Fraunhofer
USA

FOCUS 2020

For many countries, companies and people, 2020 will be the most trying year in recent history. The SARS-CoV-2 virus was first reported in Wuhan, China in December 2019. Since December, it has spread across the globe. Currently there is no vaccine or antiviral treatment. The growing number of cases has strained healthcare systems and led to shortages of medical equipment. Efforts to slow the virus have resulted in travel restrictions, nationwide lockdowns, and economic depression. These will have long lasting effects on our society and our businesses. But the pandemic has also shown the resiliency of the human spirit and difficult times always present opportunities to face the challenges head-on and come out stronger than we were before.

To begin our recovery process, we have to examine how we have changed. People and companies have been embracing technologies to get through these difficult times. There has been a boom in the use of video conference services. Whether it is for quick meetings with coworkers or telemedicine with a doctor, people all over have turned to using devices to stay connected. This brings about new challenges in security and privacy. Companies will be challenged to protect the devices and data of their users. At Fraunhofer USA we look forward to working with our partners on developing new technologies to allow people to connect in this advancing digital world while still feeling protected. In addition to our data, we will have to find ways to improve supply chains around the world. The coronavirus has forced companies to examine the benefits and risks of a global supply chain against the speed and availability of a more localized regional supply system. Using logistics and artificial intelligence technologies will allow companies to stay flexible with their supply chains so they can remain profitable without increasing costs to their consumers.

To make these new supply chains work, companies will change how they manufacture moving forward. As companies return to work, they will have to find ways to keep their employees safe while producing at high rates. Factory efficiency can be increased through the adoption of new technologies. These Industry 4.0 technologies have been at the forefront of business discussions for years now. The return to work after the pandemic is the perfect time for businesses to seriously consider adopting these technologies. Fraunhofer USA has a rich history in helping companies achieve their production potential and we look forward to supporting companies in finding and developing new technologies.

Fraunhofer USA is uniquely situated to help companies moving forward after these difficult times. It is with great financial risk that private companies develop and analyze new technologies. We strive to help our customers to implement new technologies and achieve innovation faster and more efficiently. We have applied research and development facilities staffed with technical experts and equipped with state-of-the-art machinery that can help to de-risk such investments. We partner with innovative companies across industries and excellent research universities to develop new processes, products and technologies for real-world applications. We work with companies of any size and offer value through increasing the readiness level of a technology by proving its feasibility, testing prototypes, validating system performance, and implementing solutions. We provide access to the vast technology portfolio of the global Fraunhofer Network.

Thank you for taking the time to read this year's *Fraunhofer USA Focus* magazine. Here we highlight projects and technologies that can help your business move forward into the future. We also take great pride in highlighting the extraordinary researchers who develop and test these technologies. Please contact us if you would like to learn more. We look forward to working together.

Sincerely,

Thomas Schuelke

Thomas Schuelke
President,
Fraunhofer USA, Inc.

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MANAGEMENT REPORT

"I have to set aside everything in my scientific endeavors which does not further the product."
– Joseph von Fraunhofer

The namesake of our organization, German researcher, inventor and entrepreneur Joseph von Fraunhofer, understood the need to focus his scientific and technical resources on creating a practical product. Today we follow his thinking by aiming our efforts on where technology is needed most and where we can provide the greatest impact for our customers.

At Fraunhofer USA, our engineers and scientists work together to find solutions to problems that not only benefit from but also require a multi-disciplinary approach to generate optimal results. For this reason, our research centers are continually expanding and diversifying access to core competences through multi-disciplinary collaborations across Fraunhofer USA as well as the greater Fraunhofer Network around the globe. In addition, through close and hands-on collaborations with major university partners, we strive for scientific excellence in our research work. Scientific and engineering breakthroughs are often the result of fresh perspectives and novel approaches. The days of a lone engineer or a small group of scientists working on a single project for many years are long gone and with good reason.

Project teams at Fraunhofer USA are dynamic to match customer demand with the required expertise. Project managers are tasked with providing the most suitable combination of scientists, engineers, technicians and equipment. In some cases, external partners will be involved to provide unique resources as needed. To manage the complexity of multi-disciplinary R&D projects, a fluid and dynamic approach to project management offers the best outcomes for customers. Bringing in the right people when and where needed to tackle the tasks at hand is key to agile project execution. With a modular team structure and an iterative and incremental task management approach, Fraunhofer USA aims to achieve maximum flexibility and R&D performance to get the work done in the best interest of our customers.

Our research efforts ultimately aim at having innovative societal impact by providing comprehensive solutions to our industry customers.

FHUSA 2.0

Fraunhofer USA, Inc. is a legally independent US affiliate founded by Fraunhofer-Gesellschaft, which is a not-for-profit organization in Germany with a 70-year successful history of providing applied research and development services to the benefit of both industry and the public. Fraunhofer-Gesellschaft has more than 28,000 employees working in 74 research institutes. The organization is active in 80 countries around the world. Creating tangible impact requires focusing research on goals of great relevance to current societal challenges such as affordable healthcare, low carbon energy, security and resilient society, digitalized value creation, and a holistic recycling economy. Fraunhofer concentrates on strategic research fields including "Bio-Economy, Intelligent Medicine, Resource Efficiency & Climate Technologies, Artificial Intelligence, Next Generation Computing, Quantum Technologies, and Hydrogen Technologies" to develop solutions to tackle these challenges.

These goals and research fields are as relevant to us in the United States as they are to Germany. In a new strategic initiative for Fraunhofer USA, the organization is making affirmative changes to find greater alignment with our partner, Fraunhofer-Gesellschaft, and internal changes to enhance and support these very important technology fields. We call this initiative "Fraunhofer USA 2.0". The new initiative has three main thrusts; to create a deeper beneficial cooperation with our partner Fraunhofer-Gesellschaft, to consolidate and enhance the R&D offering of Fraunhofer USA, and to improve internal administrative functionality.

The focus is on creating a much larger research and development capability, cooperation and platform. Traditionally our Fraunhofer USA Centers each partnered with one specific institute in Germany, focusing only on a few technology areas. "Fraunhofer USA 2.0" now enables our centers to collaborate with any and all of the institutes in Germany and the other Fraunhofer affiliates to make Fraunhofer-wide comprehensive solution portfolios accessible to our partners and customers.

To position ourselves for this mission, we are reorganizing our footprint in the United States by combining operations into three core research centers located in the American Midwest, Mid-Atlantic and Northeast regions. As of January 1st, 2021, the new Fraunhofer USA Center Midwest CMW will be comprised of the former Fraunhofer USA Center for Coatings and Diamond Technologies CCD and the former Fraunhofer USA Center for Laser Applications CLA. The new Fraunhofer USA Center Mid-Atlantic CMA will be comprised of the former Fraunhofer USA Center for Experimental Software Engineering CESE and the former Fraunhofer USA Center for Molecular Biotechnology CMB. The Fraunhofer USA Center for Manufacturing Innovation CMI previously took over specific technologies from the former Fraunhofer USA Center for Sustainable Energy Systems CSE. The terms of the partnership with the University of Connecticut were fulfilled and the closure of the Fraunhofer USA Center for Energy Innovation CEI was concluded as planned on May 31st, 2020, at the end date of the collaboration agreement.

The implementation of the new model began in 2020 and continues to ramp up in 2021 including the creation of a Research and Development Coordination and Representation function headed by an experienced employee with a Ph.D. in Materials Science, the development of an Internal Grants and Contracts administration team headed by an experienced attorney, the formation of a trans-organizational business development team, and the implementation of a Technical Advisory Board. Fraunhofer USA will launch a new Enterprise Resource Planning system in January of 2021 with expanded capabilities for contract and project management, time and expense accounting, and document storage.

Each one of these actions supports the overarching goal to continually improve and expand the value of Fraunhofer USA to its customers, its partners, and society. We are very much looking forward to the tremendous synergistic opportunities that the "Fraunhofer USA 2.0" approach promises.

Operating Objectives

Incorporated in Rhode Island in September of 1994, Fraunhofer USA has dedicated more than 25 years to providing technology solutions to benefit industry and society. Fraunhofer USA obtains contracts from customers in industry and State and Federal governments. Our primary focus is applied research and development to advance concepts and ideas from basic research to prototype development and validation. Thus, we aim to bridge the gap between university type research and industrial product development. Our goal is to utilize the know-how, talent, innovation and experience of our staff to partner with companies, agencies and institutions to transform ideas into reality.
We contribute to improving and benefitting society.

We continue our commitment to providing hands on training and internships to students in STEM fields and to mentor early career scientist and engineers. We promote the exchange visitor objectives of the United States government through our J-1 visa programs for interns and research scholars "to promote educational and cultural exchange to develop mutual understanding between the people of the United States and other countries".

Contract Research

Fraunhofer USA is a contract-driven, research and development organization. It is through contract research revenue, base funding, donations and grants that Fraunhofer USA acquires the necessary funding to continue its mission. As a lean operation, Fraunhofer USA strives to keep overhead low while preserving the ability to attract and retain highly-skilled scientists and engineers through competitive compensation packages and working conditions that allow individual and group innovation. Our employees frequently express that they are contributing to innovation and progress, not only in their chosen fields, but also as interdisciplinary support for colleagues and collaborators.

In the "Research Review" section of this year's *Fraunhofer USA Focus*, we report on some recent highlights. These projects illustrate a range of capabilities but represent only a small portion of the projects worked on. Please contact us or visit www.fraunhofer.org to learn more about how we can assist you.

Human Resources

This year has been extremely challenging for employees at companies across the globe. Once the news of COVID-19 broke on the world stage, businesses began an immediate scramble to manage the crisis. As governing authorities imposed restrictions on the movement of people, the ability to come into the physical workspace was severely hindered. Immediate impacts were felt in many customer-driven businesses, followed shortly thereafter by interruption in the production of goods and of the supply chain itself. Companies and the employees who work for them began to navigate the ever-changing challenges with the goal to mitigate costs to human health and life imposed by mankind's ancient and constant nemesis, the virus.

At the time of this writing, the World Health Organization is reporting more that 38 million cases and upward of a million deaths attributed to COVID-19. The impact on some families is devastating. There is a national and global mourning. Added to this are the daily struggles of the unemployed, those with unemployed family members, people with concerns about food and housing security, people having to homeschool or watch infants or small children while trying to work. Some people have underlying health or psychological conditions that make them more vulnerable during this pandemic. These are very real, difficult and demanding challenges that people are now facing every day. As employers, we need to be acutely aware of the situations of our employees. Our people need to also be aware of the stressors for the companies. These are extraordinarily challenging times for everyone. However, we are all in this together and we need to take the time to help each other.

There have been many surprising positive outcomes of the modifications required under the pandemic. Many companies have realized that working from home did not cause a marked drop in work productivity. Others realized that the internet-based meeting platforms worked very well, and frequent online meetings with team members are actually helping with collaboration and strategic planning. Employees are complying with the COVID-19 safety protocols that businesses set up and are doing their part to keep their co-workers safe.

At Fraunhofer USA, our employees have been exemplary in their professionalism and cooperation in meeting the challenges surrounding the COVID-19 pandemic. As the organization works to provide guidance to its business units during the pandemic, our employees are applying their innovative and creative ideas to protect our work force as much as possible though best practices as suggested by the various health and government authorities. We are proud of our employees for their strength during this trying time. The Fraunhofer Focus publication gives us an opportunity to feature a few of our colleagues. In the following section "Faces at Fraunhofer USA" you can read about a few of them.

Matthias Muehle
Scientist, Fraunhofer USA Center for Coatings and Diamond Technologies CCD

Dr. Matthias Muehle first joined Fraunhofer USA CCD in 2011 to work on thesis research involving synchrotron-based X-ray characterization of diamond crystals. After obtaining his M.Sc. degree from the Technical University Dresden, Germany, Matthias worked as a Project Engineer at the Center for two years before transitioning to Michigan State University (MSU) for his doctorate research. He received his Ph.D. in Electrical Engineering from Michigan State University in 2017, researching the industrial scalability of single crystal diamond wafers. Matthias now works at the Center as a Scientist with a focus on diamond applications in electronics.

Research highlights include an internally funded project on combining machine learning and crystal growth technologies to predict process outcomes. This project involves a team of researchers from across two Fraunhofer USA centers. Initial results demonstrate the predictability of the shape and size of growing diamond crystals up to six hours into the future. This is achieved by image segmentation from in-situ recorded camera images of the growth chamber. The research continues to stress-test and improve the underlying artificial intelligence algorithms and to integrate the predictions as a process feedback loop into the reactor software.

