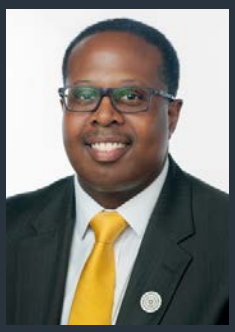
Georgia Tech

George W. Woodruff School of Mechanical Engineering

2018–2019 ANNUAL REPORT

From the Chair



After one year of my tenure as the Chair of the Woodruff School of Mechanical Engineering, I have a renewed appreciation for the caliber of our students, faculty, and staff. Throughout a year that was filled with transition, our faculty continued to produce ground-breaking research and our students continued their stellar accomplishments inside and outside of the classroom as they raised the profile of our competition teams, the Flowers Invention Studio, our Capstone program, and the numerous startups initiated through Create X. We even hosted a live event from the Flowers Invention Studio for 4th-6th graders that reached over 46,000 students during the one hour show on Georgia Public Broadcasting. Our staff also worked hard to ensure that the Woodruff School continued to run smoothly and efficiently. This entire team is a key factor that enables us to deliver a world-class educational environment year after year and I am thankful for each individual that has contributed.

During the 2018-19 school year our undergraduate mechanical engineering program was ranked third nationally, giving us five straight years in the top five. Our ME graduate program was ranked fifth and our nuclear engineering program was ninth, placing all of our programs in the top 10. Overall the Georgia Tech College of Engineering is ranked fourth in the nation and Georgia Tech as an institute rose to 29th amongst all national universities and fifth among public universities.

At the Spring Capstone Design Expo our students took home every award possible and two of those projects have spurred the creation of startups. Our student competition teams also had a banner year. The RoboRacing team won the International Autonomous Robot Racing Challenge for the third time in five years; RoboJackets won the design competition and finished third overall at the Intelligent Ground Vehicle Competition in Michigan; and HyTech racing defended their title, winning the Formula Hybrid competition at New Hampshire Motor Speedway for the second straight year while also setting a course record.

At the faculty level there was no shortage of research news or accolades, many of which are listed in this report. Combined they earned $45.8 million in research awards — a new Woodruff School record by more than $8 million. What made me particularly proud of our faculty this year is the ways in which they are being recognized for their leadership. Dr. David McDowell was honored as the Georgia Tech Class of 1934 Distinguished Professor; Dr. Steven Biegalski, our nuclear engineering chair, was elected Chair of the Nuclear Engineering Department Heads Organization (NEDHO); Dr. Surya Kalidindi was named Regents' Professor and Rae S. and Frank H. Neely Chair for his nationally recognized efforts in data analytics and materials genome; Dr. Anna Erickson is heading up the $25 million Consortium for Enabling Technologies and Innovation (ETI), a group of 12 schools and nine national labs focused on nuclear nonproliferation education, research and development; and Dr. Shannon Yee is leading an effort to provide sanitation for more than 2.5 billion people by reinventing the toilet, an initiative funded by the Bill & Melinda Gates Foundation. These awards demonstrate that our faculty are recognized as world-class leaders, researchers, and educators at the top of their fields.

Great things are happening at the Woodruff School and we continue to make an impact locally, nationally, and globally as our students, faculty, and graduates tackle the challenges of today and provide solutions for tomorrow.

Best Regards,
Samuel Graham, Jr.
Eugene C. Gwaltney, Jr. School Chair and Professor

About the Woodruff School

The first degree offered at the Georgia Institute of Technology was the Bachelor of Science in Mechanical Engineering. Today, the George W. Woodruff School of Mechanical Engineering offers:

- **2 bachelor of science programs**
- **5 master of science programs**
- **4 doctor of philosophy programs**

RANKINGS, U.S. NEWS & WORLD REPORT

No.3 national ranking of ME undergraduate program, released Fall 2019

No.5 national ranking of ME graduate program, released Spring 2019

No.9 national ranking of NRE graduate program, released Spring 2019

ENROLLMENT, FALL 2019

1,959 undergraduate students
- 456 women
- 209 international

881 graduate students
439 MS + 442 Ph.D.
- 152 distance learning
- 165 women
- 290 international

FACULTY

95 full-time, tenure-track faculty +
- 12 non-tenure track faculty
- 35 adjunct appointments
- 72 research faculty

