Fraunhofer
USA

FOCUS 2019

On July 29th, 2019 we exceeded the world's biocapacity for this year, that is, we consumed more water, energy and raw materials than can be replenished by natural resources[1]. The evidence of stressors on our environment and resources is staggering. For example, trillions of cubic meters of fresh water are used globally every year. Ground water is siphoned off, climate change is causing drought, and human encroachment and developments are removing natural water filtering and cleaning areas such as wetlands. Freshwater withdrawals have tripled over the last 50 years. In 2019 the city reservoirs in Chennai, India, a city of over 7 million people, ran dry. This is an alarming and tragic portent of the scale of the issue. Furthermore, 70% of the available fresh water is used in agriculture to ensure food supplies. Simultaneously we continue to pollute. In 2018 we had 4 billion passengers traveling by airplane and current estimates put the number of motorized vehicles on the planet at above 1 billion. Conventional vehicles cause about 100 billion liters of wasted (not used for movement) fuel consumption and associated emissions just to overcome friction within the engine. Meanwhile new sites are being identified that have PFASs-tainted water. PFASs are per- and polyfluoroalkyl substances that are used in clothing, fire retardants, non-stick applications etc. and extremely difficult to destroy and have adverse health effects.

These examples clearly show how the overuse of natural resources, mobility, water and food supplies and health are interconnected and how it is a vital matter of long-term sustainability for our society to use the available resources more efficiently, pollute less and be proactive to mitigate the stressing impact we have on our fundamental life support. Of course, this dire picture created from simple facts seems a challenge too hard to overcome. But society cannot and does not give up. We rely largely on technological progress to address these challenges. Emerging transformative technology trends (e.g. "Renewable Energy", "E-Mobility", "Industry 4.0", etc.) contribute to reducing energy consumption, to improving the utilization of raw materials, to lessening the environmental impact and to improving the quality of life in a steady and sustainable manner.

There is no "magic bullet" to solve the increasing needs for resource management, environmental stabilization and general recovery. These issues must necessarily be tackled in many ways. Fraunhofer USA, as nonprofit applied research and development organization, partners with universities and companies to contribute in many areas, including water, transportation, food supply, health etc. This is what our *Focus 2019* report is all about, to give you a glimpse of what we can do together to take on the challenge. We hope you enjoy reading our project briefs discussing innovation on desalinating water using renewable energy, optimizing trucking logistics through software, developing automated instrumentation that supports efficient industrial agriculture for sustainable food production, PFASs remediation and others.

We understand that it is risky for private companies to invest in early stage technologies. This can impede necessary innovation. At Fraunhofer USA we have applied research and development Centers staffed with technical experts and equipped with state-of-the-art machinery that can help to de-risk such investments. We partner with innovative companies across industries and excellent universities to develop new processes, products and technologies for real-world applications. Our focus is on accelerating the technology transfer to create opportunities for successful businesses. We work with companies of any size and offer value through increasing the readiness level of a technology by proving its feasibility, testing prototypes and validating system performance. Come and talk to us to find out more.

Sincerely,

Thomas Schuelke

Thomas Schuelke
President,
Fraunhofer USA Inc.

[1]https://en.wikipedia.org/wiki/Earth_Overshoot_Day

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MANAGEMENT REPORT

Strategic Development

"Scientists in different disciplines don't speak the same language. They publish in different journals. It's like the United Nations: You come together, but no one speaks the same language, so you need some translators."
– Neil deGrasse Tyson

There is an old joke circulating that once a mathematician, a physicist and an engineer were each given a red rubber ball and told to find the volume. The mathematician carefully measured the diameter with a ruler and evaluated the formula for the volume of a sphere. The physicist filled a beaker with water and submerged the ball to measure the displaced volume. The engineer took the model number from the ball and looked up the volume in his "red rubber ball" handbook. This joke was perhaps meant as a ribbing on the engineers by the mathematicians and the physicists, but it also illustrates the beauty of bringing multidisciplinary approaches together. Clearly, the engineer would have the answer fastest, and that is all that matters in this case.

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, Fraunhofer USA Centers are not only continually working on diversifying their portfolios of expertise by creating multi-disciplinary collaborations across the company, but also involving Fraunhofer affiliates around the globe. Scientific and engineering breakthroughs are often a 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 over and with good reason.