Sandra Ösp Stefánsdóttir
Computer Research Scientist, Fraunhofer USA Center for Experimental Software Engineering CESE

Sandra Ösp Stefánsdóttir holds a B.Sc. in Computer Science from Reykjavik University (RU) in Iceland. She joined the Fraunhofer USA Center for Experimental Software Engineering CESE in Maryland in June 2018 as the final requirement for her degree. Sandra completed a certificate program at MIT in User Experience and intends to study User Experience Design for her masters starting in 2021. She focuses on applying her skills to combine the technical aspects of software development with user experience tools to resolve issues between the disciplines.

Sandra began her career in information technology in 2017 when she worked for Icelandair Hotels' IT Department in Reykjavik. There, Sandra served as a Technician and Systems Administrator and transitioned to project management, designing and managing the company's entire register system. Sandra also worked as an IT consultant and Teaching Assistant at RU.

Sandra has progressed at Fraunhofer USA CESE transitioning from intern to a full-time developer to Project Manager and Tech Lead as well as co-managing the Center's international intern program.

She currently leads and contributes to multiple projects for public and private clients including: E4USA – Developing an Advanced Placement engineering course for high school students and faculty; BCA – Developing a platform for a bicycle manufacturer to track defects in real time; Mission Go – Developing a platform to track organ shipments; Prometheus – Tracking influenza spread to improve military readiness through development of a prognostic to identify pre-symptomatic virus carriers.

Sandra Ösp comments, "Working at Fraunhofer USA has given me the opportunity to be a part of multiple projects with diverse applications. It is truly an experience you would not get just anywhere. It has helped me grow tremendously and made me into the developer I am today."

Efaz Karim
Research Scholar, Fraunhofer USA Center for Laser Applications CLA

Efaz acquired his bachelor's degree from BRAC University, Dhaka, Bangladesh, in Electrical and Electronic Engineering in 2014. He joined Fraunhofer USA Center for Laser Applications CLA in 2018 as an intern for six months after completing his master's degree in Laser and Photonics at Ruhr University Bochum, Germany, in 2018. Upon completing his internship, he joined Fraunhofer USA CLA as a Research Scholar.

His master's thesis was on "Surface wettability of Stainless Steel by laser ablation under different liquid environments". The research found that the environment in which the stainless steel is ablated greatly influences the wetting characteristics. For example, ablation in air causes the wettability to range from very hydrophilic, immediately after ablation, to hydrophobic after some days. On the other hand, ablation under ethanol results in a superhydrophobic surface immediately after ablation. The research also studied the surface chemical composition and nanostructure properties, post-ablation.

His bachelor's degree thesis was on "Mode interaction of Photonic Crystal Nano Cavity Arrays" and research studied simulation-based interactions between electromagnetic modes in Photonic Crystals.

Efaz's work at Fraunhofer USA focuses on the electrical interfacing of laser and robot systems, ultra-fast pulsed ablation of metals, and more recently on copper welding. He works on various projects that involve welding of metals, including dissimilar metals, cladding with super alloys on titanium and processing metals using ultrafast lasers.

"I personally believe that my two years with Fraunhofer USA have molded my academic knowledge into an application-based skill set. Working here, I have not only been exposed to a myriad of interdisciplinary projects but also to amazing people who are truly gifted at their skills. As a result, my work here never fails to excite me and everyday includes new learning opportunities."

Thomas Kretzschmar
Project Manager, Fraunhofer USA Center for Laser Applications CLA

Thomas Kretzschmar graduated in 2002 from the University of Applied Science in Dresden, Germany with a bachelor's degree in Manufacturing Engineering. While in college, he wrote his thesis at the Fraunhofer Institute for Material and Beam Technology IWS, Dresden, and worked thereafter as a research assistant. In November 2003, he joined the Fraunhofer USA Center for Laser Applications CLA in Plymouth, Michigan.

Thomas started his career as an engineer for laser metal deposition and additive manufacturing. Not long after, he was tasked with laser welding process development. He continues to develop laser welding processes from feasibility studies, prototype batches to pilot-scale production and technology deployment. Powertrain weld processes that he developed are currently in production for several car manufacturers and automotive suppliers.

Shannon Nicley
Scientist, Fraunhofer USA Center for Coatings and Diamond Technologies CCD

Dr. Shannon S. Nicley is a researcher focused on the microwave plasma assisted chemical vapor deposition growth of doped single crystal diamond and its applications for quantum technologies. She completed her Ph.D. at Michigan State University on boron-doped diamond for high power diode applications and continued her work on high power electronics during a postdoctoral period at Hasselt University, Belgium.

She shifted her focus to quantum applications as a Royal Society Newton International Fellow at the University of Oxford, where she was also involved in research on novel multiphoton laser writing techniques for the deterministic creation of optically active defects in wide bandgap crystals. She is currently applying her combined expertise in diamond growth and optical characterization of defects at Fraunhofer USA CCD researching the growth of diamond with tailored dopants and novel defects.

She loves working at the Center because of the amazing people and the friendly atmosphere, which is neither straight industry nor academia but combines the best of both worlds.

Russell Zarras
Marketing and Communications Manager, Fraunhofer USA

Russ joined Fraunhofer USA Headquarters in 2019. Prior to that he worked at the Fraunhofer USA Center for Coatings and Diamond Technologies CCD as both a Project Engineer and the Marketing Manager. Russ completed his B.Sc. degree in Physics from Michigan State University and previously worked as a Regional Sales Manager for a representative organization that supplied life and physical science research equipment. This experience working in a variety of technical and business areas makes him uniquely suited to handle marketing and business development operations for Fraunhofer USA.

Russ is currently working to integrate marketing efforts across Fraunhofer USA as well as strengthen relationships with Fraunhofer-Gesellschaft, partner universities and customers. On this he says "The breadth of research happening at Fraunhofer USA is truly incredible. I want champion all the projects, researchers, and technologies that Fraunhofer has to offer. I love being able to talk about the exciting things happening here and I can't wait to see what the future holds for our organization."

Mikael Lindvall
Technology Director, Fraunhofer USA Center for Experimental Software Engineering CESE

Dr. Mikael Lindvall holds a Ph.D. in Computer Science from Linköpings University (LiTH) in Sweden. He joined Fraunhofer USA Center for Experimental Software Engineering CESE in Maryland in March of 1999.

Mikael has worked on many different types of projects over the years and many have been with NASA. For example, NASA software must be tested extensively to avoid disasters, but testing is often done in a manual and tedious manner. Supported by NASA, Mikael and the team developed tools and methodologies for automated software testing. These model-based testing techniques were used to test several NASA software systems and many defects were detected in the process. Over time, Mikael and the team came across systems, such as scientific and autonomous systems, that are very difficult to test. We want an autonomous drone to make decisions. But how do we test that the drone always makes correct decisions without specifying in detail what those decisions are?

Mikael and the team developed a new type of testing: metamorphic testing, which does not specify the correct behavior of a system. Instead it compares the outcomes of different but related test cases, which for those untestable systems is easier. It is like using several systems to independently determine the answer to the same question. If all systems agree, then we assume the answer is correct. If two systems agree and one disagrees, then we assume the third system is wrong. The idea of metamorphic testing is also useful for systems that are based on Artificial Intelligence, for example, face recognition systems. A new collaboration with the NAVY will look into how to test their AI-based systems. We also use metamorphic testing to test scientific systems such as the brain research platform that we are developing for the brain researchers at the University of Maryland.

Mikael comments, "At Fraunhofer USA we always work on new, exciting technologies and important problems so work never gets old. For example, this year we're working on software for DNA sequence analysis, AI-based systems, cybersecurity, brain research and organ tracking, just to mention a few. In addition, I get to work with very smart, creative and nice people so I can't ask for a better place to work."

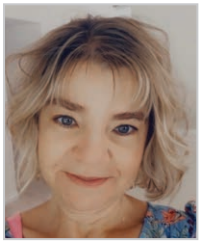
Matt Carvey
Project Engineer, Fraunhofer USA Center for Manufacturing Innovation CMI

Matt has been with Fraunhofer USA Center for Manufacturing Innovation CMI since 2016. He has worked on mechanical, electrical, and control system design for projects ranging from metal processingequipment to biotech instruments. Prior to his position at Fraunhofer USA CMI, Matt worked at startup companies developing lower limb rehabilitation devices and developing new tools for musical instruments.

His most recent work includes creating a new tool for the packaging industry and developing high-throughput packaging machines for the food industry.

Matt received his B.Sc. in Mechanical Engineering from the Massachusetts Institute of Technology

Veronica Hensler
Senior Human Resources Coordinator, Fraunhofer USA



Veronica (Ronnie) Hensler earned her Bachelor's of Business Administration from the University of North Dakota, Grand Forks, North Dakota and her Master's Degree in International Business from Schiller International University in Heidelberg Germany.

After several years working as HR Manager and Bookkeeper for a small title company in Ann Arbor, Michigan, in 2008 Ronnie began working at Fraunhofer USA, Inc. headquarters where she enjoys working in an international setting again.

Ronnie is experienced in all aspects of Human Resources. Amongst her many responsibilities are payroll, benefit administration and HR support for our centers across the US.

"One of the things I like most about working in HR is the communicating with employees, whether it be giving them information, solving problems or hearing stories about their activities and families."

She is a member of the Society of Human Resource Management, (SHRM) The American Payroll Association, (APA) and holds a Professional in Human Resources (PHR) certification.

The Fraunhofer USA Centers conduct research and development for state, federal and industry customers in fields that have been identified as directly impacting current and future societal needs. Below is a selection of some of the recent projects at the Centers.

HEALTH AND ENVIRONMENT

Fraunhofer USA and Parsons Corporation Have Announced a Mutual Partnership

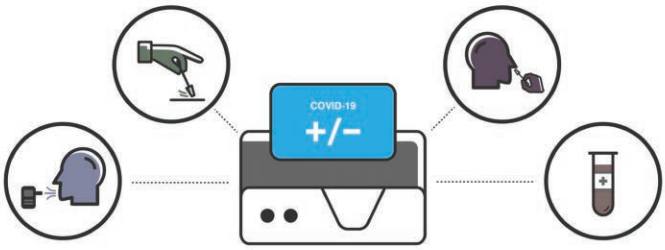
Fraunhofer USA and Parsons Corporation have announced a mutual partnership to develop a digital biosensor, capable of quickly detecting the SARS-CoV-2 virus at ultra-low concentrations. The partnership is in response to the evolving global pandemic to where the market demand and humanitarian need for the rapid screening of individuals with a history of exposure or physiological symptoms has become center-stage. The first engagement project is to develop a flexible, scalable, antibody-modified, BDD biosensor for direct and rapid detection of SARS-CoV-2.

The Fraunhofer USA Center for Coatings and Diamond Technologies CCD has established itself as a world-leading developer and fabricator of advanced biosensing applications utilizing boron-doped diamond (BDD) technology. BDD exhibits the widest electrochemical potential window of all solid electrode materials, is notoriously resistant to fouling, highly customizable, and is sensitive to many different microbial targets, such as virus, bacteria.

Leveraging in-house resources and materials know-how of BDD manufacturing and functionalization, Fraunhofer USA CCD is uniquely suited to develop a novel path to functionalize the electrode biosensor with SARS-CoV-2 antibodies and test under real-world scenarios. Coupled with Parsons' expertise, experience, product development and industry relationships, this synergistic relationship will provide the basis for a quick progression to productize one or more of applications and form factors for productization and scale-up.

"As many parts of the world start the process of reopening, testing capabilities are a critical component of a safe return to work, school and daily living," said Carey Smith, President and Chief Operating Officer for Parsons. "As COVID-19 remains invisible and elusive, development of this technology will help fill a critical need for additional testing, monitoring, and surveillance in the fight against the coronavirus."

Initial testing and development of the prototype is anticipated soon, in time to help mitigate concerns of a lingering pandemic or a possible rebound.



Developing Remediation Technologies for Per- and Polyfluoroalkyl Substances (PFAS)

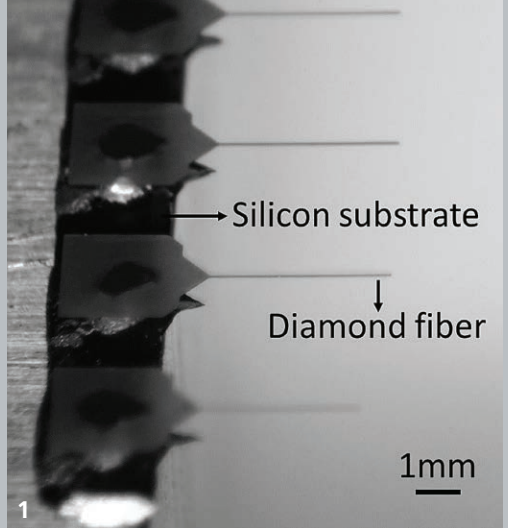
PFAS are per- and polyfluoroalkyl substances that are used in clothing, fire retardants, non-stick applications etc. and are extremely difficult to destroy and have adverse health effects.

