Testimony of

John A. Hopkins

Chief Executive Officer
Institute for Advanced Composites Manufacturing Innovation
IACMI – The Composites Institute

Before the
United States House of Representatives
Committee on Science, Space, and Technology
Subcommittee on Energy
Subcommittee on Research and Technology

"Revitalizing American Leadership in Advanced Manufacturing"

March 26, 2019

Introduction

Good morning Chairman, Madam Chair, and members of the subcommittees. It is my pleasure to speak with you on the impact that IACMI has made throughout its first four years of funding as a Department of Energy Manufacturing USA institute, as well as on the importance of leadership in manufacturing innovation to national interests. In addition to the testimony provided today, I would like to enter letters of support from the American Chemistry Council and Continental Structural Plastics and a recent IACMI outcomes report into the written record.

I am John Hopkins, the Chief Executive Officer of the Institute for Advanced Composites Manufacturing Innovation, known as IACMI – The Composites Institute. I have been with IACMI since its founding in 2015, and previously served in roles leading public-private partnerships for entrepreneurship, technology commercialization, and multi-institutional capacity building for innovation and workforce development. Throughout these experiences, I have witnessed the importance of public private partnerships in supporting regional ecosystems for innovation. In its four years since founding, IACMI has made significant progress creating local ecosystems of innovation and connecting them nationally to accelerate the path from idea to commercial adoption and economic growth. Thank you for the opportunity to testify today about IACMI, its early successes, and opportunities for future greater impact for both U.S. manufacturing and national security interests.

About IACMI and Advanced Composites

IACMI is a public-private partnership comprised of more than 160 members from industry, academia, government agencies, and trade organizations. It leads innovation and workforce development initiatives to grow the adoption of advanced composites, strengthen the U.S. manufacturing base and support U.S. national security, with a current focus on energy interests. As a Manufacturing USA institute, IACMI is supported by the U.S. Department of Energy's Advanced Manufacturing Office, as well as key state and industry partners including the states of Indiana, Ohio, Colorado, Michigan, and Tennessee. Collectively, these states have invested a comparable amount of taxpayer funds as the Department of Energy, and their support has been critical to effective implementation of The Composites Institute.

IACMI's technology impact is focused on the areas of advanced composites. Advanced composites combine strong fibers with tough polymers to provide strength and stiffness while being very lightweight: stronger than steel, lighter than aluminum, and corrosion proof. These characteristics provide advantages in many transportation, energy, and infrastructure applications. IACMI is working to make advanced composite materials more cost-competitive for large-scale adoption.

IACMI has three primary technical goals in support of the Department of Energy:

- reduce production costs of carbon fiber composites by over 25%
- demonstrate greater than 80% recyclability of polymer composites
- reduce embodied energy of carbon fiber composites by 50%

These goals address barriers to large-scale adoption for three key application areas that impact energy use and efficiency:

- lightweight vehicles with better safety, performance, and fuel economy or range
- high pressure compressed gas storage tanks to support greater use of more efficient alternative fuels such as natural gas and hydrogen
- lighter and longer wind turbine blades to increase power generation efficiency and capacity

IACMI and our partners have already achieved, or are ahead of schedule, for all of these technical goals. An even greater outcome is that the DOE-established goals created a framework for IACMI to form a community for innovation. This community is not only addressing the energy-based challenges central to our DOE program, but is also targeting other key application areas and markets that strengthen the U.S. manufacturing base, provide competitive advantages to our global peers, and support national security interests in not only energy, but also in space, defense, and infrastructure.

For example, IACMI is establishing a new paradigm for advanced composite price/performance through the validation of the first generation of textile carbon fiber developed at the U.S. Department of Energy's Carbon Fiber Technology Facility (CFTF) at Oak Ridge National Laboratory (ORNL). Substantial cost-savings can be realized using novel processing to reduce the embodied energy in manufacturing carbon fiber. This cost-saving innovation not only supports the path to adoption for vehicles and wind blades, but also opens new opportunities for infrastructure, defense, and non-traditional aerospace applications.

Additionally, the textile carbon fiber reduces the energy and carbon footprint for the production of these materials. When combined with the significant progress IACMI and partners such as ACMA are helping drive in advanced composite recyclability, it is possible to envision these materials providing an even greater global decarbonization impact by substituting lower cost, longer-lasting carbon fiber composites for steel and concrete in infrastructure.

I will speak to three areas in which IACMI is making significant impacts for the future of advanced composites: forming a consortium of members as a community, facilitating the formation of collaboration teams for innovation, and serving workforce needs.

IACMI Creates a community for innovation and validation

IACMI, through its founding partners the University of Tennessee and ORNL, and strategic university and national laboratory innovation partners across the country, provides production-relevant environments for innovation. Each innovation partner has fundamental composites R&D capacity while also providing a set of unique facilities and personnel capabilities specific to that location. These local ecosystems leverage proximity for co-located, place-based innovation, while also connecting to the greater network of innovation assets. This builds on the successful model the U.S. Department of Energy's Manufacturing Demonstration Facility (MDF) at ORNL has used to support facility-based collaborations and industry-informed innovation in support of advanced manufacturing.

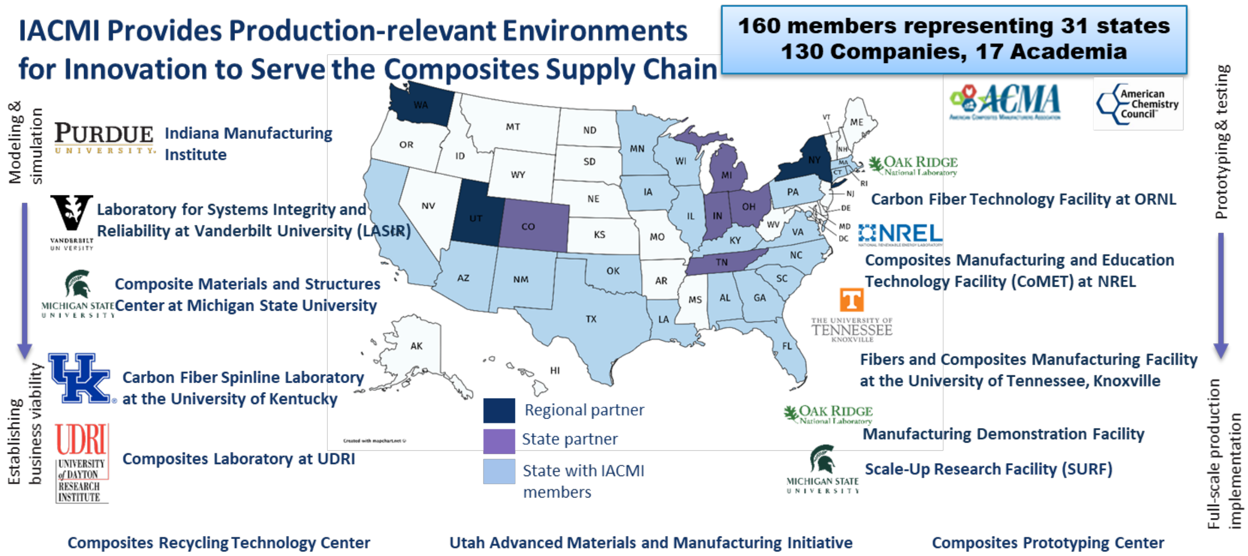


Figure 1: Illustration of IACMI membership and partner network

IACMI has created a community of consortium members that span the composites supply chain and includes specific emphasis on the engagement of small and medium enterprises (SMEs) and manufacturers. More than 50% of IACMI members are SMEs, and they are a critical part of the U.S. composites value chain. IACMI has a strong partnership with trade organizations including the American Chemistry Council (ACC) and the American Composites Manufacturers Association (ACMA). ACC represents the largest chemical companies in the United States. In addition, over 40% of ACC's approximately 200 member companies are SMEs. ACMA has more than 500 SME members, which are provided opportunities to engage with IACMI.

IACMI supports its membership through semi-annual Members Meetings and other workshops throughout the year. Some of the methods we have found effective in driving SME participation are:

- providing incentives for SMEs to participate in R&D projects
- delivering topical content directed to SME needs, including entrepreneurship, SBIR/STTR program overviews, and introduction to venture and other funding opportunities
- highlighting SME capabilities and interests to promote networking with both peers and large companies
- supporting state and regional coalitions such as the MEP network, the Utah Advanced Materials and Manufacturing Initiative, and the Tennessee Composites Coalition, to name just several. Many of these groups provide opportunities for SMEs to network with other companies and discuss common needs such as workforce development

These efforts have been successful in driving SME engagement. IACMI has more than 50 projects in its R&D portfolio, with more than 80 IACMI members participating on these projects.

