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

It is indeed a privilege to be a faculty member in an academic institution like Georgia Tech. Each year we see history in the making, as new students arrive on campus aspiring to learn and build their dreams, while other students graduate and move on with what they have learned to see their ambitions turn into reality. While the aspirations and dreams are the same each year, the faces and the challenges are different. I feel that the biggest learner in this circle of life is me, and so it is for all the faculty. We constantly discover not only more about the mystique of science and engineering from our cutting-edge research, but also more about how students learn. With a diverse group of 15 to 30 year old undergraduate students, and graduate students from multiple science and engineering disciplines joining us, we strive constantly to improve how we teach. In this endeavor, we are building the learning environment and infrastructure to educate and nurture our students with the culture of creativity, curiosity, diversity, inclusiveness, innovation, and service to society.

The MILL, MSE’s “make and measure space,” is the hub for experiential learning, creativity, entrepreneurship, and innovation for students. It has passed its infancy and it is ready for the next stage. We have completed the feasibility study to explore its renovation to approximately 6,000 square feet of open space on the first floor of the J. Erskine Love Jr. Manufacturing Building. The renovation will house laboratories, student collaboration spaces, and workspaces to create the new “Discover – Design – Make – Measure Space,” the MILL 2.0. The inside back cover shows the architectural rendering. We are counting on the support from our alumni, friends, and industry partners to help us make this dream space a reality for our students.

During the past year, we welcomed Rampi Ramprasad as the Tannenbaum Family Chair Professor and GRA Eminent Scholar in MSE. His significant research activities in computation-based materials discovery using machine learning and data analytics are strengthening Georgia Tech’s leadership in the materials genome initiative, and helping us develop new courses and programs in Computational Materials Science and Engineering. Juan-Pablo Correa-Baena will be joining us as an assistant professor in January 2019. He brings with him new capabilities for deposition methods and novel synchrotron-based characterization techniques to design better, lower cost semiconductors for energy applications.

The past year saw an increase in partnerships with industry. We developed a corporate engagement program that will provide the platform for collaborating with industry partners to promote basic and applied research, advance the frontiers of knowledge, and create building blocks for new technologies in strategic areas of engagement, in addition to developing a pipeline of the highest quality engineers and scientists.

Many of our accomplishments have been possible thanks to the generous support and encouragement provided by our alumni and friends, for which I am most grateful. Your constant engagement and contributions are crucial for our continued success. I invite you to reach out to me at any time and share your thoughts and wisdom, or come by and visit the school. I am sure you will find something new and different, for the better. I look forward to your joining us on this journey to build our learning environment and help fulfill the aspirations and dreams of the next generation of MSE students.

Go Jackets!

Naresh Thadhani
Professor and Chair
404.894.2651
Naresh.thadhani@mse.gatech.edu

Best Colleges
U.S. News
RANKINGS
Undergraduate #3
Graduate #7
If you have not been to campus lately to see for yourself the many exciting things that are happening here in the School of Materials Science & Engineering, I urge you to reach out to me to schedule a time for a visit.

As always, our faculty are taking on the societal challenges we face today. They are creating new and improving upon old technologies for, among other things, clean energy, national security and personal safety, targeted drug delivery for improved treatment without the often devastating side effects, and many other areas that will improve both efficiency of technology and enhance quality of life.

What the faculty are doing is important to the future of our global society, but I am most inspired by our students. These young men and women are among the smartest, most driven people from around the globe. They are not only brilliant, they are using their combined intelligence and drive to change the face of education. The new Materials Innovation & Learning Laboratory (The MILL) is the brainchild of our undergraduates who want more hands-on opportunities for learning. The students are directly responsible for the creation of this new center for experiential learning and currently play an integral role in the development of the plans you see on the back inside cover of this newsletter. The student management of The MILL follows a business model with a CEO, COO, CFO, and even a CSO (Chief Safety Officer), so not only are MILL student leaders gaining technical expertise, they are learning valuable skillsets in the areas of leadership and team development.

Students have helped create an environment that maximizes both their learning experience and creativity to further enhance their education with a goal to change our world for the better, not only for right now, but also for decades and centuries to come. The legacy of these students will not just be solving problems for today’s society, but developing the economy for all—locally, nationally, and globally.

In order for us to fully turn the students’ vision into reality, we need your help. With a price tag of approximately $4 million for equipment and build-out, and a goal for an additional $1.5 million in endowed funds to ensure future funding for everything from student projects to equipment repair and replacement, we need your financial support to make this happen.

I am so proud of these young men and women who are changing the face of both education and technology and am honored to have the opportunity to work with them. But, we cannot do this without your financial support. I invite you to visit campus to meet and speak with these phenomenal students. You can see what they are doing and what they could accomplish if they had the proper tools. When you speak with them, I am confident that you too will want to help their dreams become a reality.

Mary Z. McEneaney
Director of Development
404.894.6345
Mary.mceneaney@mse.gatech.edu
Welcome Back Faculty Staff Breakfast, August

Shirley Manchester received the CoE Team Builder Award at the CoE Staff Appreciation Day in July

Dean McLaughlin Brings Cultural Changes

Dean McLaughlin has established the College of Engineering Staff Culture Advisory Committee (COESCAC), comprised of one staff representative from each of the eight Schools, as well as the Dean's Office. Hope Payne serves as the MSE staff representative.

The council's objective is to solidify action steps targeted toward improving areas of need identified by staff. Council members have been working closely with School Chairs and the Office of Strategic Consulting to develop initiatives, recognition programs, and increased opportunities for CoE staff members.