Fraunhofer USA Center for Coatings and Diamond Technologies CCD and its University Partner, Michigan State University, have been awarded two new Michigan Translational Research & Commercialization (MTRAC) projects following in the footsteps of previous work in remediation of PFAS compounds in aqueous solutions. MTRAC provides resources to translational projects with high commercial potential, enabling the technology to have an impact beyond where it was developed and emphasizes commercialization as a key cornerstone activity.

The first MTRAC Tier I award focuses on the destruction of per- and polyfluoroalkyl substances (PFAS) using boron-doped diamond (BDD) electrodes at larger volumes relevant to our industrial partners. By demonstrating our ability to scale up our Center's established treatment process to larger sample volumes (10 – 20 L), we will be able to determine feasibility for industrial scale treatment volumes and throughput. Of primary interest will be PFAS-impacted regenerate and re-ject solutions from ion exchange (IX) and reverse osmosis (RO) treatment plants. IX and RO have proven capable for separation of PFAS from large water streams, but lack a destructive nature to remove PFAS once and for all. Electrochemical oxidation with BDD electrodes has proven capable at destruction of PFAS and therefore, make the technology a perfect match as a secondary treatment option (behind methods such as IX or RO). Commercialization plans will be developed with a detailed feasibility assessment for widespread distribution to water utilities and relevant industry partners.

Secondly, Fraunhofer USA CCD recently received an MTRAC Tier I award: Active Adsorption Technology for Efficiently Removing PFAS in Water. This one-year project will develop a scalable in-line technology for treating PFAS using activated biochar. This technology is particularly attractive for processing less complex water, such as ground and surface water. Biochar, derived from biomass, is an environmentally friendly, inexpensive and abundant alternative to activated carbon. Biochar must be activated to effectively adsorb impurities before it can be utilized. Conventional activation requires high temperature (>900˚C) treatment using CO_2, steam or strong base (e.g. NaOH) for over two hours. Our patented plasma activation technology on the other hand can effectively activate biochar in less than 30 minutes and under 200˚C. The developed technology offers great flexibility in tailoring micropore sizes and modulating the surface bonds to increase surface energy. Plasma treated biochar has led to increased methylene blue adsorption by a factor of 10 as compared to untreated biochar.

© Fraunhofer USA, Researcher and Electrochemical Oxidation system used to destroy PFAS with boron-doped diamond electrodes



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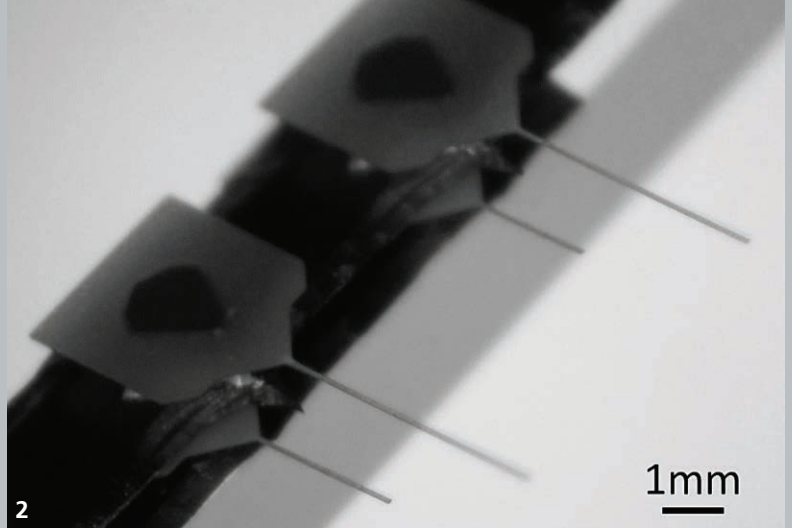

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All-Diamond Microfiber Arrays for Brain Research

The human brain consists of ~85 billion neurons that communicate with each other electrically at the neuron level and chemically at the synapses. Understanding the causal relationships between complex brain functions and behavior requires the ability to monitor both electrophysiology and neurotransmitter signaling in real time in large-scale brain networks. Dysregulated levels of neuro-transmitters (NTs) in the brain are the primary cause of many neurological disorders. For example, dopamine (DA) dysregulation has been associated with Parkinson's disease, schizophrenia, and drug addiction. Hence, elucidating the brain functions in health and disease requires real-time monitoring of dynamic changes in neurophysiology and NT concentrations from a large population of neurons. Over the past decades, tremendous efforts have been made to develop miniaturized electronic implants for large-scale, high-density brain mapping. Advances in micro/nanotechnologies have made it possible to construct electrode arrays of up to 1600 parallel recording sites for spatially resolved, high-density electrophysiology (EPhys) recording of neural activity. However, the development of electronic implants for high-density detection of neurochemicals has lagged behind and there remains room for improvement in target selectivity, background signal and noise, and bio-fouling over time. Existing neural implants suffer from poor long-term stability and cross-talk, due to long-standing challenges such as material biocompatibility, hermetic packaging, and the physical dimensions of the devices.

To meet this critical need, Fraunhofer USA CCD has teamed with its University Partner, Michigan State University, along with the University of North Carolina Chapel Hill and the University of Wisconsin, to develop a complete, diamond-based neural implant system that provides a unique combination of analytical sensitivity, long-term stability, and scalability. Funded by the National Institutes of Health (NIH) the team, led by Professor Wen Li of Michigan State University, will work closely together to enhance the all-diamond microfiber technology from single fiber to multi fiber, multi recording 2D and 3D sensing arrays.

Additional funding to advance the technology was received from the Michigan State University Foundation through its Strategic Partnership Grants (SPG) Program. The SPG project, led by Professor Erin Purcell of Michigan State University, will focus on Parkinson's disease and expand the Center's collaboration to the College of Medicine within Michigan State University.

The new system will enable high-resolution spatiotemporal probing of EPhys and neurochemical signals of neuronal circuits in both neuroscience research and clinical applications. The impact of the developed diamond electrode technology will help overcome major challenges associated with the long-term stability, invasiveness, and the scalability of technology for brain mapping, which are not adequately or simultaneously addressed by existing carbon, silicon, and polymer electrode techniques. The contribution to the neuroscience community is both substantial and far-reaching in providing a technologically-advanced, multi-modal neural interface tool for effective and stable EPhys and chemical sensing of neuronal circuits.

1 © *Fraunhofer USA, 2D Comb array*

2 © *Fraunhofer USA, 3D Fiber array*

1

Low Cost Neonatal Incubator

Providing a safe, warm environment in the earliest moments of a newborn's life is critical. Infants have a difficult time regulating their temperature due to their small thermal mass and large surface area. Maintaining the right temperature is especially exacerbated for premature babies. Neonatal incubators tightly control both the temperature and humidity provided and can prevent hypothermia and asphyxia for infants in intensive care. Additionally, these incubators create a protective environment against infectious pathogens. Unfortunately, this cost of care is extreme. NICU incubator costs in US hospitals can rise to $3,000 USD each day creating heavy burdens on both families and health care systems. The cost of care can also make these incubators prohibitively expensive in many communities. A robust, low-cost infant incubator is desperately needed.

Breegi Scientific has created a Neonatal Intensive Care Incubator (NICI) that provides the functionality of traditional incubators for under $5 USD/day. Importantly, the NICI incorporates a suite of technologies that also allows it to be deployed in low resource settings. Breegi Scientific had previously designed and built an innovative lightweight infant housing unit portion of the NICI and a prototype for the heat and humidity unit. To reduce manufacturing and user costs while providing the heat, humidity, and HEPA ventilation required, the team at Breegi turned to the Fraunhofer USA Center for Manufacturing Innovation CMI.

The engineers at Fraunhofer USA CMI created a heat and humidity unit comprised of a HEPA filter, fan, heating unit, and ultrasonic humidifier. Clean, filtered air is mixed with recirculated air from the infant enclosure tent, is passed through the heating unit, and is humidified before exiting into the tent. The team began by running simulations, optimizing the parameters of the heat and humidity unit to provide the ideal environment. Armed with this knowledge, the team was able to quickly design and build the heating unit. This unit can regulate the temperature inside the tent structure up to 37°C +/- 0.5C° across 30-minute intervals. Temperature sensors inside the tent deliver feedback in a closed loop format. The ultrasonic humidifier provides relative humidity levels determined by the user. Importantly, the components selected provide a volumetric flow rate of 3 CFM with noise levels <45 dB. Noise levels are a frequently overlooked feature of traditional neonatal incubators. Auditory systems are the latest neurons to mature and a newborn's exposure to excessive noise during this period has noticeable impacts on the developing auditory system.

The successful development of the heat and humidity unit will allow the Breegi team to reach the next steps of clinical testing and deployment. The recent completion of the project at Fraunhofer USA CMI was not a moment too soon. This incubator also provides a regulated environment that can isolate a pa-tient's head and upper chest in COVID-19 units. The Breegi team is also currently expanding on this use case.

© Fraunhofer USA, Low-Cost Neonatal Incubator

1 *© Fraunhofer USA CMI created heat and humidity unit comprised of a HEPA filter, fan, heating unit, and ultrasonic humidifier*

PRODUCTION AND SERVICES

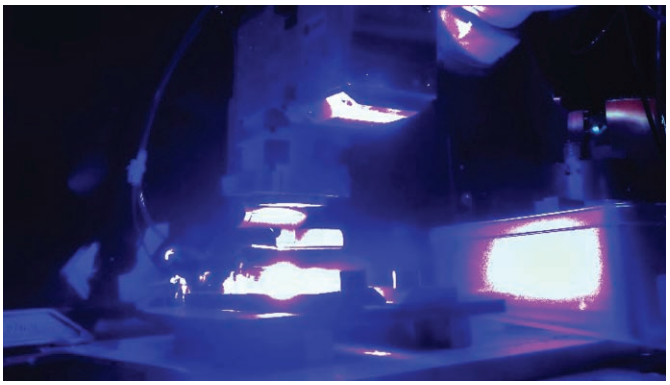
Blue and IR Wavelength Laser Welding of Copper

Increased demand for Electric Vehicles (EV) is leading to rapid development of novel joining processes for electrical connections needed in the automotive industry. Moreover, demand for performance and reliability has led to increasingly complex battery assemblies. Energy is typically transported from the individual cells of the battery pack via bus bars made of copper or aluminum in a traditional anode-cathode configuration. Connection at the interface between the bus bar and the individual cells needs to be fast, robust and reliable and have minimum Ohmic losses. Laser Beam Welding (LBW) is an ideal process to create the connection between battery cells since it can make high volumes of repeatable low-heat input welds. The laser weld process can be completed without exposing the volatile lithium-based chemicals inside cells to the potentially hazardous high heat input associated with traditional arc or resistance-based welding processes.

Laser beam sources currently used in industry are typically Nd or Yb YAG lasers (e.g. disk or fiber) that operate in the infrared (IR) range of the electromagnetic spectrum. However, copper has very low absorption rate in this range (<5%). Thus, LBW of copper using these sources require multi-kilowatt power sources with high-beam quality and very small spot sizes and pose the risk of damage to the optics and the sources themselves due to the high reflectivity of the metal.

Fraunhofer USA Center for Laser Applications CLA has recently acquired a novel next generation 1.5kW Blue laser source from Laserline GmbH which is the first of its kind in the US. Experiments were conducted with new beam sources operating the shorter wavelength "blue" region (450 nm wavelength) of the electromagnetic spectrum where copper has a higher absorption rate (~45%). Experiments were also conducted with a Blue+IR Hybrid setup and with single-mode IR sources with high beam quality and energy density in a small spot.

LBW of copper with a state-of-the-art blue laser yields excellent weld quality with minimum porosity due to the high absorption and therefore better stability of the process. Good welds were achieved with up to approximately 0.8mm penetration depth which makes this laser suitable for thin sheet electrical connections for electrical components.