IACMI Establishes supply chain-based collaborations for innovation

IACMI R&D projects validate new technologies that can then be adopted by the entire supply chain. IACMI's unique capability is to facilite collaboration among a variety of different members of the supply chain to solve a technology problem or foster new innovation. These projects sufficiently de-risk technology for critical decision-making necessary for large scale adoption. A supply chain-based approach for collaboration is an important part of the project teaming. Consortium members are encouraged to bring existing and potential supply chain partners into teaming so that innovation outcomes are achieved with participation of all the industry suppliers needed for rapid adoption and scale-up.

We have examples of project teams that include large companies such as Ford and Dow, which are driving some of our flagship projects. These projects have made great progress validating new low-cost, high-rate materials for automotive applications and wind turbine blades, and several new products are already for sale in their markets. We also have great examples of IACMI's membership community engaging SMEs to drive economic growth via collaboration.

One example is a project with two SMEs: Techmer PM and Local Motors. They collaborated with several partners, including ORNL, UT, Purdue University, and Vanderbilt University, to expand material options and consistency of printing processes for additive manufacturing (3D printing) of structural components. Project outcomes are supporting significant commercial growth for both companies. Techmer PM expanded its catalogue of additive manufacturing products, expects to double sales in 2019, and customer demand is driving the installation of a new multi-million dollar manufacturing line. Local Motors has installed the world's largest 3D printer, made by Thermwood (IN), at its Knoxville, TN microfactory and is planning to start production of its first autonomous people mover Olli beginning in July 2019. Beyond this project, Techmer PM is further benefiting from IACMI membership via launch of additional commercial projects with other industries, such as marine, aerospace, construction, and infrastructure. The use of these materials for tooling applications also provides a means to regain competitiveness in what once was a global strength for the U.S. manufacturing base.

These are examples of how IACMI is supporting supply chain based innovation teams, including SMEs, to drive the adoption of advanced composites technologies.

IACMI Serves industry's workforce needs

As innovation outcomes create and grow markets, new workforce needs must be met. IACMI is working with partners to systematically connect innovation and workforce assets across industries positioned for significant growth. IACMI and its workforce partners have:

- placed more than 100 interns through the IACMI Internship Program
- trained more than 2,000 industry workers through composites training workshops and courses, many of which are aimed at technician and apprentice levels
- engaged more than 9,000 K – 12 students in STEM activities.

Most of these programs directly leverage innovation partner facilities while connecting to IACMI industry consortium members. For example, immersive training events, such as the Closed Mold Alliance Workshops, offer opportunities for hands-on training utilizing technologies at IACMI partner facilities throughout the U.S. This not only provides impactful training, but also creates greater awareness and familiarity of capabilities across the consortium that can be leveraged for future innovation and workforce development collaborations.

An impact example in workforce development comes through the IACMI Internship Program. IACMI interns have a one hundred percent placement record for either a job offer or acceptance into a graduate program. The IACMI Internship Program provides hands-on learning experiences in national laboratories, academic labs, and industry facilities. Additionally, the interns gain networking and professional development skills through participation in poster presentations and professional development workshops. One former intern with an SME IACMI member, Vartega (CO), was hired full-time upon graduation and said the following about her experience: "IACMI and Vartega opened so many doors for me, allowing me to become a project leader, attend industry events, offer client-facing solutions, and present my work. I'm confident in my impact on the composites industry in a global capacity." The IACMI Internship Program provides depth and breadth of experiences that not only addresses current workforce development needs but is growing composites leadership for the future.

Closing and Path Forward

IACMI has created a nationally connected ecosystem for innovation that serves national security needs, supports innovation and technology validation at scales relevant for commercial adoption, and helps to drive national economic growth. IACMI's structure and accomplishments directly support the goals and strategies outlined in the October 2018 National Science & Technology report *Strategy for American Leadership in Advanced Manufacturing* released by the White House.

Since IACMI's founding, the composites industry has announced more than $400M in capital investments and 3,000 jobs in eight states. IACMI projects have led to more than 10 new products now commercially available. Through the Institute's first four years, IACMI has worked with partners to make significant strides in not only reaching our DOE goals, but also in establishing a foundation for manufacturing innovation that can continue to serve into the future.

The Department of Energy's investments in IACMI have already paid significant dividends in the Institute's areas of focus. As we look forward to the future, the physical capacity and network of thought-leaders we have developed can continue to serve the needs of Congress and the Administration in new areas, including strengthening our national defense and revitalizing the American infrastructure network.

As part of our DOE program, we have developed a sustainability plan that assumes future base operational funding will be provided by our industry consortium members. This sustainability plan provides a path for the Institute to continue operations and continue to convene and serve the consortium. However, the plan does not provide a ready means for maintaining and refreshing equipment and facilities, which creates challenges for maintaining competitive levels of capacity and expertise. As an institute that is positioned to serve across key markets for both regional and national interests, we will seek to create ongoing public-private coinvestment opportunities by leveraging the strength of our industry consortium and innovation partners. Thus, as IACMI completes its mission-specific objectives for DOE, we will seek new forms of federal and state participation that extend the value of DOE's initial investment of taxpayer dollars to grow a stronger, globally competitive American advanced composites industry.

Thank you, again, for your time today and for allowing me the opportunity to testify. I will be happy to answer any of your questions.

March 26, 2019

The House Committee on Science, Space and Technology
Subcommittees on Research and Technology/Subcommittee on Energy

Re: March 26, 2019 Hearing: *Revitalizing American Leadership in Advanced Manufacturing*

Dear Committee Members,

The American Chemistry Council (ACC), Plastics Division, is pleased to provide the following comments regarding the Institute for Advanced Composites Manufacturing Innovation (IACMI) and Revitalizing American Leadership in Advanced Manufacturing.

I. BACKGROUND

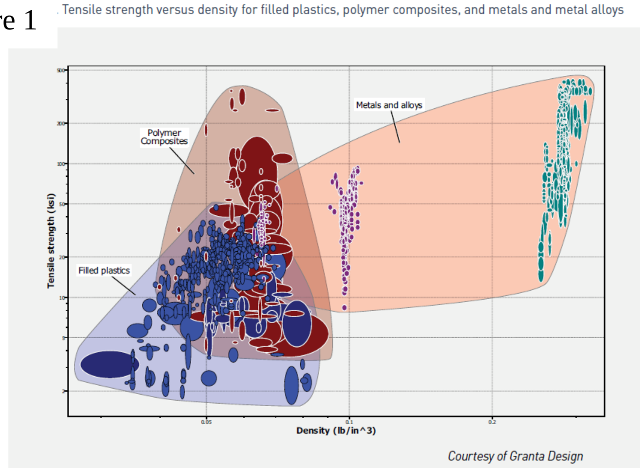
ACC is a national trade association representing the leading companies that sell and manufacture chemistry and polymers in the United States. American chemistry is an innovative $526 billion enterprise, providing 529,000 skilled american jobs. The business of chemistry plays a critical role in delivering a sustainable future through resource and fuel efficiency, material innovation, and continuous improvement in our products and operations. Every day, polymer composites help deliver cleaner air and water, safer living conditions, efficient and affordable energy sources, lifesaving medical treatments and innovative lightweight vehicle solutions. More than 96% of all manufactured goods are directly touched by the business of chemistry, including the automotive industry. Virtually every component of a lightweight vehicle, from the front bumper to the rear tail-lights, is made possible through chemistry.

Automotive composites provide countless innovative lightweight solutions, including reconfigurable flexible interiors for autonomous vehicles, antimicrobial self-cleaning surfaces for fleet and ride share vehicles, interior and exterior lighting and important safety features such as back-up cameras and air-bags. Lightweight polymer composite auto parts comprise over 50 percent of a vehicle's material volume, but less than 10 percent of its weight.

Polymer composites are a combination of tough plastic resins that are reinforced with glass, carbon fibers and other materials. These materials often weigh far less than traditional automobile materials, yet maintain high levels of strength and a high resistance to corrosion. These materials provide an economical way to innovate and lightweight vehicles while preserving important safety features and consumer preference through improved design flexibility. Additional properties, including strength to weight ratio and excellent energy absorption, make these materials especially well-suited for the design and manufacture of light-duty vehicles.