- >25% senior faculty with endowed or distinguished chairs
- 3 faculty with new NSF Early CAREER Awards
- 5 NAE members who hold emeritus or adjunct appointments
- 72 staff members

DEGREES AWARDED, 2018-2019

584 B.S. Degrees

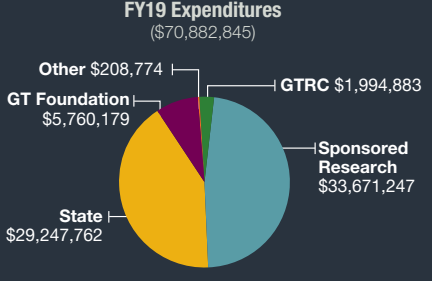
243 M.S. Degrees

56 Ph.D. Degrees

FINANCES

$45.8M FY19 new sponsored research awards

$70.8M FY19 expenditures



Awards & Promotions

FACULTY

Nazanin Bassiri-Gharb – promoted to Professor

Steven Biegalski – Nuclear Regulatory Commission Fellowship; elected Chair of the Nuclear Engineering Department Heads Organization (NEDHO); appointed to NEI board of directors

Baratunde Cola – promoted to Professor

Anna Erickson – Department of Energy NNSA Award; ANS Mary Jane Oestmann Professional Women's Achievement Award; named Woodruff Professor

Alper Erturk – promoted to Professor; named Woodruff Professor

Andrei Fedorov – named Rae S. and Frank H. Neely Chair

Craig Forest – promoted to Professor

Katherine Fu – NSF CAREER Award

Marta Hatzell – NSF CAREER Award

David Hu – promoted to Professor

Yuhang Hu – NSF CAREER Award

Kyriaki Kalaitzidou – promoted to Professor; named Rae S. and Frank H. Neely Professor

Surya Kalidindi – promoted to Regents' Professor; named Rae S. and Frank H. Neely Chair; awarded Khan International Medal

Yong Tae Kim – promoted to Associate Professor

Satish Kumar – named ASME Fellow

Seung Woo Lee – promoted to Associate Professor; NASA Early Career Fellowship

David McDowell – Georgia Tech Class of 1934 Distinguished Professor

Matthew McDowell – AFOSR Young Investigator Program (PECASE); NASA Early Career Fellowship; Sloan Fellowship

Olivier Pierron – promoted to Professor

Farzad Rahnema – Gerald C. Pomraning Award, ANS Mathematics and Computation Division

Devesh Ranjan – named Associate Chair for Research

Chris Saldana – promoted to Associate Professor

Suresh Sitaraman – GWW Zeigler Outstanding Educator

David R. Smith – co-recipient of the 2020 Breakthrough Prize in Fundamental Physics

Todd Sulchek – promoted to Professor

Susan Thomas – named Woodruff Professor

Shannon Yee – promoted to Associate Professor; $13.5 million Bill & Melinda Gates Foundation Award for Reinvent Toilet Challenge; ONR Young Investigator Program

Aaron Young – NIH Early Career Award

STAFF

Harrison Crawford – promoted to Financial Admin III

Shana Hefferon – promoted to Program Support Coordinator

Kimberley Henry – promoted to Financial Admin II

Rebecca Herrera – promoted to Admin Operations Coordinator

Angela Hicks – promoted to Director-Business Operations

Glenda Johnson – promoted to Academic Advising Manager; Georgia Tech Outstanding Graduate Academic Advising Award

Steven Sheffield – Georgia Tech Partnership Award

Millie Wan – promoted to Assistant Director-Financial Operations; Georgia Tech College of Engineering Hero Award

Amy Wang – Georgia Tech College of Engineering T'expert Award

ALUMNI

Jason Byers (ME '96) – joined the Alumni Association's Board of Trustees in FY20

Wei Chen (Ph.D. '95) – elected to National Academy of Engineering

Stacey Dixon (MSME '95, Ph.D. '00) – named deputy director of the National Geospatial-Intelligence Agency

Tom Forbes (Ph.D. '10) – recognized with the U.S. Department of Commerce Bronze Medal Award for research at National Institute of Standards & Technology (NIST)

Victor Jaworski (ME '07) – promoted to staff vice president, manager of brand experience in the Marketing Division at FM Global