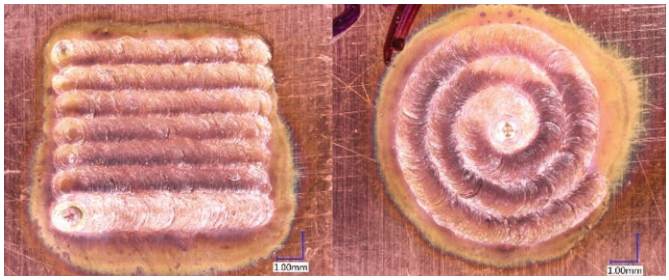
© Fraunhofer USA Center for Laser Applications CLA, Laser beam welding of copper using new Blue laser source

For deeper penetration and higher weld speeds, experiments were conducted with a hybrid setup using the same blue laser source in conjunction with an IR source. Weld quality achieved was superior with reduced porosity and better surface quality compared to conventional IR laser welding.

Experiments conducted with new single-mode IR sources and scanner systems open the possibilities for LBW of copper with much smaller beam focus for high precision welding applications. This is particularly attractive for welds in complicated battery assemblies and precision electronic components.

CLA employed a state-of-the-art K-LAB Scout Vision system for manipulating the (SPI/TRUMPF) single-mode laser. This system allows a 200 x 200 mm vision window. The system can be trained to identify the weld joint and align the beam to that area automatically. The system can also offer a myriad of weld geometries, which can be crucial for increasing cross-sectional areas at the weld interface between the bus bar and the cell to reduce Ohmic Losses and improve conductivity.

Fraunhofer USA Center for Laser Applications CLA has taken up the challenge to break through the barriers of LBW of copper by employing an array of different techniques and state-of-the-art systems and have already achieved good industry standard results. Going forward, further research possibilities are already set into motion to investigate processing of copper using novel new green (TRUMPF) laser sources as well as continuing to work with Blue and single mode IR lasers as that technology continues to improve also. Many successful prototype battery modules have been welded and provided to our automotive industry customers for vehicle testing.



© Fraunhofer USA, Examples of weld patterns generated using K-Lab Scout Vision System and single-mode IR laser

MOBILITY AND TRANSPORT

Building Operational Efficiency at the Bicycle Corporation of America

Resource-starved small and medium sized enterprises (SMEs) in the manufacturing sector are often placed at a competitive disadvantage, unable to afford the latest technological tools that their larger competitors are able to adopt to optimize production. To address this, Fraunhofer USA Center for Experimental Software Engineering CESE has joined with researchers at Clemson University and Francis Marion University during two rounds of research to assist a South Carolina-based bicycle manufacturer refine and optimize assembly operations through the introduction of software-enabling technologies and process improvements.

Based in Manning, South Carolina, the Bicycle Corporation of America (BCA) produces over 500,000 bikes annually and distributed through big box store outlets, including Walmart. In 2013, BCA parent organization, Kent International, set up the BCA manufacturing plant in Manning, SC inspired by Walmart's "Made in America" commitment to bring more US-made goods back to its shelves. Reductions in production costs and increases in production speed were required to make this new venture a cost-effective and practical investment. Additionally, BCA sought to produce new lines of bicycles and bike parts that were previously only available from foreign suppliers. The 100-person BCA workforce as well as hundreds more indirectly supported across the country in parts manufacture, freight, warehousing and retail operations rely on the success of the company's plans for increased efficiencies.

Though BCA has steadily increased production volume and expanded its product line offerings, beating foreign manufacturers at their own game requires a continuous review of operational efficiency, worker productivity and build quality. With financial support from the South Carolina Department of Commerce and the South Carolina Fraunhofer Alliance program, the SCFA assembled a team to examine BCA operations and suggest approaches to boost production volume and quality.

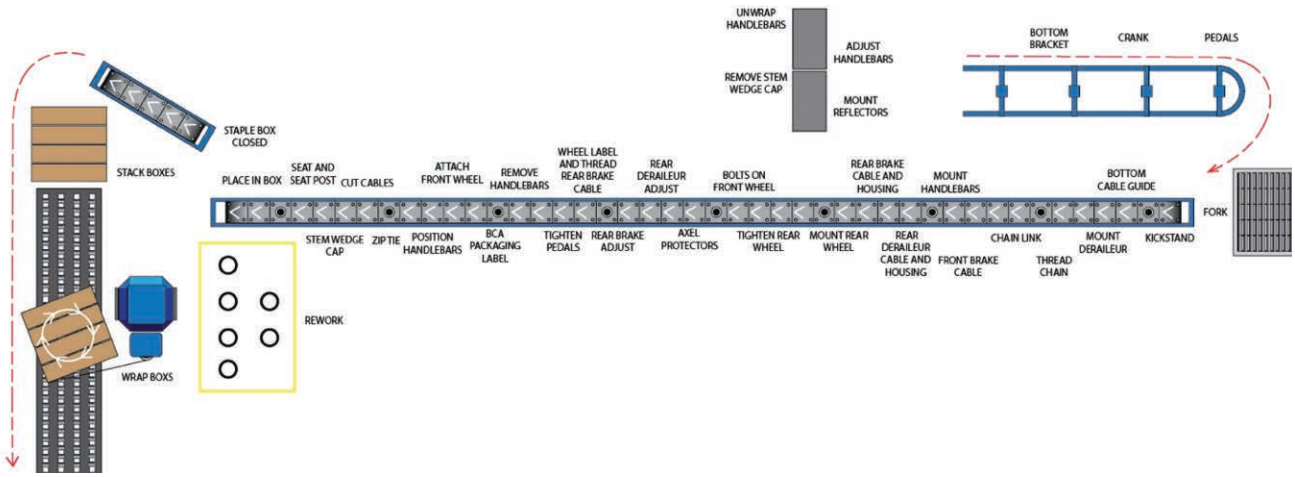
Fraunhofer USA CESE, in partnership with Clemson and Francis Marion, is developing a software platform to streamline BCA assembly operations allowing for rapid detection of defects on the assembly line. "Large industrial manufacturers are often the target audience for research because of the industries in which they reside and the impact they have. SMEs are a significant percentage of the SC economy and have unique challenges." says Dr. Gregory Mocko, an associate professor at Clemson University. "I participated [in] this project because I see the need of SMEs with limited resources to adopt technology that will have an impact, and there are many opportunities to systematically introduce [new] technologies."

The overarching goal is to reduce bike production time while increasing build quality in a flexible production environment. "There are software packages available to help build efficiency but at a huge cost and requiring ongoing vendor support....our objective is to deliver a system specifically designed for the small manufacturers to incorporate," says Sandra Ösp Stefánsdóttir, a Fraunhofer USA CESE research scientist assigned to the project. Working with BCA senior and line management, and through interviews with team members on the shop floor, the team identified multiple areas where BCA faced challenges, including streamlining production, detecting defects in the manufacturing line and overall production speed.

For example, in the past, BCA manually tracked assembly line defects on paper. The defect data was then typed into an Excel spreadsheet at the end of the day. The new system architecture provides automated real time defect tracking with the ability to pinpoint where and why the defects occurred. When a defective bicycle is detected, the assembly worker removes the bike from the assembly line and moves it to the rework station section where the defect type is recorded, its cause and reparability. The system allows the quality manager to visualize and analyze the defects in real time, intervene and initiate improvements as well as spot trends in assembly dynamics. The system is a great help as it provides the quality manager an idea of whether the defect is caused by defective parts, operational issues or if a worker may require additional training.

Dr. Rahul S. Renu, an assistant professor at Francis Marion University, said; "Data provides tremendous insight into manufacturing operations, and can propel an industry towards becoming highly efficient. Capturing and processing large volumes and varieties of manufacturing data requires a strong, robust platform."

Mikael Lindvall, Technology Directory at Fraunhofer USA CESE comments on the project's applicability to other manufacturers: "When showing the defect management system that was developed for BCA to other manufacturers, it turned out that they have similar needs as BCA. Inspired by this feedback, we are developing a generic defect management system that will fit a wide range of companies in South Carolina and elsewhere."



© Fraunhofer USA, The BCA Project Team analyzed bike assembly workflow, pinpointed inefficiencies and built the architecture and cloud-based platform for manufacturing knowledge capture

ENERGY AND MATERIALS

Using Communicating Thermostats to Remotely Evaluate Home Enclosure Performance

Space heating and cooling account for over 40% of US residential primary energy consumption [DOE/EIA 2018], and many residential single-family homes are poorly insulated or leaky. Whereas wall and attic insulation and air-sealing retrofits of existing homes can signifi-cantly reduce the pri-mary energy consumption, only a very small fraction of US homes have completed these retrofits [Goldstein et al., 2014].

Delivery of such major retrofits as insulation and air sealing often occurs through utility – and/or state-sponsored energy efficiency (EE) programs, and follows a multi-step process that is costly and challenging to scale. Initial customer outreach typ-ically occurs through energy bill mailers, mass media and online advertising, and usually lacks information about prospective home-specific energy savings opportunities, expected energy savings, and cost-effectiveness. An onsite home-energy assess-ment (HEA) is required to evaluate these factors, but they can be inconvenient to homeowners, expensive (~$250-500), and of variable accuracy. Ultimately, only about 35% of homeowners decide to implement a major retrofit after the HEA [Zeifman, Lazrak and Roth, 2018 and 2020]. Moreover, the onset of the COVID-19 crisis has brought in-person HEAs to a halt in much of the US. Thus, there is appreciable value to remotely identifying, characterizing, and prioritizing homes with the largest retrofit savings opportunities using data available to EE programs.

Fraunhofer USA CMI worked with the two largest utilities in New England, Eversource and National Grid, on a project funded by the US Department of Energy's Building America Program to develop algorithms that analyze data from communicating ther-mostats (CTs) to identify homes with significant insulation and air-sealing retrofit opportunities. CTs have become increasingly common in US homes, and collect data that provide insights into heating system (typically a furnace or boiler) operations and building thermal responses that, in turn, reflect building physical parameters corresponding to insulation and air-sealing retrofit opportunities, i.e., R-value[1] and ACH50[2], respectively. Moreover, many utilities provide EE incentives for purchasing CTs and, as a condition for providing the incentive, some obtain access to the CT data. [Zeifman, Lazrak and Roth, 2020].

Our tool utilizes a physics-based model (extended second-order grey-box model) to automatically analyze the CT data along with additional data available to utilities (floorspace, number of stories,

1 *We present R-values in US units, i.e., oF- ft2-hour / Btu; to convert to SI units (oK·m2/W) divide by 5.68*

2 *ACH50 = air changes per hour at 50Pa of pressure difference*

and monthly gas bills) and estimate the whole-home R-value, ACH50 and the corresponding prospective savings from insulation upgrades or air sealing. We successfully validated this tool by comparing the tool estimates of the overall R-values, ACH50 and prospective savings with values from HEAs for about two hundred Massachusetts homes. As shown in Figures 1 and 2, the tool characterizing homes as having a significant insulation or air-sealing retrofit opportunity or not, with an accuracy of about 90 percent. The tool appears to perform equally well for homes heating with boilers or furnaces, and for homes with one or two CTs.

Ultimately, the value of the algorithms depends on their ability to provide customized retrofit recommendations and savings potentials to market energy efficiency (EE) to individual customer and increase EE program participation. Thus, the team conducted a randomized controlled trial (RCT) pilot where a portion of customers that the algorithm identified as having a significant retrofit opportunity received customized outreach, including identification of specific retrofit opportunities and their expected energy savings. After half a year, we compared the HEA uptake of the treatment group with that of a control group that received generic messaging. Initial findings suggest that the customized outreach increases HEA uptake by a factor of 2 to 4, and Fraunhofer USA is discussing potential ways to scale up application of the algorithms with its utility partners to help them meet their very aggressive energy efficiency goals.

