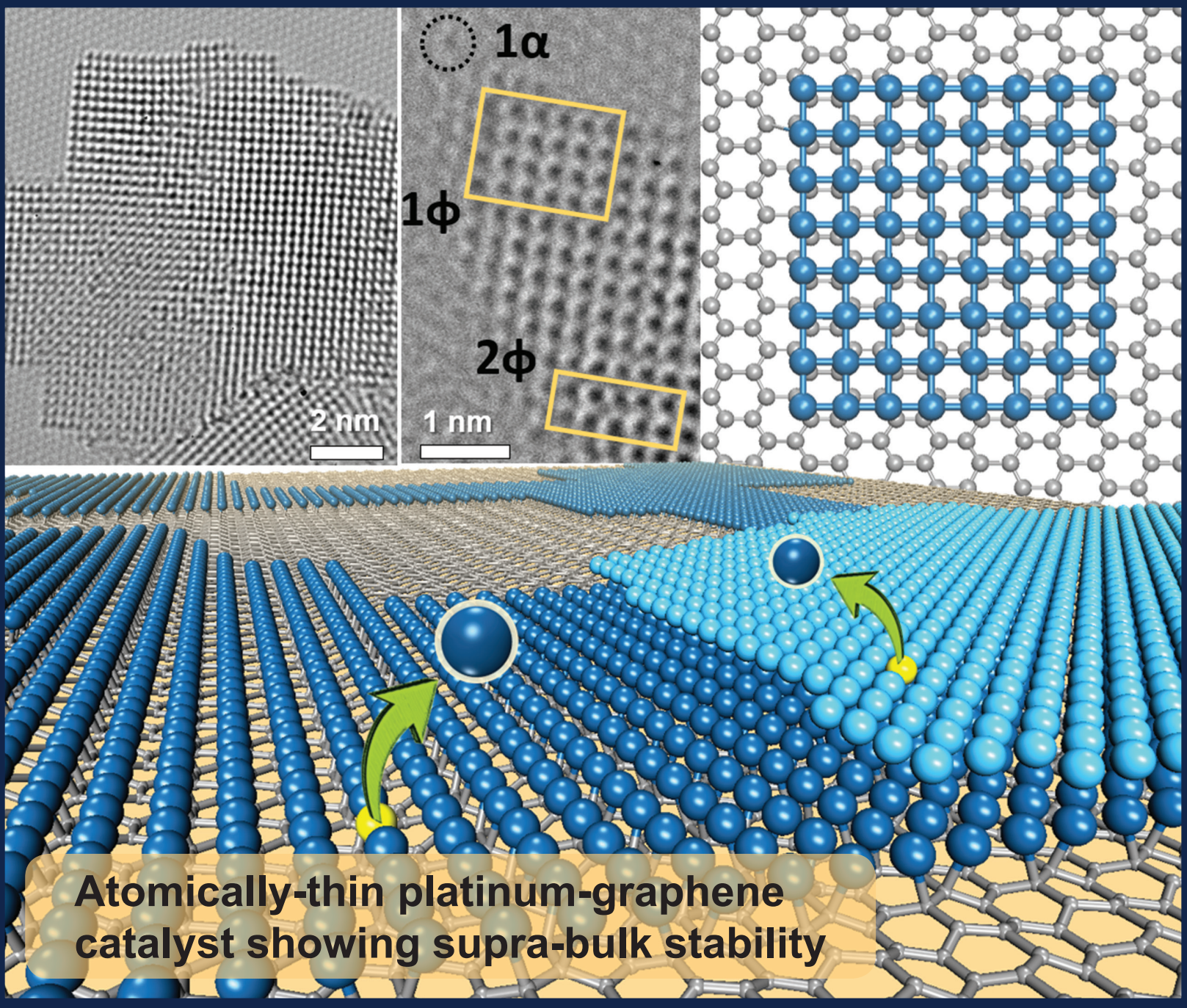
Georgia Tech School of Materials Science and Engineering



Atomically-thin platinum-graphene catalyst showing supra-bulk stability

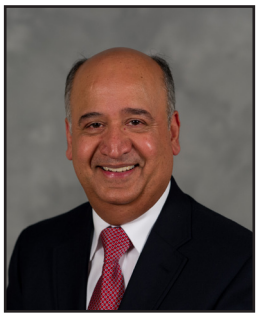
Fall 2019

CREATING THE NEXT® *in materials*

Inside

Front cover
Upper panel: TEM image showing the atomic registry of Pt with graphine depicted by the model
Lower panel: A contiguous film of platinum, 1-2 atoms thick, supported on graphene is found to be more chemically stable than bulk Pt. The energy required to pluck away a surface platinum atom (as depicted schematically in the figure) from two-layers of platinum exceeds that of bulk platinum. This figure is adapted from an article by Faisal Alamgir in Advanced Functional Materials. https://doi.org/10.1002/adfm.201902274

FROM THE CHAIR



Dear Alumni, Colleagues, and Friends,

Greetings from the School of Materials Science and Engineering at Georgia Tech!

The inherently interdisciplinary nature of Materials Science and Engineering and its breadth spanning the scientific theories of material behavior to engineering challenges imposed on material performance, make it a fascinating major. It is a major for those aspiring to make Noble Prize-winning discoveries as well as those aiming to be entrepreneurs and tackle societal problems through their innovations. In our position as faculty, we have the responsibility to educate the next generation of materials science and engineering leaders by immersing them in the fundamentals and actively engaging them in independent and experiential learning beyond the classroom. It is also our responsibility to lead the way with innovative research that solves intractable problems and creates new paths of investigation for others to follow. This requires setting a new standard for infrastructure and building an environment that nurtures the culture of creativity, curiosity, inclusiveness, and service to society. It is indeed most humbling to be in this position. I hope you will enjoy reading the stories of our people as we stride forward.

The MSE “make and measure space,” the MILL - Materials Innovation and Learning Laboratory - continues to serve several hundred students from more than 20 schools across Georgia Tech. It is a peer-to-peer learning space that is empowering student learning and inspiring creativity through hands-on discovery, design, and characterization of materials. It is promoting the culture of team work and lab safety - two attributes that are essential for training our future workforce. We are seeking funds for its expansion to a 6000 square foot open-access contiguous space, that will serve to bring together the entire community of students.

We welcomed to the School, Juan-Pablo Correa-Baena who joined us as an assistant professor in January 2019. His research focuses on the understanding and control of electronic dynamics at the nanoscale for low-cost semiconductors, including halide perovskites for solar cell and light emitting diode applications. Alena Alamgir and Himani Sharma also joined MSE this fall; Alena serves as the Director for Technical Communication, responsible for instruction of technical communication skills for both undergraduate and graduate students, and Himani takes over the teaching of our two core undergraduate laboratory courses at the junior and senior levels.

We are delighted with the establishment of the Novelis Innovation Hub. Novelis Inc., with their global R&D headquarters located in northwest Atlanta, has committed to providing a minimum of $2.5 million to promote applied and basic sponsored research, and philanthropic support for faculty/student fellowships.

We are proud of our outstanding students and graduates, whose passion for the discipline combined with their leadership with academic, research, and professional activities, has made MSE at Georgia Tech a top ranked and model program. I am most grateful for the generous support and encouragement of our alumni and friends. Your engagement and friendship are meaningful and crucial for our continued success. I invite you to come and visit us to share your thoughts and wisdom, and guide us as we build the infrastructure and environment for the next generation of MSE students.

Go Jackets!