Project teams at Fraunhofer USA are dynamically assembled to match customer demand with expertise. Project managers are tasked with pulling the most suitable combination of scientists, engineers and technicians. In some cases, external advisors might be obtained who are able to provide unique information and expertise. To manage the complexity of multi-disciplinary R&D projects, a fluid and dynamic approach to project management offers the best outcomes for customers. Pulling in the right people when and where needed to tackle the tasks at hand is key to agile project execution. The teams are comprised of existing staff, Center transfers, temporarily assigned staff from partners such as collaborating universities or other Fraunhofer affiliates. With this modular team structure and an iterative and incremental task management approach, Fraunhofer USA aims to achieve maximum R&D flexibility to the benefit of our customer base. Whenever possible, project execution follows the "SCRUM" philosophy, which is an agile framework to manage knowledge work originally created by the software industries. We believe it can and should be successfully adapted to applied research and development activities.

As part of this process, we also recognize the need to continually assess the technology portfolio of Fraunhofer USA. Recently we made the strategic decision to close down operations of our Fraunhofer USA Center for Sustainable Energy Systems CSE and transfer the Building Energy Systems group of that Center to the Fraunhofer USA Center for Manufacturing Innovation CMI. This group will not only continue its excellent research and development in the field, but the merged expertise will now offer even greater potential for the important energy saving aspects of building envelope technologies. Fraunhofer USA will also continue and expand the "TechBridge" program", which was originally developed by Fraunhofer USA CSE and is a successful open innovation and technology validation platform for investors and industry sponsors. TechBridge identifies and de-risks promising technologies. The funding for the TechBridge program is provided directly by public and private sector sponsors. The TechBridge program transitioned from Fraunhofer USA Center for Sustainable Energy Systems CSE to the Fraunhofer USA Center for Coatings and Diamond Technologies CCD.

Operating Objectives

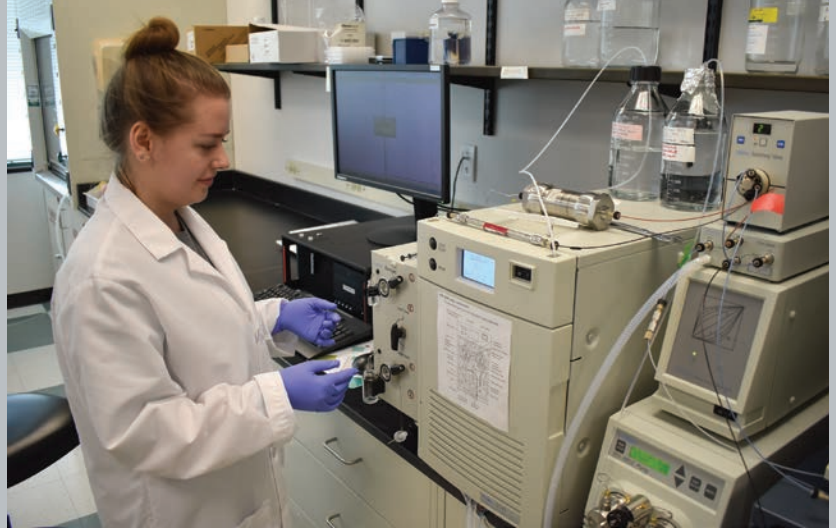
Incorporated in Rhode Island in September of 1994, Fraunhofer USA marks 25 years of operation in the United States in 2019. Fraunhofer USA continues its non-profit mission as we move beyond this wonderful milestone. Fraunhofer USA obtains contracts from customers in industry and the state and federal governments. Our primary focus is applied research and development to advance concepts and ideas from basic research to prototype development and validation. Thus, we aim to bridge the gap between university type research and industrial product development. Our goal is to utilize the know-how, talent, innovation and experience of our staff to partner with companies, agencies and institutions to transform ideas into reality. We contribute to improving and benefitting society.

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

Contract Research

Fraunhofer USA is a contract driven research and development organization. It is through contract research revenue, base funding, donations and grants that Fraunhofer USA acquires the necessary funding to continue its mission. Total Fraunhofer USA consolidated revenue, including undesignated, designated and temporarily restricted is currently forecasted at $39.5 million for FY 2019. 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 really contributing to innovation and progress, not only in their chosen fields but also as interdisciplinary support for colleagues and collaborators.

In the "Research Review" section of this year's Fraunhofer USA *Focus*, we report on some recent highlights. These projects illustrate a range of capabilities but represent only a small portion of the projects worked on. For example, in 2018, Fraunhofer USA Centers actively worked on more than 300 customer projects.