Dennis W. Kelly (ME '76 and Ph.D. '17) – named inaugural dean of the Q. William Hammack Jr. School of Business at Oglethorpe University

Calvin Mackie (BSME, MSME, Ph.D. '96) – 2019 Congressional Black Caucus Foundation Phoenix Award recipient

Michael R. Smith (ME '59, MSNE '61) – presented with the Albert Nelson Marquis Lifetime Achievement Award

STUDENTS

Askash Bajpai – NDSEG Fellowship

Matthew Barry – NASA Fellowship

Aurelio Bellott – DOE NEUP Fellowship

Camila Camargo – Alfred P. Sloan Fellowship

Matthew Cribb – NIH Fellowship

Nancy Deaton – NSF Fellowship

Pawel Golyski – NSF Fellowship

Kyle Hutchings – NRC Fellowship

Vedant Meha – First Place Department of Energy Innovations in Nuclear Technology R&D Award

Derek Nichols – NSF Fellowship

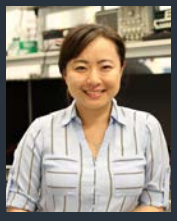
Vishnu Vardhan Reddy – SMTA Fellowship

Kristina Reed – DOE NEUP Fellowship

Bryan Watson – NSF Fellowship

Boni Yraguen – Alfred P. Sloan Fellowship

New Faculty & Staff



Ellen Yi Chen Mazumdar
Assistant Professor
began Jan. 2019

Sourabh Saha
Assistant Professor
began Aug. 2019

Ye Zhao
Assistant Professor
began Jan. 2019

Craig Burns
Mail Clerk I
began July 2019

Lucinda Erisman
Program & Ops Mgr
began Nov. 2018

Candace Jones
Admin Professional II
began June 2019

Kadian Leslie
Grants Administrator
began Nov. 2018

Virggie Lowe
Academic Assistant II
began Mar. 2019

Curtis Mack
Academic Assistant II
began Sept. 2019

Anthony McCoy
IT Support Prof I
began Dec. 2018

Reid Painter
Facilities Assistant
began Mar. 2019

Ashley Ritchie
Comm Officer I
began Apr. 2019

Nicole Thomas
Admin Professional Sr
began Dec. 2018

Ben Wright
Communications Mgr
began Nov. 2018

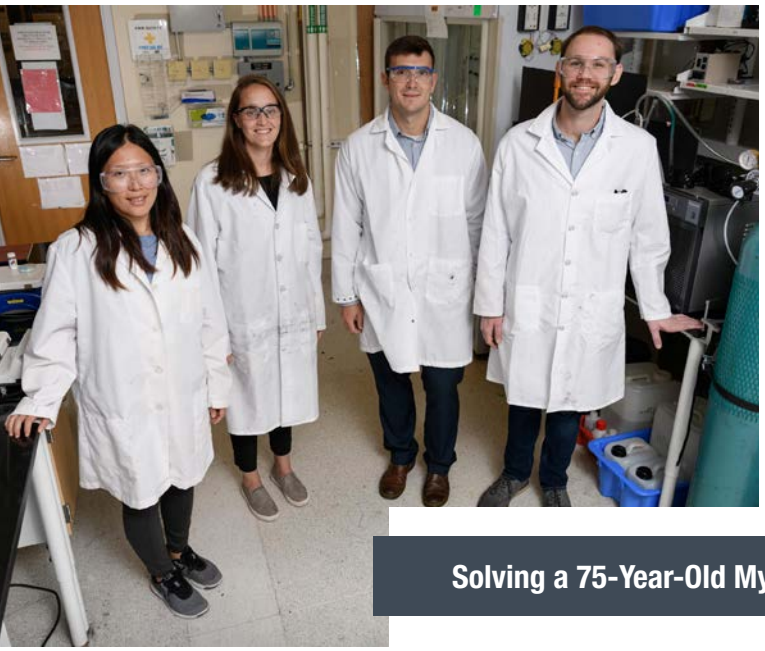
Leza Young
Faculty Support Coord
began July 2019

Research NEWS

Hydrogel Offers Double Punch Against Orthopedic Bone Infections

Surgery prompted by automobile accidents, combat wounds, cancer treatment and other conditions can lead to bone infections that are difficult to treat and can delay healing until they are resolved. Now, researchers have developed a double-duty hydrogel that both attacks the bacteria and encourages bone regrowth with a single application containing two active components.