The council advocates for the staff and promotes equity, diversity, and inclusion in its culture.

As part of the initiative, MSE has introduced more social opportunities to better unite faculty and staff.

Farewell

Sheri Calhoun, Grants Administrator
Sarah Craft, Educational Outreach Manager
Keia Dodd, Faculty Support Coordinator
Rusty Edwards, Assistant Director - Financial Operations

CoE Staff Appreciation, July

Coffee and Conversations, October

Ice Cream Social, May

Welcome Farewell Staff News
Faculty

- **Blair Brettmann**, Ralph E. Powers junior Faculty Enhancement Award
- **Sundaresan Jayaraman**, Textile Institute Research Publication Award
- **Josh Kacher**, ASM International Bradley Stoughton Award for Young Teachers, CTL/BP junior Faculty Teaching Excellence Award
- **Surya Kalindini**, DoD Vannevar Bush Faculty Fellowship
- **Satish Kumar**, POLY Fellow of the American Chemical Society, Innovation and Impact in Materials Research Award (GTRC)
- **Meilin Liu**, Charles Hatchett Award of the Institute of Materials, Minerals and Mining
- **Seth Marder**, Class of 1934 Distinguished Professor Award
- **Dong Qin**, Geoffrey G. Eichholz Faculty Teaching Award
- **Naresh Thadhani**, TMS Leadership Award
- **Z.L. Wang**, ENI Energy Frontiers Award, Academician of Academia Sinica
- **Gleb Yushin**, Sigma Xi Faculty Best Paper Award, Blavatnik National Finalist in Physical Science and Engineering

Staff

- **Shirley Manchester**, CoE Team Builder Award

Students

- **Eleanor Brightbill**, National Science Foundation Graduate Research Fellowship
- **Matthew Boebinger**, DOE Office of Science Graduate Student Research (SCGSR) Fellowship
- **Amy Brummer**, National Defense Science and Engineering Graduate Fellowship, National Science Foundation Graduate Research Fellowship
- **Matthew Drexler**, DOE Office of Science Graduate Student Research (SCGSR) Fellowship, MSE Outstanding Teaching Assistant
- **Ben Ibach**, MSE Outstanding Senior
- **James Lococo**, Center for the Science and Technology of Advanced Materials and Interfaces Graduate Student Fellowship
- **Camilla Johnson**, National GEM Consortium Fellowship, National Science Foundation Graduate Research Fellowship
- **Garrett LeCroy**, National Science Foundation Graduate Research Fellowship
- **Tyler Quill**, National Science Foundation Graduate Research Fellowship, Davidson Family Tau Beta Pi Senior Engineering Cup, MSE Outstanding Senior
- **Travis Voorhees**, DOE NNSA Laboratory Residency Graduate Fellowship
- **Stephanie Sandoval**, National Science Foundation Graduate Research Fellowship, National GEM Consortium Fellowship, Goizueta Foundation Fellowship
- **Kerisha Williams**, Goizueta Foundation Fellowship

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**MSE Students Win 2018 InVenture Prizes**

Nicknamed the "American Idol for Nerds," the InVenture Prize competition brings together student innovators from all academic backgrounds across campus in an effort to foster creativity, invention, and entrepreneurship.

MSE student Kolby Hanley took top prize with his invention, Starlight, a first-of-its-kind aiming device for competitive archery. He won $20,000 plus a free patent filing and a spot in Flashpoint, a Georgia Tech accelerator. Hanley transferred to Tech last year. His lightweight scope with integrated light is the latest product developed by his company, UltraView. He runs the company from his dorm room.

The People’s Choice Award and $5,000 went to pHAM. The MSE student team of Fredrick Gray, Michele Lauto, Tyler Quill, Aaron Stansell, and Luke Votaw designed a filter to reduce coffee’s acidity. They incorporated a mineral blend into the structure of the filter paper, reducing the acidity of the brewed coffee without negatively affecting the taste.
3M, 3M Sweating Substrate Test Method
Team Business as Usual—Spencer Johnson, Alexander Lewis, cob Lister, Andrew Middleton, Andre Mohseni, Aaron Ranallo

CDC, Building a Better Bed Net for Malaria Control
The Tassel is Worth the Hassle—Kim Adams, nnifer Burkhardt, Vincent Donald-Giando, Kayla Hendrickson, Valeria Rivero

Ecolab, Surgical Drape Redesign
Team Polymer MemBrains—Steven Clements, Tara Kilgo, Garrett LeCroy, Michael Muller, Renee Puvvada, Nikhil Shukla

GDOT, Improvement of Shrinkage Reducing Admixtures for Concrete Bridges
Team Concrete Creations—Megan Cahill, Benjamin Clark, amie Curtis, Marlee Newman, Meghan Toler, Maxwell Young

GT, Creative Composting
Team Tri-Force—Manuel DeJu an, Andrew Hanna, Michelle Lin, Mari Nguyen, Mallory Parker, Ramón Sosa

GT, pHAM
MSE Capstone Winner
Team pHAM—Fredrick Gray, Michele Lauto, Tyler Quill, Aaron Stansell, Luke Votaw

Thank you to all our Capstone Sponsors!