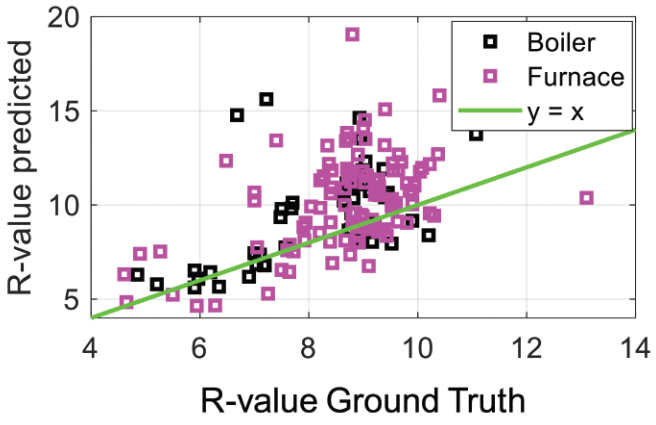


Figure 1: Fraunhofer USA algorithms achieved an 89% whole-home classification accuracy (R-value >8, ≤8) relative to home-energy assessments

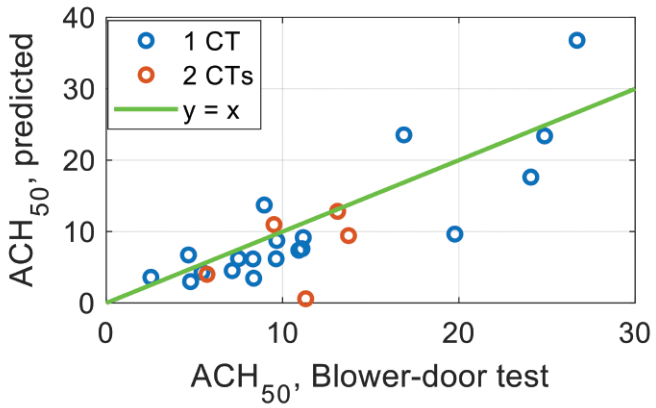


Figure 2: The algorithms classified ACH50 (>15, ≤15) with 96 percent accuracy relative to onsite blower-door tests

AI Growth State Prediction of Single Crystalline Diamond Wafers

While single crystalline diamond (SCD) would be an almost perfect semiconductor material for high-power, high-frequency and high-temperature electronics, its limitation in wafer size is handicapping any meaningful implementations outside of highly specialized applications. To this day no SCD wafers suitable for electronics fabrication have been demonstrated. Traditional wafer enlargement methods for SCD would require R&D efforts in the range of 20 years; timelines similar to those experienced in Silicon Carbide while consuming tens of billions of dollars in R&D investment. Thus, it is crucial to develop novel approaches to bypass those huge R&D financial and time costs.

Fraunhofer USA Center for Coatings and Diamond Technologies CCD and Fraunhofer USA Center for Experimental Software Engineering CESE partnered to explore the possibility of using Deep Learning (AI) techniques to classify in-situ recorded images of SCD crystals while they are being grown in their respective Chemical Vapor Deposition (CVD) reactor.

The proposed deep learning AI implementation pipeline encompasses two broad areas of work.

1) Development of image segmentation (feature extraction) models to isolate and classify accurate pixel masks of the SCD top surface, the pocket holder area and background.

2) Development of accurate models of micron-scale growth in SCD using reactor input parameters across sequential time states in order to accurately predict future states (images) comprising SCD/pocket-holder shapes. Throughout preliminary research, Fraunhofer USA CCD and Fraunhofer USA CESE partnered with Michigan State University and Air Force Research Laboratory to explore whether it is feasible to include in-situ thermal images of the SCD into the growth state prediction.

Within the Phase I project, Fraunhofer USA CCD and Fraunhofer USA CESE were able to successfully establish proof-of-concept AI models capable of identifying macro-features of SCD in the optical image and accurately predicting SCD growth states up to six hours into the future. Current feature extraction or image segmentation models developed achieved mean pixel identification accuracies above 99.5%. The SCD growth state prediction model developed advances in state-of-the-art output optical frame prediction using non-homogenous time series data comprising high resolution images and reactor parameters; predicting accurate images of the future reactor state with a 99.99989% accuracy using per-pixel loss on unseen validation data. Not only was the final shape of the SCD reasonably predicted, but polycrystalline material was also predicted to grow on the edge of the pocket holder the SCD rests in. This secondary result is highly significant as polycrystalline material strongly impacts the final shape and size of SCD due to how its growth changes the environment. This will serve as a powerful tool increase the yield of SCD growths and to accelerate R&D process on SCD area enlargement techniques.

Those encouraging results led to a provisional patent [1]. Additional internal funding is being used to stress-test and refine the respectable algorithms using larger datasets and variation amongst reactor and process parameters to validate the AI prediction sequence. The long-term goal of the project will be to integrate the AI prediction into the reactor control software for AI-controlled SCD growth based on desired crystal growth outputs.

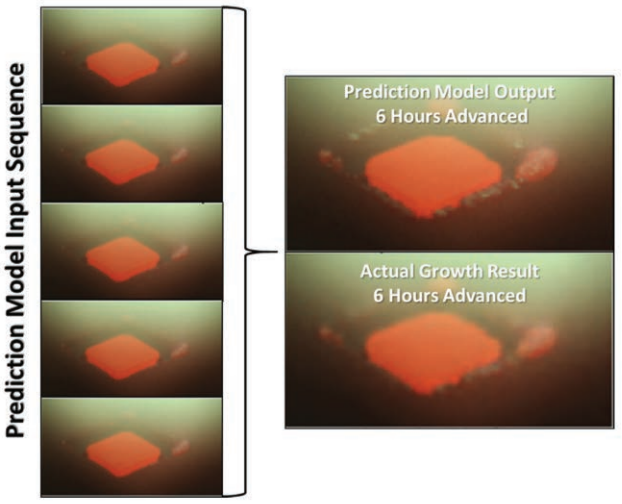


Figure 1: AI prediction of diamond shape (macro-feature) ~6 hours into the future. From the prediction model inputs (5 input images + numerical reactor variables of temperature, pressure, etc.) [above left image] the AI generated an output image [top right] which closely matches the actual growth image 6 hours into the future [bottom right]

References

[1] Rohan Reddy Mekala, Matthias Muehle, Adam Porter, Mikael Lindvall and Michael Becker: "Artificial intelligence based algorithms for prediction of diamond crystal growth" U.S. Provisional Pat. App. No. 63029177, filed 22nd May, 2020

Advancing Automated Fiber Placement Technology

Fraunhofer USA CESE scientists, in collaboration with the University of South Carolina's (UofSC) McNair Aerospace Center, Clemson University's Composite Center, and private industry partners are pushing the state of the art in advanced manufacturing. The Advanced Fiber Placement (AFP) project will integrate AI into commercial tools to greatly improve the quality and cost of manufacturing using lightweight composites. At its completion, the project will deliver an advanced composite manufacturing capability stationed at UofSC and used by industry project partners Ingersoll Machine Tools and Heraeus. This will allow these companies to demonstrate their capabilities to their customer base and offer prototyping and product development services to the aerospace industry in South Carolina and beyond. The facility is expected to position the project partners in the Thermoplastics Advanced Fiber Placement (AFP) market and increase their market share in composites R&D and production.

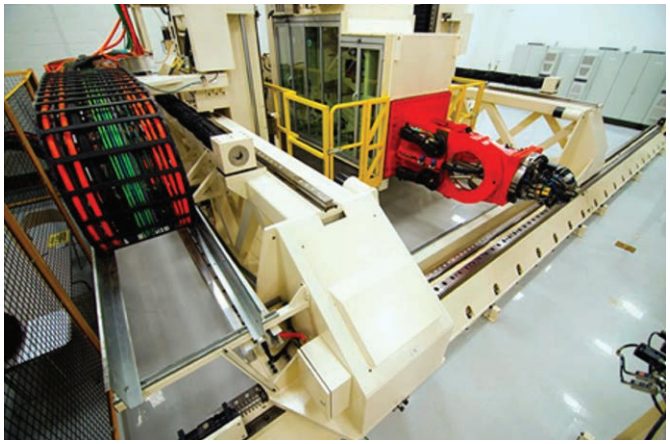
The AFP project will develop a framework for digital transformation of the manufacturing process. This framework harnesses existing process parameters and sensor outputs from the legacy control system to be used within prediction models. The models are then used to improve the layup quality of advanced materials. Other elements of the digital transformation framework will include virtual reality (VR) and augmented reality (AR) training, dashboards, and digital twins. The digital twin provides three-dimensional, real time visualization of a manufacturing process, defect prediction and prevention, and system analysis.

The project leverages the expertise of Fraunhofer USA CESE's artificial intelligence and machine learning experts, researchers in composite manufacturing and digital transformation at UofSC and Clemson University with industry partners for the purpose of developing solutions to complex manufacturing problems.

UofSC and Clemson University researchers have led the development of the physical and digital transformation frameworks with Fraunhofer USA CESE applying machine learning techniques in order to rapidly analyze advanced materials for the purpose of optimizing layup parameters. The system anticipates machine operating parameters, material properties, heater parameters, environmental factors and inspection data. Through training via an advanced machine learning system designed by Fraunhofer USA CESE, key parameters can be determined for defect prediction and prevention in fiber layup. This robust system can be used to increase the functionality of many control system types and generations and allows for the digital transformation of legacy systems greatly increasing the value of existing equipment within manufacturing plants. This framework will lay the foundation for perpetual continuous development and improvement of composite manufacturing systems.

This multi-Institute, interdisciplinary team project is funded by the South Carolina Department of Commerce through the South Carolina Fraunhofer USA Alliance program

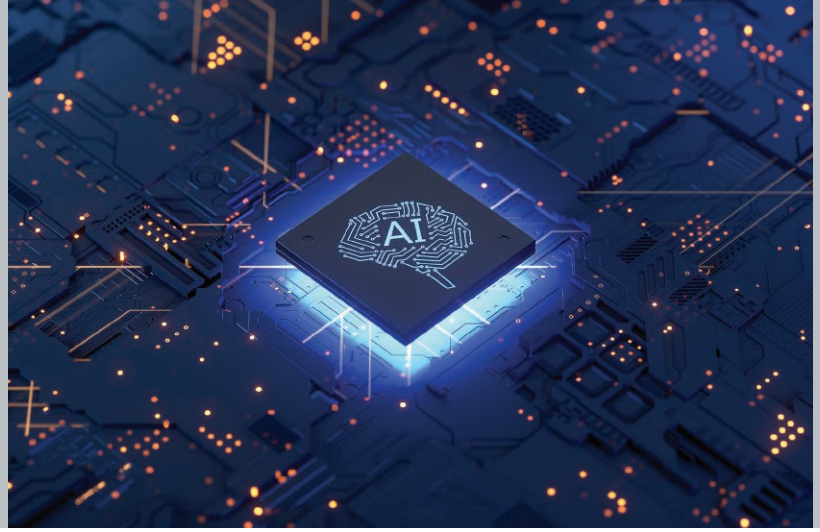
The project is divided into two tracks, the first focuses on the physical system and the second focuses on the digital system. The team plans to complete the project by the end of February 2021. Currently, all tasks are on track to meet this deadline.



AFP Project researchers are using the Ingersoll LYNX Automated Fiber Placement Machine housed at the University of South Carolina's McNair Center as the testbed

FRAUNHOFER USA CENTERS

FRAUNHOFER USA CENTER MID-ATLANTIC CMA



The current Fraunhofer USA Center for Experimental Software Engineering CESE and the Fraunhofer USA Center for Molecular Biotechnology CMB will merge their operations under one new Fraunhofer USA Center Mid-Atlantic CMA ("Fraunhofer USA CMA") effective January 1st, 2021.

The Center will consist of two divisions, a Software and Systems Engineering Division located in Maryland, and a Biotechnology Division located in Delaware. The divisions each have independent technology portfolios, but are also capable of combining expertise to the best advantage for the customer, for example in the area of bioinformatics.

The Fraunhofer USA CMA partners closely with the University of Maryland and the University of Delaware.

The Software and Systems Engineering Division Core Competencies

The Center conducts applied research to support the software-enabled innovations created by its customers in industry, government, and academia. The division develops and uses advanced, effective, and scalable approaches to software and systems engineering, delivers powerful testing and verification strategies and tools, and uses state-of-the- art measurement and analysis methods to support its customers' challenges.

Working closely with customers in the aerospace and medical industries, government agencies, research organizations, and universities; The Software and Systems Engineering division evaluates, develops, and utilizes cutting-edge tools and technologies to support customer decision-making and implementation in systems, software, and acquisition areas. The team provides critical skills and guidance that allows its customers to ensure the viability and reliability of their systems and software and enables them to identify and prevent security-related vulnerabilities. In addition to applied research, the division also conducts innovative basic research projects under research grants funded by the government and other research institutions.

Model-Based Development and Testing

- Use analysis tools to automatically extract and visualize software architecture in source code
- Evaluate software architecture to locate policy deviations
- Create software architecture design models to generate test cases, analyze test results, and conduct code inspections
- Reverse-engineer models of code and system traces to identify inefficiencies and liabilities
- Perform architecture-driven verification and validation, analyze systems for architectural risk, and test behaviors of software
- Define and evaluate strategies for automated verification and validation and identify mechanisms that capture and check requirements
- Deploy tools and train personnel on automated testing and verification methodologies, best practices, and secure programming principles

Software Safety and Security Analysis

- Analyze algorithms and architecture to measure impact of upgrading and optimizing systems
- Apply formal modeling methods to evaluate system security and safety
- Evaluate open-source components for integration with commercial systems, with a focus on risk and benefit analyses
- Model reliability data to predict fault-prone binaries in development
- Create risk and safety measurement and management programs to gain insight into safety, security, and reliability
- Quantify software safety risk by analyzing development artifacts
- Collaborate with customers to develop training materials that specify causes and remediation of weak security policies.