The chart labeled "Figure 1" below provides data regarding the tensile strength and density of filled plastics, polymer composites, metals, and alloys. As shown in the chart, there are many polymer composites that are significantly less dense than most metals and alloys while offering similar tensile strengths. This data illustrates a fundamental physical advantage that many polymers can offer over metallic automotive materials: higher strength-to-weight ratios enable automakers to lightweight while maintaining performance and innovative designs that consumers demand.[1]

Figure 1 Tensile strength versus density for filled plastics, polymer composites, and metals and metal alloys



II. THE ROLE OF IACMI IN U.S. LIGHT-DUTY VEHICLE MANUFACTURING

As a member of IACMI, ACC applauds the Committee for its efforts to maintain American leadership in advanced manufacturing and their recognition of the numerous investments made by U.S. companies in IACMI. Supporting advanced manufacturing has, and will, continue to spur innovation, growth and competition in the U.S., including within the automotive industry to meet consumer demands for innovative, stylish and safe vehicles. ACC supports these efforts and the Committee's recognition of America's leadership role in advanced polymer composite technologies. Among other numerous benefits, automotive composites play an important role in improved safety, improved design, mass reduction, aerodynamic improvement, electrification and autonomous deployment and optimized component integration.[2] Utilizing composites within the U.S. automotive industry follows well-documented trends of polymer usage to economically reduce mass, increase efficiency and realize innovative new technologies in the civilian and military aerospace industries. Choosing polymer composites to reduce mass in light-duty vehicles is a decision supported by science that can pay immediate and long term economic and environmental dividends.[3]

IACMI plays a critical role in ensuring the U.S. maintains leadership in advanced composite manufacturing. IACMI is making significant impacts for the future of advanced composites, including creating a network of members, fostering collaborative teams for innovation, and serving workforce needs across the nation. IACMI's primary goals and successes to date are helping remove significant technology barriers for advanced manufacturing of polymer composites.

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[1] American Chemistry Council, "Plastics and Polymer Composites for Automotive Markets Technology Roadmap", pp. 10-12, 36-40 and 58, (March 2014), *available at*: https://plastics-car.com/Tomorrows-Automobiles/Plastics-and-Polymer-Composites-Technology-Roadmap/Plastics-and-Polymer-Composites-Technology-Roadmap-for-Automotive-Markets-Full-Report.pdf.

[2] EPA, NHTSA and CARB, "Draft Technical Assessment Report: Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025, Appendix", pp. B-46-B-76 (July 2016), *available at* https://nepis.epa.gov/EPA/html/DLwait.htm?url=/Exe/ZyPDF.cgi/P100OYCH.PDF?Dockey=P100OYCH.PDF.

[3] Trucost, "Plastics and Sustainability: A Valuation of Environmental Benefits, Costs and Opportunities for Continuous Improvement" (July 2016), available at https://plastics-car.com/Resources/Resource-Library/A-Valuation-of-Environmental-Benefits-Costs-and-Opportunities.pdf.

III. U.S. ECONOMIC IMPACT OF AUTOMOTIVE POLYMER COMPOSITES

Developing technology to lightweight vehicles spurs advanced innovations and creates high-skilled manufacturing jobs in the United States. The $426 billion North American light vehicle industry represents an important sector of economy for the United States and is a large end-use customer market for chemistry. In 2017, the 16.88 million light vehicles assembled in North America required some 5.8 billion pounds of plastics and polymer composites valued at $7.0 billion, or $416 in every vehicle. These automotive plastic and polymer composite products are produced at 1,622 plants located in 45 states. These plants directly employ about 63,080 people and feature a payroll of $3.2 billion. Michigan is the leading state in terms of direct employment (more than 15,275) and is followed by Ohio (about 8,900), Indiana (8,280), Tennessee (nearly 4,120), Minnesota (nearly 3,155), Pennsylvania (more than 2,865), Wisconsin (2,320), Illinois (more than 2,160), North Carolina (nearly 1,720), and New York (nearly 1,515).[4]

Producers of automotive polymer composites typically purchase resins, additives, other materials, components and services from other parts of the economy. As a result, the contributions of polymers go well beyond their direct economic footprint. The automotive composites industry fosters economic activity indirectly through supply-chain purchases and through the payrolls paid both by the industry itself and its suppliers. This, in turn, leads to induced economic output as well. As a result, it is estimated that every job in the automotive polymer industry generates an additional job elsewhere in the United States' economy, totaling more than 119,000 jobs.[5] Innovation investments made by U.S. companies, as well as U.S. high-skilled manufacturing jobs, and indirect jobs, will be directly impacted if the U.S. is unable to maintain a leadership role in advanced manufacturing for automotive composites.

IV. CONCLUSION

We thank you for the opportunity to comment with regard to IACMI and its important role in maintaining American leadership in advanced manufacturing. We look forward to strengthening our partnership with IACMI, and other IACMI members, as we continue developing lightweight vehicle innovations that enable autonomous and electric vehicles, enhance fuel economy, improve safety and vehicle performance through the use of polymer composites.

Sincerely,

Gina Oliver

Sr. Director, Automotive Market Team
American Chemistry Council, Plastics Division
Gina-Marie_Oliver@americanchemistry.com
248-244-8920

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[4] Economic and Statistics Department, American Chemistry Council, "Plastics and Polymer Composites in Light Vehicles", page 1, (July 2018), available at: https://plastics-car.com/Resources/Resource-Library/Plastics-and-Polymer-Composites-in-Light-Vehicles-Report.pdf

[5] *Id.*

Continental
Structural Plastics

March 20, 2019

To whom it may concern:

I am writing this letter in support of IACMI – The Composites Institute®, as I firmly believe it provides value to my organization and to the composites industry as a whole.

Continental Structural Plastics (CSP) originally joined as members of the Carbon Fiber Consortium based at Oak Ridge National Laboratory (ORNL). At the time, we were hedging that it was the best way to stay at the forefront of carbon fiber composites development. For us, I admit, it was largely a networking organization. Although we participated in a few minor projects and created some lasting collaborative relationships, that organization did not provide sustainable value.

When the CF Consortium was absorbed by the creation of IACMI, my initial expectations were that the new organization would provide opportunities comparable to the previous consortium experiences. In the past few years, the activity and productive work has increased exponentially. The creation of exceptional facilities in Corktown (Detroit, Michigan) and at Purdue University (West Lafayette, Indiana) and the resulting collaborations are extremely exciting. I feel that a lot of good work has been started and the vision is taking shape. I foresee continued growth and significant advancements for the composites industry through the resources and partnerships afforded by the IACMI network.

In addition, CSP has recently begun to participate in the IACMI Intern program. We have always found great value in employing interns in our laboratory and have had good success developing future employees. It is difficult finding students with specific interest and training in composites at regional universities. The IACMI program provides a direct connection to top students with a specific passion for our growing industry. We are excited to currently have our first IACMI student intern (who is working out very well), and intend to continue our involvement in the program moving forward.

I would be happy to discuss my experiences with IACMI in more detail if necessary. My contact information is detailed below.

Best regards,

Michael J. Siwajek, Ph.D.
Vice President, Research and Development
Continental Structural Plastics

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IACMI – The Composites Institute®

Institute Outcomes

March 2019

IACMI – The Composites Institute is a 160+ member community of industry, academia, and government agencies leading innovation and workforce development initiatives to drive the adoption of advanced composites to grow U.S. manufacturing and support national security. IACMI, a Manufacturing USA institute, is supported by the U.S. Department of Energy's Advanced Manufacturing Office, as well as key state and industry partners.

Advanced composites provide strength and stiffness while being very lightweight. These characteristics provide advantages in many transportation, energy, and infrastructure applications. Greater deployment of advanced composites can offer benefits, such as providing safer, more energy-efficient vehicles. IACMI is working to drive the large-scale adoption of advanced composites in diverse markets.

Connecting innovation and workforce development

IACMI is uniquely and systematically connecting innovation and workforce assets across multi-billion dollar industries positioned for significant future domestic and international growth. IACMI will make the U.S. a leader in the manufacture of these strategic materials and accelerate the growth of their markets.

Creating a collaborative ecosystem

IACMI is creating a community throughout the composites supply chain, including support for small and medium enterprises (SMEs). More than 50% of IACMI members are SMEs, leveraging their unique specializations to collaborate with one another, larger organizations, and technical experts.