3M. 3M Sweating Substrate Test Method
Team Business as Usual—Spencer Johnson, Alexander Lewis, cob Lister, Andrew Middleton, Andre Mohseni, Aaron Ranallo

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GT, pHAM
MSE Capstone Winner
Team pHAM—Fredrick Gray, Michele Lauto, Tyler Quill, Aaron Stansell, Luke Votaw

Gulfstream Aerospace Company, Wood Veneer Moisture Barrier
Team Sealing the Veneer—Nicholas Chen, Tamara Krauss, Christina Miller, Xiaojun Pan, Alex Ruschau, Carlos Tiongco

LivFul, AKIVA Repellent Delivery / Application Innovation
Interdisciplinary Capstone Winner
Team Señor Design—BME: Ashley Fleck and Robert Griffith, ME: Sommy Khalaj, Kiran Rao, and Spencer Tyson, MSE: Jacob Sills

P&G, Visualization of Substrate/ABM/Skin Interfacial Mechanisms During the Cleaning Process
TP Tornados—Zachary Adams, Amy Clark, Alyssa Griffin, Anne Marie Hutchinson, Long Qian

Printpack, 3D Printing Functionality on Polymer Films
Team Maybe It’s Material Science—Katarina Adstedt, Colleen Chen, Derek Henry, Malak Muhammed, Willow Peterson, Miranda Tuck

Saint-Gobain, Drying in PTFE Films
Team Masters of Design—Kyle Edmunds, han Gyure, Hanna ng, Angela Park, Shannon Parker, cob VanEyk

Shaw, Shaw Inc Scuff Test
Team Innovation Express—Nick Bond, Daniel Harris, Sarah Howard, Morgan nes, Gabe Waksman, Ian Watt

Under Armour, Under Armour E-Nose
Team Speyers Spitfires—Marie Henshaw, Caitlin Hirschler, Eric Lopresti, Victoria Ohmer, Matthew Roth, Tony Zhou

Contact: Mary Lynn Realff at 404.894.2496 marylynn.realff@mse.gatech.edu or Blair Brettmann at 404.894.2535 blair.brettmann@mse.gatech.edu
Summer 2018

MSE Research Scholars receive a $6000 stipend for 10-week immersion in summer research following completion of first year. They are encouraged to present their research at the annual fall MSE Industry Day event and to participate in the spring MSE poster competition. Summer 2018 industry sponsors included Art and Patricia Cox, Kolon, Novelis, and Solvay.

Ayush Jain, Melt-infiltration of Solid-State Electrolytes in Common Battery Anodes

DJ Jang, The Role of Process Inherent Heterogeneities on Mechanical Behavior of Particle-Filled Composite Materials

Henri Johnson, Studies on Hydrophobic and Hydrophilic Coatings of Fabrics

Jin Lee, Extrusion Based Additive Manufacturing of Biocompatible Binders for Ceramics

Jamie Petrie, Atomic Layer Deposition of Heterogenous Multilayered Titanium Dioxide Thin Films

Tommy Marchese, Electrochemical Reactions in Solid State Batteries

Luke Pittner, Assembly of POSS based Polyionic Liquids

Michale Oneil, Microstructure of OFHC Copper Sheets

Mofolu Popoola, Optimizing the Production of Orodispersible Films

Jackson Sims, Finding DNA Aptamer Sequences that Bind to Model Molecular Drugs

Clarissa Simkins, Microstructure of OFHC Copper Sheets

Lily Turaski, MISSE Variant 2 Exposure of Photovoltaic Cells on the International Space Station

Sponsor MSE Research Scholars!

Contact Mary Z. McEneaney
mary.mceneaney@mse.gatech.edu

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Angela Mitchell, PTCh ’04, Senior Engineer, R&D, Halyard Health

Yancy W. Riddle, M.S. MSE ’98, Ph.D. MSE ’01, COO - Latin America, Nearsouth Technology

Tom Rosenmayer, Vice President, Development, Lehigh Technologies

Susan Sinnott, Head and Professor, Department of MSE and Department of Chemistry, the Pennsylvania State University

Herb Upton, Mgt. ’93, Director, Specialty Products Division, Shaw Industries Group

Phil Williams, EAB Vice Chair, Text ’70, Consultant

Emeritus Members

Jennifer P. Bailey, CerE ’70, M.S. CerE ’71, BASF (Retired)

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Lee Bryan, Global Director of Product Supply, TenCate Geosynthetics

Michael L. Fulbright, Text ’72, President and CEO (Retired), JPS Industries, Inc.

Michael Ginn, M.S. CerE ’80, President, Ginn Mineral Technology, Inc.

Parmeet Grover, M.S. MetE ’93, Ph.D. MetE ’96, Partner, BCG

Kurt Jacobus, ME ’93, Chairman, President and CEO, MedShape, Inc.

Sandra H. Magnus, Ph.D. CerE ’96, Past President, The American Institute of Aeronautics and Astronautics

Graeme Marshall, Director Global R&T Center, (Retired) Global Technology Director, Novelis

Jeffrey A. Martin, TE ’82, President and CEO, Yulex Corporation

Geoffrey P. Morris, PE, CerE ’82, Materials/3M Oral Care, Scientific Affairs Manager, 3M
2018 CoE Alumni Awards

Edward "Alex" Gregory, Jr., B.S. TE ’70, Chairman and CEO of YKK Corporation of America, received the Engineering Hall of Fame award. He joined YKK in 1973 and was named president in 2001. Alex serves on The Carter Center Board of Councilors; Cowan-Turner Servant Leadership Program advisory board at Georgia Tech’s Scheller College of Business; GCSU Foundation; University of North Georgia's Mike Cottrell College of Business advisory board and Kennesaw State University’s Asian Studies advisory board. He has mentored more than 50 college students since 2001 and has contributed to Georgia Tech’s Roll Call for 52 consecutive years. In 2017, Alex received the Atlanta Business Chronicle’s Most Admired CEO Award.