Naresh Thadhani

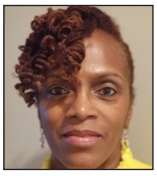
Naresh Thadhani
Professor and Chair
404-894-2651
Naresh.thadhani@mse.gatech.edu

BEST COLLEGES
U.S.News & WORLD REPORT
RANKINGS

Undergraduate #2
Graduate #7

Welcome

Latanya Buckner
Assistant Director Financial Operations



Lola Foye
Grants Administrator

Kenneth Garrick
Building Coordinator

Kerry Greene
Financial Administrator

Shirley Taylor
Faculty Support Coordinator

Kerry Wallaert
Educational Outreach Manager

Farewell

Roosevelt Bryant, Building Coordinator

Amanda Gable, Communications Specialist

Mary Z. McEneaney, Director of Development

Roderick Ray, Financial Administrator

Tom Sanders, Regent's Professor

MSE Says Goodbye to Two Longterm Members

MSE Regents' Professor Tom Sanders

MSE celebrated Regents' Professor Tom Sanders' retirement in February, as he was surrounded by family and friends, faculty, staff, and former students. Sanders graduated from Georgia Tech with his B.S., M.S., and Ph.D., and after a few years in industry and academia, returned to Georgia Tech in 1987.

The celebration was Parisian-themed, a nod toward Sander's time in France as a visiting scientist and Fulbright Fellow, as well as his years teaching abroad at Georgia Tech Lorraine. Sanders advised countless Ph.D. and M.S. students, developed and taught numerous graduate and undergraduate courses, mentored many junior faculty and research scientists, and was a recognized leader in his field. Sanders will stay as an emeritus professor, teaching study abroad programs when he can, while enjoying being a grandfather.

Tami Mace, left, and Mary McEneaney, right

Mary McEneaney, MSE Director of Development

After nearly two decades of service to Georgia Tech, faculty, staff, students, alumni, and MSE External Advisory Board members came together to celebrate Mary McEneaney's retirement in August. She was honored for her achievements and contributions to the School.

In her role as MSE Director of Development, McEneaney has impacted countless lives through her relationships and fundraising, as well as her own extraordinary philanthropy.

NEW FACULTY ARRIVALS

Alena Alamgir
Lecturer and Director of Technical Communication

Alena Alamgir brings a dual expertise to MSE: as a linguist and an accomplished researcher and scholar.

Alamgir received her M.A. in English and French Linguistics and Literature from Palacky University in the Czech Republic, and her Ph.D. in Sociology from Rutgers, The State University of New Jersey. Upon graduation, Alena held a postdoctoral position at the University of Oxford (UK), and taught at Newberry College, SC, and at Emory University.

She has published her work in peer-reviewed journals and edited volumes. Her dissertation won several prizes, including the Theda Skocpol Dissertation Award from the American Sociological Association.

In addition to her academic career, Alamgir brings many years of experience as a translator and a team leader for both content creation and candidate performance evaluation for TOEFL, a standardized test that measures the English language ability of non-native speakers wishing to enroll in English-speaking universities.

Hamani Sharma
Lecturer

Himani Sharma received her Ph.D. in Chemistry from University of Delhi, India in 2006. She later worked as a research associate on a NSA-funded project in the Department of Electrical Engineering and Computer Science at Alabama A&M University. In 2008, Himani joined Georgia Institute of Technology as a postdoc in the Packaging Research Center, where she went on to be promoted to Research Scientist-II. In her role as technical leader for 3D-IPAC (Integrated Passive and Active Component program) in PRC, she developed technologies for applications in consumer and medical electronics in partnership with companies. Her research focused on developing materials for next-generation passive components and substrates. She has authored more than 60 publications in international peer-reviewed journals and conference proceedings. She is also the author of the book *Synthesis, Properties and Surface Modifications of CdSe Quantum Dots*, three book chapters, and one pending patent. In July 2019, Himani became a fulltime lecturer in the School of Material Science and Engineering, where she is currently responsible for teaching junior and senior laboratory courses.

Juan-Pablo Correa-Baena
Assistant Professor

Juan-Pablo Correa-Baena joined MSE as assistant professor in January.

Correa-Baena received his Ph.D. from the University of Connecticut, where he studied metal oxideall aerogels as porous conductive electrodes for dye-sensitized solar cells, funded by two National Science Foundation fellowships. His work as a postdoctoral fellow at the Ecole Polytechnique Fédérale de Lausanne focused on understanding of fundamental questions regarding band alignment at interfaces and their influence on performance in perovskite solar cells. His work at MIT shed light on minority phase formation and elemental distribution in complex, multi-element halide perovskites, which determine the efficiency of the solar cells. His contributions have ultimately helped boost the efficiencies of perovskite solar cells.

At Georgia Tech, he is leading research projects on high-throughput deposition of halide perovskites with nanoscale control, synchrotron based elemental imaging with nanoscale resolution, and new materials for improving solar cell performance and durability.

In Memoriam, David Norman "Norm" Hill

David Norman "Norm" Hill, 75, passed away on Monday, April 1. Hill obtained his undergraduate degree and later his Ph.D. (under Joe Cochran) from Georgia Tech. He worked initially as a principal research scientist and then as faculty in MSE. He retired in 2004. During his time on the MSE faculty, he served as the associate director for Graduate Studies. He worked extensively on oxide superconductors and directionally solidified eutectic ceramic compounds. Hill served as host to current MSE Chair Naresh Thadhani when he interviewed at Georgia Tech in 1992, and subsequently served as his mentor.

Faculty

Zhiqun Lin, 2019 POLY Fellow and PMSE Fellow of the American Chemical Society

Mark Losego, Georgia Tech Outstanding Undergraduate Research Mentor Award

David McDowell, Georgia Tech Class of 1934 Distinguished Professor Award and TMS Fellow

Matthew McDowell, Presidential Early Career Award for Scientists and Engineers and Sloan Foundation Fellowship

John Reynolds, Arthur C. Cope Scholar Award

Preet Singh, 2019 Engineering Division Technical Award and Beloit Prize

Natalie Stingelin, 2019 MRS Fellow

Gleb Yushin, Georgia Tech Outstanding Achievement in Research Innovation Award

Zhong Lin Wang, "Albert Einstein" World Award of Science 2019, Diels-Planck Award, Foreign member of Korean Academy of Science and Technology, and Canadian Academy of Engineering

Students

Barry Goldwater Scholarship
Lily Turaski

DoE NNSA Laboratory Residency Graduate Fellowship
Travis Voorhees

Fulbright Scholarship
Andres Felipe Castro Mendez

GEM Fellowship
Amalie Atassi

Graduate Assistance in Areas of National Need Fellowship (GAANN)
Elena Ewaldz
Shawn Gregory
Cameron Irvin
Joshua Rinehart
Jacob Vagott

NASA Space Technology Research Fellowship (NSTRF)
Katie Koube
John (Jack) Lewis

National Defense Science and Engineering Graduate Fellowship (NDSEG)
Keara Frawley

National Science Foundation Graduate Research Fellowship
Amalie Atassi
Olivia George
Jessica Stelzel
Matthew West
Trevor Worthy
Michael Xu, Honorable Mention

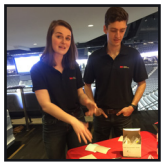
MSE Ph.D. Student Narayan Shirolkar Heads Georgia Tech's Graduate Student Government Association

Narayan Shirolkar, a Ph.D. candidate in materials science and engineering, was chosen to helm the graduate SGA presidency. As president, Narayan will be the spokesperson for the graduate student body in all government affairs and in student relations with Georgia Tech administration.

Narayan is committed to addressing the mental health issues that graduate students face. In addition, he has identified several other areas to focus on during the year.

Narayan served previously in SGA's executive branch as the vice president of Graduate Conference Funds.

