solar Turbines
- Sonalysts
- Stanadyne LLC
- Stanley Black and Decker
- Synchrony
- Synectic
- TechStars
- Thayer Mahan
- The Lighting Quotient
- Thermo Fisher Scientific
- Torrecom Partners, LP
- Travelers
- Trumph
- TTM Technologies
- U3 Advisors
- Ulbrich
- Unilever
- Unilever
- United Technologies Corporation
- United Technologies Research Center (UTRC)
- Updike, Kelly & Spellacy, P.C.
- UTC Aerospace (now Collins Aerospace)
- Weber Metals
- Welco Realty, Inc.
- Wepco Plastics Inc.
- Whitcraft LLC

OTHER

- Advanced Robotics for Manufacturing (ARM) Institute
- Clean Energy Smart Manufacturing Innovation Institute (CESMII)
- Connecticut Center for Advanced Technology, Inc. (CCAT)
- Connecticut Conference of Independent Colleges (CCIC)
- Connecticut Business & Industry Association (CBIA)
- Connecticut Economic Resource Center (CERC)
- CONNSTEP
- CTNext
- Hartford Business Journal
- Naval and Maritime Consortium
- Rebooting New England
- Women's Business Development Council

Small Business Support

As a land grant university, UConn has a responsibility to serve the citizens of the state and support economic growth for Connecticut businesses of all sizes. The Tech Park Executive Director, faculty, and staff are fully committed to this promise, and continually strive to establish new business collaborations and strengthening current research partner relationships with businesses of any size, from fledgling startups to global leaders, whose success will benefit the citizens of the State of Connecticut.

SMALL BUSINESS GRANTS – SBIR/STTR

Tech Park serves as an essential resource for innovative small and medium size businesses.

In addition to advanced technological support and instrumentation, we offer guidance on competing for government SBIR/STTR funding that can help them develop novel products and services.

Also known as America's Seed Fund, SBIR/STTR programs are one of the largest sources of early-stage capital for technology commercialization in the United States. These federal programs provide critical funding for academic/business partnerships working toward product development.

In collaboration with the Office of the Vice President for Research, Tech Park conducts a series of educational workshops for small businesses and faculty that provide strategies for winning SBIR/STTR grants/contracts. The workshops also serve as networking opportunities and help participants identify potential partners with shared technological and research interests and needs.

ENTERPRISE SOLUTION CENTER

Quiet Corner Innovation Cluster (QCIC) supports business growth potential of small and medium-sized technology and manufacturing enterprises (SMEs) in the state of Connecticut. QCIC establishes partnerships with SMEs to enhance or expand their product and service offerings by leveraging UConn's extensive R&D capabilities and office of commercialization. Participating SMEs collaborate with UConn faculty who specialize in their area of focus.

Several of Tech Park's research centers participate in QCIC partnerships addressing unique industry challenges. The **Connecticut Simulation and Manufacturing Center** partnerships include:

Aero Gear (Windsor, CT)

- Develop a finite element model to study the effects of machining parameters such as cutting tool geometry, contact conditions and coolants on deformation to optimize the process to reduce distortions in a steel workpiece.

Associated Spring (Bristol, CT)

- Develop a finite element model to understand the effects of various process input variables to the geometry of transmission compression springs to reduce distortions and scrap rate.
- Develop a finite element model to simulate blanked edge punch process and to optimize punch-die clearance and punch edge shape.

Dur-A-Flex (East Hartford, CT)

- Develop a finite element model to investigate the impact response of floor coatings and to understand the correlation between coating properties and the resulting performance.

GE Power, Gas Power Systems, HRSG Engineering (Simsbury, CT)

- Develop a finite element model to improve the design of a welded T-joint with optimized local geometry design

Jonal Laboratories, Inc (Meriden, CT)

- Develop a finite element model to model the rolling action of a diaphragm to measure energy input required to move the diaphragm with different fabrics.

Sperry Rail Service (Shelton, CT)

- Develop a finite element model to optimize the design and manufacturing of railway inspection probes

Whitcraft LLC (Eastford, CT)

- Develop a finite element model for a spinning process of metal to optimize process conditions by evaluating stress, thinning and work hardening in metal strip.

QCIC is funded by the US Economic Development Administration (EDA), UConn, and Connecticut Innovations.

Pilot-Scale HuskyJet Inkjet Printer

The HuskyJet printer is a custom-built inkjet printer equipped with three industrial print heads, in-line UV and IR curing, and drop imaging capabilities. The linear sled design ensures high drop-on-drop precision for multilayer printing. This printer is capable of laying down up to three different materials for producing passive circuit elements, flexible electronics, food, and pre-sintered ceramic and metal parts.

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uconn-tech-park/

techpark.uconn.edu

REALIZATION

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INNOVATION. COLLABORATION. INSPIRING GREAT IDEAS.

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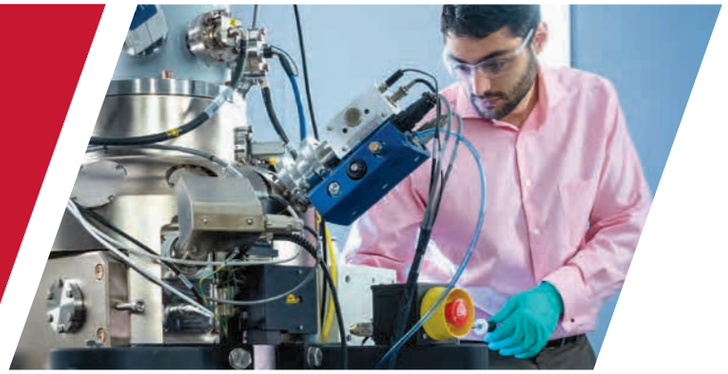

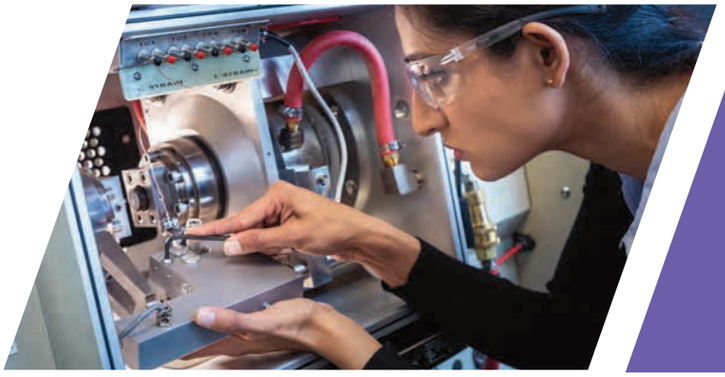

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