Kurt Jacobus, B.S. ME ’93, received the Academy of Distinguished Engineering Alumni award. Kurt is the CEO of MedShape, Inc., an Atlanta-based foot and ankle orthopedic implant company with a market-leading product to eliminate limb amputation in diabetic patients. He has served as a founder, operator, investor and advisor to nearly 20 companies over the past decade, leading to the commercialization of multiple new material technologies, the creation of many breakthrough products and strong shareholder returns. Kurt is an MSE Emeritus External Advisory Board Member.

Marilyn L. Minus, B.S. PTFE ’02, Ph.D. ’08, associate professor in the Department of Mechanical and Industrial Engineering at Northeastern University in Boston received the Council of Outstanding Young Engineering Alumni award. She is the director of the Macromolecular Innovation in Nano-materials Utilizing Systems Laboratory and has published more than 40 scientific publications in the area of polymer-based nano-composites. She is the recipient of the National Science Foundation CAREER award and is currently a member of American Chemical Society (ACS), Materials Research Society (MRS), Society for the Advancement of Material and Process Engineering (SAMPE) and the Society of Plastics Engineers (SPE).

2017 Brumley D. Pritchett Lecture

Peidong Yang, S.K. Angela Chan Distinguished Professor of Energy, Department of Chemistry and Materials Science and Engineering, University of California, Berkeley presented the 2017 Brumley D. Pritchett Lecture to a packed house. His presentation, “CO2 + H2O + Sunlight = Chemical Fuels + O2,” addressed challenges associated with fixing CO2 through traditional chemical catalytic means, contrasted with the advantages and strategies that biology employs through enzymatic catalysts to produce complex molecules at higher selectivity and efficiency.

The Brumley D. Pritchett Lecture Series was established as a memorial to the late Col. Brumley D. Pritchett. He received his bachelor’s degree in textile engineering from the Georgia Institute of Technology in 1930, graduating with an award for superior achievement in his major. While at Georgia Tech, he was instrumental in founding the Phi Psi Textile Honors Fraternity and was a member of Phi Sigma Kappa. After graduation he worked briefly at Dundee Mills, then Eagle and Phoenix Mills in Columbus, Georgia. He joined the United States Army in 1940 and served in the Pacific during World War II. Following his service in the Army, he returned to Eagle and Phoenix Mills as superintendent. Later, he joined Steel Heddle Manufacturing Company as a sales engineer and consultant, retiring in 1972. He was elected to membership in the College of Engineering Hall of Fame at Georgia Tech in 2002.
A Personal Responsibility to Help the Next Generation

Longtime MSE supporter George Corbin has retirement on his mind, as he continues his 12-year affiliation with MSE at Georgia Tech, having served on the External Advisory Board (EAB) since 2006.

Corbin, who holds chemical engineering degrees from Columbia University and MIT, began his career with Amoco in 1983 in research & development for Specialty Polymers. After four years in a leadership role in the polypropylene business, he returned to Specialty Polymers, where he served as business manager for sulfone polymers through ownership transitions to BP and Solvay. In 2004, he returned to R&D as head of the advanced polymers business, and in 2008, he was appointed president of Solvay Advanced Polymers Global Business, which merged into GBU Specialty Polymers in 2011, at which time he assumed the role of director of research and innovation.

Corbin first engaged with MSE in 2006 when Meisha Shofner was awarded the Solvay Advanced Polymers Young Faculty Award. Director of Development Mary McEneaney saw Solvay, a world leader in high performance polymers, as a potential partner for the School of Polymer, Textile and Fiber Engineering (PTFE). Corbin, then Vice President of Technology at Solvay, was recruited to be a member of the PTFE External Advisory Board. In 2010, when PTFE merged with MSE, Corbin continued on the MSE EAB, and in 2015, became the Chair, and in turn, a member of the CoE advisory board.

Solvay’s support of MSE has been significant. In addition to Corbin serving on the MSE EAB, Solvay has been the premier sponsor of the MSE poster competition since its inception in 2012. Solvay also sponsors three undergraduate research scholarships annually for student participation in research with faculty at Tech during the summer following their first year.

Corbin also helped solicit funds and equipment for the MSE Materials Innovation and Learning Laboratory, the MILL. He is currently working closely with EAB member Gary Foote and Professors Meisha Shofner and Satish Kumar with the launch of the PR:IME Laboratory, a dedicated polymer processing facility for use in undergraduate education, graduate research, and collaborative industry-university research projects.

When asked about his motivation in working with MSE and Georgia Tech, Corbin refers to a personal responsibility to help the next generation of scientists and engineers develop skills and competencies for success in industry. Solvay, he feels, also has a corporate social responsibility to support the academic community. They, in turn, receive a positive return on investment through a pipeline of employees from Georgia Tech’s Schools of MSE, ChBE, ME, and the Sciences.

To Corbin, the most satisfying part of working with MSE is the ability to interact with students and see them thrive in the Georgia Tech environment. He points out that the students today are far more advanced than he was at that age. He feels gratification in the EAB’s ability to help MSE with the three T’s – time, treasure, and talent - and the impact made through mentoring, STEM, financial resources, sponsored projects, and creating connections. He shows pride in the continuing success of MSE, which recently moved to #3 in undergraduate rankings of U.S. News and World Report. “Ratings don’t tell the whole story, but it certainly represents where we are.”

