

2nd Annual **AMPT SYMPOSIUM**

**Additive Manufacturing,
Performance & Tribology Center**
at Rice University



JANUARY 22, 2021

AMPT.RICE.EDU

Conference Program

Rev. 0

Meeting Details

ACCESS CREDENTIALS

Each **registered** participant was sent an email containing their Zoom link and meeting passcode.

- If you did not receive this email, contact George Webb at (713) 348-2704 or gwebb@rice.edu.
- If you have not registered, please [register](#) before requesting your link and passcode.

TELEPHONE AUDIO

Connection through the web is **required**. Participants joining by telephone audio only will not be admitted. If you would like to use a telephone audio connection in addition to your web connection, please merge the two connections as follows:

- Sign in via your web link.
- Locate your in-meeting Participant ID from the **Meeting Information** menu (the small green shield icon) at top left.
- Dial in by phone and enter your meeting ID, participant ID, and passcode as prompted.

JOINING THE MEETING

- Participants will start in a waiting room, from where they will be admitted by the Moderator.
- Please be mindful of minimizing background noise.
- The Symposium will be called to order promptly at 8:30 AM. Please sign in **between 8:00 and 8:25 AM** so that our opening speaker can start on time and with minimal interruptions.

IN-MEETING PROTOCOLS

As a foundation for the professional dialogue which is at the core of the AMPT Center's mission, the AMPT Symposium strives for a high degree of mutual transparency compared to most online conferences. Participants are asked to observe the following protocols:

- You are encouraged to use your company's virtual background.
- For your screen name, please identify yourself with your full name and affiliation, e.g. Firstname Lastname (Company) or Firstname Lastname (Rice).
- To change your screen name to this format, go to your name in the **Participants** list and choose **Rename** from the **More** menu.

SYMPOSIUM POLICIES

- Participants consent that Rice University may make reasonable use of their names, likenesses, and company affiliations in conjunction with the AMPT Symposium.
- The AMPT Center is committed to providing an environment of mutual respect conducive to the open exchange of ideas. We invite all participants to help us realize a safe and positive conference experience for everyone.



Welcome

Greetings!

As Faculty Directors of the [Additive Manufacturing, Performance & Tribology \(AMPT\) Center](#), we are delighted to welcome you to the 2nd Annual AMPT Symposium. Since its successful [launch](#) in 2019, the AMPT Center is on pace to be the **leading multi-disciplinary research center** in the United States on the problems of:

- advanced additive manufacturing
- materials performance and characterization
- tribology and tribomechadynamics
- and the application of data, machine learning, and other innovative techniques to drive engineering solutions.

Located in the heart of one of the world's energy, aerospace, biomedical, and manufacturing hubs, the AMPT Center is also timely. As an example, the rapidly-expanding **additive manufacturing industry** is projected to exceed \$23 billion by 2026, while engineering components and systems that involve **sliding surfaces and rotating parts** have performance challenges that additive manufacturing can uniquely meet. But qualification of AM components for critical applications remains nascent, and 3D printing in metals and high-performance materials is still at a stage where **advanced research** is required to fully progress the technology from time-intensive, trial-and-error methods to autonomous, material-independent manufacturing. The AMPT Center brings these previously siloed challenges together to forge collaborative, boundary-spanning solutions.

Beyond AM, engineering products and systems can be powerfully improved by incorporating **Industry 4.0 techniques**, in which data from embedded sensors is integrated in real time with physics-based and AI modeling to improve the performance of machines while in service. **By tying process design and manufacturing to the ultimate performance** of products and systems in their intended applications, the AMPT Center brings together Rice researchers across numerous engineering and scientific disciplines to improve products and systems through novel and predictive manufacturing techniques.

With AMPT's integrated approach, we believe that companies seeking to leverage technologies such as additive manufacturing, advanced materials, big data, and machine learning to enhance their own products and processes can achieve **strong performance gains** through focused research as [Corporate Members](#) of the AMPT Center.

On behalf of the entire community of scholars here at Rice, we welcome you to this year's **fully online** AMPT Symposium and we hope you will have a successful and productive experience.