Human Resources

Organizations regularly analyze workforce data. Such analysis is required for a variety of purposes. For example, US companies are required to report on employee demographics to various agencies, including the Equal Employment Opportunity Commission (EEOC). Beginning in 2019, companies must add salary information to required reporting along with demographic data to the EEOC. As a government contractor, Fraunhofer USA also has an affirmative action program, which requires the analysis of incumbency and availability for job groups and reviews of non-discrimination in hiring, promotion and compensation. Through data analysis, we are able to continually work to ensure equal opportunity, non-discrimination and paycheck fairness.

Analysis of staffing levels is an important component of organizational review. At Fraunhofer USA we assess whether we have the appropriate percentages of clerical support, technical support, professional administrators, scientists and engineers that is necessary to run a lean and efficient operation. As a non-profit research and development organization, we realize that too much administration and too much bureaucracy is detrimental to the outcomes we need for our customers. It is our desire and goal to find the balance between enough, but not too much. In this way we provide scientist and engineers with the appropriate framework while also allowing maximum time to work in the lab, to collaborate with colleagues, and to meet with customers.

We recognize the value of our employees and to help ensure that the organization is a productive and compliant workplace. Fraunhofer USA conducts annual on-site training at the Centers. The training covers important information on employment law, workplace rights, safety, and details where employees can go to express any concerns or suggestions. These annual training events are also designed to communicate Fraunhofer USA policies and procedures and to give supervisors tools for improving their leadership skills.

Our goal is to create an environment where our employees feel respected, appreciated and valued. It is the creativity, curiosity, education, experience and dedication that our employees possess that provide the engine to move technology forward.

In the following section "Faces at Fraunhofer" we take the opportunity to showcase some of the many talented employees who contribute so much to helping us fulfill our mission.

© Fraunhofer USA CMB, Intern Chiara Wolfbeisz is getting familiar with chromatography equipment (Waters) used for purification of antibacterial compounds.

Jennifer Jaje
Senior Research Associate, Fraunhofer USA Center for Molecular Biotechnology CMB

Jennifer Jaje earned her Master's Degree in Chemistry and Biochemistry from the University of Delaware in 2007. Her initial research focused on the development of a fusion expression and purification system in E.coli for helix-loop-helix segments of a model G-protein coupled receptor (GPCR), Adenosine A_{2A}. About 30% of current small molecule and biological drugs target this class of membrane protein and so would greatly benefit from improved structure-based drug design. Next, Jennifer focused on investigating the critical roles that disulfide bonds play in cellular processes, including oxidative protein folding. She developed a novel purification protocol for milk sulfhydryl oxidase (mSOX) from its native source (bovine milk), and fully characterized this enzyme both structurally and functionally, yielding both a publication and a patent.

In 2007, Jennifer joined Fraunhofer USA CMB in Newark, Delaware where she has been involved in numerous downstream, characterization and formulation activities. Jennifer has been an integral team member, driving process development, optimization, and biophysical characterization of biopharmaceuticals from discovery to pilot scale for numerous project initiatives, including 4 successfully completed Phase I Clinical Trials. She has contributed to biological product pre-formulation characterization, optimization of bulk drug substance formulation, and accelerated and long-term stability programs. She has also been involved in authoring and executing documentation in support of numerous campaigns for manufacturing processes, in-process monitoring, drug substance release and stability testing. In addition to laboratory work, Jennifer greatly enjoys training and mentoring junior colleagues and interns, supporting their development and future careers.

Gudjon Magnusson
Computer Research Scientist, Fraunhofer USA Center for Experimental Software Engineering CESE

Gudjon Einar Magnusson began a 6-month internship at Fraunhofer USA CESE in June 2013 before returning to Iceland to finish his studies at Reykjavik University (RU). Gudjon received his B.Sc. in Computer Science from RU in 2014, and in September that same year he returned to Maryland to take on a full-time position as a research scientist with Fraunhofer USA CESE. Gudjon's work at Fraunhofer USA has primarily focused on research related to autonomy, artificial intelligence and robotics. He has worked on research projects for federal agencies such as NASA, Naval Air Systems Command (NAVAIR) and Northrup Grumman, as well as commercial projects, involving the application of drones and development of a combination of new software and hardware solutions. Gudjon is currently pursuing a Master's degree in Computer Science at University of Maryland, while also working full time as a research scientist.