"George’s leadership of the MSE EAB has been directed and focused; he has the skills to break things down to the important points and allow everyone in the room to express their thoughts and opinions in order to collectively zoom in on key issues and proactively tackle them.”

- Mary Z. McEneaney, Director of Development

Undergraduate Laura Willows discusses her research with George Corbin at the 2018 MSE Poster Competition
Vapor deposition is a common materials processing method used to precisely deposit thin films of materials (< 1 micron thick) for microelectronics and flat panel displays found in laptops, cell phones, and televisions. In vapor deposition, the starting material is delivered in a gaseous state of atoms or molecules that eventually condense onto a surface, coalescing into a thin coating or "film". While these processes often engender images of "futuristic workers in bunny suits" ensuring atomic level precision, the Losego Lab seeks to broaden the applicability of these processes to modify and bring new value to commodity products. While atomic level purity may be necessary for microelectronic applications, lower purity conformal coatings and modifications can serve a number of useful purposes. (For example, vapor deposited metal coatings on the insides of potato chip bags have prevented this salty snack from going stale for decades.)

The Losego Lab is particularly interested in how functional inorganic constituents can be incorporated into organic plastics using vapor phase processes. Vapor modification of plastic (polymeric) materials in the Losego Lab comes in two flavors: (1) modifying the surface chemistry to adjust how the material responds to the environment in which it is in immediate contact and (2) infusing inorganic constituents into the bulk of the polymer to create entirely new organic-inorganic hybrid materials, see, e.g., Materials Horizons 2017. Unlike liquid phase processing that is constrained by solid-liquid surface tension, vapors rapidly permeate any complex structure and easily modify every surface of a polymer fiber, fabric, or foam.

At the scientific core of the Losego Lab is the development and experimental validation of thermodynamics- and kinetics-based phenomenological models used to describe these vapor phase processing schemes, see Phys. Chem. Chem. Phys. (2018). A fundamental understanding of these processes enables informed control over material composition and structure and the design for scale-up of these processes for manufacturing. To study the science of these processes, the Losego Lab operates six student-build vapor deposition systems that are custom designed to analytically monitor vapor phase processes, like real-time tracking of mass uptake on a surface (at the picogram scale) or chemical analysis of released gaseous byproducts.

Beyond fundamental studies of processing, the Losego Lab is also interested in the functional properties of these new materials. Recently, the Losego Lab has developed a new atomic-scale surface modification scheme for cellulose-based products (like cotton) that transforms them into sorbents that selectively sorb oil over water. As shown in the picture, these sorbents are of interest for oil spill remediation. This technology recently received a TechConnect National Innovation Award and Losego was selected for the National Academy’s Gulf Research Program Early Career Research Fellowship to further develop this technology.

Mark D. Losego is an Assistant Professor of Materials Science and Engineering at the Georgia Institute of Technology. He is an expert in vapor phase processing of materials and has authored or co-authored over 70 peer-reviewed journal articles, two book chapters, one patent, and has been cited more than 2000 times. He is a recipient of the 3M Non-Tenured Faculty Award (2017), CTL/BP Junior Faculty Teaching Excellence Award (2016), and in 2018 was named a “Future Star” of the American Vacuum Society (AVS).
Understanding Heterogeneous Nucleation in Nanocrystal Growth with Molecular Probes

Nanocrystals are geometrically well-ordered solids with diameters on the order of 0.0000005 inches. Bimetallic nanocrystals, made of two different metal species, have properties that are often superior to their single-metal counterparts. The arrangement of the two different metals relative to each other in the nanocrystal is very important in determining the nanocrystal properties, and considerable effort has been made to deposit one metal atop the nanocrystal surface of another metal with precision in location. It remains a grand challenge to detect and quantify the metal being deposited, particularly when the nanocrystals are still suspended in the reaction medium undergoing growth. The Qin Lab addresses this challenge by developing a class of molecules, the isocyanides (molecules containing the -NC chemical group), as probes for in situ characterization with detection of the isocyanides by a spectroscopic technique, surface-enhanced Raman scattering (SERS). The ultimate goal is to establish a scientific basis for enabling the rational synthesis of bimetallic nanocrystals with well-controlled compositions and shapes, which have broader societal impact through their need in a variety of applications. This research project encompasses multiple disciplines such as materials science, chemistry, colloidal science, solid-state physics, photonics, and surface science.

Most recently, the Qin Lab reported the use of 2,6-dimethylphenyl isocyanide (2,6-DMPI) as a spectroscopic probe to study the heterogeneous nucleation and deposition of Pd on Ag nanocubes under different conditions by SERS. As a major advantage, the spectroscopic analysis can be performed in situ and in real time with the nanoparticles still suspended in the reaction solution. The success of this method relied on the distinctive stretching frequencies ($\nu_{NC}$) of the isocyanide group in 2,6-DMPI when it binds to Ag and Pd atoms through $\sigma$ donation and $\pi$-back donation, respectively. Significantly, we discovered that $\nu_{NC}$ was sensitive to the arrangement of Pd adatoms on the Ag surface. For example, when the isocyanide group bound to one, two, and three Pd atoms, we would observe the atop, bridge, and hollow configurations, respectively, at different $\nu_{NC}$ frequencies. As such, the $\nu_{NC}$ band could serve as a characteristic reporter for the Pd adatoms being deposited onto different types of facets on Ag nanocubes with atomic-level sensitivity. When 2,6-DMPI molecules were introduced into the reaction solution, we further demonstrated in situ tracking of heterogeneous nucleation and early-stage deposition of Pd on Ag nanocubes by monitoring the evolution of $\nu_{NC}$ bands for both Ag and Pd surface atoms as a function of reaction time. This in situ technique opens up the opportunity to investigate the roles played by reaction temperature and the type of Pd(II) precursor in influencing the heterogeneous nucleation and growth of bimetallic nanocrystals. The sensitivity of isocyanide group to Pd atoms helps elucidate some of the details on the reduction, deposition, and diffusion processes involved in heterogeneous nucleation. This piece of work has been published in the Journal of the American Chemical Society, 2018, v.140, 8340-8349 (doi:10.1021/jacs.8b04824).