Building supply chain-based frameworks for decision making

IACMI provides production-relevant environments for innovation, establishes supply-based frameworks for decision making, and trains the workforce in support of the needs of the composites industry.

Driving economic growth

Through IACMI projects, member companies have developed new, commercially available products. These products have helped lead to job creation, facility expansion, and economic growth for the companies, as well as their manufacturing partners. IACMI has created an ecosystem of innovation that meets commercial needs, serves national security, and drives national economic growth.



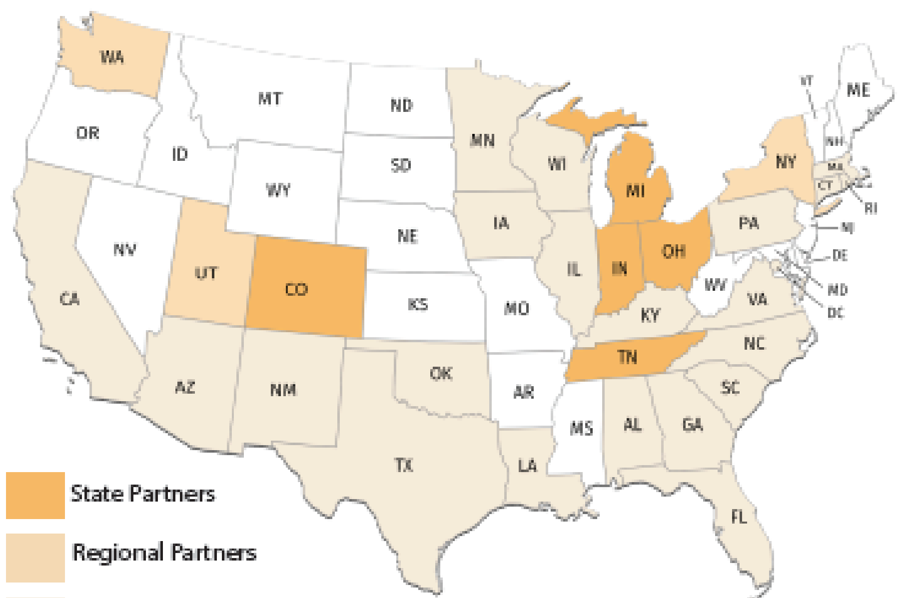
The IACMI consortium consists of more than 160 members and is a proven collaboration framework for catalyzing innovation and workforce development outcomes. IACMI projects are addressing national interests in energy and manufacturing competitiveness, training the next generation workforce, creating new commercial products and markets, and driving economic growth.

50+ IACMI technical projects

90 IACMI members participating on technical projects

$70M+ IACMI's R&D value to date

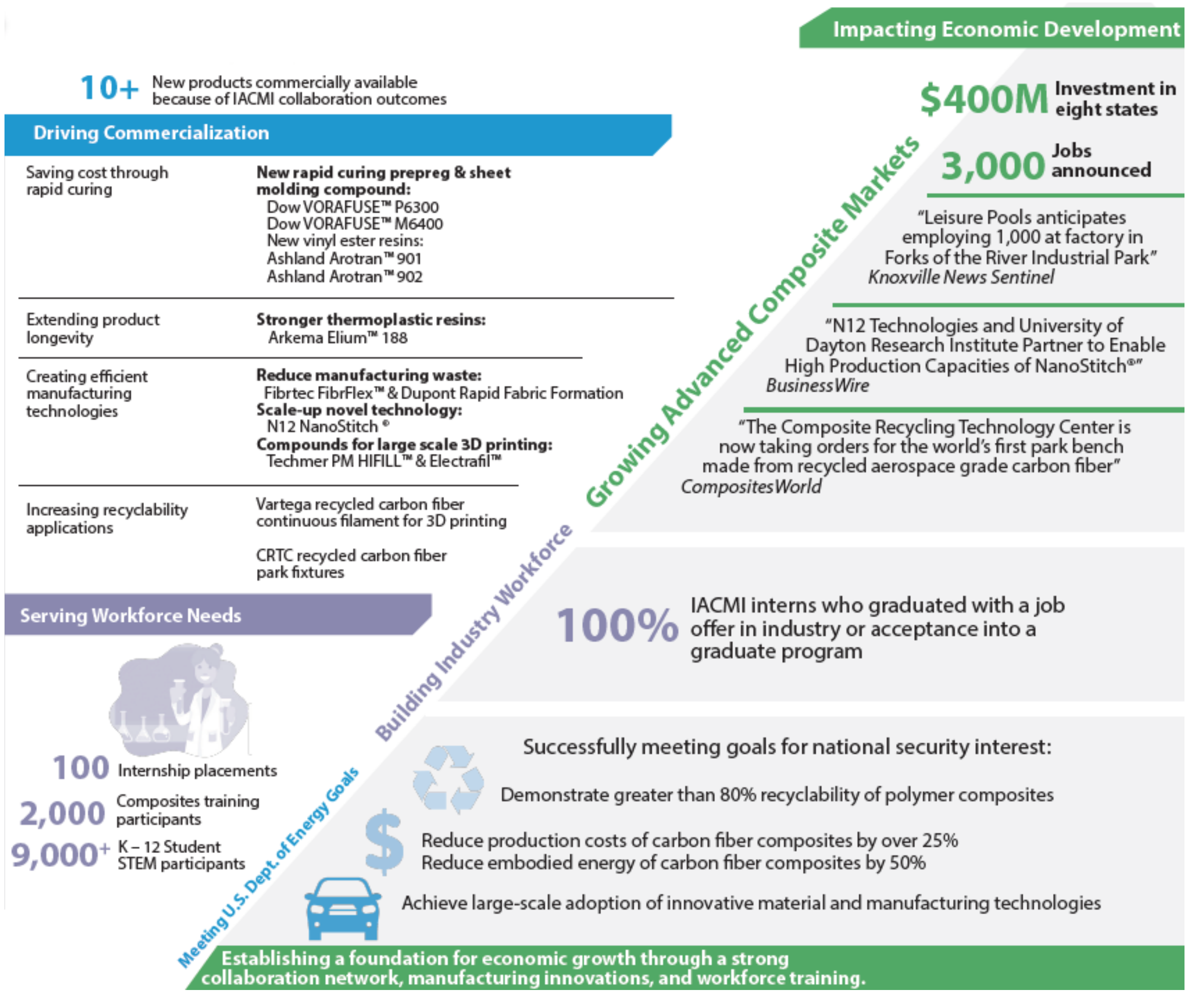
Creating an Innovation Network



160+ IACMI Members

- 130 industry members
- 53% of companies are SMEs

IACMI – The Composites Institute creates an ecosystem of innovation to drive commercial outcomes that lead to economic growth.



Overall Institute

10+ New products commercially available because of IACMI collaboration

$400M Investment in eight states

3,000 Jobs announced

Case Study

Techmer PM and Local Motors IACMI technical project example

"Our participation in IACMI allowed us to develop new technologies that have contributed to Techmer PM's growth in the additive manufacturing ecosystem."

Tom Drye, Vice President of Emerging Markets & Innovation and Application Development, **Techmer PM**

Challenge

Improve the material options and printing processes for additive manufacturing (3D printing) that enables Local Motors to commerically produce its 3D printed vehicles

Objectives

- Increase the variety of materials available for additive manufacturing
- Better understand 3D printed materials' properties to make reliable manufacturing decisions

Impact

Significant commercial growth for multiple companies involved in the project

Techmer PM

- Techmer PM has had significant sales of new 3D products and expects to double sales in 2019
- Techmer PM is helping lead the growth and acceptance of large part additive manufacturing through materials designed specifically for optimum performance and reliability in additive manufacturing
- Customer demand is driving installation of a new multi-million dollar manufacturing line to meet the increased 3D materials need of Techmer's customers

Local Motors

- Local Motors installed the world's largest 3D printer, made by Thermwood, at its Knoxville, TN microfactory
- Local Motors to commercially produce Olli 2.0 at Knoxville, TN microfactory beginning in July 2019

IACMI – The Composites Institute
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2360 Cherahala Blvd.
Knoxville, TN 27932

University, State, Regional, National Laboratory, & Association Partners

The Institute for Advanced Composites Manufacturing Innovation (IACMI), managed by the Collaborative Composite Solutions Corporation (CCS). CCS is a not-for-profit organization established by the University of Tennessee Research Foundation. As a Manufacturing USA institute, IACMI is supported the U.S. Department of Energy's Advanced Manufacturing Office in the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE).