CAPSTONE DESIGN 2019



3M, Mass Diffusion of Industrial Solvents Through 3M PVC Film
Alejandro Muñoz, Samuel Pennell, Carolyn Stanek, Samuel Stewart, Xueqiao Wang, Jonathan Yaeger

Avanos, Lubrication for Nasogastric Catheters
Alyssa Bronson, Joshua Carlson, Ashton Cowart, Emily Eastburn, Sarah Lucas, Andrew Slembarski

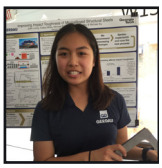
BAE Systems, SOP Design for Aluminum Composite Characterization
Zachary Bloomberg, Galvin Brady, Kaela Frazier, Bryston Spivock, Jessica Stelzel, Lina Zikas

Boeing, Coating Hardness Test Development
Sarat Eniola Lawal, Lenno Liu, Lovelyn Wirian, Ryan Wong

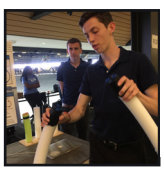
Boeing, Icephobicity Test for Boeing Materials
Jonas Braun, Justinn Po-I Chu, Anthony Joseph Esteves, Robert Wayne Peugh, Simon A. Willis

CDC, Design of a Rat Guard and Installation Device
Samuel Dratch, Christopher Johnson, Richard Lee, Srikar Pamidimukkala, Jacob Vagott

Ecolab, Design of a Smart Nonwoven Surgical Drape
Solette Collins, Daniel Eichler, Emmanuel Fregene, Madison Nisi, Claire Rohrer, Yiteng Wang



Gerdau, Improving Charpy Impact Toughness of Microalloyed Structural Steels
Julie Luong, Casey Miles, Michael Rupinen, Trevor Worthy, Michael Xu

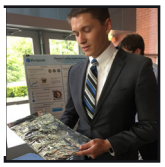


GT, HeadStart Diving Instructional Tool
Matthew Alesch, Connor Jacobson, Arthur Kim, Omar Saadeddine, Logan Vaupel

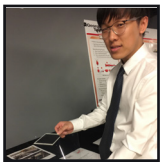
GT, Ice Capacitor for Energy Storage
Kelvin Chong (ME), Scott Claudon (MSE), Keith Coffman (MSE), James Heaton (ME), Mark Hopper (EE), Dianna King (EE), Joshua Spaeth (MSE)

Lake Lanier Association, Lake Lanier Solar Light Project
Cassiopeia Cartwright, Nadim Hammoud, Nolan Kelligrew, Patrick McVay, Catherine Schlueter, Paul Yavarow

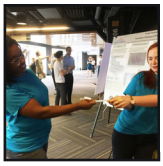
PAI, Increasing Diesel Manifold Lifetime via Flow Pattern and Materials Optimization
MSE Capstone Winner - Charles Caliendo, Eric Fitzgerald, SeungMin Lee, Jacob Lloyd, Heyinn Rho, Andreas Robertson



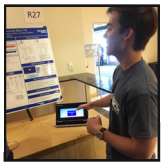
Printpack, Design of Passive Cooling Technology
Pardis Ahmadi, Kolby Hanley, Chase Scott, Veronica Thompkins, Carly Travis



SKC, Inc., Optimization of Surface and Optical Properties of Super-Clear PET Film
Rebecca Barnes, Andrew Bradshaw, Ryan Bradshaw, Dillan Cothran, Minsoo Kang, Peilin Lu



St. Gobain, Seamless Joining of Polymeric Sheets
Dariya Artsykhovska, Adam Berlinghoff, Jamie Freeland, Kira Pyronneau, Madeline Shelton



Technetics Group, Improvement of Inconel Alloy 718 Heat Treatment
Christy Brodrick, Noah LeVan, Matt O'Brien

Under Armour, 3D Printing of Novel Materials
Jack Amling, Sarah Burch, Bryce Hitchcock, Hannah Keatley, Rachel McFry, Max Walde

Under Armour, Novel Biocomposites
Christian Kozma, Parmiss Khosravi, Jack Peurifoy, Marlee Senderowitz, Kaitlyn Shipskie, Meaghan White

Summer 2019

MSE Research Scholars receive a $7000 stipend for 10-week immersion in summer research with faculty following completion of freshman year. They are encouraged to present their research at the annual MSE Industry Day event in the fall and to participate in the MSE poster competition in the spring. Summer 2019 industry sponsors included Art and Patricia Cox, Kolon, Solvay, and IWCS.

Juliette Carpet, Electrospinning Modified Cellulose Nanocrystals to observe interactions, advisor Blair Brettmann

Yizhi Huang, Iron Fluoride Carbon Nanofibers in Sodium Ion Batteries, advisor Gleb Yushin

Dharma Hufnagel, Minimizing undesirable binding events to particle immobilized targets, advisor Valeria Milam

Junjian Li, Visible light photocatalytic decomposition of acetic acid using Poly(Aniline) vapor phase infiltrated with TiCl4, advisor Mark Losego

Alex Marin, Effects of Varying Electrolyte Concentration on the Sensitivity of a Potentiometric Biosensor, advisor Eric Vogel

Konrad Muly, How anisotropy effects the dynamic response 7xxx Al alloy, advisor Naresh Thadhani

Prerana Panchumarti, Relating Solid State and Redox Properties in 3,4 Dioxythiophene Polymers, advisor John Reynolds

Dhruv Prakash, An examination of interfacial reactions between lithium metal anodes and the solid electrolyte $L_{10}SnP_2S_{12}$ to better understand solid state battery degradation, advisor Matt McDowell

Zhaoxian Zhang, A Study of Ultrasound Excited Hydrophobin Bubble and Biofilm, advisor Paul Russo

Sponsor MSE Research Scholars or Capstone Projects!

Contact MSE Development development@mse.gatech.edu or 404.894.6345.

PAI Sponsored Team Takes Top MSE Honor at 2019 Capstone Design Expo

The PAI-sponsored team took top MSE honor at the 2019 Capstone Design Expo, held in April at McCamish Pavilion. 236 teams from 11 different schools and programs and three colleges competed in the Expo. MSE had 18 teams competing, including three interdisciplinary teams.

The team, consisting of Charles Caliendo, Eric Fitzgerald, SeungMin Lee, Jacob Lloyd, and Andreas Robertson, received top MSE honors and a $1000 prize. Their project, sponsored by PAI, made structural and material changes to automotive exhaust manifolds, a common component that often fails early, affecting the ability of trucking companies to meet delivery deadlines.

The 2019 Prize for Best Overall Project award went to SmartSoil, a team of mechanical engineering students who developed an indoor, user-friendly composting devise that uses worms to produce nutrient rich compost.

WOMEN IN MSE (WiMSE)

The Women in Materials Science and Engineering (WiMSE) student group at Georgia Tech was started in 2016 by three graduate students as a means to provide support for women in a male dominated discipline. Today WiMSE is helping women graduate and undergraduate students succeed by facilitating connections with their peers across the campus, as well as with professionals in industry, academic institutions, and national laboratories.

Women represent about 37% of MSE students at Georgia Tech. WiMSE's mission is threefold: creating a platform for professional development, fostering supportive student and professional networks, and advocating for policies that support women studying materials science and engineering at the school, institute, and professional levels. WiMSE has been successful in supporting the mission by organizing a large array of events that serve as opportunities for female MSE students to socialize, bond, learn, and explore. The largest networking event is WiMSE Annual Banquet, which connects students with industry representatives, alumni, EAB, and faculty and staff in a casual setting. In the inaugural year, 2018, the banquet, dubbed "Connect and Dine," had about 50 attendees; attendance doubled in its second year. The summer ice cream social attracted more than 100 students, faculty, and staff, and the 2018 Friendsgiving event had over 80 attendees.