The injectable hydrogel, which is a network of cross-linked polymer chains, contains the enzyme lysostaphin and the bone-regenerating protein BMP-2. In a study using a small animal model, researchers in the lab of **Regents' Professor and IBB Executive Director Andrés J. García** showed significant reduction in an infection caused by Staphylococcus aureus – a common infection in orthopedic surgery – along with regeneration within large bone defects.



Solving a 75-Year-Old Mystery Might Provide a New Source of Farm Fertilizer

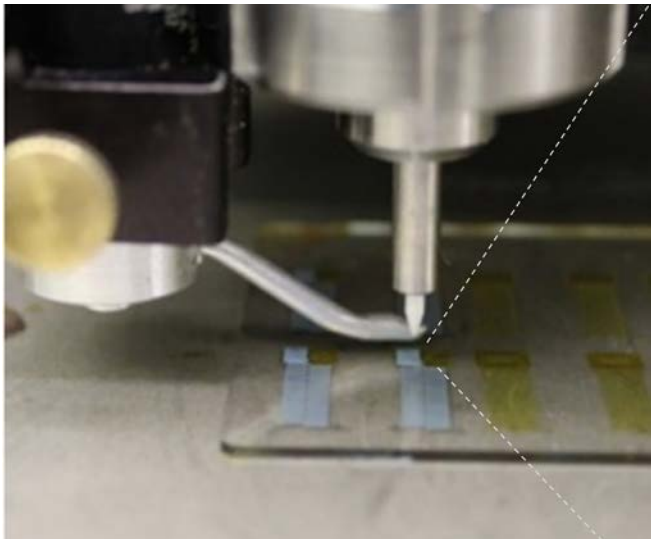
Thanks to a specialized X-ray source at Lawrence Berkeley National Laboratory, **Assistant Professor Marta Hatzell** and her collaborators have confirmed the existence of a long-hypothesized interaction between nitrogen and titanium dioxide (TiO2) – a common photoactive material also known as titania – in the presence of light. The catalytic reaction is believed to use carbon atoms found as contaminants on the titania.

If the nitrogen-fixing reaction can be scaled up, it might one day help power clean farm-scale fertilizer production that could reduce dependence on capital-intensive centralized production facilities and costly distribution systems that drive up costs for farmers in isolated areas of the world. Most of the world's fertilizer is now made using ammonia produced by the Haber-Bosch process, which requires large amounts of natural gas.

$25 Million Award Will Support Nuclear Nonproliferation R&D, Education

A consortium of 12 universities and 10 national laboratories led by Georgia Tech **Assistant Professor Anna Erickson** has been awarded $25 million from the U.S. Department of Energy's National Nuclear Security Administration (NNSA) to develop new technologies and educational programs to support the agency's nuclear science, security and nonproliferation goals.

The award will provide $5 million per year across a five-year period to link basic research at universities with the capabilities of national laboratories through the Consortium for Enabling Technologies and Innovation (ETI). The effort will focus on three core disciplines: computer and engineering science research through machine learning and high performance computing, advanced manufacturing and nuclear detection technologies.



Tiny Vibration-Powered Robots Are the Size of the World's Smallest Ant

A Georgia Tech research team that includes **Associate Professor Jun Ueda** has created a new type of tiny 3D-printed robot that moves by harnessing vibration from piezoelectric actuators, ultrasound sources or even tiny speakers. Swarms of these "micro-bristle-bots" might work together to sense environmental changes, move materials or perhaps one day repair injuries inside the human body.

The prototype robots respond to different vibration frequencies depending on their configurations, allowing researchers to control individual bots by adjusting the vibration.

