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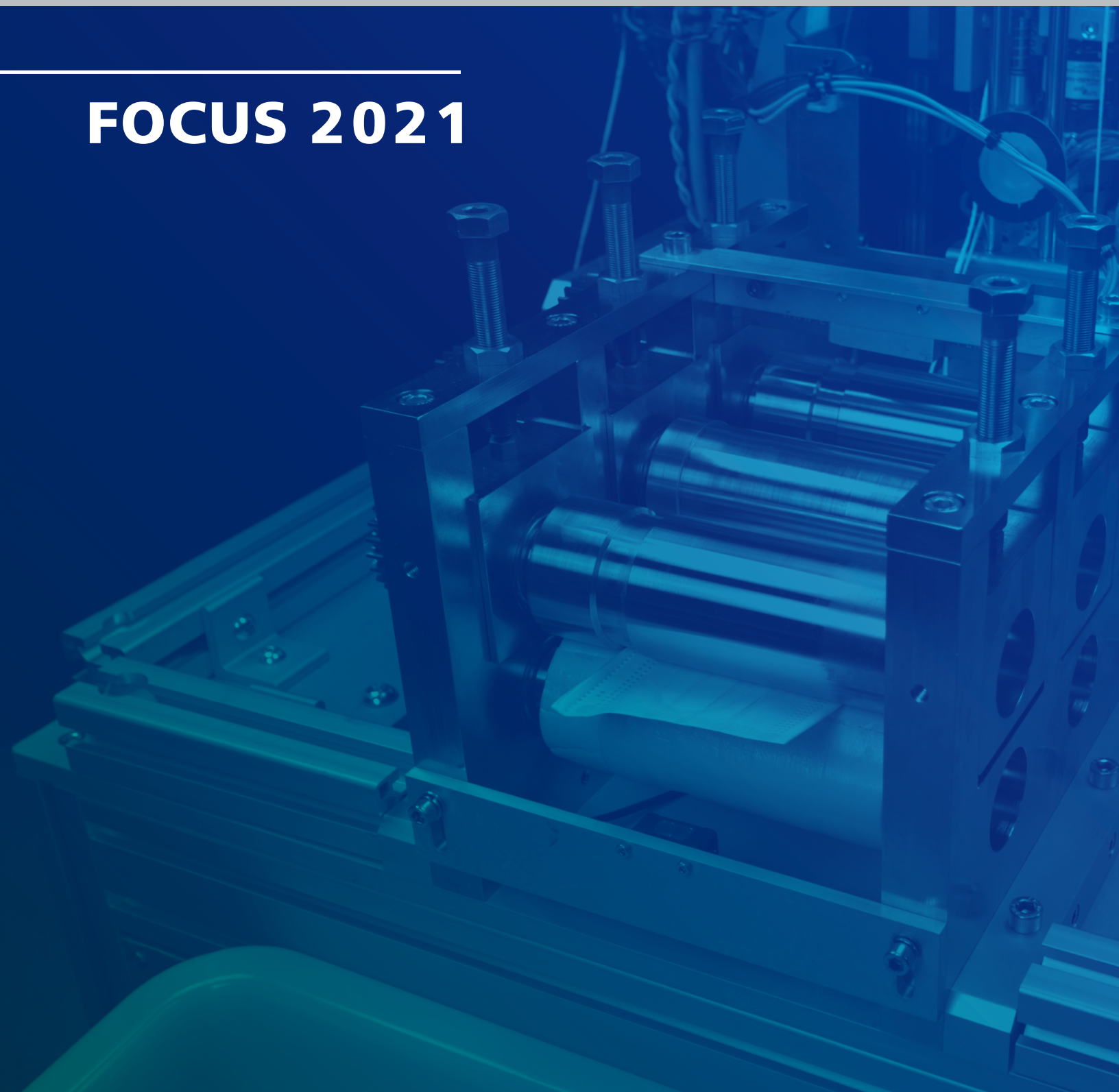
USA

FOCUS 2021



FOREWORD

More than eighteen months into the COVID-19 pandemic, the world has not yet recovered. The rollout of functional vaccines within just one year was impressive and demonstrated the power of scientific discovery in combination with rapid deployment of the technology. Nonetheless, the spread of the virus continues to cause illness and death for way too many. For now, we need to maintain actions that provide additional protection for our families, our co-workers and the general public, and continue to work to overcome the challenges that the pandemic has caused in all areas of life.

Fraunhofer USA is structured and operated as a non-profit organization that engages in research and development activities in technical and scientific fields of high relevance to the public. As reported here, we work on a multitude of research projects with a broad selection of topics such as building early awareness and interest in engineering careers, applying artificial intelligence technologies in manufacturing, improving building energy management, water safety, aerospace technologies and biomedical applications, to name a few. Our core activity is applied research and development and our laboratories in Michigan, Massachusetts and Maryland closely cooperate with major research universities. Our goal is to bridge the traditional "innovation gap" by advancing early-stage research results to technology readiness levels so that our projects help to reduce the commercialization risks for companies. New ideas and scientific results must be deployed as innovative products and services to have positive societal impact. To do so, we work with universities and industry partners alike. We perform internal and publicly funded research and development to advance our core competences, to identify novel solutions and applications. We then bring our know-how to work with companies addressing their R&D and product development opportunities. Fraunhofer USA's balance of publicly and industry funded research is what makes working with us unique. Companies like to work with us because they can access a sound scientific and engineering foundation as well as an understanding of their commercial challenges and a focus on their product development needs. Universities like to work with us because we cooperate, share, and offer opportunities to students and faculty to work with us on projects of high scientific value yet always driven toward real-world applicability. Ultimately, we consider our work to be successful when our industry partners start to sell products that were enabled at least in part due to our efforts.

To increase our organization's societal impact and its relevance to our customers and to the greater Fraunhofer-Network, Fraunhofer USA is implementing affirmative changes focusing on greater strategic alignment with our partner, Fraunhofer-Gesellschaft. We call this initiative "Fraunhofer USA 2.0". Efforts include a new level of internal core competence development and a much deeper Fraunhofer-wide cooperation across strategic research fields. Fraunhofer USA is also reorganizing its R&D offering and improving internal administrative functionality. The focus is on creating a platform with substantially enhanced research and development capabilities, cooperation opportunities, and simplified access.

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

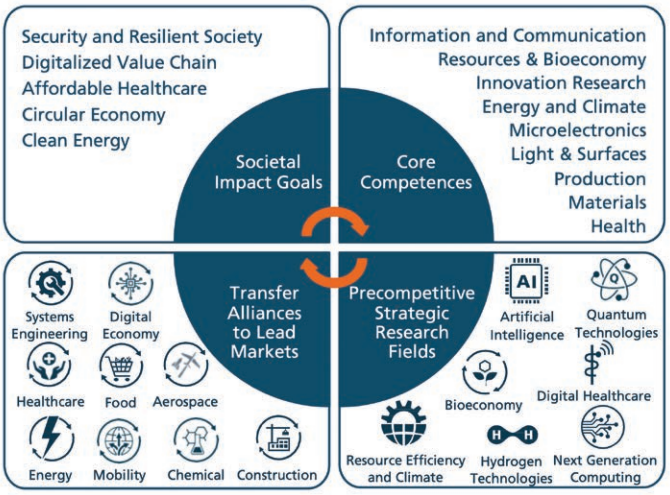
About Fraunhofer USA

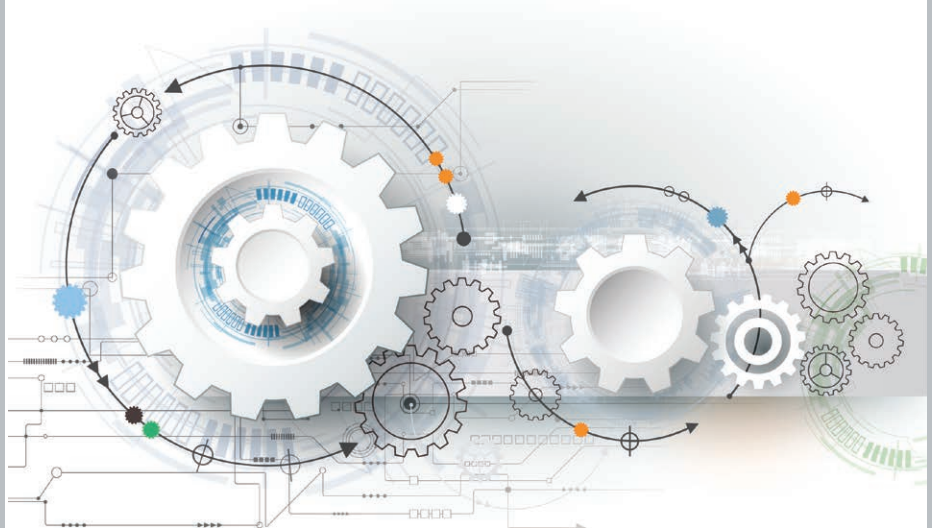
"I have to set aside everything in my scientific endeavors which does not further the product."
– Joseph von Fraunhofer

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 example by aiming our applied research and development efforts on where technology is needed the most and where we can achieve, jointly with our partners, relevant impact to the benefit of society. We aim to bridge the gap between university 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 to the benefit of society.

Fraunhofer USA Inc. is a 501(c) (3) non-profit applied research and development organization partnering with government, universities, and industry. Fraunhofer USA was founded by the German non-profit applied research organization, Fraunhofer-Gesellschaft. Fraunhofer USA is a membership-based organization with Fraunhofer-Gesellschaft as the Sole Member. Fraunhofer-Gesellschaft is Europe's largest applied research and development organization with a history spanning more than seven decades, providing applied research and development services to the benefit of both industry and the public. The organization has nearly 30,000 employees across 75 research institutes and is active in 80 countries around the world. Fraunhofer-Gesellschaft partners with Fraunhofer USA in many areas.

At Fraunhofer USA we align our research strategy with that of Fraunhofer-Gesellschaft. To maximize available resources, we focus our efforts on areas of clear relevance to current societal challenges in affordable healthcare, clean energy, security and resilience, digitalized value chains, and resource efficient circular economies. True impact to the benefit of society can only be achieved when new technologies are deployed in the market. Accelerating the transfer of new technologies from the laboratories to the markets is one of Fraunhofer USA's key objectives. To do so we work closely with companies of all sizes across many industry sectors. Companies work with us because we provide efficient and comprehensive access to teams of engineers and scientists with deep and wide technical competences in areas including information and communication technologies, materials, microelectronics, light and surfaces, and production technologies. To remain relevant and competitive, we continually refine and expand our competences through strategic research and development in carefully selected areas such as artificial intelligence, resource efficiency and climate, quantum technologies and others.