Prior to studying computer science and working at Fraunhofer USA, Gudjon studied 3D animation and worked in the small, but growing video game industry in Iceland. Gudjon lives in Rockville, Maryland with his wife, Lauren.

Gudjon comments, "Working at Fraunhofer USA has been a great launch pad for both my academic and professional career. I don't think I could have been exposed to such a variety and scale of projects anywhere else."

Betty Chou

Business Operations Manager, Fraunhofer USA Center for Experimental Software Engineering CESE

Betty Lee Chou started at Fraunhofer USA CESE in October 2015 as a Contracts Administrator supporting revenue, forecast, and proposal tracking in addition to her duties in pre-award and post-award contracts management. After approximately 7 months at Fraunhofer USA CESE, Ms. Chou assumed additional responsibilities in the development of proposals at various levels including creating templates for both technical proposals and cost estimating; advising on pricing, content, and structure; and managing the review and approval processes. At the request of management, Ms. Chou designed and implemented a weekly War Room meeting to track the status of the business development efforts of senior team leads and management. Additionally, Ms. Chou led various stretch assignments such as the migration of data, reorganization, and retention efforts of the internal Sharepoint site; selection and configuration of the Insightly CRM system; and modernization of the company website.

After a little over a year of working at Fraunhofer USA CESE, Ms. Chou moved into the position of Business Operations Manager, supporting executive management, company business, and project planning initiatives. Over time, Ms. Chou assumed the responsibility of managing Fraunhofer USA CESE's internship program to include the recruiting, interviewing, hiring, onboarding, and managing of students from the University of Maryland, Technical Universities of Kaiserslautern and Mannheim, and Reykjavik University. Eventually Ms. Chou also was tasked to perform facilities and office management responsibilities, assisting the Headquarters Finance and Human Resources departments with various functions and becoming a liaison between staff, customers, and other stakeholders.

Ms. Chou played a large role in managing the critical effort to obtain a federally negotiated indirect cost rate agreement in order to continue bidding on and receiving awards for government grants and contracts. More recently, Ms. Chou led and managed efforts to negotiate subleasing agreements with other companies, terminate the existing office lease to right-size the office space, and negotiate terms of a new office lease agreement to reduce costs. Following these efforts, Ms. Chou went on to manage the office relocation effort including the selection, negotiation, and contracting of vendors; design and oversight of the office construction and buildout; and organization and physical relocation of the entire office and staff.

During her years in college, Ms. Chou worked part-time as a Resident Assistant while pursuing and graduating with a Bachelors degree in English. Ms. Chou currently is in the process of completing her first year in graduate school pursuing a Master's in Business Administration part-time as a "Double Terp" at the University of Maryland while maintaining full-time employment at Fraunhofer USA CESE.

John C. Briggs, PhD

Senior Engineer, Fraunhofer USA Center for Manufacturing Innovation CMI

John C. Briggs received his doctorate in Mechanical Engineering from the Massachusetts Institute of Technology (MIT) with a focus on Tribology (study of friction and wear). His early career was at Iomega and was on the team that developed the Zip Drive removable cartridge data storage device. He has worked at other companies focusing on measurement technologies and fiber optics.

His work at Fraunhofer USA CMI has been quite varied from working on the development of an automatic factory for plant-based pharmaceuticals to developing prototypes of a device that incorporates a

fiber optic probe into a needle tip for spectroscopic in-vivo examination of nodules suspected of being cancer.

The last five years have been mostly working with the US Mint developing new processes including pushback blanking of coin blanks. In his spare time, his passion is environmental issues such as renewable energy and electric cars. John occasionally writes for articles for Green Car Reports focusing on issues related to electric vehicles.

Aaron Hardy
Project Engineer, Fraunhofer USA Center for Coatings and Diamond Technologies CCD

Aaron Hardy received his B.S. in Physics from the Lyman Briggs College at Michigan State University (MSU) in 2012 and began working as a lab technician for the Diamond group at the Fraunhofer USA Center for Coatings and Diamond Technologies CCD in 2013. His initial role was to take charge of the diamond polishing operation within the Center and to make improvements to the polishing equipment and processes.

Within a year Aaron was promoted to the position of Project Engineer and became responsible for the microwave plasma-assisted chemical vapor deposition (MPACVD) system, DS1, which is configured to grow heavily boron-doped (p+) diamond. Shortly thereafter, he was tasked with process development to improve the quality of p+ diamond epitaxial layers for the fabrication of diamond-based diodes and transistors in the ARPA-E SWITCHES program: a hugely successful three-year collaborative effort between Fraunhofer USA CCD and the Electrical and Computer Engineering department at MSU.