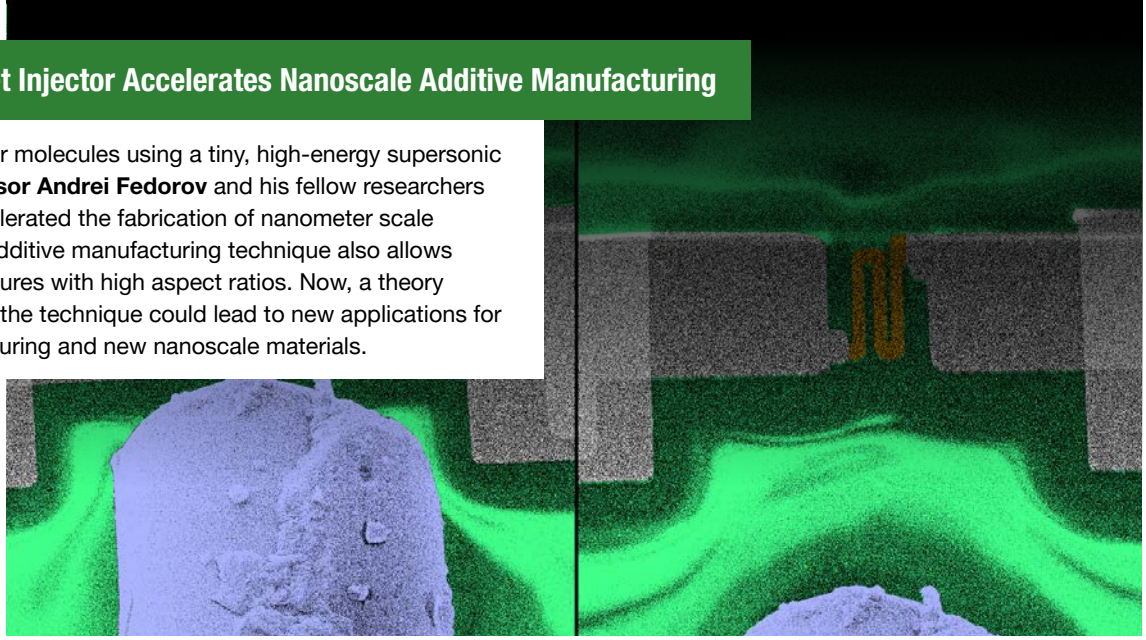
Stretchable Wireless Sensor Could Monitor Healing of Cerebral Aneurysms

A wireless sensor small enough to be implanted in the blood vessels of the human brain could help clinicians evaluate the healing of aneurysms — bulges that can cause death or serious injury if they burst. The stretchable sensor, which operates without batteries, would be wrapped around stents or diverters implanted to control blood flow in vessels affected by the aneurysms.

To reduce costs and accelerate manufacturing, fabrication of the stretchable sensors developed in the lab of **Assistant Professor Woon-Hong Yeo** use aerosol jet 3D printing to create conductive silver traces on elastomeric substrates. The 3D additive manufacturing technique allows production of very small electronic features in a single step, without using traditional multi-step lithography processes in a cleanroom. The device is believed to be the first demonstration of aerosol jet 3D printing to produce an implantable, stretchable sensing system for wireless monitoring.

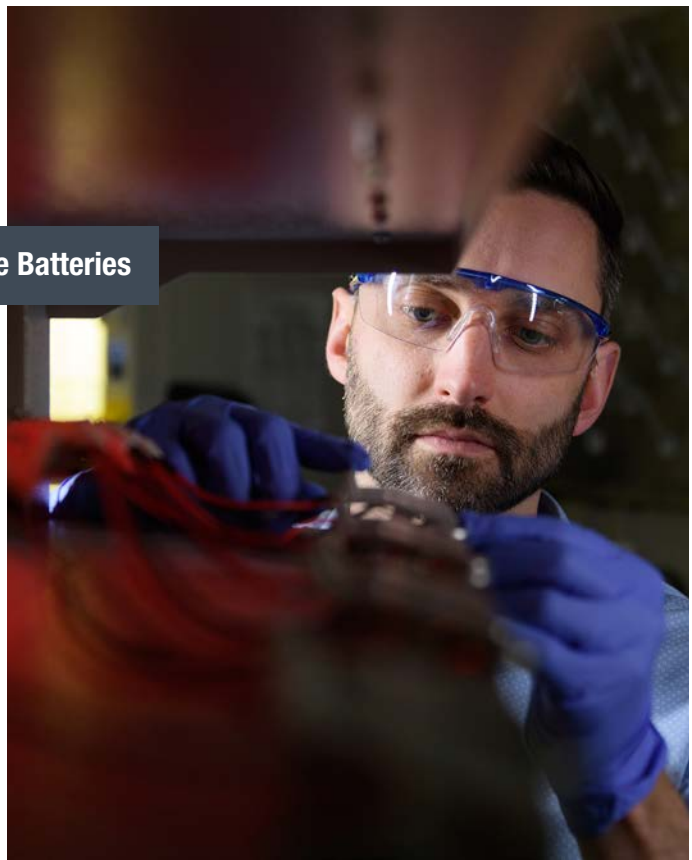
Tiny Supersonic Jet Injector Accelerates Nanoscale Additive Manufacturing