C. Fred Higgs III

*John & Ann Doerr Professor of Mechanical Engineering
Co-Director of the AMPT Center*

Matthew R. W. Brake

*Assistant Professor of Mechanical Engineering
Co-Director of the AMPT Center*

Schedule at a Glance

For detailed agenda, see pages 8-9.

MORNING

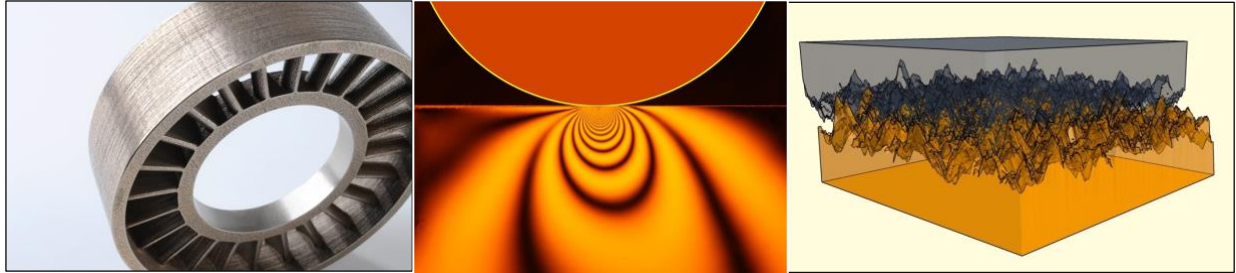
- 8:00-8:25 Sign-in period
- 8:30 Call to Order and Welcome
- 8:35 AMPT Review / Preview
- 9:15 Technical Session 1 –
Materials and Structures
- 10:45 Mini-break
- 11:00 Technical Session 2 –
Surface Sciences
- 12:00 Lunch break

AFTERNOON

- 12:35 Re-join period
- 12:45 Technical Session 3 –
Data, Machine Learning, and Industry 4.0
- 2:15 Mini-break
- 2:30 Preview of Final Sessions and
Presentation of 2020 Resiliency Awards
- 2:45 Final Sessions (parallel tracks)
 - Graduate Student Lightning Round
 - Executive Session for Industry Decision-Makers
- 3:45 2nd Annual Symposium concludes

Founding Vision of the AMPT Center

The Additive Manufacturing, Performance & Tribology (AMPT) Center at Rice University is an **industry-focused, multidisciplinary research center** that leverages the deep expertise of **Rice engineering faculty** to solve the fundamental problems facing **Industry 4.0**. This designation refers to companies driving the Fourth Industrial Revolution, in which technologies spanning the physical, digital, and biological worlds are changing how people work and live, and how products are produced and consumed.



The AMPT Center originated in the collaboration of Rice Engineering [faculty](#) who understood that the problems they are working on, while historically viewed as distinct sub-disciplines, involve intersecting challenges and **powerful opportunities for research synergy**.

The **core competencies** of the AMPT Center — advanced additive manufacturing; materials performance and characterization; tribology and tribomechadynamics; and the application of data, machine learning, and other innovative techniques to drive engineering solutions — underpin the emerging technologies of Industry 4.0. The work of the AMPT Center:

- **Broadly impacts** the way engineering machines and devices (including biomedical, energy, aerospace, and electromechanical systems) with **surfaces in relative motion** are designed, manufactured, monitored, and maintained for extended lifetimes, specialized environments, and critical applications.
- **Brings together** [Rice and industry researchers](#) to use sophisticated tools to advance the performance of Industry 4.0 technologies, including artificial intelligence, internet of things (machines, sensors, and the big data they produce), augmented/virtual reality, and multiphysics simulations-based engineering.
- **Prepares the Industry 4.0 workforce**, by training engineering students from the undergraduate to post-doctoral levels to design application-specific products and systems from the end to the beginning. In working collaboratively with our corporate partners, AMPT students apply deep fundamental engineering concepts to discern and design materials, components, and systems that are custom-tailored to achieve extended lifetimes and optimized mechanical, tribological, and dynamic performance.