Contract Research with Fraunhofer USA

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 feel they are contributing to innovation and progress, not only in their chosen fields but also as interdisciplinary support for colleagues and collaborators.

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.

In the "Research" section of this year's Fraunhofer USA Focus, we report on 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.

Center for Manufacturing Innovation CMI
Brookline, Massachusetts

Center Midwest CMW
- **Coatings and Diamond Technologies**
  East Lansing, Michigan
- **Laser Applications**
  Plymouth, Michigan

Center Mid-Atlantic CMA
- **Software and System Engineering**
  Riverdale, Maryland
- **Biotechnology**
  Newark, Delaware
- **South Carolina Alliance Office**
  Columbia, South Carolina

Digital Media Technologies Office DMT
San José, California

Headquarters
Plymouth, Michigan

Our Research Locations

The organization is headquartered in Plymouth, Michigan. Research Centers are in the Midwest, Northeast and Mid-Atlantic regions of the United States. Center Directors are professors at nationally ranked research universities (Boston University, Michigan State University, University of Maryland). Additional smaller offices are operated in California and in South Carolina. Fraunhofer USA employs approximately 118 full-time staff, university faculty, and student interns. Fraunhofer USA's 2020 research expenditures were approximately $28M.

Human Resources

New Work

Companies across the world have been impacted by the COVID-19 pandemic. The challenges have been numerous, ever-changing and difficult to navigate. In very short order, employers and employees had to change how work was done, how meetings and communication were accomplished, make changes in infrastructure, and deal with mental and physical fatigue. Many companies faced and continue to face financial challenges. Workers have dealt with school and daycare closings, home schooling, eldercare issues, and numerous other stressors.

In many ways the pandemic's effect on the workforce is leading to seismic shifts in what employees are looking for in their careers. As an employer, Fraunhofer USA is investigating how to preserve the positive lessons learned during the pandemic response. This includes incorporating flexibility, hybrid work schedules for qualifying employees, and utilizing new technologies to allow for better communication and workflow. Employees and employers alike discovered that virtual meetings were a viable working alternative to in person meetings. In spite of the working from home necessity for many during shut-downs, work was accomplished professionally and with integrity. Business travel will undergo more scrutiny for necessity as businesses, including Fraunhofer USA, weigh environmental considerations and employee health and welfare. Employee satisfaction is the biggest factor in retention, and it is our goal that employees continue to have high levels of job satisfaction at the organization.

Fraunhofer USA is in the final stages of a multi-year consolidation and restructuring to make a solid and comprehensive foundation to grow and expand the wonderful scientific and engineering research and development that it offers to customers. Employees, stakeholders and customers have provided positive feedback and encouragement. The fact that it mainly took place during a global pandemic is even more remarkable and is a testimony to the dedication and support of the employees at all levels of the organization.

Intern Program

As part of its mission, Fraunhofer USA is committed to offering opportunities for meaningful, hands-on internships to those studying in STEM fields to both international and domestic students. While COVID certainly did impact the internship program, we are already seeing intern candidates applying with hope that the restrictions and uncertainty associated with COVID will subside. The Fraunhofer USA J-1 visa program, promoting international exchange, has received very positive feedback from participants in the program. The following pages highlight the experiences of interns as narrated in their own words.

Intern Experiences

Julian W. Internship 09/16/2019-03/13/2020, *Fraunhofer USA Center for Manufacturing Innovation CMI:*

"When I started studying Mechanical Engineering a few years back in Duisburg, Germany, I soon wanted to apply my new theoretical knowledge practically. I think what made me choose Fraunhofer then was their emphasis on innovation and creativity, and I was not disappointed! So, as I entered my fifth semester in which I wanted to complete an internship, I was sure that I would fare well at Fraunhofer USA too. During my internship, I was lucky enough to see most of the steps of one whole engineering cycle of a single project. In this case, it was our "Guacamole Maker" or, formally "Plant Tissue Dissociator" that was being developed for a local biotech startup. When I arrived, the project was just about to leave the experimental stage. In fact, I was entrusted with running some of the last tests, evaluating them, and presenting them to the rest of the team. Then, I was able to help out with mechanical design and caught a glimpse of the ordering and manufacturing system. The successful assembly of both the electronics and mechanical parts led to another stage of testing and troubleshooting. I sadly wasn't there anymore for the final customer approval and shipping, but I have heard that the machine is now fully functional and in use which is a great feeling! All along these stages, I worked together with very different people and therefore mindsets, leadership styles and management systems. Client meetings, project group sessions and working hand in hand with the senior engineers on the shop floor were all great opportunities for me to observe and learn. Also being exposed to this diversity in a short period of time helped me enormously to rethink and improve my own methods. Additionally, I now feel much more confident to experiment on my own. That is because I have seen that to try and fail and try again (as long as you structure the process and learn along the way) is the only way to build something truly innovative (and maybe because I have seen these incredibly intelligent and experienced engineers fail a few times as well so it's probably okay for me to do too). Apart from the fast professional growth I was experiencing during my internship, I also tried to make use of my private time in the best way possible. I am also thankful for the diverse set of colleagues that I had a chance to work with at Fraunhofer. They allowed me to glance into their everyday life in America which I wouldn't have had otherwise. For some of them, it was life as they were used to since they were very young. For many others, however, just like for me, it was still a relatively different and new life as they had come from China, India, or Europe to work there. I enjoyed seeing them becoming Americans and the challenges they had overcome. They are chasing the American Dream and I could try to put myself into their shoes, seeing if they would fit me too."

Eileen N. Internship 04/16.2019-03/27/2020, *Fraunhofer USA Center Midwest CMW:*

"I heard about the Internship first from a professor at my university. When he told me about it, I wanted to go immediately. I had never been outside of Europe, I never worked in another country and having the chance to do all that while working at a world-renowned research company was just a thing I couldn't say no to. Arriving in the US, everything was new to me; even the windows looked weird. But the people where very nice and helpful and my boss even came over to our house and helped me with the paperwork. The work itself was great. Even though I was just an Intern people took me seriously and responded to my questions and suggestions. They let me do my own project, which I used to obtain a bachelor degree at my university. But the job was also demanding. I had to attend meetings, do paperwork and learn that communication is key to success. The internship also allowed me to travel the country and see things I had always wanted to see. I have been interested in technology since I was little and the first chance I got, I went down to Huntsville to see the Saturn 5 Rocket. That trip really showed me something about the culture in the States. I was totally alone, thousands of miles away, on a different continent, looking at a machine that took people to the moon and everybody was helpful and nice. They helped me when I couldn't figure out how to operate the gas pump that wouldn't take my card. They chatted with me when I was sitting alone in a restaurant. And they made an exception when I arrived too late at the hotel. I made friends in Michigan, and I really want to go back and visit again. That year changed me. It was a year that made everything seem possible and showed me what I could do in life, and I am really glad that I had that opportunity."

Franziska S. Internship 01/16/2020-07/31/2020, *Fraunhofer USA Center Mid-Atlantic CMA:*

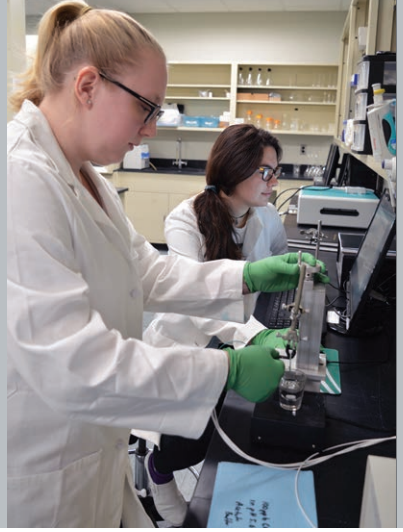
"I´m a master degree student at the University of Würzburg with a focus on biotechnology and microbiology. Since the university studies are very theoretical, an internship at an international company like Fraunhofer USA is a big opportunity to improve technical, practical, and language skills. I found a contact at the Fraunhofer USA webpage I wrote to. I had some skype interviews with my mentors and supervisors to talk about the projects I would work on during my six-month internship at Fraunhofer USA. My main project at Fraunhofer USA was to develop a prophylactic treatment for SARS-CoV-2 via protein expression of modified Pichia pastoris yeast cells. My main tasks at Fraunhofer USA were to express and purify recombinant therapeutic proteins in the methylotrophic yeast Pichia pastoris. For that intent I performed upstream and downstream biotechnological tasks: (1) Cloning the genes of interest in different vectors (including in silico design using cloning software, PCR, E. coli transformation by heat shock, plasmid DNA purification, DNA restriction digestion, etc.); (2) Transformation of the vectors harboring genes of interest into multiple Pichia pastoris strains by electroporation, followed by screening for the selection of high expression clones (expression level analysis is performed by Western Blot, ELISA, SDS-PAGE electrophoresis, etc.); (3) Culture scale up and process optimization for enhanced protein expression (14-liter bench bioreactor operation, fermentation process characterization by the determination of specific growth rates, product accumulation, optimal fermentation feeding strategies, etc.); (4) Purification of the proteins of interest and characterization (proteins are initially purified by Immobilized Metal Affinity Chromatography, the purified proteins are later characterized by SDS-PAGE, Western Blot and other more specific techniques i.e., Transmission Electron Microscopy, Dynamic Light Scattering, etc.) My supervisors Konstantin and Ruben explained those tasks in detail and answered all of my questions. After a few weeks I was able to work in the laboratory independently on my own project. I learned a lot about the lab routine."

Patrick B. Internship 10/01/2019-09/30/2020, *Fraunhofer USA Center Midwest CMW:*

"I studied Nano-technologies at the University of Applied Sciences in Zwickau, Germany and wrote my Master Thesis at Fraunhofer IWS in Dresden, Germany. I got to know Michael B. during his Presentation at IWS and Lars H. during a workshop on carbon and carbon coatings. Lars was my mentor during my time at CMW. I worked on a couple of smaller projects at CMW. One of the most important projects was to build a filter system for the Laser Arc coating system for DLC, which I did successfully. Besides that, I worked on different projects. All of them were related to wear-resistant coatings. I've been able to learn more about tribological coatings and their applications. I also learned a lot about the American culture, and I've been able to improve my English a lot – unfortunately not as much as I wanted to learn due to the pandemic. After the lockdown ended, I've been able to travel a bit – at least within Michigan. Unfortunately, I haven't been able to travel to Hawaii for a couple weeks after my internship as planned, since they still had a mandatory quarantine at that time. Besides that, I would recommend that kind of international internship."