Rapid Prototyping of Mobile and Web Applications

- Design and facilitate user focus groups and empirical experiments to validate customer innovations

- Conduct technology evaluations in cloud, mobile, and other emerging platforms and suggest solutions based upon discovery
- Provide project management support including agile and scrum methodologies – to mitigate risk, manage cost and schedule, and ensure delivery
- Evaluate and create software engineering approaches and tools to improve software development productivity

Software Engineering Analytics

- Assess software processes and artifacts to ensure sound design and architecture, use of best practices, and regulatory compliance
- Apply best practices (e.g., CMMI, scrum) to systems acquisition and development
- Build process performance baselines and models to manage development projects
- Implement tools and processes for data collection, analysis, and reporting on products and processes
- Oversee design and development to mitigate risks related to requirements creep, software growth, and schedule changes

Cybersecurity and Embedded Systems

- Model-based automated penetration testing and vulnerability analysis of hardware and software systems
- Compliance testing of security standards and standard practices for embedded safety systems
- Offensive and defensive penetration testing for medical, automotive, industrial control, and wireless network infrastructure systems
- Hardware, software, and communications protocol reverse engineering for command and control systems
- Integration of cybersecurity practices and technologies for industrial process control and manufacturing systems
- Conventional and model-based secure system design and security requirements engineering
- Cybersecurity awareness, training, education, and workforce development

Digital Transformation

- Offer a service suite of Industry 4.0 technologies, methods that move industry's products and processes from independent, disconnected platforms to "smart" interoperable, synchronized and connected platforms
- Assist industry to develop "data as a service" and as an added revenue stream using unique techniques for data capture from existing products, analysis, visualization and interpretation providing added value offerings to the client
- Enable smart, in situ processes for predictive diagnostics to monitor real-time machine performance and maintenance
- Employ Digital Twin Test Bed methods that allows clients to manipulate, test and evaluate a virtual, cyber-physical model of a product, process or platform before moving into production, reducing risk prior to physical production.
- Assessment of threat surfaces created through wireless control entry points and building defensive systems to secure process controls

Project Measurement and Analytics

Fraunhofer USA CESE offers experienced project management expertise in the startup, deployment and management of complex, critical systems, including:

- Risk assessment
- Regulatory compliance
- Project management consulting
- Strategy innovation
- Technology and capability evaluation
- Process assessment

Data Protection Policy Effectiveness

- Craft data protection and privacy policies to satisfy corporate and regulatory needs
- Analyze data protection processes for effectiveness and improvement
- Create executive-level dashboards on data protection effectiveness across the enterprise
- Identify data protection policy gaps and recommend process improvements

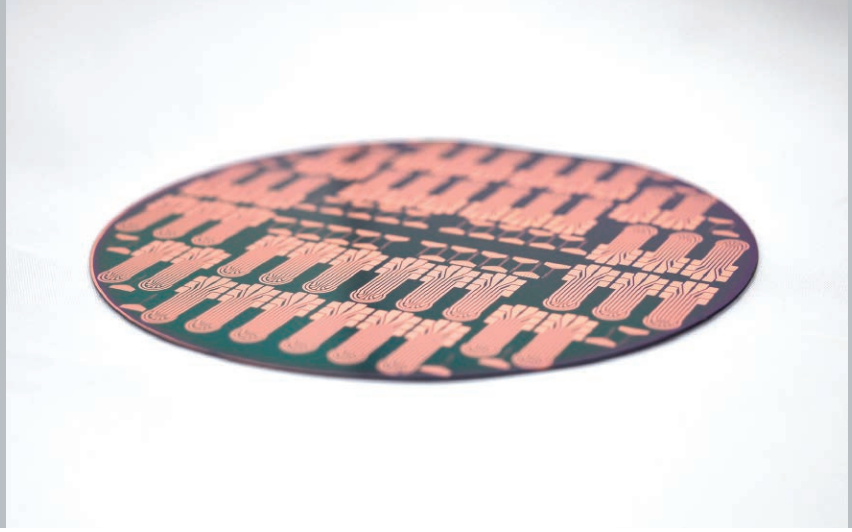
Biotechnology Division Core Competencies

The Biotechnology Division has expertise and experience in biotechnology, primarily, though not exclusively, emphasizing human health applications. The Center has engineered novel molecular designs for vaccine candidates and developed expression platforms for the production of recombinant proteins, including vaccine antigens, antibodies and other therapeutic and diagnostic molecules. Fraunhofer USA CMA has progressed lead vaccine and therapeutic targets into clinical trials, working extensively with US Government, not-for-profit and industry partners. The Center has also developed formulations of some of these vaccine targets with improved stability, immunogenicity and efficacy. In addition, the Center has developed metabolically engineered cell culture systems for the production of secondary metabolites and optimized hydroponic growth systems for plant biomass production. Furthermore, the Center has generated an extensive microbial library, in part using quorum quenching technology to isolate previously uncultured microbes. This library has been screened for strains producing molecules with novel activities, including new antibiotics. Such lead molecules have progressed into preclinical development and their structures have been determined.

Scientific staff within the Biotechnology Division have expertise in molecular biology, protein biochemistry, immunology, virology, microbiology and plant biology. In addition to research laboratories, the Center houses a pilot plant facility with GMP production capability and associated quality control and quality assurance functions. Staff in the division also have experience in managing large research programs and guiding lead targets through preclinical development and early phase clinical trials including preparing documentation for IND submissions.

The Biotechnology Division is focused on working with partners and clients to solve problems and overcome roadblocks on the path to developing novel technologies in the bio space and progressing target molecules to the clinic and market. Scientists at the Center are particularly experienced in engineering molecules and pathways, developing assays, formulating lead targets for improved stability and efficacy, scaling processes and producing and releasing material under GMP.

© Fraunhofer USA, Scaling fermentation processes in R&D prior to progressing to pilot scale manufacturing



The current Fraunhofer USA Center for Coatings and Diamond Technologies CCD and the Fraunhofer USA Center for Laser Applications CLA will merge their operations under one new Fraunhofer USA Center Midwest CMW ("Fraunhofer USA CMW") effective January 1st, 2021.

The Center will consist of two divisions, the Coatings and Diamond Technologies Division located in East Lansing, Michigan and the Laser Applications Division located in Plymouth, Michigan. The divisions each have independent technology portfolios, but are also capable of combining expertise to the best advantage of the customer, for example, in the area of dissimilar materials attachment.

Coatings and Diamond Technologies Division Core Competencies

The Coatings and Diamond Technologies Division performs applied research and development contracts with industry and government organizations. Customers include companies from industry sectors such as manufacturing, semiconductor, biomedical and energy. Fraunhofer USA CMW is a confident and reliable partner providing proprietary and competitive R&D services based on core competences in diamond and coating technologies. The Coatings and Diamond Technologies Division's quality management system is certified according to the standard ISO 9001.

Our customers know that maintaining a leadership position in today's competitive business environment requires ever more rapid innovation cycles and sustainable manufacturing solutions. Fraunhofer aims at accelerating innovation for its customers by driving technologies faster along the technology-readiness-level chain from basic research toward commercialization. Fraunhofer USA CMW connects with world-class basic research through its close partnership with Michigan State University in East Lansing, Michigan. The Coatings and Diamond Technologies Division shares 20,000 square feet of laboratory and office space and is fully integrated with the College of Engineering with access to faculty, students and additional research facilities.

The Fraunhofer USA Center Midwest CMW works closely with its customers to determine specific project objectives and requirements. Prior to commencing work, every project is structured with mutually agreed upon deliverables, schedules, milestones and costs. Fraunhofer USA CMW's customers are provided with access to the extensive laboratory and engineering resources. Project results are treated with strict confidentiality. Fraunhofer USA CMW recognizes the need to protect intellectual property rights for its customers; and staff work with customers to negotiate mutually acceptable terms and conditions so that the developed solutions can be readily deployed.

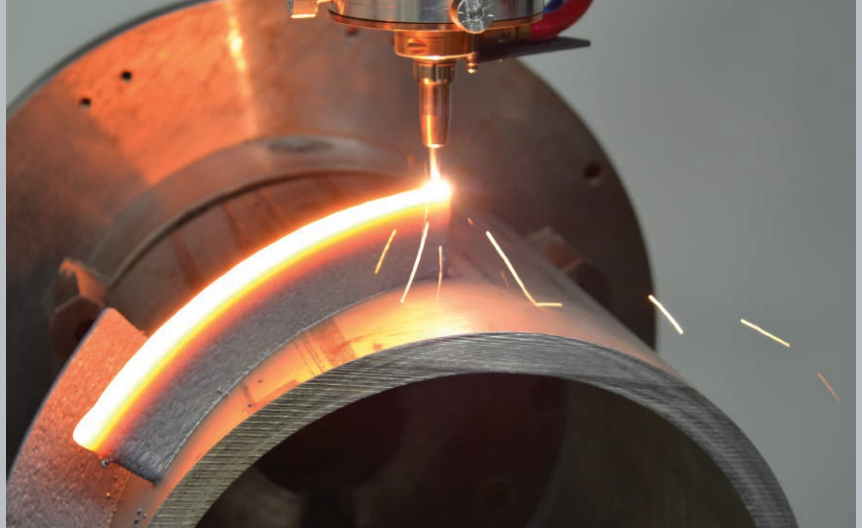
Core Competence: Coating Technologies at Fraunhofer USA

Fraunhoder USA CMW surface coatings are an enabling technology across industrial sectors. Surfaces of parts, devices, components and tools need to be engineered so that they can perfectly function in the environment of a specific application. By providing engineered surface properties, coatings enable high performance applications that would otherwise only be possible with expensive bulk materials. Such functionalities include, for example, improved wear and corrosion resistance, reduced friction, biocompatibility or, in some cases, simply a specific appearance. Fraunhofer USA CMW's coating technologies focus on applications of physical and chemical vapor deposition (PVD and CVD coatings) process and systems technologies and materials knowhow. The Center works with its customer to identify and develop the best coating solutions for their applications and supports them to deploy the developed processes and materials in manufacturing.

Core Competence: Diamond Technologies at Fraunhofer USA

Diamond is a crystalline allotrope of carbon and the material with the highest atomic density found in nature. As such it is an extraordinary material with a unique combination of extreme properties such as highest hardness, highest thermal conductivity and highest dielectric breakdown strength, to name a few.

© Fraunhofer USA, Boron-Doped Diamond Electrode Array for Flexible Electrodes



The field of diamond synthesis and applications is undergoing a spectacular period of transformation as the ability to deposit high-quality monocrystalline diamond materials advances. Fraunhofer USA CMW develops processes and systems to synthesize diamond and to make it accessible to customers for integrating it in applications in optics, electronics and electrochemistry. Diamond is not expensive. In fact, at Fraunhofer USA CMW, the material is synthesized by chemical vapor deposition using a process very much like depositing coatings from other materials. It is used by our customers in the form of coatings such as poly- and nanocrystalline diamond fields or a poly- or monocrystalline bulk material.

Core Competence: Laser Applications Division at Fraunhofer USA CMW

The Fraunhofer USA CMW Laser Applications Division has been operating in the US for over 20 years developing and commercializing laser applications and technology. The Laser Applications Division's state-of-the-art Plymouth, Michigan facility conducts contract research and development in the field of laser materials processing.

With extensive experience and expertise in laser applications development for processes such as welding, cutting, and additive manufacturing, Fraunhofer USA CMW is your ideal partner for laser applications development. Fraunhofer USA CMW's state-of-the-art laser application facility features the latest and greatest in laser technology with a wide range of lasers from 1 watt to 16 kilowatt output power.