Now focusing on the ongoing DARPA DREaM program, which aims to develop "millimeter-wave high power density diamond-collector heterojunction bipolar transistors," Aaron's research scope has expanded to include chemical mechanical polishing (CMP) for achieving atomic scale roughness on diamond. While several projects and research tasks compete for highest priority, Aaron maintains that his most important role is to help facilitate communication and collaboration within the Center and with our partners at MSU. Outside of work Aaron enjoys writing and recording music on guitar, and improv jam sessions with his musically inclined friends.

Arkan Abdulkadir
Project Manager, Fraunhofer USA Center for Laser Applications CLA

Arkan Abdulkadir started working at the Fraunhofer Institute for Material and Beam Technology IWS in Dortmund, Germany in 2009 as an engineer's assistant. Arkan received his B.Sc. in Material Science with a concentration in laser welding from the Ruhr-University in Bochum, Germany in 2013.

Arkan joined Fraunhofer USA Center for Laser Applications CLA in Plymouth, Michigan as an intern and worked on his Master's thesis on Additive Manufacturing of large-scale components. The topic of the work was developing strategies for generating graded material components and high-volume 3D structures by laser direct metal deposition.

After receiving his M.Sc. in Material Science from the Ruhr-University in 2015, Arkan accepted a project engineer position at Fraunhofer USA CLA.

Today, Arkan continues to support Fraunhofer USA CLA's research and development team as project manager, where the main focus of his work is laser applications such as laser cutting, welding, and additive manufacturing.

In his free time, Arkan enjoys traveling with his family and riding sport motorcycles.

Yuzhang Yang

Project Engineer, Fraunhofer USA Center for Manufacturing Innovation CMI

Yuzhang Yang received his Bachelor's Degree in Mechanical Engineering and Automation from Southeast University, China in 2011 and Master Degree in Systems Engineering from Boston University in 2013. He joined Fraunhofer USA CMI in July 2013 and has worked on mechanical, electrical and control system design for a number of medical instrument and industrial automation projects.

Highlights include: developing drive mechanisms for a number of minimal invasive surgery instruments, upgrading a Fraunhofer proprietary .NET automation control software framework, and designing a number of vision-based automation control systems. He has recently been involved in developing a high-throughput automated packaging system for the food industry.

Lars Haubold

Manager Coatings Technology, Fraunhofer USA Center for Coatings and Diamond Technologies CCD

Lars Haubold graduated in 2002 from the University of Applied Science in Dresden, Germany with a Bachelor degree in Manufacturing Engineering. Starting in college, he worked at the Fraunhofer Institute for Material and Beam Technology IWS, Dresden as a research assistant in the area of thermal spraying and laser deposition. Shortly after he graduated he joined the former Fraunhofer USA Center for Coatings and Laser Applications CCL in Plymouth, MI (now Fraunhofer USA Center for Laser Applications CLA) before he moved to East Lansing, MI in 2003 to work at the Fraunhofer USA Center for Coatings and Diamond Technologies CCD. His research interest shifted from thick millimeter range coatings deposited at atmosphere to micrometer and nanometer thin film coatings applied in high vacuum.

As the manager of the Coatings Technology group, Lars and his group develop solutions based on Physical Vapor Deposition. With his background in tribological coatings and diamond-like carbon in particular, the majority of applications traditionally focuses on wear and friction applications such as automotive, cutting or forming tools and machine components. More recent activities also include other functional surfaces for energy storage, conversion or saving, consumer and medical products from feasibility studies to pilot-scale production and technology deployment. He thrives in this unique, overlapping field of materials and technologies.

Adopted to Michigan, Lars appreciates the beauty of classic American cars and the state's scenic nature, where he often spends the summers at lakes and camping with his family.

Edward Wazer
Laboratory Director, Fraunhofer USA Center for Energy Innovation CEI

Edward Wazer has been with Fraunhofer USA Center for Energy Innovation CEI since 2016, helping to relaunch the Center with a focus on separation technologies. Ed prepared the preliminary designs and requirements for the new Fraunhofer USA CEI laboratory and office space and coordinated with the contractors during construction. Ed designed the space for high power and high-pressure liquid and gas separation research the Center is and will be performing.