Thomas F. Internship 09/16/2019-03/15/2020, *Fraunhofer USA Center Mid-Atlantic CMA:*

"My name is Thomas, I'm currently studying bioengineering at the University of Applied Sciences Munich, Germany. I worked at the Biotechnology Division at CMA in Newark, Delaware from September 2019 till March 2020 as part of my studies. I found out about internship opportunities through a flyer my professor gave me. I was part of Konstantin M.'s group and was supervised by Ruben M. They were both great mentors and helped me whenever I had a problem or question. I worked on a new platform for the expression of heterologous proteins and had my own experiments after I was trained in all the different methods. The whole team was great and really interested in training me and giving me a lot of information while always being respectful and really nice. I was taught the basics of molecular cloning, transformation of vectors, screening of clones, micro- and small-scale fermentations, and purification of produced proteins. The aim was to find a platform for heterologous protein expression which can be used for producing vaccines. While I worked 40 hours a week, I still had enough time on the weekends and over the holidays to travel to Washington DC, New York City, Baltimore, Philadelphia, Toronto and the surrounding National and State Parks. I would recommend the program to anybody thinking about coming to Fraunhofer USA. Not only was I able to travel to different locations, but I was also able to become really good friends with many Americans and learn a lot about the differences and similarities of our cultures."



Vikrant G. Internship 03/16/2020-12/15/2020, *Fraunhofer USA Center Mid-Atlantic CMA:*

"I am an Indian National attending the Frankfurt University of applied Sciences: Germany (master's in data science and Software Development). I learned about the internship from my friend who interned here two yearsago. I worked on several projects, including implementation and deployment of an App, documentation, de-bugging, adding new features, and adding a log-in feature. I learned Django, Flask, Vue, Docker, JS, AWS and a little bit of React. I had three mentors: Sandra, Marcel and Gudjon. Other interns and I took a trip to New York, LA and Vegas. Sadly, we couldn't make it to a ski trip we had booked. I feel the internship program helped me with both personal and professional growth. I am happy with my experience and that's why I wanted to stay longer and was able to extend my internship as well and we got to travel to a few places and see the culture of the US. It was a pretty good experience, and I would definitely want to come back to the States."

Katja M. Internship 10/01/2019-03/27/2020, *Fraunhofer USA Center for Manufacturing Innovation CMI:*

"My undergraduate studies were in Industrial Engineering. I graduated from the RWTH Aachen University in August 2019 and started the internship at Fraunhofer Center for Manufacturing Innovation CMI in October 2019. One of my professors works for Fraunhofer in Germany and has collaborated with Fraunhofer CMI in the past. I became aware of the internship opportunity in summer 2018 when my professor presented CMI in one of his lectures. During my time at CMI, I worked on two main projects. One project was about designing a quality-control machine which employs machine vision. I was mostly involved in the software and programming of the machine. I built the graphical user interface which allows the end-user to see what quality class a produced item is grouped into by the computer. The worker can correct these groupings as needed. This allowed me to further my understanding of integrating hardware and software design as well as becoming familiar with a new programming language. Moreover, I also lead the implementation of a new customer-relationship management software. By interviewing the business development manager, I figured out which software requirements were essential. Based on this information, I pre-selected and presented multiple software providers to the business manager. After deciding on a company, I transferred the information stored in the old customer-relationship management system to the new one and customized it to the needs of Fraunhofer CMI. CMI is in Boston which is a great location to learn a lot about the US. There is an abundance of historic locations. The public transportation system, as well as the closeness to the airport, enables easy and cheap traveling. Therefore, I was exploring Boston with friends on the weekends and used holidays, such as Thanksgiving, to get to know places like Florida. Overall, the internship at Fraunhofer USA provided me with many insights into working culture, graduate studies and increased my cultural understanding of the US. I am thankful for the people I got the know during my time at CMI and for the advice they gave me."

Research & Development Coordination

Since the beginning of 2021, Fraunhofer USA has formally started to engage in a strategy process to create overall alignment with Fraunhofer-Gesellschaft and create alignment across all Fraunhofer USA Centers. The goal of the strategy process is to produce a center action plan which entails long-, mid-, and short-term objectives that are supported by initiatives and key results to facilitate the implementation and execution of the R&D strategy. This first phase of the strategy process will be finished in 2022 followed by annual progress evaluations and adjustments, if necessary. This strategy process aims to help us accomplish our key missions:

- To build an international collaboration platform to connect the US R&D market with stakeholders in Germany.
- To identify and promote critical and emerging technologies in the US to address societal needs through scientific research.
- To translate R&D results into innovative applicable solutions for our business partners in the US, which in turn bring new products, initiatives and policies to the market.

Major R&D Coordination activities entail the coordination of operations, people and strategy to streamline project acquisition and execution. The work benefits from close cooperation with Fraunhfoer USA's Science and Technology Advisory Council (STAC). A major aspect of our growth strategy moving forward is the PACT (Program Affiliate Cooperation for Knowledge Transfer) program. Through our PACT program, we invest in strategic precompetitive research topics to expand our core competences to address critical and emerging technologies in the US. We have seven active PACT projects with a total volume of $3.6M and are planning to add nine additional PACT projects in 2022 with a total volume of $4M. These projects aim to develop new competences at Fraunhofer USA aiming at the following goals:

- To create new and innovative technologies required to address future technological challenges.
- To align with current with the current socioeconomic developments and R&D market trends.
- To develop solutions needed by industry to bring their innovative products to market.

These precompetitive research programs are done in partnership with Institutes from Germany to foster collaboration, teamwork and cooperation across multiple disciplines to prepare for the technological challenges ahead.

Suzanne Witt
Scientist, Fraunhofer USA Center Midwest CMW

Dr. Suzanne Witt earned her PhD in Chemistry from The Ohio State University in 2017, advised by Prof. Claudia Turro in the Inorganic Chemistry Division. Dr. Witt's PhD research focused on the investigation of dirhodium complexes as electrocatalysts for carbon dioxide reduction and water splitting reactions. After finishing her PhD, she applied her electrochemistry knowledge for new applications, first moving to the University of Missouri for a postdoctoral position to research nuclear batteries. While in Missouri, she was awarded a National Research Council Postdoctoral Associate position at the National Institute of Standards and Technology (NIST). At NIST, she investigated structure-property-performance relationships of novel solid oxide fuel cell anode materials.

Dr. Witt joined Fraunhofer CMW in March 2020 as a Scientist. Her research interests include the electrochemical applications of the carbon-based materials grown at the center, with a current emphasis on boron doped diamond (BDD) for sensor applications and water treatment technology. Of note, she led the effort on functionalizing BDD surfaces for the electrochemical detection of SARS-CoV-2 shortly after starting at Fraunhofer. She also leads all projects related to the electro-chemical destruction of perfluoroalkyl substances (PFAS) and other emerging contaminants in water using BDD electrodes. This includes the investigation of electrochemical PFAS destruction in landfill leachate in partnership with the Water Resource Recovery Facility in Grand Rapids, Michigan.

Marcel Schaefer
South Carolina Fraunhofer USA Alliance Senior Program Coordinator

Dr. Marcel Schäfer serves as Senior Research Scientist for the Fraunhofer USA Center Mid-Atlantic CMA in Maryland since January 2019. From 2009 to 2018 he was with the Fraunhofer Institute for Secure Information Technologies SIT in Germany. He holds a master's degree in mathematics from the University of Wuppertal, Germany, and a PhD in computer science from the Technical University of Darmstadt, Germany. As PI, Co-PI and researcher Dr. Schäfer has led and worked on various projects that discover new challenges and opportunities broadly spread over the fields of cybersecurity and software engineering in both the public and private sector.

Since March 2021 he has been the Senior Program Coordinator for the South Carolina Fraunhofer USA Alliance. Projects cover a broad spectrum ranging from smart manufacturing, IoT, Industry 4.0, digitization to predictive maintenance, predictive analytics and other data driven and machine learning featured technologies. Typically, those projects have a strong manufacturing focus.

From his office in South Carolina, Marcel is working to expand the Fraunhofer brand in the State and the whole south-east region. His goal is to institutionalize Fraunhofer USA as an established organization in South Carolina and to bring the newest technology "Made by Fraunhofer" from the global Fraunhofer-Network into the south.

Beth Fohrman
Senior Account, Fraunhofer USA

Beth Fohrman has been with Fraunhofer USA for almost 27 years and is a Senior Accountant reporting directly to the Treasurer. She is currently responsible for the financial accounting for Fraunhofer USA Center Mid-Atlantic CMA and Fraunhofer USA Digital Media Technologies DMT. In this role, she ensures compliance with the Uniform Grant Guidance, works with contract administration and center personnel, processes month-end and year-end closes, prepares annual budgets and forecasts, and provides information for the annual audits. She is presently part of the implementation team for Fraunhofer USA's new ERP system and continues to be involved with the various phases of this project.

Beth received her B.A. with a dual major in Economics and German from Michigan State University. As an undergraduate, she had a summer internship with a furniture company in Goslar, Germany. She obtained her M.S. in Accounting from Eastern Michigan University.

Aaron Sharpe
Senior Electromechanical Systems Design Engineer, Fraunhofer USA Center for Manufacturing Innovation CMI

Aaron joined the Fraunhofer USA Center for Manufacturing Innovation CMI in 2001 as an intern while attending Boston University. After his internship he was offered a position as an engineer at the center. Since that time he has developed precision automation systems specializing in unique out-of-the-box solutions for very difficult automation tasks for a range of industries including: fiber optic, telecom, plastic molding, bio pharmaceutical vaccine production, metal forming, corrosion mitigation, and wood inspection. His background is in precision multi-actuator electro-mechanical machine design and process development.

Recently, he developed software and hardware tools to inspect wooden dowels for grain defects. Wood grain is highly variable and traditional inspection techniques rely on highly skilled human operators to make snap judgments. The project leveraged a unique imaging system to create a 360° view of the dowels surface and machine learning to mimic the operator's judgements.

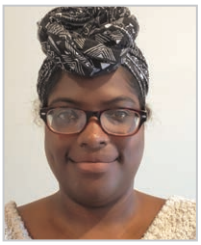
Aaron received his M.S. in Global Manufacturing Engineering and B.S. in Mechanical Engineering from Boston University.

James Siegenthaler
Scientist, Fraunhofer USA Center Midwest CMW

Dr. James Siegenthaler is a research scientist, joining Fraunhofer USA CMW in 2020, where he works on applications and technologies for electrochemical measurements using boron doped diamond. Specific focuses include using diamond microelectrodes for neurochemical measurements of dopamine, in the brain in real time. In addition to diamond, he also spearheads efforts into additive manufacturing, focusing on 3D printing titanium parts using metal fused filament fabrication. He is heavily involved in the Fraunhofer USA PACT program, where we are working to study and optimize the 3D-printing-to-sintering process.