Laser Cladding and Additive Manufacturing

- Additive manufacturing
- Rapid prototyping
- Coatings for wear and corrosion
- Remanufacturing of worn parts
- ID (internal diameter) cladding
- Induction assisted laser cladding
- Diamond cladding
- Powder and wire fed processing heads
- Process monitoring and control

Laser Welding and Joining

- Laser beam welding
- Remote laser welding
- Laser hybrid welding
- Laser brazing / laser soldering
- Glass welding
- Plastic welding
- Process monitoring and control

Laser Heat Treatment

- Laser hardening and softening
- ID (internal diameter) laser hardening
- Laser assisted forming
- Color marking

Laser Cutting and Drilling

- 5-Axis 3D laser cutting
- Remote laser cutting
- Micromachining/drilling

Industries Served

- Automotive
- Aerospace/space
- Oil and gas
- Power generation
- Agricultural and mining equipment

© Fraunhofer USA, Additive Manufacturing process at Fraunhofer USA CMW

FRAUNHOFER USA CENTER FOR MANUFACTURING INNOVATION CMI

The Fraunhofer USA Center for Manufacturing Innovation CMI performs cutting-edge research and development, tackling the toughest problems for both industry and government agencies. This includes developing custom automation systems, finding innovative and more efficient processes, building biomedical instruments and devices, as well as benchmarking against best practices. Fraunhofer USA CMI bridges the gap between academic research and industrial needs, and leverages both in doing so.

Fraunhofer USA CMI offers
- Custom automation systems
- Biomedical instruments and devices
- Process management and consulting

Custom Automation Systems
Manufacturing automation begins with a thorough understanding of the requirements of the process, followed by a review of available state-of-the-art technologies that may be incorporated. When commercially available technology is not sufficient, Fraunhofer USA CMI develops new custom automation systems, based on the latest emerging academic research, and provides its clients with a turnkey solution.

Fraunhofer USA CMI staff begin by analyzing and, if necessary, modifying the process to make it more conducive to automation. Once the manufacturing process is completely understood, staff begin the design and build process, which is comprised of a number of phases and exit points that mitigate risk for our clients.

Biomedical Instruments and Devices
One of Fraunhofer USA CMI's core strengths is the application of advanced engineering to biological problems. Fraunhofer USA CMI combines multiple engineering and scientific disciplines in tackling such problems, and is trusted by leading pharmaceutical and medical device companies and research collaborators to successfully carry out project goals.

To meet these needs, Fraunhofer USA CMI has over 16,000 square feet of fully equipped laboratories including five CNC machines, which are housed adjacent to its on-site BL1 and BL2 laboratories that are capable of bacterial, viral and mammalian cell culturing. Fraunhofer USA CMI's major activities include developing rapid diagnostics, exploring tissue engineering approaches, producing medical devices and building scientific instruments.

Industries Served
- Aerospace
- Biotech/biomedical
- Consumer products
- Energy
- Fiber optics/photonics

Building Energy Systems
- Test, demonstrate, and evaluate the performance of emerging building technologies in the field
- Develop building performance assessment and control algorithms
- Evaluate the impact of people and behaviors on energy consumption
- Characterize building energy consumption to inform policy decisions
- Assess building technologies to identify high-impact opportunities

Grid Integration (Distributed Energy Resources)
- Field demonstrations and pilots of novel technologies in controlled and "real-world" environments
- Technology assessment and characterization of DER technologies, including analytic assessment, benchtop testing, hardware-in-the-loop evaluation, and field trials
- Systems integration and implementation of reference technology platforms to support development and testing of integrated storage systems
- Development of control, analysis, and monitoring software for controlling and monitoring DERs on embedded, mobile, and cloud-based platforms

Building Energy Systems Research Facilities
- Data Acquisition Lab

Grid Integration Research Facilities
- Energy Storage Integration Lab
- Battery Storage Testbed
- Module Level Power Electronics Testbed
- Field Testing of Storage Integration

© Fraunhofer USA, Fraunhofer USA CMI facilities

FRAUNHOFER USA DIGITAL MEDIA TECHNOLOGIES DMT

Fraunhofer USA also has a Digital Media Technologies Office DMT promoting state-of-the-art audio coding and multimedia real-time system technologies.

Fraunhofer USA Digital Media Technologies DMT promotes and supports the audio and media technologies of Fraunhofer IIS in the US.

When it comes to advanced audio and video technologies for the rapidly evolving media world, the Fraunhofer Institute for Integrated Circuits IIS stands alone. Spanning from the creation of mp3, the co-development of AAC, and building the DCI test plan for the worldwide interchangeability of digital cinema movies, to designing the future of audio and video entertainment, Fraunhofer IIS Audio and Media Technologies division has been an innovator in sound and vision for over 25 years.

Today, audio technologies such as Fraunhofer Cingo® for immersive VR audio, Fraunhofer Symphoria® for automotive 3D audio, AAC-ELD and EVS for telephone calls with CD-like audio quality, xHE-AAC for streaming and digital radio, and the MPEG-H TV Audio System, that allows television viewers to adjust dialogue volume to suit their personal preferences, are among the division's most compelling new developments.

© Fraunhofer IIS, MPEG-H allows viewers to select different audio mixes from a menu or even make their own mix

In the field of moving picture technologies, the latest achievements include easyDCP for the creation and playback of digital cinema packages and master formats, as well as Realception®, a tool for light-field data processing. In addition, Fraunhofer is developing new image coding systems based on JPEG2000 and JPEG XS.

Fraunhofer USA operates two additional programs that work to provide our expertise and technologies to society. These programs help us to accomplish our mission of providing cutting edge technologies to companies and organizations of all sizes. In the following section you will find a FAQ on each program. Please contact us to learn more about how you can participate in these programs.

Fraunhofer USA TechBridge Program

The Fraunhofer TechBridge Program works with corporations and startup companies to identify and de-risk promising technologies to solve industry challenges. By performing targeted technical searches and conducting validation and demonstration work, TechBridge evaluates and prepares innovative early-stage products for investors and industry.

FAQ: The Fraunhofer TechBridge Program:

Promising game-changing technologies often struggle to reach the market due to challenges in meeting the demand from investors, industry partners, and early adopters for industry-relevant testing, demonstration, and third-party validation. The Fraunhofer TechBridge Program leverages Fraunhofer's world-class industry-grade technical expertise and facilities for the development, testing, demonstration, validation, and de-risking of promising new technologies, at no cost to entrepreneurs, successfully bridging the commercialization "valley of death," and making technologies more attractive for private sector investment and uptake.

Moving forward, the TechBridge Program is coordinated by Russ Zarras (rzarras@fraunhofer.org). Russ is Fraunhofer USA's Marketing and Communications Manager.

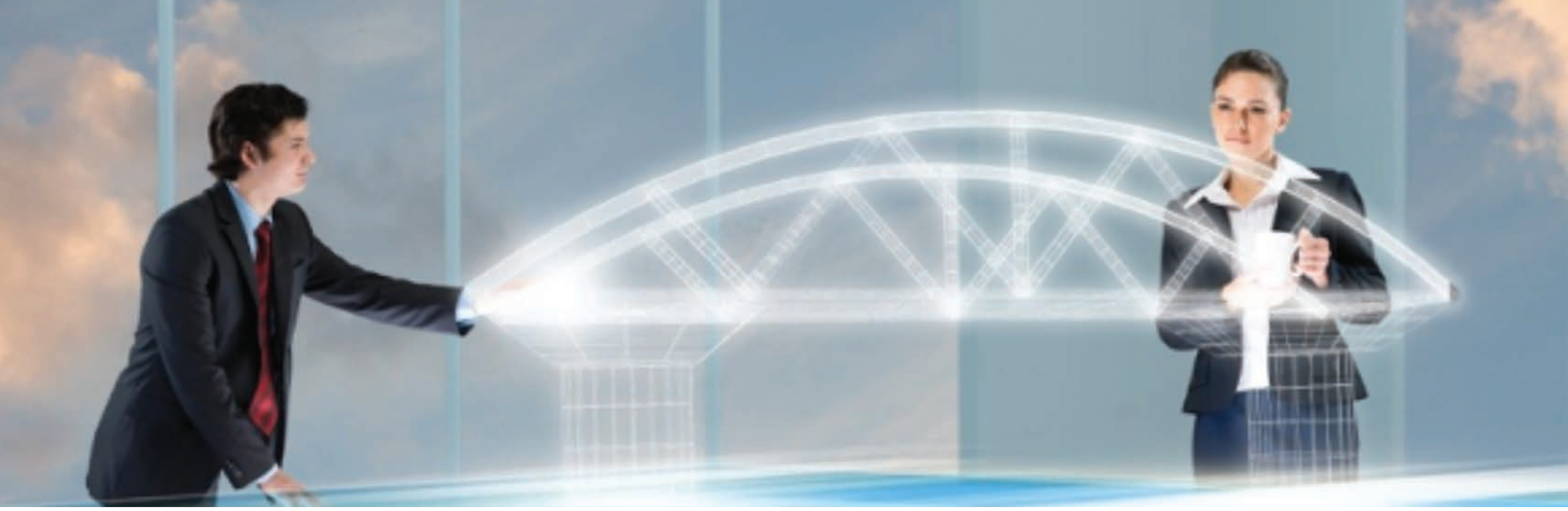
Q: What is the purpose of TechBridge Program?

A: Most early-stage technology developers lack the necessary industry knowledge, resources, and funding to cost effectively meet these requirements, preventing both promising technologies from getting to market and high-potential companies from growing. Often the entrepreneurs with the highest potential for growth are those developing game-changing solutions to significant market challenges, yet those very solutions are the hardest ones for a risk-averse market to adopt.

The core offering of TechBridge is applied, industry-focused projects performed for entrepreneurs by Fraunhofer with the goal to de-risk their novel technologies for the private sector through testing, demonstrating, and validating.

Q: How is the TechBridge Program unique?

A: Fraunhofer is a leading network of industry-focused applied R&D facilities. Through its non-profit R&D Centers around the globe, the organization performs contract research for companies in nearly all industry sectors. Fraunhofer USA, an affiliate of the global organization, has developed the TechBridge Program in order to leverage its global expertise and resources for entrepreneurs developing game-changing early-stage technologies. Fraunhofer's highly desired capabilities are otherwise financially out-of-reach for these entrepreneurs, leading to the deployment of TechBridge as the frontend to bring Fraunhofer's technical services to startups, funded by third-party sponsors.



Q: How are companies selected for the program? Are there qualification criteria?
A: Early-stage companies and technologies are selected on a competitive proposal basis through multiple "TechBridge Challenges" per year. These Challenges are a application-based competitions to select relevant technologies tied to particular corporate innovation requirements.

Q: Why would a large corporation be interested in collaborating with Fraunhofer through the TechBridge Program?
A: Through its "TechBridge Challenge" platform, Fraunhofer USA TechBridge facilitates strategic corporate 3rd party validation for startups and their products as they enter the market. The model is of strategic interest to corporate partners, who acknowledge the need to engage in "Open Innovation" practices but encounter many internal barriers to doing so. TechBridge acts as an effective tool for corporations to explore and support the development of novel technologies and provides a mechanism for industry feedback to entrepreneurs during early product development.

This structure allows large corporate sponsors to incubate the technical solutions they seek within the startup community while maintaining the independence of motivated entrepreneurs.

This early alignment of industry buy-in with entrepreneurial endeavors around technical validation and development projects creates pre-vetted technologies tuned to address particular corporate needs, improving the chances of adoption into incumbent industry operations.

Q: What kinds of tangible success has Fraunhofer TechBridge delivered to our corporate partners?
A: Examples are the "SunRISE I" and "SunRISE II" Challenges funded by Royal DSM. These Challenges were designed to identify innovations in solar materials and technologies to reduce the cost of energy for photovoltaic systems, a topic of strategic industry interest to DSM. During SunRISE II, companies such as QD Solar™ and Wattglass™ not only had the unique opportunity to connect and build relationships with employees across DSM's executive suite, business arm, and technical teams, but also received seed financing from DSM. These, among other similar examples, were a direct result from the SunRISE Challenges model of corporate collaboration.

Q: Can the program be modified to suit a specific corporations' interest and needs?
A: Yes. "TechBridge Challenges" are modified and tailored to best identify and select startup companies and early stage technologies within a corporation's strategic areas of interest. This structure allows large corporate sponsors to incubate the technical solutions they seek within the startup community, even while the independence of motivated entrepreneurs – who are often most productive and innovative outside of large corporate structures – is entirely maintained.

Q: Can you provide examples of companies benefitting from the program?
A: Arctic Sand's power electronics cut power conversion losses drastically, enabling low-cost miniature devices. Through TechBridge, Fraunhofer fabricated prototype photovoltaic modules that integrated Arctic Sand's "invisible electronics," and then proved their resilience by subjecting the modules to industry-grade durability tests. This work helped guide the startup's go-to-market strategy, and helped Arctic Sand raise their first $9.6M in private-sector funding.