WiMSE leadership: Jyotsna Ramachandran, graduate vice president, Mica Landwermeyer, undergraduate design chair, Nicole Arroyo, undergraduate president, Aditi Khirbat, graduate president, Miriam Koga, undergraduate finance chair, and Laura Wu, undergraduate professional development chair

WiMSE collaborates with other women organizations at Tech, including the Pi Day Celebration with SWE, Success Seminar with Women in ECE, Paint Night with Woodruff School Graduate Women, and Lunch and Learn with Women in Chemistry. WiMSE's members are also active in recruiting new graduate students, participating in FASET orientation sessions, and MSE open house info sessions. They are involved in the annual TEC camps, hosted by Women in Engineering, offered to middle school girls with the goal of introducing them to materials science and engineering through fun, hands-on activities.

WiMSE is making Materials Science and Engineering at Georgia Tech more welcoming to female students, helping them to thrive, and increasing female enrollment.

TEC Camp 2019

2019 WiMSE Connect & Dine participants

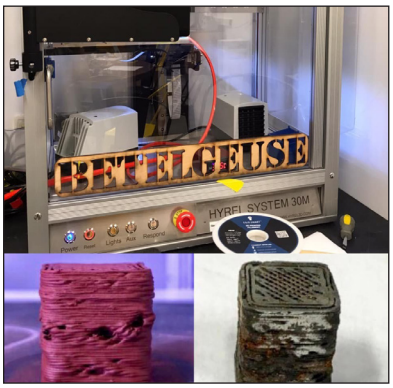
The Materials Innovation and Learning Laboratory (MILL)

Thanks to our Summer MILL Fellows and volunteer staff, The MILL has come a long way in the last few months. The processing team has expanded and moved in the hub in Love 176. The team has also diversified their 3D printer line-up with Prusa and Ultimaker units and added a sewing machine, an embroidery station, and a vinyl cutter. The measurement team has added a differential scanning calorimetry. In the Learning and Discovery (L&D) division, the Recycling Innovation Team was created at the beginning of the fall semester to research how to develop processes to reliably recycle the MILL's 3D-printed PLA parts into new PLA filament. The Cold Sintering Team won the MSE poster competition award last spring, and the High Entropy Alloys Team has been hard at work experimenting with 3D printing and sintering metal alloys.

In October, the MILL started offering workshops to the GT community through their Science of Art L&D Team. It has held 11 events to promote materials science and engineering among other Schools and to teach artists how they can take advantage of material properties to create art. The MILL specializes in glass fusing events, and in collaboration with the ECE Hive Makerspace, it has recently expanded its selection of materials to include stained glass. When not managing events, the Science of Art Team works on experimental materials art research in epoxy and glass fabrication, such as creating imprints of organic materials in glass.

For updates visit
mill.mse.gatech.edu

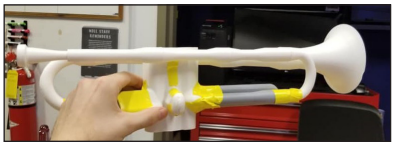
MILL staff members David Liu, Manuel Regalado, Anika Hong, Jin Lee, Aaron Thomas

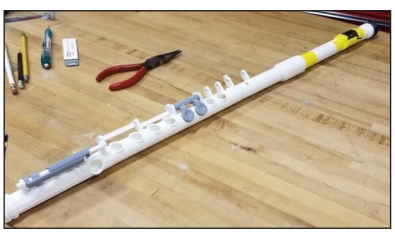


The **High Entropy Alloy Team,** led by Annie Mullins (4th year, MSE), uses ink-based 3D printing to create complex metal and oxide parts, which are then sintered and reduced to create solid parts. They aim to give the final alloy unique properties, such as high strength at conditions approaching cryogenic temperatures.

As part of the **MILL Outreach,** Emily McGuinness (Ph.D. student) led our first stained glass event in collaboration with the ECE HIVE, where she taught students how to cut and grind glass and line the edges with copper in preparation for soldering.

Gillian Brown (2nd year, MSE) in the **Science of Art Team** has experimented with imprints of leaves and flower petals in glass. By burning off the organic material in the kilns, a ghostly ash impression is left preserved for display.





Aaron Thomas (3rd year, MSE/CHIN), a member of the **Processing Team**, has recently crafted his own musical instruments using the 3D printers in the MILL.

2019 CoE Alumni Awards

Robert Shelley Blount, B.T.E. '71, Engineering Hall of Fame

Cynthia "Cindy" Lodge, B.Cer.E. '84, Academy of Distinguished Engineering Alumni

Yancy W. Riddle, M.S. MSE '98, Ph.D. MSE '01, Academy of Distinguished Engineering Alumni

Brumley D. Pritchett 2018 Lecture

Frances M. Ross, Ellen Swallow Richards Professor in Materials Science and Engineering at MIT School of Engineering gave the 2019 Brumley D. Pritchett Lecture. Her presentation, Imaging and Controlling Nanoscale Growth in the Transmission Electron Microscope, described examples in which *in situ* electron microscopy helps explore growth mechanisms and suggests strategies to build new types of structure, such as nanocrystals on graphene, electrochemically deposited nanostructures and catalytically grown semiconductor nanowires. She concluded with a perspective on the exciting recent advances in electron microscopy and how these developments will impact *in situ* experiments in the future.

The Brumley D. Pritchett Lecture Series was established as a memorial to the late Col. Brumley D. Pritchett.

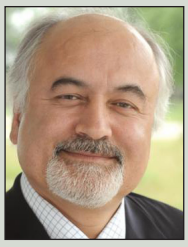
Novelis and GT Establish Novelis Innovation Hub

GT executive leadership with Novelis executives memorializing the establishment of the Novelis Innovation Hub, August 20, 2019

Novelis Inc., the world leader in aluminum sheet products, technologies, and recycling, has committed $2.5 million to initiate research, faculty and student fellowships, and educational program support in the establishment of the Novelis Innovation Hub at Georgia Tech. The collaboration will promote basic and translational research, innovative business models, and related educational endeavors at Georgia Tech and serve as a cross-functional hub connecting Novelis' technical and business innovators with Georgia Tech's students and faculty.

With this investment, Novelis is building upon its longstanding ties with Georgia Tech. Over the years, the company has sponsored research, provided internships and full-time employment, as well as mentorship to more than 50 graduate students. Most recently, Novelis has co-invested in additive manufacturing in the Advanced Manufacturing Pilot Facility at Georgia Tech.

Alumnus Ali Erdemir Elected to NAE



MSE graduate Ali Erdemir has been elected to the National Academy of Engineering (NAE). Erdemir graduated from Georgia Tech with a master's degree and Ph.D. in Materials Science and Engineering in 1982 and 1986, respectively. He is a Distinguished Fellow and program lead for materials for harsh conditions in the applied materials division at Argonne National Laboratory. He was honored for his contributions to the science and technology of friction, lubrication, and wear.

Adam Jakus

Adam Jakus, B.S. '09, M.S. '10, is a co-founder and Chief Technology Officer of Dimension Inx - a Chicago based company that designs, develops, and produces new advanced manufacturing (3D-Printing, textile, coatings, foams, etc.) compatible materials, processes, and end-use devices/products based on the 3D-Painting technology he developed during his Ph.D. From metals and alloys to ceramics, electronics, graphene and 1D and 2D materials, extraterrestrial regoliths, complex polymers, and advanced, clinically applicable soft and hard tissue and organ fabrication biomaterials, the 3D-Painting platform allows nearly any material to be rapidly 3D-printed at room temperature. It also allows for near infinite material versatility due to the ability to blend (similar to blending normal paints to get different shades) and 3D-print multiple 3D-Paints into singular objects.