Prior to Fraunhofer USA, James completed his PhD at the University of Arizona in analytical chemistry, focusing on developing techniques and technologies for real-time dopaminergic measurements. At the University of Arizona, he also helped run an imaging facility, training users on material characterization, using SEM, AFM, FTIR, TGA techniques. Prior to that, he worked at Tree Top Inc, spearheading the testing of heavy metals and pesticides in fruit products, while simultaneously completing a master's thesis at Central Washington University focusing on the spectroscopic control of molecular complexes in solution.

Shermany Hickman
Operations Support Coordinator, Fraunhofer USA Center Midwest CMW



Shermany Hickman is an Operations Support Coordinator at Fraunhofer USA Center Midwest CMW. She obtained her English B.A. at Michigan State University. Shermany came to Fraunhofer USA as an office intern in 2018 and transitioned into full time work in 2019. Her work revolves around supporting daily operations such as purchasing, shipping, and general administrative work.

She loves the work environment that Fraunhofer USA has created. "I love working at Fraunhofer USA! I am always learning something new, and despite me not having a research background, everyone explains their projects in terminology I understand. I couldn't have started my career at a better place." Her favorite part of the job is being involved in multiple processes. "It feels really good to see that my work is essential to keeping the daily operations flowing". Shermany hopes to continue her growth within the company.

Jeno Szep
Senior Research Scientist, Fraunhofer USA Center Mid-Atlantic CMA

Dr. Jeno Szep is a senior research scientist at Fraunhofer Center Mid-Atlantic CMA. He holds a PhD in Physics and MS in Mathematics from the Eotvos University in Hungary. At Fraunhofer USA, he is the project lead for projects related to providing cutting-edge data analytics and AI for Industry 4.0 applications, and providing IV&V for a DARPA project the utilizes blockchain technology.

After earning his PhD degree, he worked as an Associate Professor for the Department of Physics at the Eotvos University of Sciences Budapest. His university research included computational modeling, simulation, and data analytics in the fields of nonlinear systems, electron optics, and physiology. He has been working with advanced machine learning models and deep neural networks. He participates in Kaggle competitions and currently holds a 'Kaggle Competition Expert' rank.

He also has many years of experience in the design, development, testing, and operation of large-scale governmental IT systems. He was the head of the software development team, which was responsible for critical national IT systems in Hungary, including the National Population Register System, the Hungarian Drivers License System, the National Parliamentary, and statewide Municipal Election Systems. His expertise includes project management, IT system lifecycle management, and IT security.

"Due to my diverse professional experience, I always wanted to work on not only a small niche area, but where multiple areas of academic research, business management and IT development are all present together as part of my work – and that is what Fraunhofer USA provides me"provides me"

Bryan Urban
Senior Engineer, Fraunhofer USA Center for Manufacturing Innovation CMI

Bryan Urban joined Fraunhofer USA in 2008 to form the Building Energy Technology Group at the Center for Sustainable Energy Systems that became part of a new Energy Systems activity at the Center for Manufacturing Innovation in 2019. Bryan holds degrees in Mechanical Engineering: an M.S. from MIT's Building Technology department and a B.S. from Cornell University. His thesis work at MIT focused on physics-based modeling and simulation of building energy systems.

Bryan's main R&D focus is evaluating system performance of emerging energy technologies. Projects typically involve rigorous experimental design, followed by a combination of laboratory and field testing of advanced energy products or services. Sample technologies include smart thermostats, advanced boiler controls, steam radiator retrofits, phase change insulation materials, cool roofs, and a solar-powered net-zero energy elevator concept. In addition, Bryan has led the analysis for multiple survey-based research efforts for the Consumer Technology Association, quantifying the energy used by common electronic devices in US homes. He is an avid user of the R programming language.

Bryan currently leads multiple US Department of Defense ESTCP technology validations for an HVAC analytics platform and for a wireless lighting controls platform. Cybersecurity is a major element of all DoD Facility Related Control System projects. To support government compliance efforts, Bryan is part of a Fraunhofer USA IT working group seeking to unify and improve our corporate cybersecurity practices.

Keliang Wang
Scientist, Fraunhofer USA Center Midwest CMW

Dr. Keliang Wang received his PhD degree from South Dakota State University in 2017, working on carbon-based materials development for energy storage applications. Then, he continued his research on energy storage materials development as a Postdoctoral researcher at Michigan State University (MSU). In 2018, he joined Fraunhofer USA CMW as a Scientist, focusing on plasma technology research and development for applications of water treatment (water desalination and PFAS destruction) and energy storage (supercapacitor and battery). He has authored over 50 peer-reviewed papers in several highly-respected professional journals and holds two US patents.

His current research is mainly focused on plasma processing technology, which can be used for biochar activation, functionization, and PFAS destruction. The featured plasma activation technology can tune the biochar surface to be either hydrophilic or hydrophobic, demonstrating a great potential in desalination and oil/water separation. Under the fund support from Department of Interior and MTRAC, a scale-up rotary plasma system is developed with the cooperation of faculty at MSU. The proposed plasma destruction of PFAS also shows amazing effectiveness, allowing the destruction of the persistent PFAS species into harmless compounds in an economic approach. He is also interested in energy storage and would like to utilize the advanced coating technologies at Fraunhofer USA CMW to develop high-performance all-solid-state energy storage devices.

Sebastian Wicklein
Lead, Corporate R&D Coordination, Fraunhofer USA

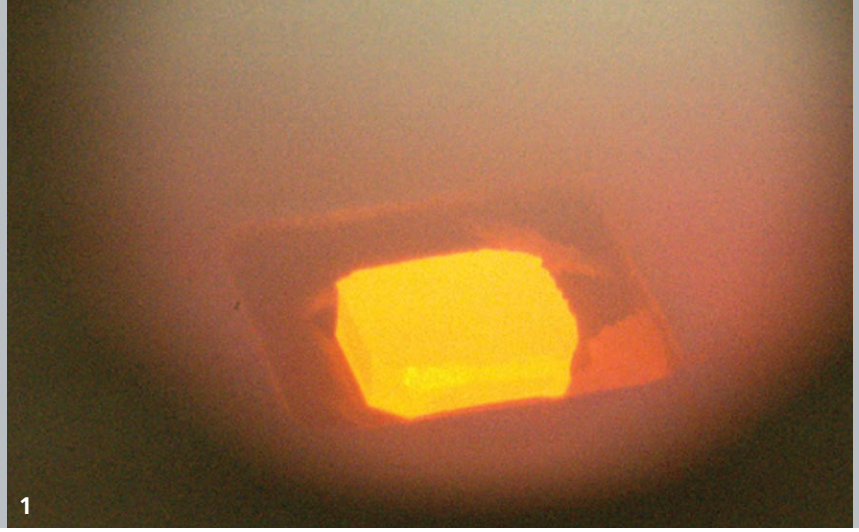
Dr. Wicklein earned a Master's from the University of Applied Sciences Aalen with a degree in materials science and surface engineering and a PhD from the Christian-Albrechts University in Kiel, Germany. He has a comprehensive knowledge of technology and device development and process integration, thin film technology, semiconductor manufacturing and computational materials science. In his position as Lead, Corporate R&D Coordination, he notes "Global challenges such as climate change, resources scarcity and global health and security issues cannot be sufficiently addressed on any national stage, alone, or by large global corporations. Fraunhofer's mission is to address these issues. That is why I joined Fraunhofer USA. My mission with Fraunhofer USA is to facilitate meaningful connections for R&D collaborations and to coordinate our efforts on important topics to increase Fraunhofer USA's relevance in the world's largest and most competitive R&D market. Some of my most important duties are to monitor, support, measure and evaluate all Fraunhofer USA R&D activities, represent Fraunhofer USA in R&D related endeavors, organizations and alliances and help develop our corporate R&D strategy. I firmly believe that to be truly innovative, the process of research and technology development requires not only technical ingenuity but also the free flow of talent, ideas and capital in our human network. Therefore, to build a successful innovation ecosystem, we need to cultivate a diverse talent portfolio, build trust across social barriers, build long-term motivation and promote collaboration and experimentation among all individuals."

SELECTED R&D PROJECTS

Building Early Awareness and Interest in Engineering Careers (E4USA)

Since late 2018, Fraunhofer USA Center Mid-Atlantic CMA has collaborated with the University of Maryland (UMD) in College Park, Maryland, as part of a cross-functional team to build early awareness and interest in careers in engineering disciplines (STEM) among high school students with a particular emphasis on women and minority communities. The Engineering for US All (E4USA) project, funded by the National Science Foundation (NSF), and led by UMD, incorporates distance learning technologies such as a web-based E4USA learning tool developed by Fraunhofer USA CMA. After successful installation of the learning tool in several high schools during 2020, it will be rolled out nationwide to thousands of high schools and colleges in the years to come. The core of the learning tool is the E4USA rubric (a scoring guide used to evaluate students and students' submissions). The E4USA rubric methodology is unique in that it aims at motivating pre-college students to work in the field of engineering. The requirements for the implementation of the tool with the E4USA-specific rubric are: 1) A modern user interface; 2) Tool integration with the with existing learning management systems (LMS), such as Canvas. 3) Scalability: The system will need to serve a larger number of concurrent users. To address these requirements, Fraunhofer USA CMA developed a scalable and highly available architecture for the tool that includes an interactive user interface (UI) and multiple back-end services. System design allows a user to operate the rubric as needed by UMD and its partners. The system is currently being used in multiple high schools across the country with new schools signing on each month.

As a follow-up to the project's initial launch, Fraunhofer USA CMA is working with UMD to investigate the feasibility of a pioneering human-machine learning and teaching innovation for E4USA. The proposed work, entitled "Assist Educators with Student Scoring (ASSESS), will leverage the E4USA methodology rubric to develop a powerful scoring system to differentiate performance levels for engineering design-based projects using mature Natural Language Processing (NLP) and Machine Learning (ML) processes. AI/NLP algorithms backed by ML will bring a transformative change to student assessment activities in engineering design by delivering solutions for AI/NLP-aided screening, assessing, and expediting of the student engineering design portfolio scoring process for teachers. The ASSESS team is a collaborative effort with expertise in learning sciences, education research, computer and information science and engineering, design, curriculum and instruction, and ethics. Methodologies employed will collect student engineering design portfolio and rubric scoring data from the E4USA program and university level design courses; experts will score the student portfolios, and the resulting data will be combined to inform training of the ML algorithms in the existing NLP application. The overarching goals of the proposed work are to design a hybrid machine-aided evaluation testbed with tools to help teachers to 1) Create standards of formative assessment via AI/NLP-aided identification of key passages in student portfolios; 2) Reduce uncertainties in the student portfolio scoring process, and 3) Ease teachers' workload. The impact on teacher-learning and the delivery of student instruction will be assessed. Careful attention will be paid to the possible roles of bias – reducing its presence in the ML models – and other ethical considerations. Future applications of ASSESS research leveraging AI/NLP tools for student portfolio evaluation based on rubric standards have wide-ranging implications in engineering education and beyond, presenting unprecedented opportunities to benefit society by investing in the US engineering workforce pipeline on design-based, problem-solving approaches.