FAQ: The Fraunhofer USA State Alliance Program

In October 2018, the State of South Carolina's Department of Commerce and Fraunhofer USA signed a MOU establishing the South Carolina Fraunhofer USA Alliance (SCFA). The SCFA was formed to assist the State's business community with the challenges and opportunities presented by rapid technological change in manufacturing processes, product development and service delivery. Due to its success, Fraunhofer USA is launching the Fraunhofer USA State Alliance Program this year to offer state governments, economic development agencies and academic institutions the opportunity to develop technical assistance programs based on the Alliance template and tailored to states' specific needs and interests.

The Fraunhofer USA State Alliance Program is managed by Pete O'Neill. Pete has served as Director of Business Development for Fraunhofer USA CESE since 2016. Prior work experience includes executive level positions in international business development and strategic industries for state government economic development agencies in Maryland and Pennsylvania. From 1982 to 1990, he began his career in Riyadh, Saudi Arabia as a Systems Analyst for BDM International and Sysorex International under a modernization contracts with the Royal Saudi Air Force, the Saudi Ministries of Defense & Aviation and Finance and National Economy. Pete received a B.A. in International Relations from the University of California, Davis, which included a year abroad studying Arabic and economics at the American University in Cairo, Egypt. He received his Master's degree in International Management from the University of Maryland.

Q: What is the Fraunhofer USA State Alliance Program?

A: The Alliance model can vary in makeup but its foundation is a partnership of the state agency that oversees economic development, university research arms, the business community and organizations focused on technology promotion and innovation. This consortium works with Fraunhofer USA to design and deploy a technical assistance program, spanning basic research to problem definition and conceptualization, to prototyping to commercialization. The program allows state-based businesses to tap Fraunhofer and university resources for solutions to complex issues associated with technology innovation for improvement of production processes, product development, service delivery and a host of other challenges facing today's businesses. A specific focus on solving competitiveness and innovation issues facing the state's manufacturing community is often deemed as a priority.

Q: Why do State Governments engage Fraunhofer USA for this work?

A: Every state, regional and local government agency responsible for economic development is concerned about maintaining economic vitality, encouraging technological innovation, and ensuring the workforce is trained, ready and able to meet the needs of a globalized and dynamic world economy. Creating an ecosystem that spurs technology innovation can prove challenging if large parts of the business community are unable to adopt and afford those technologies key to their long-term vitality. Given Fraunhofer's capacities to transform cutting edge research into real world solutions for industry, the State Alliance Program serves as a springboard for state governments to engage Fraunhofer researchers for long term cooperation. By bringing together state officials, academic researchers, Fraunhofer experts, and businesses to understand and overcome those barriers. With reducing costs, boosting quality and efficiency, developing new products and services, the state is more likely to maintain a healthy and competitive business ecosystem.

Additionally, Fraunhofer USA staff have experience working for and with state and local economic development programs. We understand the challenges and responsibilities of government officials charged with job creation and retention, workforce development, business creation and preservation, fostering business environments conducive to growth and innovation, as well as helping to bolster the state's strategy to attract out-of-state and international businesses looking for expansion opportunities.

Q: The Fraunhofer USA State Alliance Program got its start in South Carolina. What was the motivation to launch the South Carolina Fraunhofer Alliance (SCFA)?

A: Over the last 15 years, the State's leadership and economic developers have scored major wins encouraging multinational companies to establish large-scale manufacturing operations in the State. Major investments by Boeing, Samsung, Continental Tire, BMW are just a few in a long list of new production facilities. These investments help drive the State economy through increased employment, tax revenues and they present great opportunities for local businesses to join these firms' supply chains. Yet there remains concern that the State's small and mid-sized businesses struggle to keep up with the demands that multinationals place on all local suppliers to be as technologically advanced as they are in production quality, response time, data usage, logistics – in short, leveraging the latest technologies available for maximum efficiency and innovation. The SCFA was designed to help State businesses adapt and adopt new technologies to ensure a more complete supplier pipeline by building a robust, advanced industrial ecosystem and workforce. State economic developers can also point to the program as an asset when attracting new investments into the state from around the country or abroad.

Q: What kinds of businesses and problems has the SCFA addressed for their clients?

A: The SCFA team has worked with companies involved in aircraft subsystems, bicycle manufacturing, thermoplastics, appliances, shipping and logistics, telemedicine, auto assembly, among others. Projects have focused on reducing defects in assembly operations, image analysis, workforce training and onboarding process improvements, capturing data and integration of data sets for better insights into operations, and automation of manual production tasks to allow workers to focus on higher value add tasks. The variety of industries and challenges addressed speaks to the SCFA team's capacity and capability to take on tough issues facing companies large and small, and delivering success where off the shelf solutions do not exist. There's no reason to believe the Alliance model cannot be replicated to deliver similar results and successes across the country.

Q: Can the program be modified to suit a specific state's interest and needs?

A: Yes! As the program grows and is offered to other states, the Alliance program will be adapted to each state's unique needs and interests. That could include focusing the program on a specific industry or region, or focusing on a large-scale project, for example, examining an industry supply chain for robustness or vulnerabilities. The basic tenet of the Alliance concept however will remain constant: Sound applied research provided by teams of in-state and Fraunhofer experts across a wide span of technology disciplines for the benefit of industry.

Q: What are the lessons learned from the program's operations so far?

A: Clients should expect to invest financial resources and devote executive and technical talent to work with the Alliance team members to maximize the chance of success, in return for the technical assistance and matching funds that the program provides (projects typically run for 6 to 12-month terms). In addition, though state government underwrites a portion of the program, this is not a typical grant program; the use of Alliance funding comes with restrictions on usage, and progress/closeout reporting are required.

Q: What are Fraunhofer's plans for the Alliance program's future?

A: The plan for 2020 and 2021 is to begin a broad educational and outreach program to inform states across the US of this unique opportunity. In addition, we want to ensure every Fraunhofer USA Center and Fraunhofer Institute in Germany has the opportunity to engage in the programs and projects that we uncover. Through the Alliance model, we hope to make Fraunhofer USA a household name among government, academia and the business community in the US.

© Fraunhofer USA, South Carolina Fraunhofer USA Alliance launch at BMW USA, Spartanburg, SC

University Partnerships

University of Maryland: The Fraunhofer USA Center Mid-Atlantic CMA has collaborated with the University of Maryland since 1997, specifically within the College of Computer, Mathematical and Natural Sciences.

Founded in 1856, the University of Maryland has an enrollment of approximately 41,000 students, of which circa 11,000 are graduate students. The University of Maryland has become one of the nation's leading public research and innovation universities, receiving $570M in research awards in 2019.

University of Delaware: The Fraunhofer USA Center Mid-Atlantic CMA partners with the University of Delaware to expand the innovation pipeline by enhancing technology and product development activities.

One of the oldest universities in the US, the University of Delaware traces its roots to 1743. It continues to have a large impact with over $4.7B in economic impact in the Northeast Corridor. Currently the enrollment is made up of circa 24,000 enrolled students.

Michigan State University: Since 2003, the Fraunhofer USA Center Midwest CMW and Michigan State University (MSU) have closely collaborated on applied research and development projects in the areas of diamond and coatings technologies. Michigan State University, founded in 1855, has a total of approximately 50,000 students, of which circa 11,000 are graduate students. MSU is a top 100 global research university, and ranks No. 2 nationally for combined Department of Energy and National Science Foundation expenditures. Total research expenditures for MSU totaled approximately $715M in 2018. Fraunhofer USA CMW collaborates closely with the College of Engineering and Natural Sciences.

Boston University: The Fraunhofer USA Center for Manufacturing Innovation CMI has collaborated closely with Boston University since the Center's inception in 1995. The Center is located on the University's Charles River campus.

Boston University has a student body of approximately 34,000 students of which circa 15,000 are graduate students. As a leading global research institution, BU has been awarded over $570M in grants and contract awards in 2020.

Fraunhofer USA CMI collaborates directly with a number of its schools and colleges, including the College of Engineering, the Medical School, the Business School, and the College of Arts & Sciences.

The Global Fraunhofer Network

Fraunhofer USA Centers work and collaborate with the Institutes of the Fraunhofer-Gesellschaft. The Fraunhofer-Gesellschaft, headquartered in Germany, is the world's leading applied research organization. With its focus on developing key technologies that are vital for the future and enabling the commercial exploitation of this work by business and industry, Fraunhofer plays a central role in the innovation process. As a pioneer and catalyst for groundbreaking developments and scientific excellence, Fraunhofer helps shape society now and in the future. Founded in 1949, the Fraunhofer-Gesellschaft currently operates 74 Institutes and research institutions throughout Germany. The majority of the organization's 28,000 employees are qualified scientists and engineers.

Fraunhofer USA has many collaborative and cooperative initiatives and projects with universities, economic development entities, scientific groups and others. It is the goal of Fraunhofer USA to help in the facilitation of greater global benefits for applied research and development.

The restructuring of Fraunhofer USA for 2021 begins an exciting new phase for the company. The formation of the new centers with their combined and expanded expertise portfolios will allow for greater flexibility and lead to new and innovative interdisciplinary research work.

Uncertainties about the COVID-19 pandemic's duration are naturally leading to very conservative planning across the country on financial matters. Many of the universities in the United States are facing particular issues with revenue loss due to expected reductions in tuition. Government agencies may face negative impacts on their budgets now or in the next several years due to the massive government spending in 2020 counteracting the economic fallout from the pandemic containment measures. Industry has been impacted in various ways ranging from mandated or voluntary closures and/or staff reductions to supply chain issues and the reduction of demand for products and services.

Fraunhofer USA has planned its budget carefully for the upcoming year with a clear intent of conservative caution. We are however optimistic that we will see a stabilization of business operations by 2022 after the effective development and deployment of a safe and reliable vaccine for COVID-19.

Fraunhofer USA, Inc.

Balance Sheet
As of December 31, 2019

Assets		
Current Assets		
Cash and Cash Equivalents	$	6,420,748
Accounts Receivable		6,110,624
Investments		5,323,814
Prepaid Expenses and Other Current Assets		1,598,174
Total Current Assets		**19,453,360**
Property and Equipment - Net		**17,190,970**
Intangible Assets		**91,283**
Long-Term Receivable		**-**
Total Assets	**$**	**36,735,613**
Liabilities and Net Assets		
Current Liabilities		
Accounts Payable	$	897,264
Deferred Revenue		1,479,757
Accrued Liabilities and Other		5,315,041
Total Current Liabilities		**7,692,062**
Long-Term Obligation		**-**
Total Liabilities		**7,692,062**
Net Assets		
Unrestricted		
Undesignated		**7,727,258**
Increase (Decrease) in Undesignated Net Assets		**767,712**
Designated		**24,185,745**
Increase (Decrease) in Designated Net Assets		**(7,729,466)**
Predetermined		
Predetermined		**6,173,154**
Increase (Decrease) in Predetermined Net Assets		**(2,080,852)**
Total Net Assets		**29,043,551**
Total Liabilities and Net Assets	**$**	**36,735,613**

Fraunhofer USA, Inc.

Statement of Activities and Changes in Net Assets
Year Ending December 31, 2019

Contract Revenue	
Industry	$ 4,263,001
Government & Universities	9,023,309
Fraunhofer Institutes	1,870,629
Miscellaneous	741,702
Total Contract Revenue	**15,898,641**
Support	
Base Funding	14,197,885
In-Kind Contributions	3,509,487
Other	623,205
Total Support	**18,330,577**
Funds Transferred from Predetermined Funding	**2,972,771**
Total Undesignated Revenue, Support and Predetermined Funds	**37,201,989**
Labor Costs	**17,465,873**
Undesignated Other Expenses	
Administrative Expenses	**14,592,693**
Cost of Goods Sold - Excluding Labor	**4,220,267**
Depreciation and Amortization	**155,444**
Total Undesignated Other Expenses	**18,968,404**
Total Labor Costs and Undesignated Other Expenses	**36,434,277**
Increase (Decrease) in Undesignated Net Assets	**767,712**
Undesignated Net Assets	**7,727,258**
Designated Revenue	**1,126,480**
Designated Expenses	**(8,855,946)**
Increase (Decrease) in Designated Net Assets	**(7,729,466)**
Designated Net Assets	**24,185,745**
Predetermined Funding	**891,919**
Net assets transferred to other support	**(2,972,771)**
Increase (Decrease) in Predetermined Net Assets	**(2,080,852)**
Predetermined Net Assets	**6,173,154**

BOARD OF DIRECTORS AND OFFICERS

Board of Directors

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