Jakus obtained his B.S. and M.S. degrees from Georgia Tech. During his Ph.D. at Northwestern University, where he was the Hartwell Foundation Postdoctoral Fellow from 2015-2017, he focused on the design of new 3D-printable materials and processes, ultimately resulting in the 3D-Painting technology platform, which includes the globally recognized and utilized Hyperelastic Bone®, 3D-Graphene™, Fluffy-X™, 3D-Metals™, 3D-Ceramics™, Tissue Papers™, and other materials.

In addition to 3D-Paint related publications on ovarian tissue engineering and extraterrestrial manufacturing, Jakus is the author of several book chapters and publications on medical 3D-printing and advanced additive technologies. He holds more than one dozen patents and patent applications from advanced biofabrication materials to multi-ceramic solid oxide fuel cells.

Jakus actively participates in the art and design world using the 3D-Paint technology as a medium to create aesthetic pieces to communicate the importance of new materials and advanced manufacturing. His pieces are on display at the Smithsonian Design Museum in New York City and the CUBE Design Museum in the Netherlands. Jakus' ultimate goals are to transform global manufacturing through advanced material fabrication technologies and to help establish the global biofabrication industry, including leading educational and workforce development and helping direct related regulatory and policy decisions.

Caitlin Meree

Cait Meree, B.S.11, Ph.D. '15, is a research specialist in the Safety and Industrial Business Lab at 3M, as well as an adjunct professor at Saint Thomas University in Saint Paul, MN. Meree received her Bachelor of Science degree in Polymer, Textile, and Fiber Engineering, and Ph.D. in polymer structure-property-processing relationships with Professor Meisha Shofner.

Since joining 3M in 2015, Meree's research has focused on developing new materials for personal safety products, building applications, healthcare systems, and commercial solutions. Specifically, Meree uses her understanding of structure-property-processing relationships to develop novel material solutions to address 3M customers' needs. In addition, she is also working on understanding the factors that make workers feel comfortable to wear personal safety equipment.

In the spring of 2019, Meree participated in the 3M Impact program, a project in which 3M sponsors a global cross-functional team that travels to developing countries and works with NGOs to help sustain and grow their mission. Meree, together with her colleagues Roberta Sadi (3M Brazil), Cesar Sequera (3M Panama), and Eric Altman (3M Decatur), worked with the Virlanie Foundation to provide homes, families, education, healthcare, and food to homeless children in Manila, Philippines.

Recently, Meree was awarded the 3M Circle of Technical Excellence Award, a peer-nominated award that recognizes an individual's global technical contribution to the 3M scientific community.

Meree is an author of five externally published papers and over 27 patent submissions. She is very active in the 3M Technical Forum, a grassroots organization of technical employees geared toward collaboration. Meree is a member of the GT MSE external advisory board and leads 3M recruitment at Georgia Tech.

Mark A. Tschopp

Mark A. Tschopp, Ph.D. ’07, is the Regional Lead for ARL Central in Chicago, IL, at the US Army Research Laboratory (ARL), the corporate research and development laboratory for the Army. He leads efforts to accelerate discovery, innovation, and transition of science & technology to the Army to capitalize on strong academic institutions by leveraging the talent ecosystem for ARL within the Midwest. Tschopp joined ARL in 2012 and served as a materials engineer, team leader, and branch chief in ARL’s Weapons and Materials Research Directorate in Aberdeen Proving Ground, MD.

Tschopp received his B.S. and M.S. degrees in Metallurgical Engineering from the Missouri University of Science and Technology in 1998 and 1999, and his Ph.D. in MSE from Georgia Tech in 2007. He was the recipient of an NSF Graduate Research Fellowship and received the Sigma Xi Best Ph.D. dissertation award. He spent two years working in the Life Prediction and Behavior group at the Air Force Research Laboratory, and four years as research faculty in the Center for Advanced Vehicular Systems at Mississippi State University, where he received the Mississippi State Pride Faculty Award for excellence in research, teaching, and service.

Tschopp's research has focused on accelerated design of materials using modeling and simulation, data science, machine learning, and design optimization. He has published over 160 journal articles, book chapters, conference papers, and technical reports, and given over 130 presentations and seminars. He received the ASM Silver Medal Award from ASM International in 2016, the distinction of Fellow of ASME in 2017, and the distinction of Fellow of ASM International in 2018.

“I have been fortunate to have excellent mentors, teachers, and colleagues throughout my career. My experiences at Georgia Tech have truly helped forge the path for where I am today. I have always been very passionate about making an impact, whether that is through contributions to the research community, mentoring the next generation of scientists and engineers, STEM outreach to K-12 students, or forging collaborative partnerships in our regional campus to produce outcomes for the Army.”

Chekesha Liddell Watson

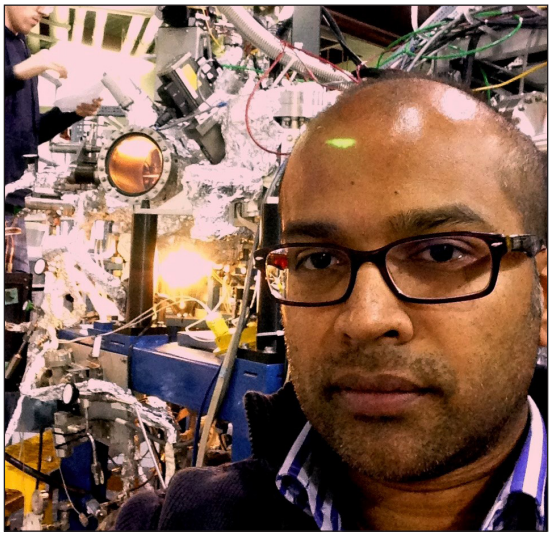
Chekesha Liddell Watson received a Bachelor of Science in Chemistry with Highest Distinction from Spelman College (1999) and a Bachelor of Materials Engineering from Georgia Technology (1999). She was awarded the NASA Women in Science and Engineering Scholarship and held internship appointments at NASA, Kennedy Space Center in the Cryogenics and External Tank Branch and the Microchemical Analysis Laboratories. After receiving a Ph.D. in Materials Science and Engineering with a minor in Science and Technology Policy from Georgia Tech, she joined the Cornell University faculty in November of 2003. Watson’s research interests focus on issues in energy and information technology, with the goal of developing photonic materials based on colloidal particles. Her work enhances the fundamental understanding of [1] the synthesis and processing science for colloidal materials under external forces, and [2] the structure-optical property relationships in these materials. In particular, her group’s recent work focuses on photonic mesophases (i.e., colloidal liquid crystals) from anisotropic particles and photonic alloys from binary size and shape particle systems.

Watson's work addresses the challenges of developing inexpensive fine-scale periodic materials with large photonic band-gaps at visible and near-infrared frequencies. For this purpose, her group has created complex colloidal crystals using building blocks of diverse morphologies and functionalities.

Watson's awards for scholarly achievement include the Distinguished Lecturer Awards, UCSB (2016); University of Massachusetts Amherst (2009); Provost’s Award for Distinguished Scholarship, Cornell University (2010); National Science Foundation (NSF) Presidential Early Career Award for Scientists and Engineers (PECASE) (2007); and the NSF Career Award (2006).