Growing Diamond Crystals with Artificial Intelligence

Fraunhofer USA Center Mid-Atlantic CMA and Center Midwest CMW are collaborating on developing AI models to drive defect prediction and micron-scale growth analytics for single crystal diamonds in controlled chemical vapor deposition reactor environments. As part of the overall target objective, if the lateral size of the diamond being synthesized can be increased to 2-inch by 2-inch, it has the potential to revolutionize applications in microelectronics, electric grid, communications, and quantum information technologies. Understanding the growth process in diamond manufacturing is extremely complex, involving high-dimensional environmental and input state parameter setups. Due to the sequential nature of dependencies between diamond growth states, the more states that are added over time, the larger the number of time dependent parameters affecting the resulting growth state. Our work in the project entails developing deep-learning models to capture the spatio-temporal growth in diamonds over two steps: 1) Develop segmentation models to isolate accurate pixel masks of both the diamond and pocket holder 2) Develop accurate models of micron-scale growth in single crystal diamonds using reactor input parameters across sequential time states. Fraunhofer USA CMA and CMW solved problems with diamond contour detection using a deep-learning approach based on semantic segmentation and automated feature/label synthesis. Using a set of only 20 image/segmentation mask pairs of the diamond and pocket holder, the team used computer vision algorithms to generate 30,000 images containing variations in size, shape and orientation with both objects. The set of fully convolutional models is used to classify every pixel in an image as being part of the diamond, pocket holder or background. The pipeline does not require voluminous training data and performs extremely well on unseen test images (mean pixel identification accuracy of ~99.8, ~99.44 and ~99.66% for the background, pocket holder and diamond pixels respectively).

NASA Space Network Ground Segment Sustainment (SGSS)

From 2009 to 2021, Dr. Frank Herman, Managing Director of the Fraunhofer USA Center Mid-Atlantic CMA, has served as a senior technical consultant to NASA on software development for the Agency's Space Network Ground Segment Sustainment (SGSS) Program. The SGSS mission is to implement a flexible and extensible ground segment that will allow the Space Network (SN) to maintain a high level of service in the future, accommodate new users and capability requirements, and reduce the effort required to operate and maintain the system in the future. The SGSS project has the responsibility to update the SN's ground segment infrastructure, including two ground stations at the White Sands Complex in New Mexico, a Tracking and Data Relay Satellite (TDRSS) terminal at the Guam Remote Station, and a TDRSS Terminal at the Blossom Point Ground Terminal in Maryland. The aging hardware and software at these sites became increasingly difficult to sustain and maintain – posing substantial risks to the highly-reliable service that has been provided for two decades – and required replacement. Additional issues included: the ground system architecture had aged, with its operation and maintenance staff intensive, and unable to accommodate future demands for expanded capabilities in the management and movement of satellite-relayed information. In 2009, NASA turned to Fraunhofer to help the Agency oversee this effort, as an upgrade of this magnitude, while simultaneously maintaining operational viability, had never been performed. Over the years, Fraunhofer USA CMA played a major role in the development of SGSS software by researching and applying new and innovative approaches for the mitigation of risk associated with development, integration, testing while transitioning to the SGSS system. This included researching and transferring the most effective techniques from NASA, government, and industry best practices to the development of SGSS software subsystems and developing models such as defect prediction, operability maturity, etc.

1 *© Fraunhofer USA, Single crystal diamond being grown at Fraunhofer USA CMW with artificial intelligence.*

The NASA Space Network Ground Segment Sustainment project implemented critical upgrades to space communications infrastructure. These upgrades modernized the Space Network (SN) ground stations and improved many of its capabilities. SGSS's upgrades enabled increased customer data rates and volume. And as technology improves, the SN will be able to gather much more data, for example, capturing images from space with higher resolution. This enables the scientific community to perform more in-depth research and allows the transfer of this data to communities of interest much faster than before. These upgrades improve data quality, which means fewer errors and data gaps during data transmission. Upgrades also improve customer coverage, so that missions e.g., Space Station, SpaceX, etc. can stay in contact with their spacecraft more frequently. Reduced maintenance requirements and extended system longevity will make it more cost effective for NASA to operate ensuring the Space Network will remain a viable communications network for many years to come. Development and transition to operations to the Space Network has now been completed.

In April 2019, Dr. Frank Herman announced his retirement from Fraunhofer USA CMA following many years of service. The Fraunhofer USA team thank him for his friendship and service and wish Frank and his family all the best in his next life chapter.

Controlled Release Thermostable Formulations

Over the last three years, the Fraunhofer USA Center Mid-Atlantic CMA has been developing spray-dried formulations of biopharmaceuticals with improved stability at elevated temperatures. Working with the NIH, the Center has applied this approach to an anthrax vaccine candidate that includes a protein subunit antigen and a saponin-based adjuvant. Lead formulations showed greatly improved stability extending out over at least several months at ambient temperatures, and even at elevated temperatures, exceeding any likely to be encountered in supply chains for worldwide distribution. Importantly, the formulations were shown to be of equivalent immunogenicity to the comparator formulation comprising soluble antigen and adjuvant. Building on these developments, Fraunhofer USA CMA is extending this work to vaccine candidates to combat COVID-19 with interest from the US Government (project pending). Recently, the Biotechnology Division has further progressed the anthrax vaccine spray dried formulations to develop multi-layer versions designed for the controlled release of the vaccine after administration, such that a single administration can result in the delivery of multiple doses. Such formulations are currently being evaluated in animal studies with the NIH and a patent on this technology was filed in late 2020. Furthermore, scientists at the center are working with partners at the Fraunhofer Institute for Biomedical Engineering IBMT on better controlling the production of these delayed-release formulations.

1 *NASA Tracking and Data Relay Satellite.*

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Neonatal Intensive Care Incubator with Disposable Housing

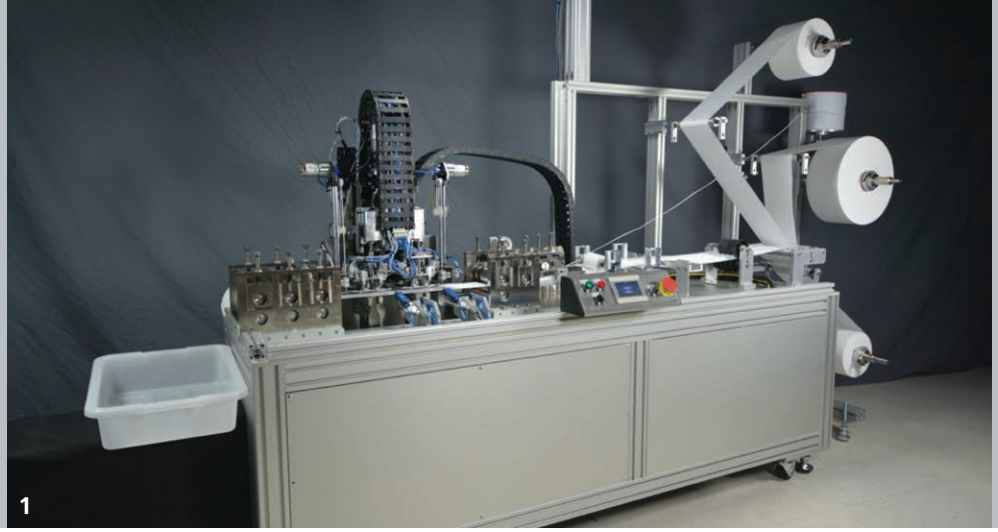
Breegi Scientific's infant incubator is engineered to be the first multi-functional neonatal intensive care unit incubator that is both disposable and low-cost. It has been designed to be user-friendly and energy efficient requiring only minimal maintenance while supporting neonatal health and survival. Overall, the device is less than 1% of the cost, size, and weight of a standard hospital incubator which will allow for broad use in low-resource communities. Fraunhofer USA Center for Manufacturing Innovation CMI is focusing on designing a heat and humidity unit that keeps the incubator tent environment at a steady state while maximizing energy efficiency and minimizing costs. The heat and humidity unit is a small detachable box comprised of an air filter, a fan, a heating unit, and an ultrasonic humidifier. Clean, filtered air is delivered to the heating unit and humidified before exiting into the infant enclosure tent. The heating unit regulates the temperature inside the tent structure up to 37°C +/- 0.5°C across 30-minute intervals. Temperature sensors inside the tent structure deliver feedback on current temperatures in a closed loop format. The second critical component is the ultrasonic humidifier which provides relative humidity levels that can be regulated by the user through the controller.

© Fraunhofer USA, Fraunhofer USA created heat and humidity unit for Neonatal Intensive Care Incubator.

Mass Customization of Panel Blocks For Deep Wall Insulation Retrofits

The Fraunhofer USA Center for Manufacturing Innovation CMI at Boston University was selected by the US Department of Energy's (DOE's) Building Technologies Office (BTO) to pursue building technology innovations to "unlock deeper energy savings in the US building sector, which still consumes 40% of the nation's energy and 75% of its electricity." Fraunhofer USA CMI is developing an integrated deep wall-insulation retrofit process that uses customized, prefabricated insulated panel blocks, along with a cost-effective installation process that uses augmented reality (AR) to reduce onsite labor. This is in line with DOE-BTO's interest in developing "new technologies that can enable superior building energy performance, without disruption to occupant comfort, and can be deployed quickly and affordably, with minimal onsite construction in the existing building stock, as well as new construction." The proposed system uses lightweight (less than two kilograms) insulating foam blocks based on a design that has been deployed in the harsh Antarctic environment. The complete integrated panel block fabrication and installation process is envisioned as follows: (1) Using scanning technology to generate a high-resolution 3D model of the existing exterior façade of the home; (2) This 3D model feeds into a CAD (computer-aided design) program that determines the geometries of the panel blocks that will clad the existing façade, fitting around features such as doors, windows, vents, etc. (3) The panel-block geometries feeds an automated manufacturing process to automatically fabricate and kit the complete panel-block set needed to clad a home. (4) Using AR glasses, the installers identify and pick up a panel block. As they look at the house, they see in their glasses a projection of that panel block superimposed on the existing façade that guides them exactly where to install each block to ensure that all blocks fit perfectly. Although robots could potentially install the panel blocks instead of people, that would not be a cost-effective solution for the residential market. Instead, our method empowers workers and improves efficiency.