Fraunhofer USA CEI is rapidly expanding and Ed is responsible for overseeing the staff, ongoing projects, the fabrication of membrane separation systems, and the operations of the laboratory. Ed is encouraging and assisting staff in building separation systems that are automated for the efficiency benefits and safety reasons. Fraunhofer USA CEI is building equipment with the technical assistance of Fraunhofer Institute of Keramic Technologies and Systems IKTS, and Ed is coordinating these interactions.

Prior to his position at Fraunhofer USA CEI, Ed worked as an engineer in the aerospace industry with technical focuses in powerplant performance and engine secondary airflow systems.

Ed holds a BS in Electrical and Computer Engineering from UCONN. He and his family run a small-scale fruit, vegetable, and cattle farm. Ed is particularly fond of his own kale salad.

Kathryn Bevington
Senior Accountant, Fraunhofer USA Headquarters

Kathryn Bevington has been with Fraunhofer USA for over 18 years and is a Senior Accountant reporting directly to the Treasurer. She is currently responsible for the financial activities of the Fraunhofer USA Center for Manufacturing Innovation CMI and the Lead Account. In this role, she ensures compliance with the Uniform Grant Guidance, assists in contract administration, submits federal reports, processes month-end and year-end closings, prepares annual budgets and quarterly forecasts, and provides information for the annual audits. She was instrumental in the set-up of a federally compliant accounting system and participated in multiple system upgrades.

Kate received her Bachelor of Business Administration degree with a major in Accounting Information Systems from Eastern Michigan University in 2000. As a student, she had an accounting internship with the Fraunhofer USA Headquarters. Prior to joining the Fraunhofer USA team full-time in 2001, she obtained internal auditing experience from Dana Corporation.

She stays busy outside of work with the activities of her four school-age children. She enjoys being outside and staying active, especially running. She participates in road races and has completed one full marathon and several half marathons.

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

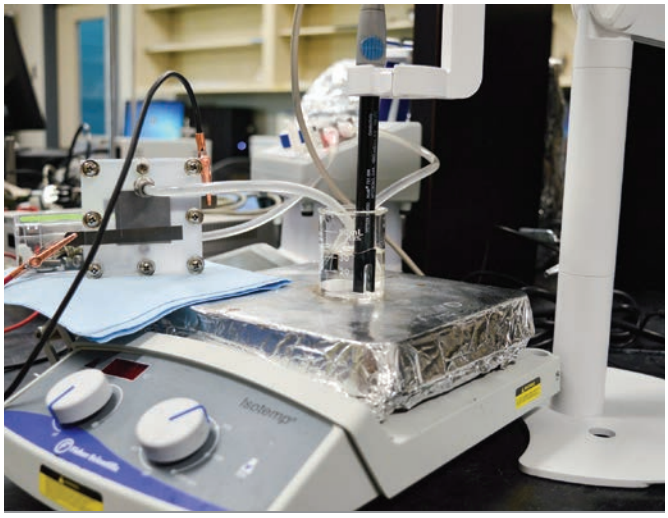
HEALTH AND ENVIRONMENT

Desalination for Drinking Water

A variety of water purification methods have been developed in the past years. These methods include reverse osmosis, ultrafiltration, distillation, electrodialysis, and capacitive desalination. Researchers at Fraunhofer USA Center for Coatings and Diamond Technologies CCD have found that capacitive deionization (CDI) appears promising for water desalination due to its high efficiency and low energy consumption.

Captive deionization technology (CDI) for water desalination uses an innovative plasma-activated biochar. Biochar is a porous carbon material derived from sustainable biomass through pyrolysis. The porous structures make biochar very suitable for the CDI electrodes to electrochemically adsorb the ions. Biochar must be activated to create nanosized pores with large specific surface areas and high-surface energies. The conventional activation requires chemical treatments at high-temperatures using CO_2, steam, or a strong base for over two hours followed by washing and prolonged drying. This energy-intensive and lengthy process is expensive and has become a critical barrier to producing high-performance activated carbon for CDI desalination.

Fraunhofer USA CCD proposes use of plasma to efficiently activate biochar. A plasma is an ionized gas that consists of a large number of reactive species, which can selectively etch certain carbon phases in the biochar to create nanoporous structures. Our preliminary studies strongly support the feasibility of this innovative technology. The research will enhance scientific understanding of the chemical and physical reactions involved in the plasma activation process. Biochar is a sustainable material with abundant resources. Using plasma activated biochar for water treatment can significantly promote the desalination efficiency at greatly reduced materials cost and power consumption. This innovative desalination technology will have a positive impact on the environment and society at large.