Faisal Alamgir

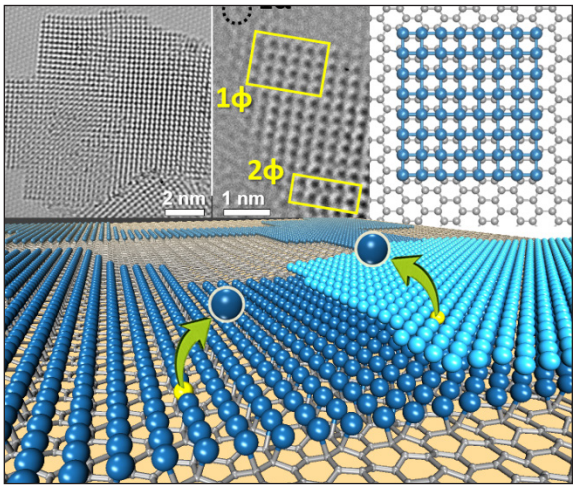
Fundamental Mechanisms Behind Functioning of Active Materials



What excites Faisal Alamgir most in his research is the prospect of figuring out the fundamental limits on how materials work and then, if possible, conspiring to emancipate them from their constraints. Detailed knowledge gained from the former allows him to design materials to realize the latter. Both of these research paths have already been successfully explored by his lab projects on materials for energy storage, conversion, and capture.

Elucidation of how energy-materials work: To determine in fine detail how materials work, the Alamgir lab uses element-specific x-ray techniques to reveal atomic-level structure (under real-world conditions whenever possible). Using these methods, the role of each element can be determined and detailed roadmaps can be produced. The members of the Alamgir lab have demonstrated this approach on Li-ion batteries, as well as on polymer electrolyte membrane and solid oxide fuel cells (PEMFC and SOFC).

Pushing materials beyond their limits: Dr. Alamgir and his group have been the first to demonstrate a new paradigm for graphene-templated, epitaxial, dimensionally-tunable, atomically-thin catalyst system that is support-flexible in design. This epitaxial graphene-metal system is a platform that transcends the activity-stability dilemma in catalysis since atomically-thin films render nearly every atom to a surface site while the bonds from the epitaxy also provide increased stability against catalyst deactivation. The platinum-graphene (Pt/GR) catalyst discovered by the Alamgir group exemplifies this effect by providing a “chemically transparent” barrier with “infinite” resistance to activity loss from Pt dissolution and agglomeration in 1000 cycles of the canonical oxygen reduction reaction. By inducing chemical bonding with graphene in the Pt/GR catalyst, the Alamgir lab has pushed the catalytic properties beyond that of a standard Pt catalyst, i.e. they have produced a supra-Pt catalyst.



Core competency and philosophy: The research conducted in the Alamgir lab benefits from a unique combination of three synergistic capabilities; synthesis of near-surface architectures, measurement of atomic-level structure evolution under *in situ* conditions, and measurements towards prediction of electrochemical properties, all from the perspective of the local atomic structure. Taken together, they reflect Alamgir’s philosophy of always returning to the atomic scale to discover the origins of structure-property relationships in materials.

Faisal Alamgir is an associate professor in the School of Materials Science and Engineering at the Georgia Institute of Technology. Research in Alamgir's group has focused on unraveling the fundamental mechanisms behind the functioning of active materials in (electro)catalysts, batteries and (photo)electrochemical devices. Often, synchrotron based (in/ex)-situ/operando methods are used to elicit underlying relationships between composition, electronic/atomic structure and material properties (e.g. electrical, optical, magnetic). In the materials space, Alamgir has been working on charge and strain transfer between/through 2D materials and metals/metal-oxides on layered-oxide based cathode materials for rechargeable batteries, development of poison tolerant electrodes for solid oxide fuel cells, and on transparent conductors and nanostructured semiconductors for solar cells.

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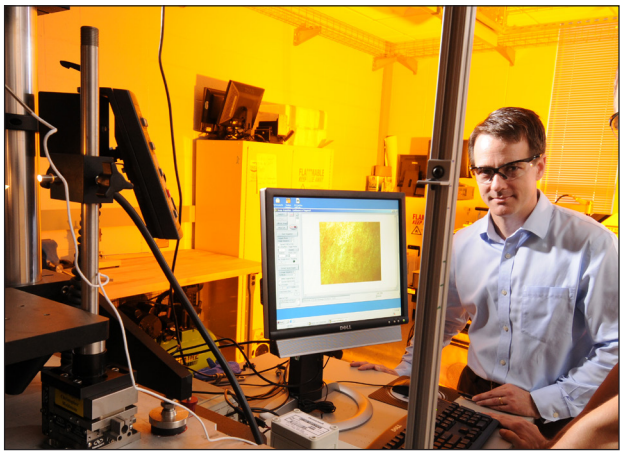
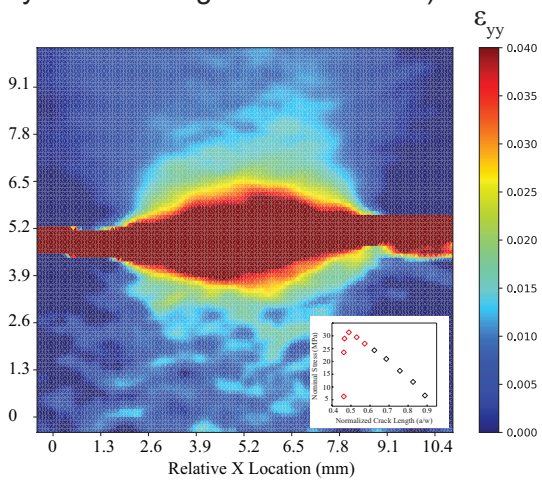
Chris Muhlstein

Understanding and Controlling Subcritical Crack Growth in Ultrathin Sheets

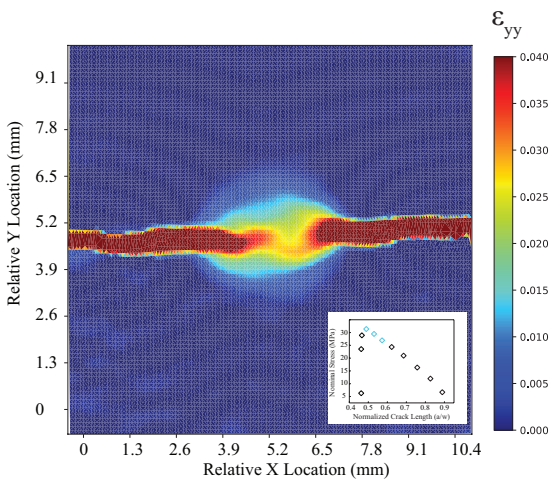


Deformation and fracture of materials must be controlled to insure effective manufacturing and product performance. Many of the conventional characterization and design tools are ineffective when the material is in the form of a very thin sheet. When the sheets are flexible and can drape and sag under their own weight, engineering models must capture extreme aspect ratios (low thickness-to-width ratios), complex 3-dimensional effects (wrinkling, buckling, necking, etc.), and unique thickness-dependent properties. The Muhlstein Research Group is addressing this challenge by developing novel techniques to characterize and model the deformation, degradation, and failure of flexible forms of such materials. Their work is the state of the art in engineering of flexible substrates for applications such as disposable electronics, flexible displays, and even packaging applications.

Muhlstein leads an interdisciplinary group that uses techniques from electronics, computer science, materials & manufacturing, and optics. In their NSF-sponsored program, “Understanding and Controlling Subcritical Crack Growth in Large Freestanding Metallic Nanosheets (NSF DMR 1609817),” they found a crack growth mode that is unique to very thin forms of materials. The quasi-static steady-state crack growth under fully-plastic conditions was detected using their open-source, full-field strain mapping platform. They discovered previously unknown zones of active plasticity that remained the same as the crack grew. Permanent (plastic) strains spanned the width of the specimen when cracks grew under fully-plastic conditions (Figure 1a). The details of the crack growth mechanism were lost in the extensive damage that developed between the opposing cracks in the double edge notched tearing specimen. Data mining of the strain fields between the crack tips revealed stable, incremental zones of active plasticity that surrounded fracture process zones (Figure 1b). The fracture toughness (steady-state crack growth resistance) could be predicted from a characteristic stress that was a function of the specimen thickness. These developments will change how we engineer components based on flexible forms of materials. Some of the results of this work are available in the open-source article that was published in *Engineering Fracture Mechanics* (DOI: 10.1016/j.ngfracmech.2019.106540).