1 *© Fraunhofer USA, Fraunhofer USA Engineer aligns panel blocks for Deep Wall Insulation using AR glasses.*



On-Demand Manufacturing of Surgical Masks

Fraunhofer USA Center for Manufacturing Innovation CMI has developed a concept for a compact, high-speed automated machine capable of producing 3,000 surgical masks per hour. The machine uses a fully-continuous process with all operations, including ultrasonic welding, ear loop attachment, separation, etc., all performed on-the-fly. It is based on the operating principle of a flying cutoff saw. This allows the entire mask production process to be performed on a single machine under 3 meters in length. It is envisioned that every hospital and other organization can have such a machine on its premises, and be able to produce, on-demand, as many masks as necessary each day.

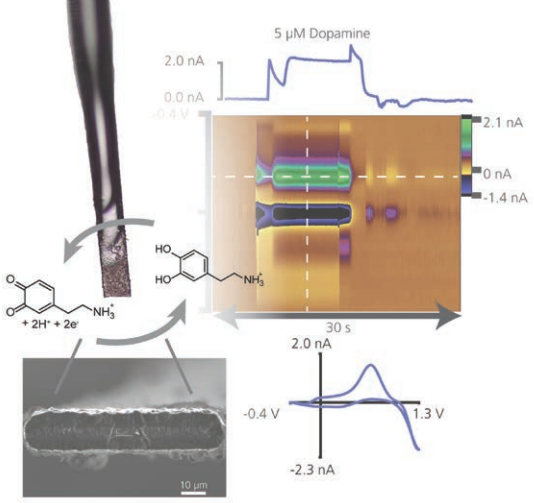
Future Manufacturing – Artificial Intelligence Algorithms for Crystal Synthesis

Fraunhofer USA Center Mid-Atlantic CMA and Fraunhofer USA Center Midwest CMW, in collaboration with Michigan State University, successfully attracted a Future Manufacturing Grant of the National Science Foundation (NSF). The project entitled "Designing Artificial Intelligence Algorithms for Insitu Predictive Crystal Synthesis" seeks to develop deep learning AI pipelines aiding materials manufacturing processes. Chemical Vapor Deposition (CVD) was chosen as a method to develop these AI pipelines as it is a broadly employed manufacturing technique to grow high-quality power semiconductor materials for power conversion in electric grid, hybrid/electric vehicles, and wireless communications, etc. The project is tailored to overcome the current reactive modus operandi to AI driven predictive material synthesis reducing development time by leveraging in-situ data to detect macro and microscopic defects, predict future states of the material, and guide the process towards desired (e.g., defect free) states. Diamond power semiconductor material was selected as a test bed for its process similarities to SiC and GaN, and its potential to revolutionize the power semi-conductor and larger power electronics markets. This project will advance previous successes of the deep learning AI pipelines to detect and predict future states of macroscopic defects by increasing in-situ data resolution and volume and correlating in-situ data with ex-situ data to detect microscopic defects. From this project, feedback loops will be implemented to enable full process control with AI to be more broadly implemented through research collaboration with industry partnerships like Automation Alley.

Diamond Micro-Fibers for Brain Research

Fraunhofer USA Center Midwest CMW and Michigan State University have been collaborating on an NIH funded projected titled "Microfabricated all-diamond microelectrode arrays for neurotransmitter sensing and extracellular recording". The goal of this project is the targeted development of diamond based neural probes to facilitate the discovery of new biomarkers and therapeutic targets for neuro-degenerative diseases (e.g., Parkinson's Disease), mental health disorders, and drug addiction. Additional collaborators include the University of Wisconsin Madison and the University of North Carolina. Long-standing challenges this field has faced have been material biocompatibility, hermetic packaging, physical dimensions, and mechanical compliance of implantable electrodes. The major challenges for in vivo electrochemical neurotransmitter sensing are poor target selectivity, poor signal-to-noise ratios, limited electrochemical channel counts, device fouling, and degradation over time. Achieving high-density, electrical, and chemical detection of an individual neuron's activity in real time will require a sophisticated sensing interface technology that is highly-sensitive, selective, scalable, biocompatible, and stable. Specific objectives of this project are 1) Develop innovative engineering techniques for material and device design and fabrication that push the spatial resolution of diamond electrodes to sub-micron and micron scales; 2) Develop a scalable strategy to integrate miniaturized head-mounted electronics with diamond electrodes to achieve large-scale, high-density, three-dimensional (3D) diamond electrode arrays; 3) Systematically evaluate the functionality, biocompatibility, and long-term stability of the diamond electrode arrays both ex vivo and in vivo. This project has a total funding level of $3.2M over a period of five years.

1 *© Fraunhofer USA, Fraunhofer USA mask production system.*



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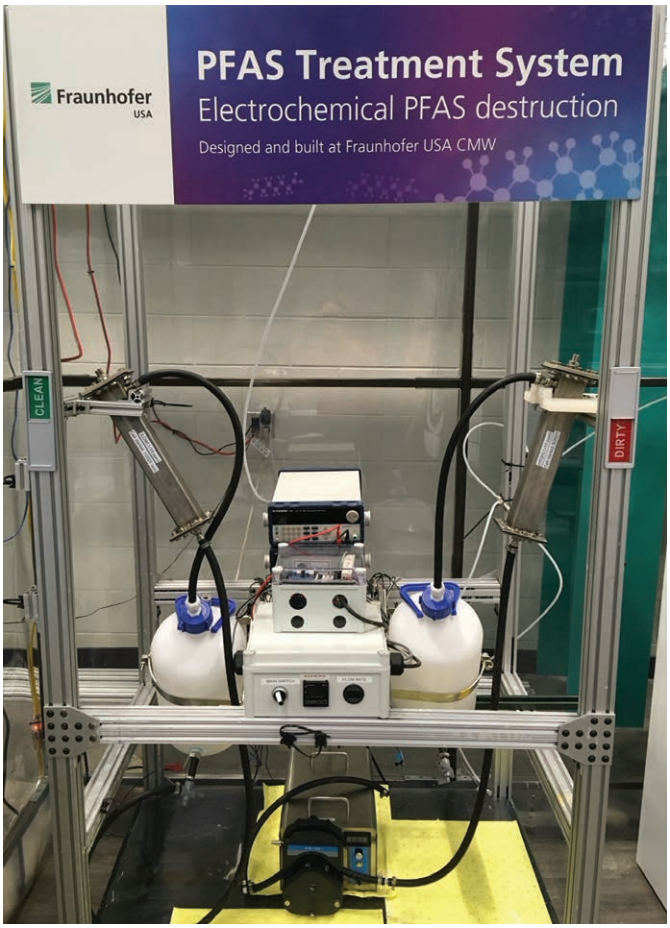
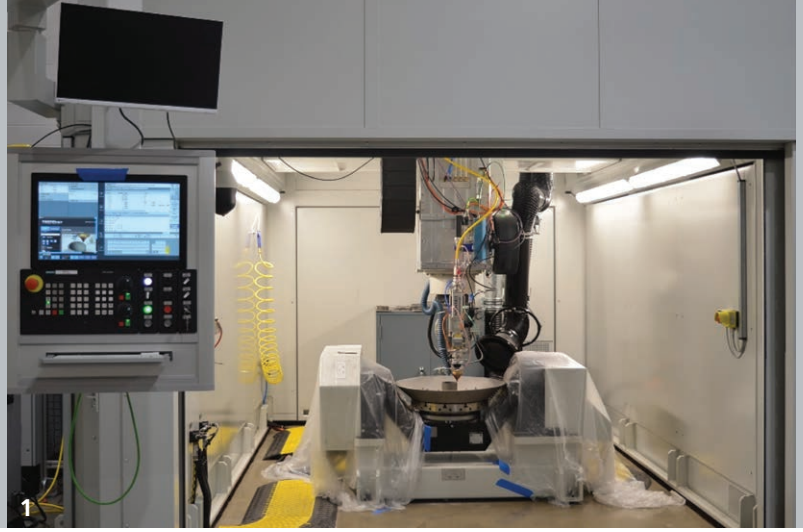
Remediation of PFAS Contaminated High Ionic Strength Aqueous Solutions

The City of Grand Rapids Michigan is funding the project "Electrochemical remediation of per- and polyfluoroalkyl substances (PFAS) in landfill leachate and other complex matrices". In this project Fraunhofer USA Center Midwest CMW works with the Grand Rapids Water Resource Recovery Facility (WRRF) to address PFAS contaminated landfill leachate and other high ionic strength aqueous solutions. PFAS are bio-accumulative recalcitrant compounds that can cause various health issues. The extreme stability of PFAS under environmental conditions has rendered remediation methods such as biodegradation, photo-oxidation, hydrolysis, and direct photolysis ineffective. While processes such as granular activated carbon adsorption, ion exchange, reverse osmosis and membrane filtration are capable methods for most PFAS-impacted waters, a more complex sample environment such as landfill leachate or industrial wastewater could pose issues. Electrochemical oxidation utilizing boron-doped diamond electrodes showed great promise to degrade PFAS. Scientists at Fraunhofer USA CMW aim to develop an electrochemical treatment protocol for PFAS contaminants in complex water systems. This includes the direct electrochemical treatment of raw landfill leachate, but also the investigation of electrochemical oxidation as a secondary treatment for concentrated PFAS solutions, such as reverse osmosis rejects, ion exchange regenerates and nanofiltration retentates.



Dual PFAS treatment setup for low (left cell) and high (right cell) PFAS concentrations.

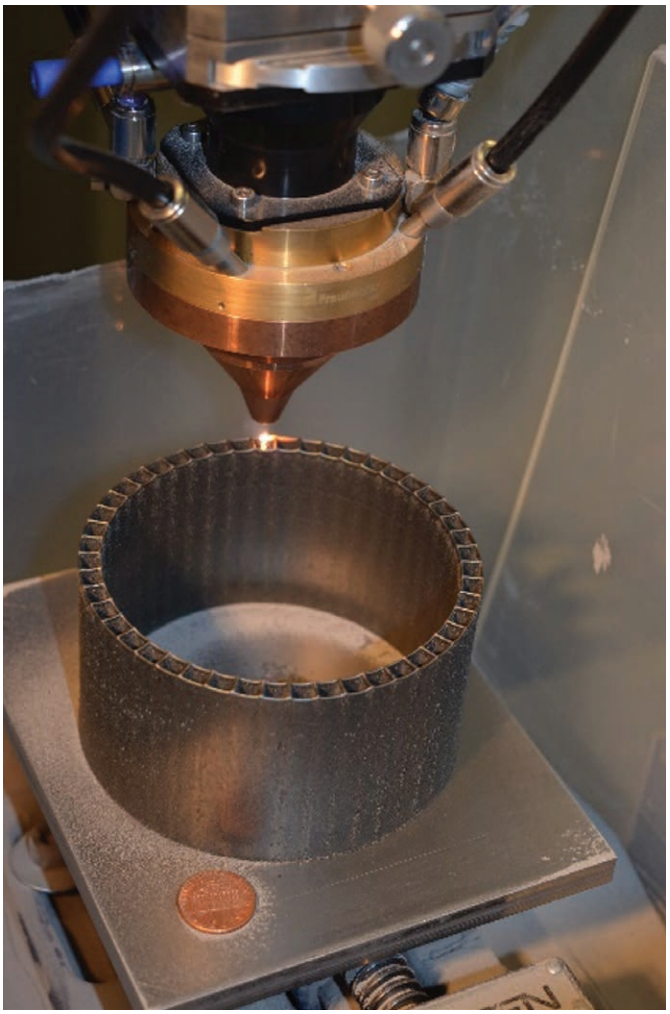
1 © *Fraunhofer USA, Real-time dopamine detection on an all diamond microelectrode [with an electroactive area of 50 µm x 4 µm].*



Laser Additive Manufacturing of Aerospace Components

The Laser Division of Fraunhofer USA CMW has been active for many years in laser cladding and additive manufacturing research for aerospace applications. Pilot robotic laser metal deposition systems have been developed and installed at several large aerospace companies and a system was developed for GKN Aerospace which was installed at Oak Ridge National laboratory. Applications have ranged from additive manufacturing of titanium structural aircraft components to development of processes for the production of rocket engine components.