By energizing precursor molecules using a tiny, high-energy supersonic jet of inert gas, **Professor Andrei Fedorov** and his fellow researchers have dramatically accelerated the fabrication of nanometer scale structures. The rapid additive manufacturing technique also allows them to produce structures with high aspect ratios. Now, a theory developed to describe the technique could lead to new applications for additive nanomanufacturing and new nanoscale materials.



New Technology Could Provide Safe and Sustainable Sanitation for 2.5 Billion People

A $13.5 million award from the Bill & Melinda Gates Foundation will improve sanitation to 2.5 billion people worldwide by reinventing the toilet, technology that hasn't changed much in more than a century. **Associate Professor Shannon Yee** is leading the project, dubbed Generation 2 Reinvented Toilet (G2RT), along with GTRI Research Scientists Kevin Caravati, and Ilan Stern. The goal is to develop a low-cost toilet that does not require plumbing or sewage connections and uses minimal electricity to turn human waste into byproducts of water and a dry, odor-free sanitized solid that can be placed into municipal landfills, buried or even burned.

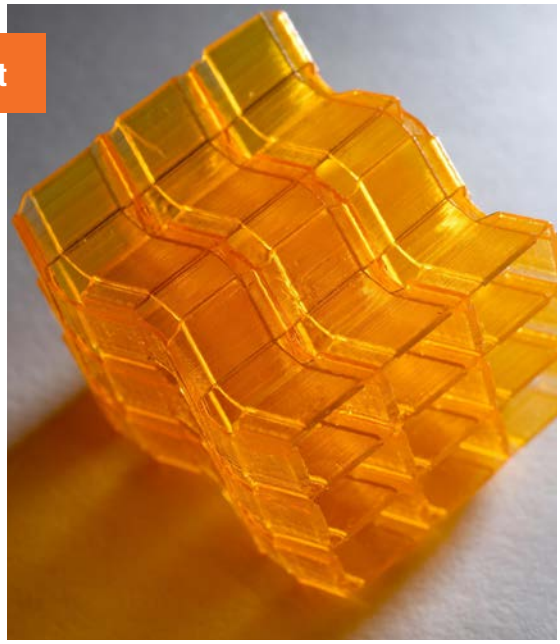


X-ray Imaging Provides Clues to Fracture in Solid-State Batteries

Solid-state batteries – a new battery design that uses all solid components – have gained attention in recent years because of their potential to hold much more energy while simultaneously avoiding the safety challenges of their liquid-based counterparts.

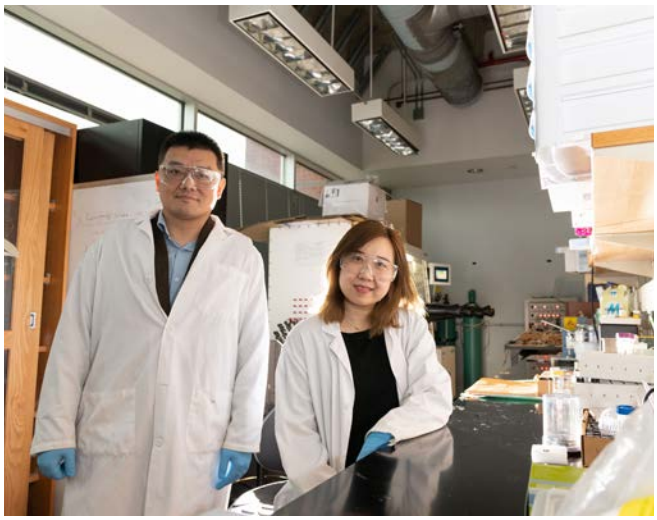
But building a long-lasting solid-state battery is easier said than done. **Assistant Professors Matthew McDowell** and **Christopher Saldana** and their fellow researchers have used X-ray computed tomography (CT) to visualize in real time how cracks form near the edges of the interfaces between materials in the batteries. The findings could help researchers find ways to improve the energy storage devices.