(a) Accumulated ε_{yy} with reference image X= 0 and current image x = 350. Inset showing red symbols as the datapoints covered by the strain map



(b) Evolving ε_{yy} with reference image X= 300 and current image x = 350. Inset showing blue symbols as the datapoints covered by the strain map

Steady-state strains of a growing crack in aluminum foil.

Chris Muhlstein is an associate director of MPRL and associate professor in the School of Materials Science and Engineering at the Georgia Institute of Technology. His research group is focused on experimental studies of deformation, degradation, and failure of flexible forms of materials such as thin sheets and fibers. The research is driven by the engineering demand for flexible electronics, biomedical devices, and advanced structural materials. In most cases the materials are so thin and fragile that non-contact techniques must be used to measure the strains that develop during deformation.

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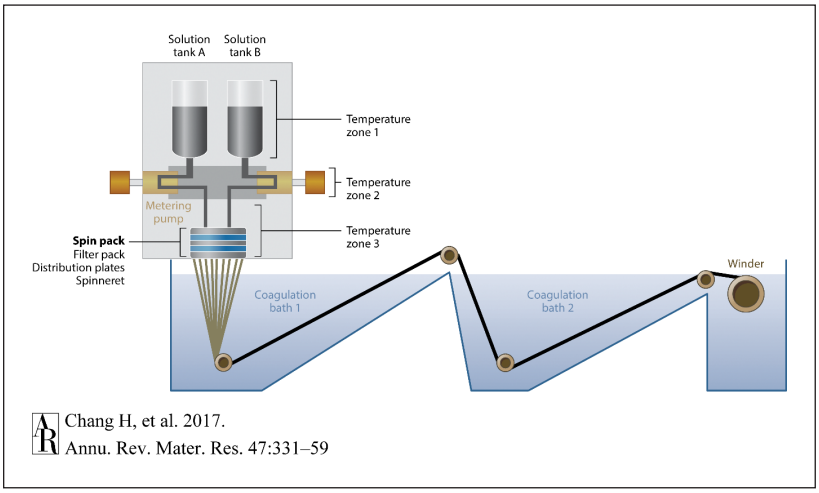
Satish Kumar

Carbon Fibers, Multifunctional Fibers, Nanocomposite Materials, and High Surface Area Carbon

Through funding from a **DARPA** program, Satish Kumar has set up a unique fiber manufacturing facility, which includes spinning and continuous stabilization and carbonization lines in 4000 square feet of class 1000 clean room space at Georgia Tech. Kumar utilizes this facility to manufacture various types of fiber and their composites.

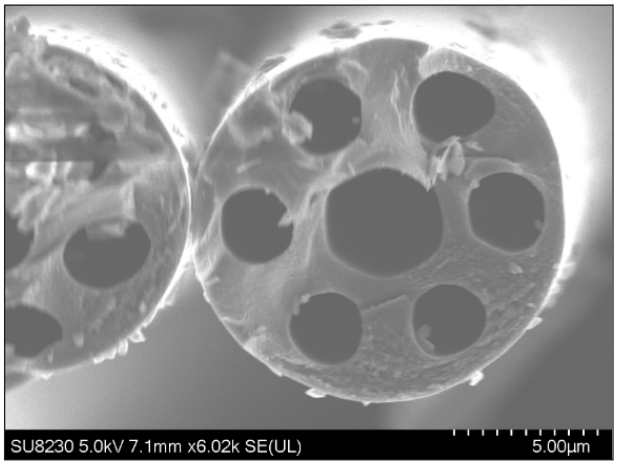
High Strength and High Modulus Carbon Fibers. Using gel fiber spinning technology, novel carbon fibers have been manufactured reaching 30% higher modulus over the state-of-the art carbon fiber (e.g., IM7) without compromising tensile strength. Composites taking advantage of these fiber properties, are expected to further reduce the weight of airplane parts (e.g., in Boeing 787) by additional 15%.

Polyacrylonitrile (PAN) /carbon nanotube (CNT) nanocomposites. Nanocomposites fibers made using PAN/CNT show that carbonized PAN is templated on the CNT surface, and that even a small amount of CNT (<1 wt%) significantly affects their thermal and electrical conductivity. Consequently, Joule heating can be used to increase the fiber temperature by up to several hundred degrees Celsius, even approaching 1,000°C. Likewise, other polymer/CNT fibers can be developed for heating applications, including heated textiles. Carbon nanotubes change the properties of polymers, including the ability to tailor electrical conductivity over 16 orders of magnitude, thermal conductivity, thermo mechanical properties, microwave absorption capability, etc. Polymer crystallization, orientation, and rheological behavior is also significantly affected using CNTs.



Fiber spinning system at Georgia Tech

Nanocomposite fibers with multiple functionalities. Hollow Carbon Fibers with honey-comb structure have been fabricated having a density of 1.2 g/cm^3; by comparison, the density of the state-of-the-art solid carbon fiber is 1.76 g/cm^3. Similar to CNTs, carbonized PAN can also be templated on BNNTs to provide additional functionality to carbon fibers. Fibers from iron oxide nanoparticles containing PAN have been shown to exhibit super paramagnetic behavior. By using a novel **bi-component fiber spinning** approach, Kumar's group has been able to manufacture carbon fibers with an effective diameter as small as 1-2 μm, while the current state-of-the-art carbon fibers have a diameter of ~5 μm. PAN-based carbon fibers incorporating renewable bio-content such as **cellulose nanocrystals** (CNC) and **lignin**, and bi-component fibers with **sheath-core**, **islands-in-a-sea**, and other cross-sectional geometries have been fabricated. Fibers with many other functionalities can also be fabricated.



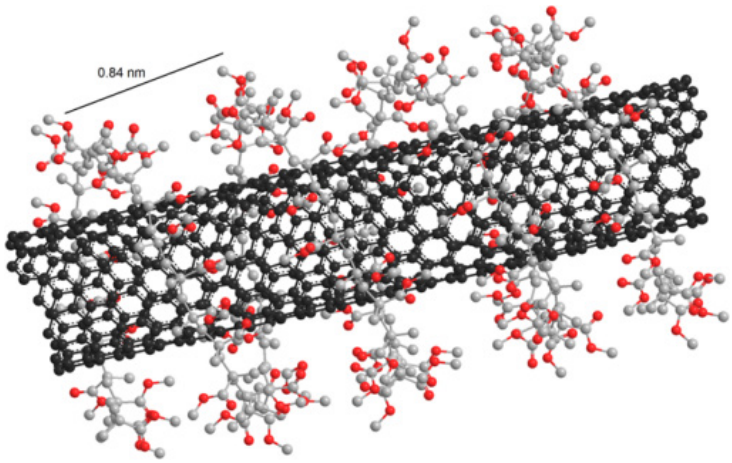
Hollow carbon fibers manufactured at Georgia Tech

High surface area carbon. Kumar's group has invented a process to economically manufacture large-scale quantities of **high surface area carbon** (3000 to 3500 m^2/g) from polyacrylonitrile (PAN) copolymer for applications such as supercapacitor electrodes (with more than two times energy density than the current state-of-the-art), electrode material for hybrid Li-ion battery, catalysis support, and for capacitive water desalination.