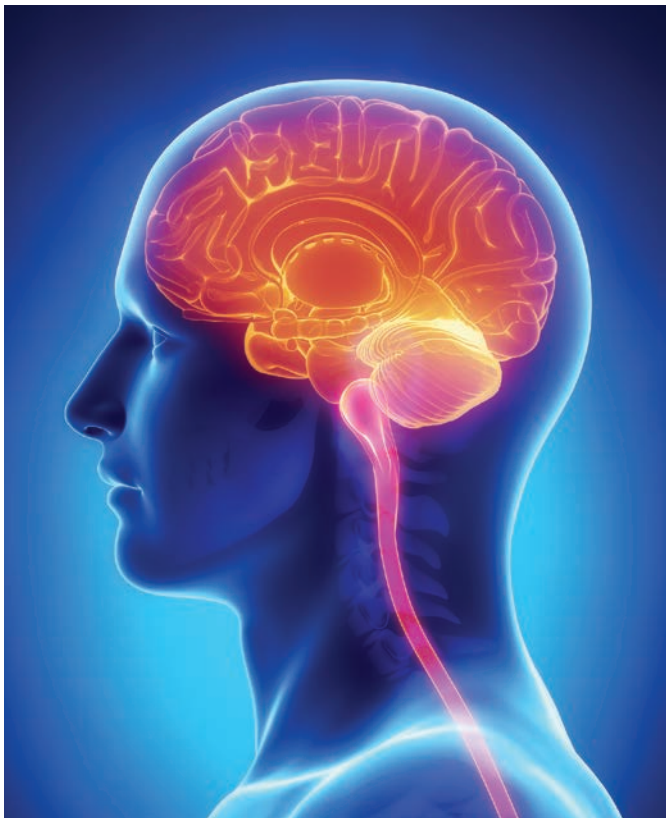
© Fraunhofer USA CCD, The system consists of a pump to keep the brackish water flowing, a cell with two electrodes for processing, a conductivity meter to measure the conductivity, and DC power to provide driving force.

BRAIN Initiative

As part of an approximately $20M National Institutes of Health (NIH) U19 grant, the Fraunhofer USA Center for Experimental Software Engineering CESE is providing software engineering to accelerate and improve scientific research. The U19 comprises a worldwide consortium of computational and systems neuroscientists, physicists and engineers, working to better understand the the human brain. With members from the University of Maryland (UMD), the University of Chicago, the Italian Institute of Technology, NYU, NIH and more, the project's objective is to gain a deep understanding of the basic neuronal mechanisms related to sensation and action. Ultimately, this information could improve the assessment, diagnosis and treatment of many debilitating nervous system disorders.

To do this work, the team's neuroscientists need novel software tools and best practices and need to apply these across multiple geographically distant laboratories. Fraunhofer USA CESE's challenge is thus to enable neuroscience researchers to perform their research faster, better and more collaboratively.

Fraunhofer USA CESE's approach is to build a software and systems platform that enables researchers to easily and safely share software code and data. The platform will integrate software packages and toolsets from different neuroscience researchers regardless of the programming language used. This will allow researchers to create workflows by mixing/chaining these software packages and source code. To do this, the platform incorporates the use of a newly established unified data format "Neurodata Without Borders" to facilitate data sharing and compatibility among the software codebase. To ensure accuracy of the process, the platform will also incorporate metamorphic testing as a way to test and validate the compatibility of newly added, modified modules, or the defined workflow.



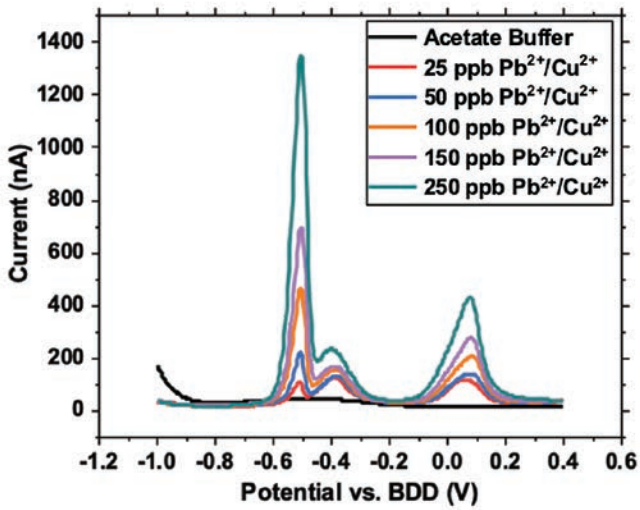
Fraunhofer USA CESE's current platform prototype incorporates multiple software algorithms and is being tested by UMD researchers. Fraunhofer USA CESE expects to distribute the code to other consortium researchers shortly. Dr. Madeline Diep, Senior Research Scientist and Project Lead for Fraunhofer USA CESE's effort, comments, "Our approach and the platform is enabling the digital transformation of scientific discovery. So what we are building has great potential not only for neuroscience, but for any domain where researchers may be geographically separated but can leverage the platform to provide a dynamic collaboration environment that will drive research of many kinds to new results."