Auburn University and NASA have recently been working with the Laser Division on laser direct metal deposition process development as part of their Rapid and Analysis Manufacturing Propulsion Technology (RAMPT) program. Sample parts are being built using a new state-of-the-art machine from Arnold Machine Works GmbH in combination with a Fraunhofer IWS Coax® 14 powder deposition head at the Laser Division facility, as seen in Figures 1 and 2.



© Fraunhofer USA, Figure 2. Sample part with integrated cooling channels build using direct laser metal deposition.

1 *© Fraunhofer USA, Figure 1: Arnold Machine Works GmbH state of the Art 7 axis CNC laser machine for direct metal deposition additive processes recently commissioned at the CMW Laser Division.*

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Unique Plasma Source For Advanced Thin Film Manufacturing Processes

Scion Plasma LLC, a spin-off company from partner University Michigan State University, in collaboration with Fraunhofer USA Center Midwest CMW, has made significant progress in developing a single beam ion source technology, enabling high-rate deposition of high-quality thin films at low temperature. Ion sources are plasma generation devices that enable ion beams to interact with materials at the atomic level as they are deposited. The deposited films have densely packed structures with tunable morphology, physical characteristics and superior stability. Conventional ion sources either generate ions with energies too high or are incompatible with reactive gases. Magnetron sputtering is the most widely used technology for depositing thin films. However, sputtering has limitations – the deposited atoms have loosely packed structure. Therefore, slow deposition at high temperatures is required to produce high quality thin films, leading to increased manufacturing costs and material selection limitation. The Fraunhofer USA Center Midwest CMW is working together with Scion Plasma to enhance magnetron sputtering deposition of thin films utilizing a proprietary and innovative single-beam ion source technology. Highly transparent and conductive indium-tin oxide (ITO) thin films have been produced at room temperature. The single beam ion source enhanced sputtering leads to 30% increase in the ITO deposition rate without compromising the film quality, providing an attractive approach to cost-effective manufacturing of thin film products. Currently the team is working on scaling the ion source to a length of 250mm for photo-voltaic applications. The ion source will be incorporated into an industrial in-line coater for demonstration of high-quality ITO coatings uniformly covering 6'' wafers at double the deposition rates when compared to conventional sputter systems. The ion source enhanced sputtering can be used for the production of a broad variety of thin films used in solar, displays, glass coatings, optical coatings, thin-film batteries, wear-resistant coatings, barrier coatings, and many more technical products. Upon lab-scale validation of the single beam ion source enhanced sputtering, the team has started working with leading solar manufacturers and vacuum equipment manufacturers to scale up this ion source technology. This technology is developed with support from the Department of Energy and National Science Foundation.

1 © *Fraunhofer USA, Vacuum deposition system housing unique single beam ion source technology.*

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Kromer, M, Roth, K, Yip, T. "Optimizing DER Dispatch in a Renewables Dominant Distribution Network Using a Virtual Power Plant." IEEE Power and Energy Society General Meeting. Aug 2020.

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FRAUNHOFER USA CENTERS

FRAUNHOFER USA CENTER MID-ATLANTIC CMA

The Fraunhofer USA Center Mid-Atlantic CMA was formed in late 2020 by merging the former Fraunhofer USA Centers for Experimental Software Engineering CESE (founded in 1998) and Molecular Biotechnology CMB (founded in 2001). The former centers were reorganized to form the software and system engineering and biotechnology divisions of the new center.

Scientific Focus and Strategy

Fraunhofer USA CMA develops and uses innovative, effective, and scalable approaches to software and systems engineering, delivers powerful testing and verification strategies and tools, uses state-of-the-art measurement and code analysis methods, and develops and tests artificial intelligence-based systems. In the field of biotechnology, the center focuses on the development of applications with an emphasis on human health such as the development of thermostable formulations of target pharmaceuticals.

Combining biological and computer sciences at the center aims at developing new competences in overlapping scientific fields such as bioinformatics to obtain a unique advantageous technology position and enable the center to explore new market segments. Both divisions have previously developed successful collaborations with other Fraunhofer USA centers leading to joint projects utilizing competences in the physical, materials and engineering sciences. Seeking the combination of complementary competences across centers is a key strategy for Fraunhofer USA to create sustainable technology leadership.

The center leverages strategic partnerships with the state of South Carolina, the Applied Research Lab for Intelligence and Security ARLIS at the University of Maryland, the National Institute for Innovation in Manufacturing Biopharmaceuticals NIIMBL, and a long-term relationship with the National Aeronautics and Space Administration NASA.

Strategically, the center is planning to improve communications and marketing efforts, to increase the use of transparent key performance indicators, and to maintain prime contractorship on at least one federal contract. For 2021 it is also planned to adjust the facility utilization in Delaware to the needs of the now significantly smaller biotechnology group.

Core Competences

Information and Communication Technologies

- Model-based software and systems engineering
- Software safety and security methods and tools
- Software design and development
- Software process analytics and improvement

Health

- Molecular engineering
- Formulation development
- Metabolic engineering
- Heterologous expression systems

Production

- Pilot scale production under current Good Manufacturing Practice (cGMP)

Research Fields

- Applications, software, and systems infrastructure of AI-based systems
- Internet of Things/Autonomy
- Bioinformatics in molecular biology
- Bioengineered sensors
- Vaccine engineering, formulations, and scaling
- Cell cultures for secondary metabolites

The Fraunhofer USA Center for Manufacturing Innovation CMI was formed in 1994. In 2019 the center absorbed a building energy technology group from the former Fraunhofer USA Center for Sustainable Energy CSE.

Scientific Focus and Strategy

Fraunhofer USA CMI focuses on automation and instrumentation of systems in the industrial, energy, and biomedical technology sectors. Within the industrial technology sector, Fraunhofer USA CMI develops next generation automation systems for the aerospace/automotive, consumer products, photonics, materials processing and renewable energy markets. The center leverages expertise in engineering design and biological sciences to develop cutting edge solutions in the biomedical space, and is active in microfluidics, biosensors, medical devices, tissue engineering, and laboratory automation. Energy systems engineering focuses on building energy systems and grid integration. Building energy systems work develops creative and quantitative means of analyzing and using data generated by an ever-increasing number of communicating sensors in buildings, combined with thermal modeling, to reduce energy consumption. In the field of grid integration, Fraunhofer USA CMI is focused on the development of efficient algorithms for integration of distributed energy sources, such as solar, wind, hydro, storage, etc. into the grid, as well as reduction of strain on the grid through load balancing. A unique advantage of the center is the combination of energy, manufacturing, and biomedical competences. For example, the center leverages its automation and manufacturing expertise to facilitate cost-effective sustainable energy solutions.

Core Competences

Production

- Mechanical and electronic design
- Plant engineering, automation, and instrumentation
- Data acquisition and analysis

Energy and Climate

- Model-based optimization
- Power grid integration of distributed energy sources

Health

- Microfluidics
- Tissue engineering

Research Fields

- Specialized production systems
- Healthcare devices and biosensors
- Building energy envelope
- Energy distribution systems

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FRAUNHOFER USA CENTER MIDWEST CMW

The Fraunhofer USA Center Midwest CMW was formed in late 2020 by merging the former Fraunhofer USA Centers for Coatings and Diamond Technologies CCD and Laser Applications CLA, both of which date back to 1998 and 1994, respectively. The former centers were reorganized to form the Coatings and Diamond Technology and Laser Applications Divisions of the new center.

Scientific Focus and Strategy

Fraunhofer USA CMW performs applied research and development projects in the fields of diamond and coating materials, surface engineering, 3D printing and additive manufacturing technologies, and power laser applications. Projects involve research and development of materials, processes, devices and systems with a focus on bridging the innovation gap between laboratory research and customer applications. Customers include government organizations and commercial clients from multiple sectors such as the manufacturing, semiconductor, biomedical and energy industries. Fraunhofer USA CMW sets a high priority on quality management and is ISO 9001 certified.

Core Competences

Light and Surfaces

- Surface engineering
- Coating processes and systems
- Vacuum and plasma technologies
- Direct energy powder deposition
- High-power robotic laser systems

Materials

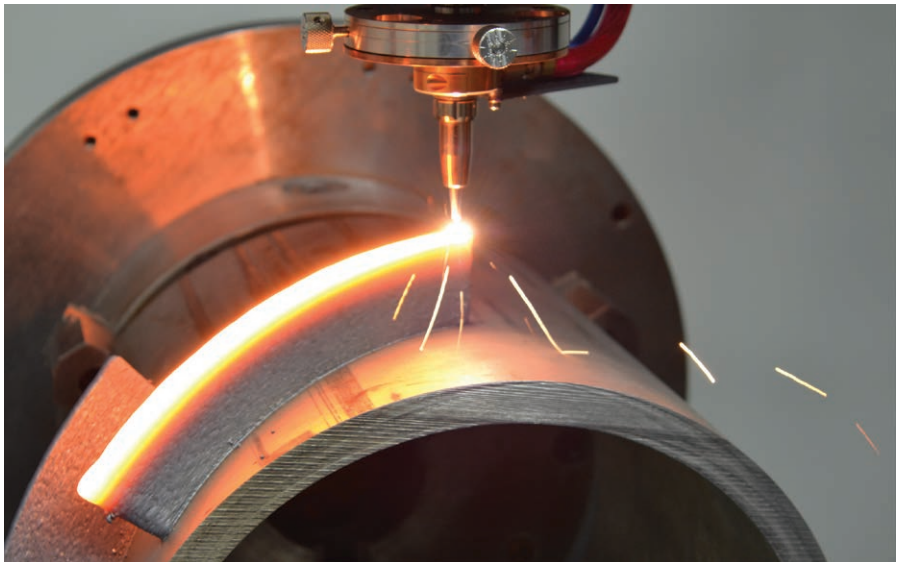
- Coating materials
- Diamond materials and applications
- Materials characterization

Microelectronics

- Electrochemical sensors and methods
- Microfabrication

Research Fields

- Power and radio frequency electronics
- Clean water
- Quantum systems
- Wear, friction and corrosion
- Optical thin films
- Thermal barriers
- Biomedical sensors and devices
- Additive manufacturing and 3D printing



© Fraunhofer USA, Additive manufacturing process at Fraunhofer USA CMW.