Biomedical Applications. Kumar's group is also interested in developing biomedical applications of fibers, nanofibers, and nanocomposite materials. They have collaborated with Biomedical Engineering faculty at Georgia Tech to fabricate polymeric nanofiber scaffolds, which have been found to be effective in bridging long peripheral nerve gap. The group has also collaborated with Augusta University on dental materials research to help prevent effects of gum disease.

Interphase tailoring. Kumar's research has shown that large changes in properties can be achieved with appropriately tailored interphase. For example, 150% increase in impact strength of polypropylene has been achieved by using only 1 wt% CNT, with previous best increase in **impact strength** being ~20%. In another development, Kumar's research has shown that PMMA forms an ordered helical wrap around **single wall carbon nanotubes (SWCNT)**, creating very stable dispersions in select organic solvents.

Nanocomposites using thermosetting resins. Under NASA's Space Technology Research Institute on composite materials, Kumar's group is fabricating nanocomposites using thermosetting materials (e.g., BMI and epoxy resins), and CNTs.



PMMA wrapped Carbon nanotube

Satish Kumar is a professor in the School of Materials Science and Engineering at the Georgia Institute of Technology. Kumar's research focuses on high performance materials, bio materials, energy storage, nano materials, functional electronics, optical materials, as well as fibers and composites. Poymer/carbon nanotube composites, as well as polymeric nano composites with other nano materials are areas of special emphasis.

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Natalie Stingelin

Cool Plastics for a Greener World

With seabirds trapped in six-pack plastic rings and islands of indestructible garbage accumulating mid-ocean, the idea that plastics could significantly contribute to a sustainable future might seem far-fetched. However, new smart photonic and electronic plastics may yet rescue the reputation of this ubiquitous 20th-century material. The use of such functional plastics in car manufacturing and building construction could improve energy efficiency and drastically reduce the need for air conditioning. Various members of the Stingelin group work on designing plastics whose photonic and electronic functions could be used to make more sustainable technologies. One line of inquiry that we are pursuing concerns the question whether the new polymer-based systems can offer the same flexibility, softness, and light weight as commodity plastics, such as polyethylene, polypropylene, polyesters and polyamides (Nylons®), while also controling the flow of light (i.e. photons). Such a function could enhance the energy (light) harvesting capability of, e.g., photovoltaic devices by reducing unwanted light reflections at critical device interfaces. These systems can also be used to aid light out-coupling from light-emitting diodes, increasing their brightness while keeping their energy consumption the same. Other potential uses for such systems include photonic heat mirrors that can prevent heat from building up in solar cells while they are in use, which would, in turn, reduce their performance degradation. Moreover, such mirrors can be used to reduce the energy we currently expend to keep buildings at the temperature we want, or to provide new alternatives for dynamic greenhouse technology platforms, which can manage light for optimal plant growth, harvest excess light energy for power generation to be used in the greenhouse, and provide thermal management to reduce energy use and control pests.

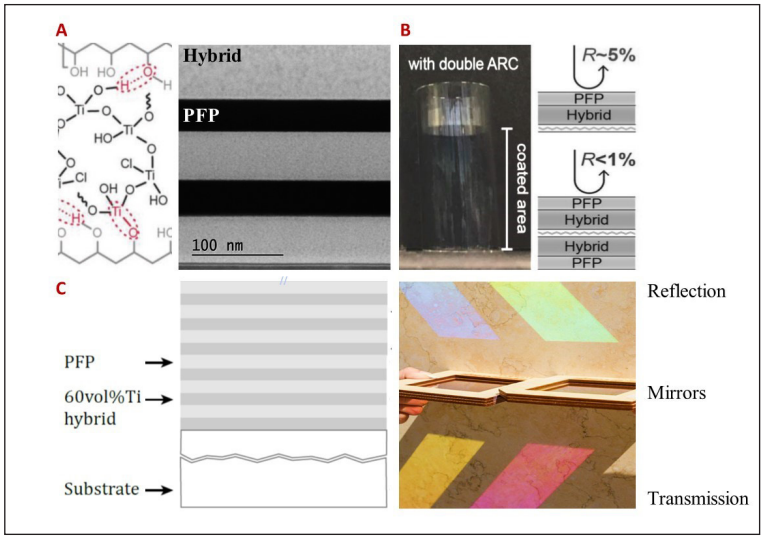

Figure 1. *Inorganic/organic hybrid materials developed in the Stingelin group allow to produce a large variety of photonic structures.* ***A.*** *Simplified schematic of the hybrid materials produced with commodity plastics such as poly(vinyl alcohol) that allow to produce multilayer structures using low-refractive index component fluorinated polymers or commodity plastics such as PMMA (Plexiglas®).* ***B.*** *Picture of a glass tube that was partly coated with an antireflection coating based on such high-refractive index hybrids/low refractive index multilayers.* ***C.*** *Using slightly different multilayer structures based on so-called distributed Bragg reflectors, mirrors can be produced by simple solution-processing. The reflection/transmission of those mirrors can be tuned by the selection of the refractive index of the materials used and layer thicknesses.*

Bachevillier, S., Yuan, H.-K., Strang, A., Levitsky, A., Frey, G.L., Hafner, A., Bradley, D.D.C., Stavrinou, P.N. & Stingelin, N., *Adv. Funct. Mater.* 1808152 (2019): "Fully solution-processed photonic structures from inorganic/organic molecular hybrid materials and commodity polymers" (DOI: 10.1002/adfm.201808152)

Russo, M., Campoy-Quiles, M., Lacharmoise, P., Ferenczi, T. A. M., Garriga, M., Caseri, W.R. & Stingelin, N., *J. Pol. Phys. B: Pol. Phys.* **50**, 65 (2012): "One-pot synthesis of polymer/inorganic hybrids: Towards readily accessible, low-loss and highly tunable refractive index materials and patterns" (DOI: 10.1002/polb.22373)

Natalie Stingelin is a professor in the School of Materials Science and Engineering at Georgia Institute of Technology. She previously held positions with Imperial College London; the Cavendish Laboratory, University of Cambridge; Queen Mary University of London, the Philips Research Laboratories, Eindhoven; and ETH Zürich. The research in Stingelin's group focuses on the broad field of organic-based functional materials, including organic electronics, multifunctional inorganic/organic hybrids, solution-processable photonics and bioelectronics.

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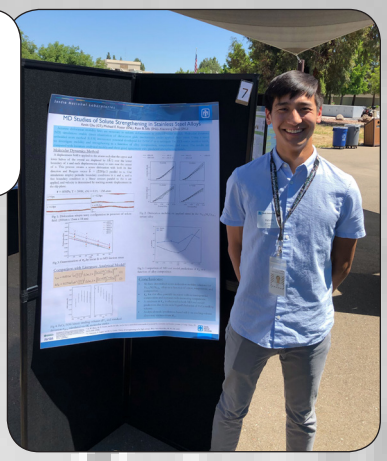
LEARNING NEVER ENDS

Undergraduates Conner Burkhardt (left) and Rebecca Barnes (right) were interns at ACM Chemistries in Norcross, working at their quality control and R&D labs.



Ph.D. student Kevin Chu presenting a poster at Sandia National Labs in Livermore, CA.

Ph.D. student Julia Allen was an intern at Corning in Washington, D.C.

Undergraduate Ben Wright was in Los Angeles as an additive materials development intern at Relativity Space.

Ph.D. student Neha Kondekar was an intern at Google X in Mountain View, CA.

Undergraduate Samantha Hestad was an intern at Corning in Wilmington, NC.

Background image: Transmission electron microscopy image of dislocations interacting with a twin boundary in stainless steel from research done by Josh Kacher.

Georgia Tech School of Materials Science and Engineering

Fall 2019

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Subsurface dislocation structures formed in an indented Ni sample as calculated by electron backscatter diffraction measurements. Research done by Josh Kacher.

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