Origami, 3D Printing Merge to Make Complex Structures in One Shot



By merging the ancient art of origami with 21st century technology, a research team that includes **Professor Jerry Qi** has created a one-step approach to fabricating complex origami structures whose light weight, expandability, and strength could have applications in everything from biomedical devices to equipment used in space exploration. Until now, making such structures has involved multiple steps, more than one material, and assembly from smaller parts.

The researchers used a relatively new kind of 3D printing called Digital Light Processing (DLP) to create groundbreaking origami structures that are not only capable of holding significant weight but can also be folded and refolded repeatedly in an action similar to the slow push and pull of an accordion. When Paulino first reported these structures, or "zippered tubes," in 2015, they were made of paper and required gluing. In the current work, the zippered tubes – and complex structures made out of them – are composed of one plastic (a polymer) and do not require assembly.



Powerful X-ray Beams Unlock Secrets of Nanoscale Crystal Formation

High-energy X-ray beams and a clever experimental setup allowed **Assistant Professor Hailong Chen** and his fellow researchers to watch a high-pressure, high-temperature chemical reaction to determine for the first time what controls formation of two different nanoscale crystalline structures in the metal cobalt. The technique allowed continuous study of cobalt nanoparticles as they grew from clusters including tens of atoms to crystals as large as five nanometers.

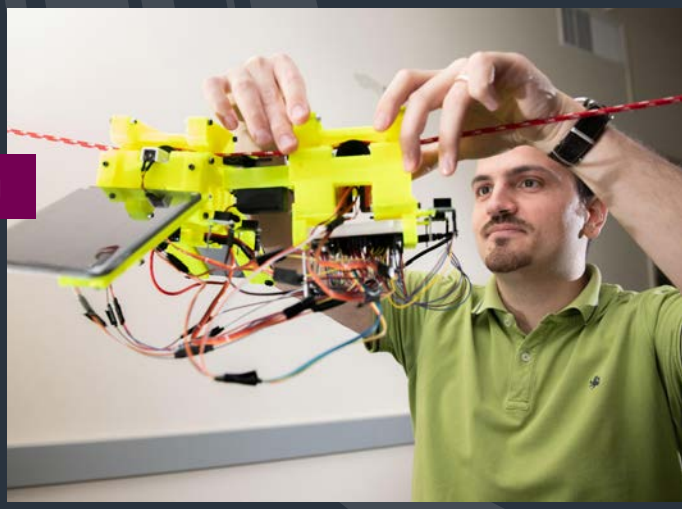
The research provides the proof-of-principle for a new technique to study crystal formation in real-time, with potential applications for other materials, including alloys and oxides. Data from the study produced "nanometric phase diagrams" showing the conditions that control the structure of cobalt nanocrystals as they form.

When Human Expertise Improves the Work of Machines

In many specialized areas of science, engineering and medicine, researchers are turning to machine learning algorithms to analyze data sets that have grown much too large for humans to understand. In materials science, success with this effort could accelerate the design of next-generation advanced functional materials, where development now depends on old-fashioned trial-and-error.

In a paper published in the journal NPJ Computational Materials, **Professor Nazanin Bassiri-Gharb** and her collaborators explain how to give the machines an edge at solving the challenge by intelligently organizing the data to be analyzed based on human knowledge of what factors are likely to be important and related. Known as dimensional stacking, the technique shows that human experience still has a role to play in the age of machine intelligence.

Student News



Slothbot Takes a Leisurely Approach to Environmental Monitoring

For environmental monitoring, precision agriculture, infrastructure maintenance and certain security applications, slow and energy efficient can be better than fast and always needing a recharge. That's where "SlothBot" comes in.

Mechanical engineering PhD student Gennaro Notomista and his colleague, Yousef Emam, designed SlothBot to hang in the forest canopy continuously for months, moving only when it must to measure environmental changes.

RoboJackets Place First at Annual International Autonomous Robot Racing Challenge (IARRC)

RoboJackets' RoboRacing outscored all other teams at the International Autonomous Robot Racing Challenge (IARRC) July 11-14 in Waterloo, Canada, to bring home a first place win and $3000 CAD. The competition consisted of four events- a straight-line drag race, a winding circuit race, an obstacle course, and an urban challenge where the vehicle must identify road signs and keep within its lane on a two-lane road.