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 supports the Audio and Media Technologies division of Fraunhofer IIS in the United States.

For over 30 years, they have been shaping the globally deployed standards and technologies in the fields of audio coding and moving picture production. Fraunhofer IIS systems and tools help create, transmit and provide excellent audio and video content as well as enable high-quality real-time communication. Today, almost all computers, mobile phones and consumer electronic devices are equipped with Fraunhofer IIS technologies and are used by billions of people around the world every day.

It all started with the creation of mp3, then evolved with the co-development of AAC and HE-AAC.

Now the fourth generation of best-in-class audio technologies – MPEG-H Audio, EVS, LC3/LC3plus and xHE-AAC – elevates the media experience to new heights. In terms of audio signal processing, Symphoria and the Sonamic product family provide enveloping and enhanced sound in cars, while the upHear product family dramatically improves 3D audio playback or recording quality of professional and consumer devices. Fraunhofer technologies also power digital radio. First and foremost, in the form of the ContentServer, combining audio encoding, multimedia data management and multiplexing. In the field of moving picture technologies, establishing the Digital Cinema Initiative test plan boosted the creation of professional tools for digital film and media production, such as easyDCP, Realception 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.

Fraunhofer 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.

The current TechBridge program, known as the Carbon to Value Initiative (C2V Initiative), is a unique partnership between Fraunhofer USA, Greentown Labs, and the Urban Future Lab at New York University-Tandon. The three-year C2V Initiative will connect innovative young companies with industry leaders in the chemicals, advanced materials, energy, and other sectors that can provide the resources and market access necessary to enable rapid commercialization of carbontech.

The C2V Initiative will also create a first-of-its-kind collaborative ecosystem among carbontech innovators and leading corporations with the end goal of making carbontech cost effective and achieving its deployment at scale. A select group of corporate, academic, and government thought leaders will be invited to join the program's Carbontech Leadership Council (CLC) to foster commercialization opportunities and to identify avenues for technology validation, testing, and demonstration. Through participation in the CLC, corporations will both advance their sustainability goals, and take a leadership role at the forefront of a new industry, as the world seeks to rapidly decarbonize in response to climate change.

Members of the CLC will create a technology roadmap for the future of the carbontech industry and will also have the opportunity to work closely with the highly-selective first cohort of startups participating in the C2V Initiative.

Program lead partners Fraunhofer USA, Urban Future Lab, and Greentown Labs, have strong experience jointly curating, testing, and launching successful game-changing climate solutions into the marketplace. The combination of incubation space, innovation services, technical testing capacity and knowhow they provide forms the basis of a highly unique and proven technology acceleration model that will now be applied to carbontech as part of the C2V Initiative.

Fraunhofer USA State Alliance Program

The Fraunhofer USA State Alliance Program 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 South Carolina – Fraunhofer USA Alliance

After years of fruitful partnership with the State of South Carolina, including state funding of three research projects between Fraunhofer IESE and selected state universities, the South Carolina Fraunhofer USA Alliance was established in 2018. Following an invitation from South Carolina's Secretary of Commerce, Fraunhofer USA has engaged in this promising alliance with the State's Department of Commerce, industry and local universities. The consortium includes Fraunhofer USA, the South Carolina Council on Competitiveness, Clemson University, the University of South Carolina, and Francis Marion University.

The program developed with the State of South Carolina supporting the Fraunhofer USA corporate mission of providing cutting-edge technologies to companies and organizations of all sizes. The State Alliance Program, now in its third year, offers 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 program works to assist local businesses with the challenges and opportunities presented by rapid technological change in manufacturing processes, product development and service delivery. The State of South Carolina contributes $2M to the South Carolina Fraunhofer USA Alliance per year. Overall, 14 projects have been implemented with a total value of $2.3M, whereby $1.6M were provided by the State of South Carolina and $700K through industry matches. Fraunhofer USA received a total of $1.4M in funding to perform projects, the balance of which went to university partners. South Carolina is a perfect state to begin this initiative as it has over 250 German companies such as BMW, Bosch, IFA, MTU, and more. Since its inception, the Alliance Program team has worked with companies involved in aircraft subsystems, bicycle manufacturing, thermoplastics, appliances, shipping and logistics, telemedicine, auto assembly, and many 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 Alliance Program's 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. The projects address topics in various industry segments including aerospace, automotive, life sciences, and logistics. The technical areas include wearables, artificial intelligence, Industry 4.0, advanced quality management, and robotics.

Innovation Projects Supported by the South Carolina Fraunhofer USA Alliance

TECHNICAL AREA	SC COMPANIES/AGENCIES	LEAD INSTITUTE/OTHER
Telehealth & Data Analytics		
Assembly Defect Detection Using Wearables		
Production Line & Workflow Optimization		
Wire Harness Automation		
Cloud-Based Data Platform	DATOS TECHNOLOGIES	
Machine System Integration	SIEMENS, Heraeus	
Advanced Visual Inspection System	SAMSUNG	
Development of Cloud-Based AI Platforms		
Implementing Industry 4.0	Rexroth Bosch Group	
Robotic Guided Fixture Loading		
Predictive Analysis of Manufacturing		
Business Readiness for Vaccine Production	nephron	
Proactive & Automated Material Control		
Fuel Cells Manufacturing	JTEKT	

As the program is still in its initiation phase, more marketing efforts are planned.

South Carolina focuses on manufacturing and has made big strides in the past two decades to attract major manufacturers in the automotive, medical device and aerospace industry sectors. The alliance funding, by design, supports the acquisition of industry projects for Fraunhofer USA. This is a very useful model for Fraunhofer USA to support SMEs with applied research and development efforts, which is our core business.

FRAUNHOFER USA PARTNERSHIPS AND COLLABORATIONS

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, $1.096B combined research expenditures in FY19 with the University of Maryland, Baltimore.

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. Michigan State University is a top 100 global research university, with total research expenditures for MSU totaled approximately $725M in 2019. Fraunhofer USA CMW collaborates closely with the College of Engineering and Natural Sciences.

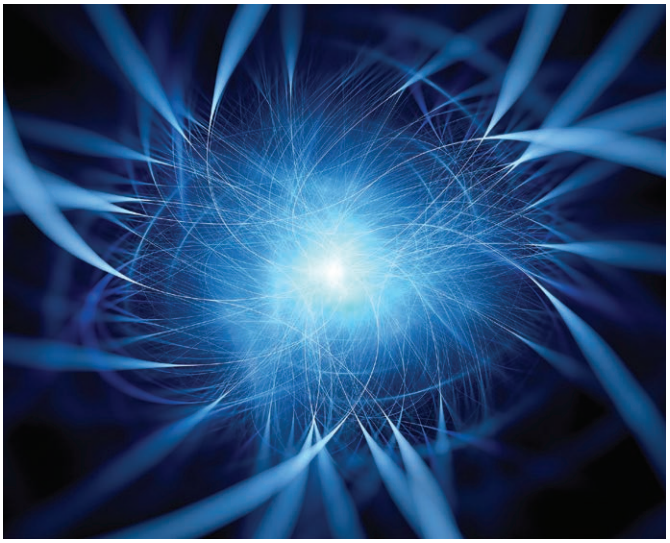
Boston University: The Fraunhofer USA Center for Manufacturing Innovation CMI has collaborated closely with Boston University (BU) since the center's inception in 1995. The center is located on the BU Charles River campus. Boston University has a student body of approximately 34,000 students of which circa 16,000 are graduate students. As a leading global research institution, BU has been awarded over $560M in grants and contract awards in 2021. 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.

American National Standards Institute ANSI

Fraunhofer USA is a member of ANSI and supports interests of the Fraunhofer-Network in standardization matters in the United States.

Automation Alley

Automation Alley is a World Economic Forum Advanced Manufacturing Hub (AMHUB) and a nonprofit Industry 4.0 knowledge center with a global outlook and a regional focus. Based in Michigan, Automation Alley is very well connected to manufacturing companies throughout the midwestern US providing its more than 1400 members the knowledge necessary to adopt new Industry 4.0 technologies. Fraunhofer technical experts will have the opportunity to present new technologies to the members of Automation alley through seminars, presentations, and at their yearly international conference Integr8.



Association of University Research Parks

The Association of University Research Parks (AURP) is the United States' leading organization of universities, municipalities, federal labs, and corporations. It brings together this diverse group of members to foster communities of innovation that provide society with jobs, resources, and technologies. This aligns very well with the Fraunhofer mission to create a better, stronger society through technology. Fraunhofer USA will use the AURP network to help grow the Alliance Program as well as build new relationships with universities and corporations.

German American Chamber of Commerce

Starting in 2021 Fraunhofer USA is a National Partner of the German American Chamber of Commerce (GACC). The GACC is part of a global network of German Chambers of Commerce Abroad (AHKs) who have 140 offices in 92 countries. In the United States more than 2500 German companies maintain memberships with the GACC. The GACC will assist with increasing the awareness of Fraunhofer's presence within the United States as well as providing visiting German delegations opportunities to meet with Fraunhofer experts here in the US.

Ingenuity is Fraunhofer USA's most important asset. It enables the efficient and sustainable transfer of scientific knowledge into commercial use. This transfer is the backbone of our innovation system. The coronavirus pandemic has changed our world. But change brings opportunities. We must gain more sovereignty in key technology areas. We are focusing on strategic research fields to create industry impact in the markets of tomorrow. Now we have the opportunity to become even more resilient than before the crisis. We have the opportunity to not only maintain, but also deepen our skills and expertise, through a targeted push in innovation. We are always seeking new partners to bring these technologies to society. Together, we can emerge from the crisis stronger and better prepared for future challenges. We look forward to changing the world together. Please contact us to get started.

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Cover: © *Fraunhofer USA, Close-up image of the mask production system designed and built by the Fraunhofer USA Center for Manufacturing Innovation CMI.*

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