Faculty Directors

Based in Rice's Mechanical Engineering department, the Faculty Directors of the AMPT Center are versatile experimentalists with well-equipped laboratories hosting a broad array of specialized instruments.

C. Fred Higgs III

Fellow of the American Society of Mechanical Engineers

John & Ann Doerr Professor of Mechanical Engineering

Vice Provost for Academic Affairs

Faculty Director, Rice Center for Engineering Leadership (RCEL)

<https://higgslab.org>



Bio:

Fred Higgs joined Rice Engineering in 2016 after thirteen years at Carnegie Mellon University, where he was the thrust leader of powder mechanics in CMU's Next Manufacturing Center. Within the AMPT Center, Higgs's Particle Flow & Tribology Laboratory conducts **coordinated high-performance computing and high-fidelity experimentation** to predict the behavior of applications with **particle media in sliding contacts**.

Higgs is a member of the ASME Tribology Executive Committee and an Associate Editor for the STLE *Tribology Transactions* journal. A Fellow of ASME, he has received an NSF CAREER Young Investigator Award and the ASME [Burt L. Newkirk Award](#), given to a tribology innovator under age 40. Higgs has published over 100 archival papers in journals ranging from *Nature Materials* to the *Journal of Tribology*, while generating significant IP in concert.

Matthew Brake

Fellow of the American Society of Mechanical Engineers

Assistant Professor of Mechanical Engineering

<http://brake.rice.edu>



Bio:

Matthew Brake joined Rice Engineering in 2016 after nine years as Principal R&D Engineer at Sandia National Laboratories, the premier Federal laboratory for national security and technology innovation. In the AMPT Center, his research focuses on **interfacial mechanics, tribology, coatings, damage mechanisms (wear, fatigue, etc.), and dynamics** to both design and optimize machines and systems that are more efficient and longer lasting.

Brake has been elected to numerous research leadership positions, including chair of the ASME Research Committee on the Mechanics of Jointed Structures, vice-chair of the Nonlinear Dynamics Technical Division of SEM, and secretary of the ASME Technical Committee on Vibration and Sound. He is a recipient of the 2012 [Presidential Early Career Award for Scientists and Engineers](#), the NSF CAREER Award, the 2018 [C.D. Mote Jr. Early Career Award](#), and was recently named a Fellow of ASME.

Faculty and Research Staff

Leveraging Rice University's unique capacity for **boundary-spanning research**, the AMPT Center encompasses six of the nine departments of Rice's School of Engineering, with many AMPT researchers having appointments in **multiple departments**. AMPT Center [Corporate Members](#) (see page 7) are able to work with this [growing roster of faculty](#) along with their research scientists, graduate students, and laboratory staff. AMPT presenters at the **2021 Symposium** are:



Matthew Brake ¹
Mechanical Engineering



Fred Higgs ¹
Mechanical Engineering
Rice Center for Engineering Leadership



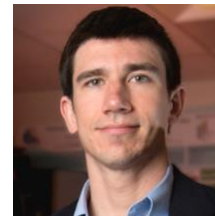
Christopher Jermaine
Computer Science
Rice Data Science Initiative



Jun Lou
Materials Science & NanoEngineering



Satish Nagarajiah ^{2,3}
Civil & Environmental Engineering
Mechanical Engineering



Daniel J. Preston
Mechanical Engineering



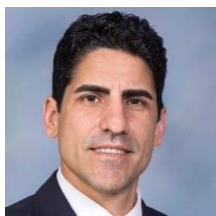
Muhammad M. Rahman
Materials Science & NanoEngineering



Anshumali Srivastava
Computer Science



James Tour ^{2,4}
Chemistry
Materials Science & NanoEngineering
Computer Science



Rafael Verduzco
Chemical & Biomolecular Engineering
Materials Science & NanoEngineering



Geoff Wehmeyer
Mechanical Engineering

¹ Fellow of Am. Society of Mechanical Engineers
² National Academy of Inventors
³ Fellow of Am. Society of Civil Engineers
⁴ Fellow of Am. Assn. for the Advancement of Science

For a complete roster of AMPT faculty and research staff please visit ampt.rice.edu/faculty/

Corporate Partners

The AMPT Center at Rice University is poised to be the **leading multi-disciplinary research center** in the United States on the problems of:

- advanced additive manufacturing
- materials performance and characterization
- tribology and tribomechadynamics
- and the application of data, machine learning, and other innovative techniques to drive engineering solutions.