GPB Invention Studio Live Exploration Draws 46,000 Viewers

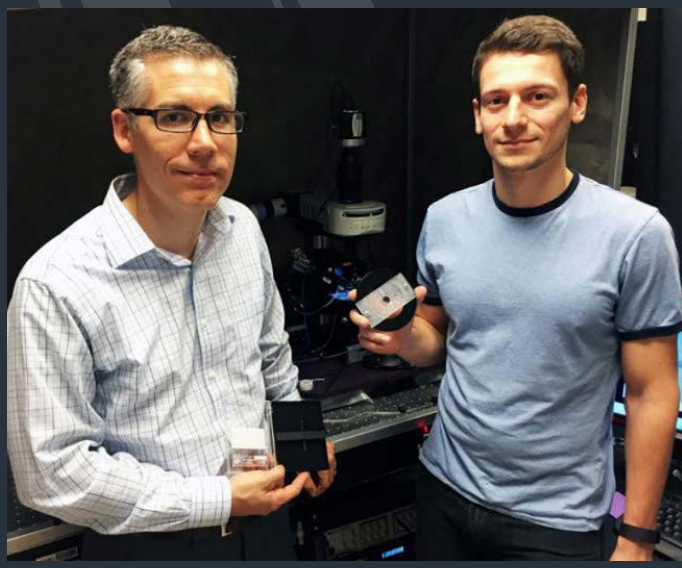
In May GPB Education live streamed from Georgia Tech's Flowers Invention Studio, giving students and teachers an inside look at the largest student-run makerspace in the world. During the virtual field trip, viewers learned about engineering design, saw ideas transform into inventions, and interacted with Tech students and engineers. The Invention Studio also celebrated its 10th anniversary in the spring.

HyTech Racing Brings Home First Place Trophy at Formula Hybrid Competition

For the second year in a row, HyTech Racing brought the first-place trophy from the Formula Hybrid back to Georgia Tech. The team outperformed its previous record, running in the Acceleration and Autocross events for the first time at this competition and placing first in the Autocross event. With their 368 lb vehicle, the lightest at the competition, HyTech was the only team to finish the 44 km Endurance course this year, becoming the second electric team to ever complete the 44 km Endurance course in Formula Hybrid history.

Entrepreneurship

PatcherBot Going to Market



For decades, a laboratory technique called patch clamping has been the gold standard for measuring the electrical properties of individual cells. The process involves bringing a pipette filled with electrolyte solution and a recording electrode connected to an amplifier, into contact with the membrane of a single cell. “Thousands of people practice this technique every day around the world,” says **Professor Craig Forest**. “But it is painfully tedious and time consuming.”

So Forest and his colleagues decided to speed things up a bit. And now, their automated patch clamping robot – the ‘patcherBot’ – is being commercialized and will be made available to researchers worldwide with the signed licensing agreement between Georgia Tech Research Corporation (GTRC) and Sensapex, an electrophysiology device company based in Finland.

Ph.D. Grad Turns Machine Learning Research into Startup

Ph. D. graduate **David Montes De Oca Zapiain** didn’t plan to be an entrepreneur, but a great experience in Georgia Tech’s TI:GER program encouraged him to turn his research into a business plan that he is pursuing while working as a postdoc at Sandia National Laboratory.

SwiftMat will offer materials manufacturers sophisticated modeling based on machine learning that can perform crystal plasticity finite element simulations, helping them get their new materials to market quicker and at a lower cost. Montes De Oca Zapiain is basing his software modeling on research he conducted as a student under the supervision of **Regents’ Professor Surya Kalidindi**.

PhD Student Partnering with VentureLab to Commercialize Chip Cooling Technology

Overclocking computers can lead to improved performance, but generates a lot of heat which needs to be addressed.

Ph.D student **Daniel Lorenzini**, who worked in **Professor Yogendra Joshi**’s lab, developed a liquid cooling system on a micro scale that outperforms commercial thermal control hardware, and he commercialized that research after he graduated earlier this year. He worked with Georgia Tech’s VentureLab to get his company (EMCOOL) established and he secured seed funding.

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