John A. Hopkins is the Chief Executive Officer of The Institute for Advanced Composites Manufacturing Innovation, IACMI – The Composites Institute. A former senior leader for IACMI and the University of Tennessee (UT), Dr. Hopkins is credited with establishing IACMI's national technical advisory board and research and development project process.

As CEO, Dr. Hopkins leads the U.S. Department of Energy supported Manufacturing USA composites institute. This public-private partnership leads domestic production research and development knowledge, and catalyzes economic development across the U.S. advanced composites industry. The institute is supported by a $70 million commitment from the U.S. Department of Energy's Advanced Manufacturing Office, and over $180 million from other public and private partners.

Prior to his role with IACMI, Hopkins served as Director of Strategic Operations in the UT Office of the Executive Vice President. In this role, he led several statewide initiatives, including a National Science Foundation (NSF) program, TN-SCORE, consisting of more than 30 academic and industry partners focused on solar energy and energy storage research, as well as related K-12 outreach. In support of TN-SCORE and related NSF EPSCoR programs across the country, he chaired both a national conference and workshop series for innovation and entrepreneurship.

Dr. Hopkins served in several leadership roles at the UT Research Foundation, including Director of Technology Transfer, and led the organization through several restructurings to build capacity and improve processes in service of a growing the UT research enterprise. As faculty member at the University of Tennessee Space Institute, he managed funded research projects in laser materials processing sponsored by numerous industry partners and the U.S. Departments of Energy and Defense. Dr. Hopkins is a licensed engineer in Tennessee, author of 50 technical papers, and named inventor on 11 U.S. patents, which resulted in two start-up companies.

Dr. Hopkins earned his Ph.D. from the University of Tennessee, Knoxville while supporting flight experiments on the First International Microgravity Laboratory as a NASA pre-doctoral fellow. He has an MBA from Vanderbilt University's Owen Graduate School of Management.

John A. Hopkins

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Citizenship: United States

PROFILE

Demonstrated leader of multi-institutional teams, creator of new programs, developer of improved processes to support innovation and technology transfer, and innovator of unique solutions for key scientific and engineering challenges:

- New funding - leveraging research projects into >$35M of new funding
- Innovation via personal research - 11 US patents, 50 papers, 2 start-up companies
- Impact - > 50 technology licenses/options, >$10M licensing revenue

EXPERIENCE

COLLABORATIVE COMPOSITE SOLUTIONS
Institute for Advanced Composites Manufacturing Innovation (IACMI)
Knoxville, Tennessee, **9/17 to present**

CEO

- Lead national center of excellence for manufacturing excellence in polymer composites; One of 14 *Manufacturing USA* Institutes for Manufacturing Innovation.
- Manage $175M Cooperative Agreement with Department of Energy and cost share supporters to operate IACMI.
- Direct technical and workforce development collaboration projects among consortium of 150 members and eight innovation partners.
- Develop and execute strategies for advancing deployment of advanced polymer composites manufacturing in six partner states and nationally.
- Served as Interim CEO from 9/17-1/18

CONSULTANT
Knoxville, Tennessee, **1/17 to 8/17**

Part-time Consultant, University of Tennessee, Office of the Vice President for Research, and Business Mentor

- Provided domain expertise to Tennessee Advanced Energy Business Council and LaunchTN inaugural Energy Business Mentor Program.
- Led outreach development and implementation at Interstate 40 Information and Welcome Center Rest Area co-located with University of Tennessee 5 MW Solar Farm.

COLLABORATIVE COMPOSITE SOLUTIONS
Institute for Advanced Composites Manufacturing Innovation (IACMI)
Knoxville, Tennessee, **8/15 to 12/16**

Senior Project Controls Manager

- Developed framework and supporting documents and processes for establishing and managing industry-led research projects as a central focus of institute goals:
    - Request for Proposal, review processes, scoring rubric, recommendation forms, data archiving and tracking systems for proposal review and selection, and templates for both periodic reporting and management of mandatory cost-share.
- Engaged industry partners to promote project engagement and establish contracting requirements.
- Initiated 11 projects with 25 key industry leaders across supply chain, including: DuPont, Toray Composites, and Volkswagen America.

UNIVERSITY OF TENNESSEE
Knoxville, Tennessee, **10/10 to 8/15**

Director of Strategic Operations, Office of the Executive Vice President
Director TN-SCORE, Tennessee NSF EPSCoR RII Track 1

- Established working office to support state EPSCoR awards.
- Created and managed network of 30+ partners to successfully execute Tennessee's first RII Track 1 Award
- Served as co-PI for DOE Neutron Scattering Research Network for EPSCoR States
- Developed and chaired programs for the NSF 2013 EPSCoR National Conference and follow-on workshop series for Innovation, Entrepreneurship, and Translational Research.
- Managed Tennessee through graduation from NSF EPSCoR starting in 2013, including wrap-up of projects and administration team.
- Led team to develop hand-on STEM exhibit to support University of Tennessee West Tennessee Solar Farm and hosted 31,000 visitors by creating a coalition of community supporters to house and operate exhibit.

UNIVERSITY OF TENNESSEE RESEARCH FOUNDATION
Knoxville, Tennessee, **8/01 to 9/10**

Director/Vice President (1/03 to 9/10), Vice President of Marketing (8/01 to 12/02)

- Managed and administered technology commercialization efforts for University of Tennessee campuses and institutes; Portfolio included 350+ U.S. Patents and 130+ active licenses/options.
- Increased outcomes and impact of operations - Cumulative 2007-2009:

- 51 licenses executed, $7.3M licensing revenue, 12 companies created
- $11.6M new funding acquired for further technology development
- $3.0M invested in intellectual property protection

- Established Proof of Concept investment program with Tennessee Community Ventures (TNCV) as part of state TNInvestco initiative.
- Created internal funding program to mature technologies and foster licensing partnerships with related extramural research sponsorship.
- Implemented multi-office processes and data systems to improve invention evaluation and marketing and better serve faculty inventors.
- Established new programs and partnerships to create and support start-up company opportunities via incubator facilities and mentoring.

UNIVERSITY OF TENNESSEE SPACE INSTITUTE
Center for Laser Applications, Tullahoma, Tennessee

Research Associate Professor, Mechanical Engineering, *8/98 to 7/01*

- Demonstrated new approaches for laser surface processing, laser beam delivery, and application of fluidized metal powder precursors.
- Developed industry partnerships to address application-specific wear and corrosion problems and establish manufacturing pathways for solutions.
- Co-managed laboratory resources including high power laser systems, optical diagnostics, computational modeling infrastructure, seven graduate students, and five staff.

Research Assistant Professor, Mechanical Engineering, *8/96 to 7/98*

- Demonstrated patented platform process for creating wear and corrosion-resistant surfaces using laser surface alloying.
- Performed basic and applied research in the areas of laser welding, laser surface processing, laser optics design, thin film characterization, and modeling of moving heat source problems.

Post Doctoral Research Associate, *11/92 to 7/96*
Adjunct Assistant Professor, 1/94 to 7/96
Engineer, 1/92-10/92

- Established keyhole formation mechanism for laser welding by using novel technique for direct, through-plasma imaging of liquid weld surface.
- Performed ground-based experiment support and post-flight analysis for joint NASA-ESA-CSA First International Microgravity Laboratory experiments flown on space shuttle Discovery, STS-42.