Membership in the AMPT Center is open to corporations, Federal laboratories and other organizations approved by Rice who agree to support the mission of the AMPT Center. Members have the opportunity to learn from and collaborate with the AMPT Center's [deep bench](#) of faculty and research staff, including working with AMPT researchers on mutually agreed research projects.

Membership Tiers

The AMPT Center offers a tiered membership structure with different levels of research direction and corresponding investment. A summary of tiers and benefits for 2021 is available on the [Corporate Members](#) page of the AMPT website page. For ease of comparison, the more limited benefits of a traditional stand-alone, single-project research agreement are summarized alongside.

How to Join

Application information is available on the [Corporate Members](#) page of the AMPT website (ampt.rice.edu). Application for membership begins by completing a **Membership Agreement**. To obtain a Membership Agreement or for any questions about joining the AMPT Center, please contact:



George Webb, AMPT Industry Liaison

Rice University – MS 363
6100 Main Street, Houston, TX 77005
(713) 348-2704
gwebb@rice.edu



Friday, January 22

MORNING

| | | | <u>NOTES</u> |
|---------------|--|---|--------------|
| 8:00 -8:25 | Sign-in period | | |
| | | <i>Participants are encouraged to sign in during this interval.</i> | |
| 8:30 | Call to Order | George Webb <i>Symposium Moderator</i> | |
| 8:30 | Welcome | Luay Nakhleh <i>Dean of Engineering</i> | |
| 8:35 | AMPT Review / Preview | | |
| 8:35 | Highlights and success stories of 2019-2020 | Matthew Brake | |
| 9:55 | AMPT Center vision for 2021 and beyond | Fred Higgs <i>AMPT Faculty Directors</i> | |
| 9:15 | Technical Session 1: Materials and Structures <i>Session chair: Fred Higgs</i> | | |
| 9:15 | Additive Manufacturing for Multi-Functional Applications | Muhammad M. Rahman <i>Materials Science & NanoEngineering</i> | |
| 9:35 | 3D Printed Schwarzites for Damping Enhancement and Vibration Isolation | Satish Nagarajaiah <i>Civil & Environmental Engineering</i> | |
| 9:55 | Quantitative Nanomechanical Characterization of Low Dimensional Nanomaterials | Jun Lou <i>Materials Science & NanoEngineering</i> | |
| 10:15 | Digital Twin Modeling of Assemblies to Enable Data Science Applications via Tribomechadynamics | Matthew Brake <i>Mechanical Engineering</i> | |
| 10:45 | Mini-break | | |
| 11:00 | Technical Session 2: Surface Sciences <i>Session chair: Fred Higgs</i> | | |
| 11:00 | Materials and Coatings for Manipulation of Fluids | Daniel Preston <i>Mechanical Engineering</i> | |
| 11:20 | Next-generation Materials and Devices for Improved Thermal Performance | Geoff Wehmeyer <i>Mechanical Engineering</i> | |
| 11:40 | Fluidic Development of Chemically-Tailored Surfaces Using Bottlebrush Polymers and ToF-SIMS | Rafael Verduzco <i>Chemical & Biomolecular Engineering</i> | |
| 12:00 | Lunch break | | |

Session times, topic details, and order of speakers subject to change.