Dong Qin is an Associate Professor of Materials Science and Engineering at Georgia Institute of Technology, with an adjunct appointment in the School of Chemistry & Biochemistry. Her current research focuses on the unique properties and applications of nanoscale materials and systems. Qin is the recipient of Georgia Tech CETL/EPdfior Faa Ity Teab ing Ee ilene Award 2015, 3M Non-tenured Faa Ity Award 2015-2018, and Georgia Tech Geoffrey G. Eibholz Faa Ity Teab ing Award 2018, respectively.
Materials development over much of the last 7,000 years has been guided largely by philosophy, experience and intuition. That trend has been changing in the past several decades, thanks to quantitative theories, advanced experimental capabilities and modern computing power. Rational search and design strategies have emerged to deal with the combinatorial explosion of materials possibilities offered by the palette of the (now known) ~ 95 stable elements of the Periodic Table. These developments have been epitomized and further stimulated by the White House Materials Genome Initiative (MGI) launched by President Obama in 2011. The MGI urges the community to bring together experimentation, computation and materials data science “to help businesses discover, develop, and deploy new materials twice as fast.”

The Ramprasad group studies materials on the computer—virtually—using fundamental theories such as quantum mechanics and data-driven methods such as machine learning. These methods accelerate significantly the design and discovery of new application-specific materials by virtually screening thousands of new materials even before they are actually made, and provide guidance for the specific types of materials that should be made and tested. This type of activity, which would have been viewed as “science fiction” just a few decades ago, is rapidly becoming a prominent sub-field of materials science here at Georgia Tech and around the world.

A recent highlight of Ramprasad’s research relates to his work on polymer insulators for electrostatic energy storage. The Office of Naval Research (ONR), through the Multidisciplinary University Research Initiative (MURI), funded this work. Along with colleagues involved in materials synthesis and characterization, the Ramprasad group has been able to show how quantum mechanics-based computations can truly drive and transform the discovery of new materials. Several new polymers that appear to be very suitable and very promising for capacitor-based energy storage applications have been discovered and validated through synthesis and testing. The figure below shows a comparison of biaxially oriented polypropylene (BOPP)—the current standard polymer dielectric used in high energy density capacitors—with three other computation-guided rationally designed polymers. This work—highlighted at the fifth-year MGI anniversary event at the White House as one of the MGI accomplishments—has been summarized in articles in Materials Today (2018), Advanced Materials (2017), and Progress in Materials Science (2016).

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<tr>
<th>Polymer name</th>
<th>BOPP</th>
<th>PDTC-HDA (Polythioure)</th>
<th>BTDA-HDA (Polyimide)</th>
<th>BTDA-HK511 (Polyimide)</th>
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<td><img src="image2" alt="repeat unit" /></td>
<td><img src="image3" alt="repeat unit" /></td>
<td><img src="image4" alt="repeat unit" /></td>
</tr>
<tr>
<td>Synthesized polymer</td>
<td><img src="image5" alt="synthesized polymer" /></td>
<td><img src="image6" alt="synthesized polymer" /></td>
<td><img src="image7" alt="synthesized polymer" /></td>
<td><img src="image8" alt="synthesized polymer" /></td>
</tr>
<tr>
<td>Dielectric constant</td>
<td>2.2</td>
<td>3.7</td>
<td>3.6</td>
<td>7.8</td>
</tr>
<tr>
<td>Breakdown field (MV/m)</td>
<td>700</td>
<td>685</td>
<td>812</td>
<td>676</td>
</tr>
<tr>
<td>Energy density (J/cm3)</td>
<td>~5</td>
<td>~9</td>
<td>~10</td>
<td>~16</td>
</tr>
</tbody>
</table>
A new addition to Ramprasad’s computational toolkit portfolio is “machine learning”, a branch of artificial intelligence that is concerned with how we can create a computer system that can automatically and progressively learn and improve through experience and past data. Within the context of materials science, by using available materials data, machine learning can help transform the discovery process. Using the polymer data created as part of the MURI project and by collecting and curating literature data, the Ramprasad group has created “Polymer Genome”, an on-demand polymer property prediction pipeline polymergenome.org. This framework was recently described in *Journal of Physical Chemistry C* (2018).

Another materials design project the Ramprasad group is working on, in collaboration with researchers at the University of Connecticut and North Carolina State University, deals with the unusual behavior of a well-known material, hafnium dioxide (or hafnia). Under certain conditions, this material displays switchable electrical polarization, i.e., ferroelectricity— the electrical analog of ferromagnetism. Again, utilizing quantum mechanics-based computations, the Ramprasad group has been able to explain the origins of this ferroelectricity and has provided guidance on dopants that may be inserted in hafnia to further enhance this ferroelectricity; article in *Chemistry of Materials* (2017). The figure below illustrates the stages of computation-guided dopant selection in hafnia. The dopant recommendations were subsequently and independently validated experimentally.