EDUCATION

MBA, Vanderbilt University, TN, 2006
Ph.D., Mechanical Engineering, University of Tennessee, 1992
M.S., Mechanical Engineering, University of Tennessee, 1989
B.S., Mechanical Engineering, University of Tennessee, 1988

PROFESSIONAL DEVELOPMENT

- Licensed Engineer, Tennessee (24 PDH every two years)
- Coursera Delivered Courses from Wharton School, University of Pennsylvania (Certified, with scored coursework): Finance, Financial Accounting, Marketing
- NSF Communicating Science Workshop
- Kaufmann Foundation FastTrac Program
- Greenwood Consulting Group SBIR Proposal Workshop
- Association of University Technology Managers: various workshops
- Society of Automotive Engineers: Workshop on Piston Ring Design and Materials

HONORS & AWARDS

- FLC Southeast Region Excellence in Technology Transfer Award (2005)
- American Museum of Science and Energy Technical Achievement Award (1998)
- Huntsville Area Technical Societies (HATS) 1997 UTSI Professional of the Year
- NASA Pre-Doctoral Fellow, August 1988 – December 1991
- Golden Key, Tau Beta Pi, Pi Tau Sigma

U.S PATENTS

6,660,962 “Method for gas assisted energy beam engraving of a target object”
6,497,985 ”Method for Marking Steel and Aluminum Alloys”
6,423,162 “Method for Producing Decorative Appearing Bumper Surfaces”
6,328,026 “Method for Increasing Wear Resistance in an Engine Cylinder Bore and Improved Automotive Engine”
6,299,707 “Method for Increasing the Wear Resistance in an Aluminum Cylinder Bore”
6,294,225 “Method for Improving the Wear and Corrosion Resistance of Material Transport Trailer Surfaces”
6,284,067 “Method for Producing Alloyed Bands or Strips on Pistons for Internal Combustion Engines”
6,229,111 “Method for Laser/Plasma Surface Alloying”
6,223,137 “Method for Marking, Tracking, and Managing Hospital Instruments”
6,173,886 “Method for Joining Dissimilar Metals or Alloys”
6,016,227 “Apparatus and Method for an Improved Laser Beam”

OTHER

- President, TN Alpha Alumni Chapter, Tau Beta Pi, 2018
- Invited Speaker, Glenwood Elementary – Ask a Scientist Program, August 2017
- Invited Speaker, National Academy of Science, October 2017
- Board Member, Knoxville Chapter, UTK Alumni Association, 2016-present
- Class Representative, Vanderbilt Owen School Alumni Council, 2015-present
- Member Representative, Tennessee Advanced Energy Business Council, 2014-present

- Board Member and Treasurer, TN Center for Research and Development, 2009-2018
- Invited Speaker, Knoxville Muse Lunch and Learn, April 2014
- Invited Speaker, Technical Society of Knoxville, April 2013
- Invited Speaker, TSU Engineer's Week, April 2012
- Guest Lecturer, UT HE 650 *Fiscal Policy in Higher Education*, 2008, 2009, 2010, 2012
- Guest Lecturer, UT LAW 957 *Law, Science & Technology*, 2006, 2007, 2008, 2010
- Invited Panel Speaker, Chattanooga Enterprise Center Technology Transfer Conference, 2009, 2010
- Board Member, Technology 2020, 2010
- Chair of Innovation Valley Technology Council, 2010
- Panel Speaker, Tennessee Biotechnology Association Annual Meeting, September 2006, 2007
- Panel Speaker, University of Tennessee Nanoday Symposium, October 2004
- Panel Speaker, AUTM Central Region Meeting, July 2002
- Chair, Technical Session, Laser Cutting and Surface Treatment Systems, 19^{th} International Congress and Exposition for Lasers and Electro-Optics (ICALEO), November 2000
- Member, University of Tennessee Research Corporation Advisory Board, 1997-1999, 2000-2002
- Invited Speaker, Alabama Laser, Inc., Laser Day 1998, August 1998
- Invited Speaker, Technion, Israel Institute of Technology, December 1998
- Chair, Technical Session, Fundamentals of Laser Processing -Modeling, 13^{th} International Congress and Exposition for Lasers and Electro-Optics (ICALEO), 1994
- Technical Paper and Proposal Review, Journal of Laser Applications, ASME, AIAA, and NSF
- Mentor, Local, State and National Award Winning Science Fair Projects (middle and high school)

THESIS AND DISSERTATION COMMITTEES (* Major Professor)

"A Feedback-based Quality Control System for Laser Surface Processing," Matthew Anderson, December 2001, Master of Science.*****

"A Model for Determining Mechanical Properties Resulting from Multi-Track Laser Surface Processing," Brent Blaha, August 2001, Doctor of Philosophy.

"Influence of Gas Assist Nozzle Design on Laser Surface Processing," Terri Trammel, May 2001, Doctor of Philosophy.

"A Feasibility Study Comparing Bonding Optics In House vs. Subcontracting The Bonding Of Optics," Robert Waldrop, December 2000, Master of Science.

“Investigation of Gas Porosity in Laser Melted Gray Iron,” Denise Duncan, May 2000, Master of Science.**

“Experimental Study of the Effects of Annealing Time, Equilibrium Angle, and Absolute Misorientation Angle on Thermal Grain-Boundary Grooving in Cube-Textured Nickel,” Conrad J. Simon, May 1999, Master of Science.

“Improvement of Wear Characteristics of Aluminum Through the Addition of Silicon Via Laser Processing,” Nathanial Kennedy, May 1999, Master of Science.**

“Study of Convective Flow within a 3-D Ampoule using Numerical Simulation,” Thomas Holocek, May 1999, Master of Science.

“Electron Beam Welding of Stainless Steel and Copper,“ Kevin Zysk, December 1998, Doctor of Philosophy.

“Use of Plasma Arc Assist to Provide Greater Fusion Zone Width during Laser Welding,” Glendon Tyree, December 1998, Master of Science.**

"An Experimental Investigation of Jetting Convection during Bridgman Solidification of Aqueous Ammonium Chloride,” Ruben C. Bons, August, 1996, Master of Science.

"Modeling the Depth of Penetration in Laser Welded Al 6061 Using Statistical and Neural Network Approaches," Martin A. Kalberer, May, 1995, Master of Science.

"An Investigation of Surface Modification Due to the Deposition of Silicon onto Molybdenum," Robert A. Waldrop, May, 1995, Master of Science.

"Study of Fluid Flow During Directional Solidification of H_2O-NH_4Cl Using a Particle Displacement Tracking Technique," Ram Sivakumaran, December 1994, Master of Science.

"A Holographic Reconstruction System for Measuring Concentration Profiles in an Alloy Metal Model Under Directional Solidification," Brent W. Blaha, May, 1994, Master of Science.

COURSES TAUGHT

- Engr 246 Mechanics of Materials (Spring 2000)
- Engr 225 Engineering Computations and Numerical Techniques (Fall 1999)
- ME 612 Numerical Modeling in Heat Transfer, Fluid Mechanics, and Mass Transfer (Spring 1999)
- Engr 405 Heat and Mass Transfer (Fall 1998)
- ME 512 Heat Transfer II (Spring 1997, Spring 1998)
- ME 511 Heat Transfer I (Fall 1996, Fall 1997)

- ME 599C Materials Issues for Piston Engine Design and Production (Spring 1998)
- Engr 405 Heat and Mass Transfer (Fall 1996)
- AE 599 Analysis of Gaseous Emissions (Spring 1996)
- ME 612 Numerical Modeling in Heat Transfer, Fluid Mechanics, and Mass Transfer (Fall 1995)
- ME 599 Transport Phenomena in Materials Processing (Spring 1995)
- AE 522 Aerodynamics of Compressible Fluids II (Fall 1993)
- AE 521 Aerodynamics of Compressible Fluids I (Spring 1992)

FUNDED RESEARCH PROJECTS (PI/Co-PI/Director)

National Science Foundation, EPSCoR Workshop Series on Innovation, Entrepreneurship, and Translational Research, $200k, 1/15-6/16

National Science Foundation, 2013 NSF EPSCoR National Conference, $420k, 3/12-2/14

Department of Energy, Neutron Scattering Research Network for EPSCoR States, $1.6M, 10/12-10/15

National Science Foundation, Tennessee Solar Conversion and Storage for Research, Outreach, and Education (TN-SCORE), $24M 8/10-6/16

Department of Defense, US Army, LISI Surfaces for Erosion Resistant Cannon Bores, $2.2M 1/00-8/02

Department of Defense, USAF-AEDC, Task 99-08 LISI Applications for AEDC Facilities, $474k 7/00-9/01

Department of Defense USAF-OSR, Investigation of the Laser Material Interaction Regimes During Thermal and Compositional Superposition in Laser Surface Improvement, $100k 12/98-11/99

Saturn Corporation, Evaluation of LISI-Processed Lost Foam Cast Engine Blocks, 1/99-10/99

Dana Corporation, LISI Surfaces for Corrosion Resistance on Steel Tube, $5k, 11/99-1/00

Briggs and Stratton, Evaluation of LISI-Processed Engine Bores and Valve Seats, $24k 8/98-6/99

CFD Research Corporation, Evaluation of IR Diagnostics for DARPA MICE Program, $3k