Friday, January 22

AFTERNOON

12:35 Re-join
-12:45 period

*Participants are encouraged
to re-join during this interval.*

NOTES

12:45 Technical Session 3: **Data, Machine Learning, and Industry 4.0**

Session chair: Matthew Brake

12:45 One Shot Learning and Learning-to-Learn

Chris Jermaine
Computer Science

1:05 Flash Graphene Scale-up Through Automation
and Machine Learning

James Tour
Chemistry

1:25 Learning with Exponential Outcomes:
Deep Learning with K outputs and
only $\text{Log}(K)$ Parameters

Anshumali Srivastava
Computer Science

1:45 AM+P+T synthesis: Industry 4.0 Design
for Additive Manufacturing in Drilling

Fred Higgs
Mechanical Engineering

2:15 Mini break

2:30 Preview of Final Sessions and
Presentation of 2020 [Resiliency Awards](#)

George Webb
AMPT Industry Liaison

2:45 Final Sessions (parallel tracks)

- Graduate Student [Lightning Round](#):
compact (six-minute) presentations
by AMPT Center students

Moderator:
George Webb
AMPT Industry Liaison

*This track is open to all registrants. Prizes will be awarded for the
best presentations as selected by industry participants.*

- Executive Session for Industry Decision-Makers:
Research Gaps and Goals
for Industry-Academic Collaboration

Facilitators:
Fred Higgs
Matthew Brake
AMPT Faculty Directors

*This track is intended for decision-making representatives
of current and prospective [corporate members](#) of the AMPT Center. If
your organization is interested in becoming a member, please contact
George Webb, AMPT Industry Liaison, at
(713) 348-2704 or gwebb@rice.edu.*

3:45 2nd Annual AMPT Symposium concludes

Session times, topic details, and order of speakers subject to change.



AMPT News Digest

EXCELLENCE AMONG AMPT STUDENTS

Groundbreaking research requires not only outstanding faculty but also the most talented and ambitious students from the U.S. and around the world. To that end, the AMPT Center has recently launched two programs to recognize and incentivize excellence:

- The [AMPT Center Ph.D. Signing Bonus program](#), to ensure that AMPT faculty continue to attract the best and brightest graduate students to Rice to work on AMPT-related research. This concrete investment in future excellence is specific to the Rice AMPT Center and is made possible by our [corporate member](#) ConocoPhillips.
- The [2020 Resiliency Awards](#), to reward AMPT students “who have demonstrated exceptional resilience in research in the face of challenges posed by COVID-19.” The winners of this first-time award were chosen by a selection committee consisting of one Rice faculty member and representatives of the two award sponsors: ConocoPhillips and Rice Engineering Alumni. The award recipients and their faculty advisors will be recognized during the afternoon session of the AMPT Symposium (see page 9).

RECENT RECOGNITION FOR AMPT RESEARCHERS

Despite the challenges of COVID-19, investigators in the AMPT Center have continued to earn national and international recognition. Here are just a few of their honors:

- On January 1, 2021, **Christopher Jermaine** became interim [Chair of Computer Science](#), the largest department in Rice’s School of Engineering. Previously he received a substantial [National Science Foundation grant](#) to develop principles and methods for designing machine learning systems that use multiple machines to develop large-scale models. Jermaine’s [expertise in machine learning](#) is a key asset to the AMPT Center, and his active participation in AMPT exemplifies Rice’s distinctive integration of computational methods and data-driven technologies to solve engineering problems.
- **Satish Nagarajaiah** (Civil Engineering) received three important honors in recognition of his pioneering work in [adaptive systems to protect structures from vibrations](#): the American Society of Civil Engineers’ prestigious [Newmark Medal](#); induction as a Fellow of the [National Academy of Inventors](#); and the [Takuji Kobori Prize](#) from the International Association for Structural Control and Monitoring (IASCM).
- As part of Rice’s nationally recognized COVID-19 response efforts, **Daniel Preston** (Mechanical Engineering) was awarded an NSF [Rapid Response Research Grant](#) to study [critical thermal properties](#) of the COVID-19 virus in order to optimize sterilization methods.
- **James Tour** (Chemistry) was awarded the Royal Society of Chemistry’s [Centenary Prize](#) in recognition of his [extensive and wide-ranging innovations in materials chemistry](#).
- **Geoff Wehmeyer** (Mechanical Engineering), one of the youngest faculty members in the AMPT Center, continues his work under a [NASA Early Career Faculty award](#) to develop [temperature-controlled materials for regulating heat flow between surfaces and components](#).