In more recent work, along with collaborators from the University of Connecticut, Purdue University, Stanford University and the University of Southern California, and funded through a second ONR-sponsored MURI project, the Ramprasad group is attempting to understand the behavior of insulators under the influence of enormous electric fields. This work is expected to lead to design principles for the creation of electric field tolerant insulators. On the machine learning side, the Ramprasad group is also exploring how a computer system may be trained to learn from itself and its own experiences during the course of a quantum mechanics-based materials simulation, *npj Computational Materials* (2017). These efforts could lead to materials simulation capabilities that preserve the high-fidelity of quantum mechanical calculations by six-for-eight orders of magnitude faster.

**Rampi Ramprasad is the Michael E. Tennenbaum Family Chair and Georgia Research Alliance Eminent Scholar in Energy Sustainability in the School of Materials Science & Engineering at the Georgia Institute of Technology. He is a Fellow of the American Physical Society, an elected member of the Connecticut Academy of Science and Engineering, and the recipient of the Alexander von Humboldt Fellowship and the Max Planck Society Fellowship for Distinguished Scientists. He has authored or co-authored over 180 peer-reviewed journal articles, six book chapters and four patents. He has delivered over 150 invited talks at universities and conferences worldwide, and has organized several international symposia.**

### Connect with MSE

**Alyssa Barnes**
Communication Officer
404.586.1650
alyssa.barnes@mse.gatech.edu

**Meilin Liu**
Associate Chair for Academics and Research
404.894.6114
meilin.liu@mse.gatech.edu

**Mary Lynn Reallff**
Associate Chair for Undergraduate Programs
404.894.2496
marylynn.reallff@mse.gatech.edu

**Preet Singh**
Associate Chair for Graduate Studies
404.894.6641
preet.singh@mse.gatech.edu
Zhong Lin Wang

Research Innovations: nanogenerators and piezo-phototronics

The piezoelectric nanogenerators and the field of nanoenergy
Developing novel technologies for wireless nanodevices and nanosystems are of critical importance for in-situ, real-time and implantable biosensors, environmental science, personal electronics and national security. It is highly desired for wireless devices to be self-powered without using battery; otherwise 90% of internet of things would be impossible. Groundbreaking research by Wang in 2006 led to the invention of the piezoelectric nanogenerators for self-powered nanodevices. He demonstrated an innovative approach for effectively converting mechanical energy into electric energy by piezoelectric zinc oxide nanowire arrays. This research opens up the area of nanoenergy, a field that uses nanomaterials and nanodevices for highly efficient harvesting of energy from ambient environment, which is now a focal area of research for applications in sensor networks, mobile electronics, and internet of things.

Triboelectric nanogenerator for internet of things
The principle of electromagnetic generator (EMG) that converts mechanical energy into electricity was first introduced by Faraday in 1831, which is most efficient at high frequency (>10-60 Hz). For low frequency mechanical triggering (<1-5 Hz) in our living environment with random amplitudes, EMG is inapplicable for harvesting such energy. Therefore, the triboelectric nanogenerator (TENG) was established by using high-quality, regulated energy that has a high operation frequency. As the world is advancing into the era of internet of things and artificial intelligence, distributed power sources are desperately needed. In 2011, Wang made a discovery of utilizing the conjunction of triboelectrification effect and electrostatic induction for electricity generation using organic thin film materials. The TENG is a simple, low cost and effective approach for power generation using human motion. It is fabricated by stacking two polymer sheets made of materials having distinctly different triboelectric characteristics, with metal films deposited on the top and bottom of the assembled structure. Wang has systematically invented the models and theories for the TENG to meet a variety of needs. TENG has been demonstrated to exhibit an unprecedented conversion efficiency of 50-85%, and an area power density of 500 W/m². TENGs have revolutionary applications, as shown in the figure to the right, for harvesting energy from human activities, rotating tires, mechanical vibration and more, with usage in self-powered systems for personal electronics, environmental monitoring, medical science and even large-scale power generation from ocean waves. Wang is referred to as the father of the nanogenerator.

The piezotronic effect
Owing to the polarization of ions in a crystal that has non-central symmetry, a piezoelectric potential (piezo potential) is created in the material by applying a stress. This internal field created inside of a ZnO nanowire can effectively tune the Schottky barrier height between the nanowire and its metal contact, which can effectively tune and gate the charge carrier transport process across the interface. This is the piezo tronic effect first proposed by Wang in 2007, based on which piezoelectric field effect transistor, piezoelectric diode

Figure 1. The nanogenerators discovered and developed by Wang with applications in micro/nano-systems, large-scale blue energy and self-powered sensors.
and strain gated logic operations have been developed. The electronics fabricated by using the piezopotential as a gate voltage is coined piezotronics. The design of piezotronics fundamentally changes the design of traditional CMOS transistors in three ways: the gate electrode is eliminated so that the piezotronic transistor only has two leads; the externally applied gate voltage is replaced by an internally created piezopotential so that the device is controlled by the strain applied to the semiconductor nanowire rather than gate voltage; the transport of the charges is controlled by the contact at the drain (source)-nanowire interface rather than the channel width.

The piezo-phototronic effect
Due to the polarization of ions in a crystal that has non-central symmetry, a piezoelectric potential (piezopotential) is created in the crystal under stress. The presence of polarization charges at an interface can largely tune the local band structure as well as shift the charge depletion zone at a pn junction, which can be effectively used to enhance the separation or recombination of charge carriers at the junction as excited by photon. This is the piezo-phototronic effect first introduced by Wang in 2009 for tuning and controlling optoelectronic processes by strain induced piezopotential. Using this effect, his team has demonstrated individual-nanowire light-emitting-diode (NW-LED) based pressure/force sensor arrays for mapping strain, highly sensitive UV sensors, largely enhancing LED efficiency, and high performance solar cells. Piezo-phototronic effect is a newly found physics effect, which has a broad range of applications in optimizing the performance of optoelectronic devices.