Surface Treatment Technologies Task Order Projects

Phase II SBIR Department of Defense, Navy, $70k 11/99-6/01

LISI Surfaces for Antenna Components, $36k 6/00-9/00

CTC Corrosion and Wear Research, $13k 5/00-7/00

LISI Surfaces for Truck Latches, $5k 10/99-12/99

Phase I SBIR NASA, $17k 5/99-7/99

Phase I SBIR Environmental Protection Agency, $15k 12/98-4/99

Phase I SBIR Department of Defense, Navy, $17k 8/98-12/98

American Pipe Company, Super Alloy Surfacing of Centrifugal Pipe Molding, $15K 11/97-3/98

Carbite Golf, Golf Club Face Treatment, $2K 8/97-3/98

Allison, LISI Erosion Resistance Surfacing of Aluminum and Steel Substrate Materials, $15K 1/98-3/98

United Defense Limited Partnership, LISI Surface Alloying for Military Systems, $25K 6/97-3/98

United Defense Limited Partnership, LISI Processing of Aluminum Tank Blocks, $15K 10/97-1/98

Laser Applications Incorporated, Evaluation of LISI Processed Wear Surfaces on 4140 Steel, $9k 8/98-10/98

Laser Applications Incorporated, Support of Wear Band Processing, $4k 6/98-8/98

General Motors, Evaluation of LISI-Processed E85 Cylinder Bore Surfaces, $45k 3/98-6/98

CiMatrix, Testing of Laser Marked Anodized Aluminum Surfaces, $2.5k, 3/98-4/98

Department of Defense USAF-OSR, Investigation of the Laser Material Interaction Regimes during Thermal and Compositional Superposition in Laser Surface Improvement, $198K 2/97-11/97; $100K 12/97-11/98

Department of Defense USAF-AEDC, Task 98-05 AEDC LISI Applications, $25K 11/97-10/98

East Manufacturing, LISI Development for the EAST Manufacturing Dump Trailer, $5K 6/97-3/98

Department of Defense USAF-AEDC, Task 97-04 Laser Surface Alloying for Rust Elimination, $383K 11/96-10/97

Department of Defense USAF-AEDC, Task 96-06 AEDC Laser Surface Alloying for Rust Elimination, $223K 2/96-10/96

Department of Defense USAF-AEDC, Task 96-05 Advanced Materials Technology Applications to AEDC Operational Testing, $83K 11/95-10/96

Department of Energy, UTSI/CFFF High Temperature Superconductor Evaluation and Modeling, 1/96-5/99

Johnson Controls, Inc., JCI Laser Development Program, 7/97-12/98

Department of Defense SBIR Subcontract from RedZone Robotics, 3/97-8/97

Department of Defense SBIR Subcontract from Accurate Automation, 5/97-9/97

Sverdrup Technology, Thermal Loading of High Temperature Flow Probe, $15K 11/92-01/93

Department of Defense USAF-AEDC Advanced Materials Technologies for AEDC Operational Testing, $65K 11/94-10/95

PUBLISHED PAPERS

"Laser Alloying Provides Next Generation of Truck Components," S. Dupay, T. Langan, and J.A. Hopkins, *Industrial Laser Solutions for Manufacturing*, pp. 9-11, June, 2003.

"Plasma Assisted Laser Surface Alloying," M.H. MCay, C.M. Sharp, J.A. Hopkins, B. Szaprio, and T.D. McCay, *Journal of Laser Applications, Vol. 15,* No. 2, pp. 84-88, 2003.

"Evaluation of Nozzle Geometries for Laser Surface Alloying," T.L. Trammel, M.H. McCay, J.A. Hopkins, and T.D. McCay, *Journal of Laser Applications, Vol. 14*, No. 3, pp. 174-184, 2002.

"Melt Instabilities during Laser Surface Alloying," M.H. McCay, J.A. Hopkins, and T.D. McCay, *Journal of Laser Applications, Vol. 14,* No. 1, pp. 24-30, 2002.

“Wear Enhancement of Aluminum by Laser Surface Alloying with Silicon,” M.H. McCay, N. Kennedy, J.A. Hopkins, and N.B. Dahotre, *Lasers in Engineering, Vol. 10,* No. 2, pp. 107-122, 2000.

“The Effect of Chromium and CrB_2 Additions on the Formation of Borides During Laser Surface Modification of Steel,” M.H. McCay, N.B. Dahotre, and J.A. Hopkins, *Surface Engineering: Materials Science I*, Eds. S. Seal, N.B. Dahotre, J.J. Moore, and B. Mishra, Minerals, Metals, and Materials Society/AIME, pp. 385-394, 2000.

“The Influence of Metals and Carbides during Laser Surface Modification of Low Alloy Steel,” M.H. McCay, N.B. Dahotre, J.A. Hopkins, T.D. McCay, and M.A. Riley, J*ournal of Materials Science, Vol. 34, Issue 23*, pp. 5789-5802, December, 1999.

Surface Alloying Goes Mainstream,” J.A. Hopkins and M.H. McCay, *Industrial Laser Solutions for Manufacturing*, pp. 23-26, September, 1999.

“Performance of Laser Processed Aluminum Alloys for Engine Bore Applications,” J.A. Hopkins, M.H. McCay, N.B. Dahotre, T.D. McCay, and F.A. Schwartz, *Aluminum in Automotive Applications*, SAE SP-1350, pp 55-60, 1998.

“The Influence of Gravity-Related Convection on Secondary Arm Evolution in NH_4Cl-H_2O,” M.H. McCay, J.A. Hopkins, and T.D. McCay, *Metallurgical Transactions, A*, Vol. 29A, pp. 1137-1139, March 1998.

"Optical Methods for Study of Mass Transfer During Metal Model Directional Solidification," J.A. Hopkins, M.H. McCay, L.M. Smith, and T.D. McCay, *International Symposium on Manufacturing and Materials Processing, Vol. 1,* W. Aung, ed., pp. 131-146, 1997.

“Convection Affected Growth Regimes for Vertical Bridgman Solidification of Metal Models,” T.D. McCay, M.H. McCay, and J.A. Hopkins, *Recent Research Developments in Metallurgy and Materials Science, Vol. 1,* pp. 133-138, 1997.

"The Effect of Bulk Flow Concentration on Diffusion Coupling Between Dendrites," J.A. Hopkins, M.H. McCay, and T.D. McCay, *Metallurgical Transactions, A, Vol. 27A,* No. 2, pp. 477-479, February 1996.

"Melt Pool Dynamics during Laser Welding," V.V. Semak, J.A. Hopkins, M.H. McCay, and T.D. McCay, *Journal of Physics D: Applied Physics, Vol. 28,* No. 12, pp. 2443-2450, December, 1995.

"Refractive Index of NH_4Cl-H_2O as a Function of Wavelength: The Effect of Temperature and Concentration," M.H. McCay, V.V. Semak, and J.A. Hopkins, *Journal of Applied Optics, Vol. 144,* pp. 346-352, 1995.

"Shrinkage Flow Effects on the Convective Stability of NH_4Cl-H_2O Directional Solidification," J.A. Hopkins, T.D. McCay, and M.H. McCay, *AIAA Journal*, Vol. 33, No. 8, pp. 1531-1534, 1995.

"Relationship Between Flow Direction and Dendritic Growth Rate in NH_4Cl-H_2O," M.H. McCay, J.A. Hopkins, and T.D. McCay, *Metallurgical Transactions, Vol. 26A*, No. 1, pp. 227-229, 1995.

"A Particle Displacement Tracking Technique for Analysis of Convective Motion During Solidification of NH_4Cl-H_2O," R. Sivikamuran, J.A. Hopkins, M.H. McCay, and T.D. McCay, *Transport Phenomena in Materials Processing, ASME Vol. HTD-317-2,* P.J. Prescott, H.R. Jacobs, J. Sayed-Yagoobi, J. Pulknowski, C.P. Griboropoulus, T.J. Moon, A.S. Lavine, P.H. Ousthuizen, Y. Boyazitoglu, eds., pp. 361-369, 1995.

"Convective Flow Effects on Diffusion Layers During NH_4Cl-H_2O Dendritic Solidification," M.H. McCay, J.A. Hopkins, and T.D. McCay, *Journal of Crystal Growth, Vol. 144*, pp. 346-352, 1994.

"Investigation of Convection During Bridgman Solidification of NH_4Cl-H_2O," J.A. Hopkins, M.H. McCay, and T.D. McCay, *Experimental and Numerical Flow Visualization, ASME Vol. FED-172*, B. Khalighi, M.J. Braun, D.H. Fruman, C.J. Freitas, J.G. Georgiadis, and M. Keyhani, eds., pp. 369-376, 1993.

"Modeling of Laser Welding: Comparison of 1-g and μ-g Predictions," J.A. Hopkins, T.D. McCay, M.H. McCay, and A.H. Eraslan, *Transport Phenomena in Nonconventional Manufacturing and Materials Processing, ASME Vol. HTD-259*, C.L. Chen, F.P. Incropera, and V. Prasad, eds., pp.17-24, 1993.

"Development of a Weld Keyhole Monitoring Technique for Laser Welding," T.D. McCay, V. Semak, J.A. Hopkins, F.J. Kahlen, M.H. McCay, and A.H. Eraslan, *Transport Phenomena in Nonconventional Manufacturing and Materials Processing, ASME Vol. HTD-259*, C.L. Chen, F.P. Incropera, and V. Prasad, eds., pp.25-31, 1993.

"Two-Phase Considerations for the Linear Analysis of Convective Stability During Vertical Directional Dendritic Solidification," J.A. Hopkins, T.D. McCay, and M.H. McCay, *Heat Transfer in Porous Media, ASME Vol. HTD-240* , M. Faghri and L.C. Burmeister, eds., pp. 67-76, 1993.

"Influence of Gravity Level on Free Convective Effects During Bridgman Directional Dendritic Solidification of NH_4Cl-H_2O," T.D. McCay, J.A. Hopkins, and M.H. McCay, *Heat Transfer in Microgravity Systems, ASME Vol. HTD-235*, S.S. Sadhal and A. Hashemi, eds., pp. 11-24, 1993.

"Optical Analysis of Fluid Flow Effects on Directional Dendritic Solidification Rates in NH_4Cl-H_2O Solution," M.H. McCay, T.D. McCay, and J.A. Hopkins, *Heat Transfer in Melting, Solidification, and Crystal Growth, ASME Vol. HTD-234*, I.S. Habib and S. Thynell, eds., pp. 1-12, 1993.

"The Nature and Influence of Convection on the Directional Dendritic Solidification of a Metal Alloy Analog, NH_4Cl, and H_2O," M.H. McCay, T.D. McCay, and J.A. Hopkins, *Metallurgical Transactions B, Vol. 24B,* August, 1993, pp. 669-675.

"Heat and Mass Transfer Effects on Dendrite Growth During Vertical Directional Solidification of NH_4Cl-H_2O," T.D. McCay, M.H. McCay, and J.A. Hopkins, *Journal of Materials Processing and Manufacturing Science, Vol. 1*, January 1993, pp. 315-330.

CONFERENCE PAPERS AND OTHER REPORTS

"Laser Surface Processing for Powertrain Applications," J.A. Hopkins, *Advanced Powertrain Materials and Manufacturing, Vol. 23, Global Powertrain Congress*, 2002, pp. 7-17.

"The University of Tennessee, an Engine for Economic Development in the State of Tennessee," M. Kerrigan and J.A. Hopkins, *Commissioned Report for Science Applications International, Corp.*, 2002.

"Laser Surface Processing of Compressor Blades for Erosive Environments," M.H. McCay, J.A. Hopkins, and M. Amundson, *43rd AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference*, 2002.

"Laser Surface Alloying of Aluminum Engine Bores," J.A. Hopkins, M. Murray, N.B. Dahotre, and M.H. McCay, *20th International Congress on Applications of Lasers and Electro-Optics (ICALEO)*, 2000

"Feasibility Analysis of Laser Cleaning and Surface Alloying Using Laser Induced Surface Improvement (LISIsm) for Bridge Structures," M.H. McCay, T.P. Lynch, and J.A. Hopkins, A*ir & Waste Management Association Technical Symposium, June 2000.*

"The Effect of Chromium and CrB_2 Additions on the Formation of Borides during Laser Surface Modification of Steel," M.H. McCay, N.B. Dahotre, and J.A. Hopkins, *129th TMS Annual Meeting*, March 12-16, 2000.

"The Performance of Laser Surface Processed Aluminum Alloys for Commercial Applications," M.H. McCay, T.L. Tramel, and J.A. Hopkins*, 18th International Congress on Applications of Lasers and Electro-Optics (ICALEO)*, 1998.

"Laser Processed Aluminum Surfaces in Automotive Applications: Performance Requirements for Cylinder Bores and Valve Seats," J.A. Hopkins, M. Murray, M.H. McCay, and N.B. Dahotre, *SAE-SAM-123, Southern Automotive Manufacturing Conference*, 1998.

“The Formation of Wear and Corrosion Resistant Surfaces using Laser Induced Surface Improvement,” M.H. McCay, N.B. Dahotre, J.A. Hopkins, T.D. McCay, J.B. Bible, F. Schwartz, *TMS Fall Meeting*, 1998.

“A Technique for Melt Pool Oscillation Monitoring during Laser Spot Welding,” V.V. Semak, J.A. Hopkins, and M.H. McCay*, 17th International Congress on Applications of Lasers and Electro-Optics (ICALEO)*, 1997.

“Weld Seam Tracking and Lap Weld Penetration Monitoring Using the Optical Spectrum of the Weld Plume,” R.E. Mueller, J.A. Hopkins, V.V. Semak, and M.H. McCay, *16th International Congress on Applications of Lasers and Electro-Optics (ICALEO)*, 1996.

“Weld Pool Oscillations in Laser Welding,” V.V. Semak, J.A. Hopkins, M.H. McCay, and T.D. McCay, *15th International Congress on Applications of Lasers and Electro-Optics (ICALEO)*, 1995.

“Shape and Position of Keyhole During Laser Welding,” V.V. Semak, J.C. West, J.A. Hopkins, M.H. McCay, and T.D. McCay, *15th International Congress on Applications of Lasers and Electro-Optics (ICALEO)*, 1995.

"Calorimetric Measurements of the Influence of Surface Preparation on the Absorption of 10.6 μm Radiation," J.A. Hopkins, V.V. Semak, and M.H. McCay, *Laser Materials Processing, Vol. 79*, Laser Institute of America, pp. 838-845, 1994.

"A Concept for a Hydrodynamic Model of Keyhole Formation and Support During Laser Welding," V.V. Semak, J.A. Hopkins, M.H. McCay, and T.D. McCay, *Laser Materials Processing, Vol. 79*, Laser Institute of America, pp. 641-650, 1994.

"Dynamics of Penetration Depth During Laser Welding," V.V. Semak, J.A. Hopkins, M.H. McCay, and T.D. McCay, *Laser Materials Processing, Vol. 79*, Laser Institute of America, pp. 830-837, 1994.

"Space Applications Industrial Laser System," T.D. McCay, J.B. Bible, R.M. Mueller, M.H. McCay, C.M. Sharp, and J.A. Hopkins, *AIAA 94-2448*, Colorado Springs, CO, 1994.

"Space Applications Industrial Laser System (SAILS): An Update," T.D. McCay, J.B. Bible, R.E. Mueller, M.H. McCay, C.M. Sharp, and J.A. Hopkins, *Laser Materials Processing, Vol. 77*, Laser Institute of America, pp. 463-470, 1994.

"Transient Predictions of Laser Spot Welds in Inconel 718," J.A. Hopkins, T.D. McCay, M.H. McCay, and A.H. Eraslan, *Laser Materials Processing, Vol. 77*, Laser Institute of America, pp. 106-116, 1994.

"Thermal Loading of High Temperature Flow Probe using a 3 kW CO_2 Laser," J.A. Hopkins, UTSI Report 93-06, May, 1993, UTSI, Tullahoma, TN 37388.

"The Effects of Gravity Level and Shrinkage Flow on the Onset of Convection During Vertical Directional Dendritic Solidification of NH_4Cl-H_2O," J.A. Hopkins, T.D. McCay, and M.H. McCay, *AIAA 93-0261*, Reno, NV, 1993.

"Interferometric Measurements of a Dendritic Growth Front Solutal Layer," J.A. Hopkins, T.D. McCay, and M.H. McCay, *AIAA 91-1334*, Honolulu, Hawaii, 1991.

"Thermal and Solutal Conditions at the Tips of a Directional Dendritic Growth Front," T.D. McCay, M.H. McCay, and J.A. Hopkins, *AIAA 91-1333*, Honolulu, Hawaii, 1991.