Zhong Lin Wang is Regents’ Professor and Hightower Chair in the School of Materials Science and Engineering, and College of Engineering Distinguished Professor at the Georgia Institute of Technology. He is ranked No. 1 in Google Scholar public profiles in Nanotechnology & Nanoscience both in total citations and h-index impact s: webometrics. info/en/node/198. He has received numerous international honors and awards including the 2018 ENI award in Energy Frontiers (the Nobel prize for energy); Distinguished Scientist Award from (US) Southeastern Universities Research Association (2016); Thomas Router Citation Laureate in Physics (2015); World Telbology Award (Materials) (2014); Distinguished Professor Award (Highest faculty honor at Georgia Tech) (2014); The World Most Highly Cited Scientists in New Materials from America in Physics (2014); MRS Medal from Materials Research Society (2011). Wang was elected as a foreign member of the Chinese Academy of Sciences in 2009, member of European Academy of Sciences in 2002, and member of Academia Sinica (Taiwan) 2018. He is a fellow of APS, AAAS, MRS, Microporous Materials Society of America, World Innovation Foundation, Royal Society of Chemistry, World Technology Network. He is the founding editor of the international journal Nano Energy, which now has an impact factor of 13.12.

Figure 2. The piezotronics and piezo-phototronics fields coined and pioneered by Wang and their potential applications in various fields.
ON CAMPUS

MRS Fall Tailgate & Cookout

Spring Capstone Design Expo

Spring Poster Competition

Fall Career Fair

Fall MSE Social

Mallory Parker working in The MILL

May 2018 Ph.D. Commencement

Spring Women in MSE Connect & Dine Event
Ph.D. student Travis Voorhees feeding giraffes while learning about wildlife conservation efforts at the San Diego Wild Animal Park.

Ph.D. student Bartlet Deprospos visits Mount Fuji during his three week trip to Japan to work on his thesis.

Undergraduate student Heyinn Rho co-oping at Robert Bosch Materials Laboratory in North Charleston, SC.

Undergraduate student Justin Steiner takes a break from his internship at Los Alamos Laboratory in New Mexico.

Undergraduate student Luke Soule in Prague after visiting the Max Planck Institute in Stuttgart to learn more about their programs and research.
MILL 2.0

THE MATERIALS INNOVATION + LEARNING LABORATORY

A feasibility study was undertaken in summer 2018 to explore renovating approximately 6,000 square feet on the first floor of the J. Erskine Love Building at Georgia Tech. This renovated space would house open-access labs, collaborative and teaching spaces to create a ‘Discover | Make | Measure Space’ known as the MILL 2.0.

MISSION
Be the global leader in experiential peer-to-peer materials science and engineering education.

VISION
Create the Next in Education by offering Georgia Tech students open access to safe, user-friendly, peer-staffed facilities that allow students to investigate the fundamentals of materials processing, characterization, and measurement. Strengthen Georgia Tech’s experiential educational ecosystem to enhance and empower student learning and creativity through hands-on discovery and design opportunities outside the traditional classroom. Promote student collaboration and leadership within a space devoted to imagination, invention, and innovation.

PURPOSE
Serve as Georgia Tech’s Materials Science and Engineering educational hub for student experiences in course-based projects, laboratory-based courses, entrepreneurial endeavors, independent research or educational pursuits, and team-based capstone design, promoting inquiry-based discovery science and engineering design.

Conceptual renderings of The MILL 2.0

VIEW 1 - MAIN ENTRY
As one enters The MILL 2.0 suite, the Materials Fab Lab (3D Printing and Textile Manufacturing Studio) is on the right, showcasing highly adaptable, multi-material 3D printers, granulators, filament extruders, heat presses, and digital knitting equipment. Through the double doors, one enters the lobby space, with views into the conference and meeting room and the Materials Characterization + Measurement Lab.

VIEW 2 - MATERIALS LAB
This view inside the main analytical facility showcases an open workspace for teaching and student collaboration. Unistrut frameworks above provide power and data as well as mounting for video screens displaying instrumentation work. In this instance, the microscope in the foreground is transmitting its image to the screen above. To the right is a view into the Wet Works Lab for chemical synthesis and electrochemical analysis.

VIEW 3 - PUBLIC CORRIDOR
Science is fully on display along the public corridors outside The MILL 2.0 suite. Highlighted here is the Nano Fab Lab (Thin Film Processing), with the WetWorks and Materials Fab Lab beyond. To the right, onlookers can peer into the Materials as Art Studio for polymer, metal, and glass casting. This view also highlights the external visualization wall and informal public gathering space for students and visitors.
The MILL has rapidly evolved into a hub for undergraduate and graduate research. It excels as a collaborative space for MSE, and we are hoping to expand our collaborative culture to COE as a whole upon the renovation of the space.

- Tom Miller, Sophomore, Materials Innovation and Learning Lab, CEO Undergraduate Researcher, Pump Squared Lab
Illustration of polyelectrolyte (charged polymer) brushes collapsed on a surface into octopus micelle structures from research done by Blair Brettmann on multivalent ion interactions with polyelectrolytes. The artist is Peter Allen, UCSB.