Flexible, Wearable Boron-Doped Diamond Sensors for Metals Detection in Sweat

Metals toxicology and the associated health effects is a problem facing many communities across the world. Due to the vast number of exposure routes, the issue has been brought to the forefront of industry and government. Recently, the Flint (Michigan) water crisis saw over 8,000 children exposed to high levels of lead (Pb) in drinking water. In southeast Ohio, people in Washington County have been exposed to harmful levels of manganese (Mn). Chronic exposure to Mn can cause neurological damage in adults and children and can lead to impotence. The EPA recommends not exceeding 0.05 mg/L in water and the OSHA recommends not exceeding 5 mg/m3 in air. However, exposure can reach much higher levels. As such, the call for advancements in research and development to generate tangible solutions to assess exposure has never been stronger.

Biological fluids such as perspiration, saliva, and urine can contain several metal compounds such as lead (Pb), manganese (Mn), nickle (Ni), zinc (Zn), copper (Cu), cadmium (Cd), mercury (Hg), and many other disease biomarkers as well. Concentration ranges are broad (1 ppb - 1 ppm) and can depend on the nutritional/health status of an individual. Most importantly, these bodily fluids represent non-invasive biological samples that can be used for exposure assessment. Furthermore, epidermal measurements represent a non-invasive way to monitor exposure in a wearable device; perspiration contains many metabolomics biomarkers that are indicative of exposure to harmful compounds or even disease.

As such, in conjunction with Michigan State University, researchers at the Fraunhofer USA Center for Coatings and Diamond Technologies CCD have developed flexible, wearable all-diamond sensors for detection of several metals in sweat. These sensors are robust and batch-fabricated, offering improved reproducibility from device to device. With current funding from the National Institute of Health (NIH), the Fraunhofer USA CCD team partnered with Bioanalytical Systems, Inc. (BASi) to develop a fully-integrated, Bluetooth-controlled device for rapid metals detection and improved health-outcome.



© Fraunhofer USA CCD, Square wave stripping voltammogram (SWSV) for lead (Pb2+) and copper (Cu2+) detection in pH 5.5 acetate buffer on a flexible BDD sensor. Deposition Potential: -1.35 V.

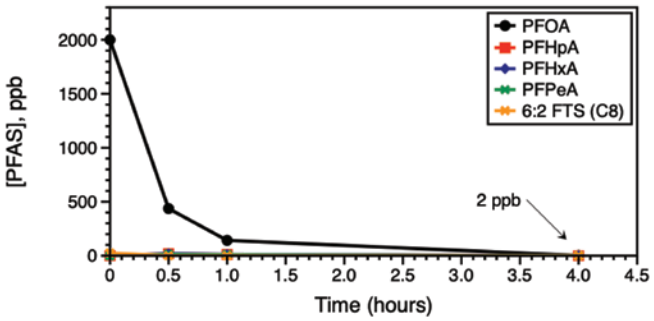
© Fraunhofer USA CCD, Diamond Wearable Sensor.

Electrochemical Destruction of Per- and Polyfluoroalkyl Substances with Boron-doped Diamond Electrodes for Water Treatment

Per- and polyfluoroalkyl substances (PFASs) are recalcitrant compounds that, through bioaccumulation, can cause a number of adverse health issues. PFASs cause endocrine disruption, are potential carcinogens, and have led to birth defects and obesity. Furthermore, perfluorooctanoic acid (PFOA), a perfluoroalkyl acid (PFAA), has been detected in human blood serum.

These complications have led the Environmental Protection Agency (EPA) to establish health advisory levels of 70 parts per trillion (ppt). Unfortunately, the extreme stability of PFASs (and PFAAs, specifically) under environmental conditions has rendered remediation methods such as biodegradation, photo-oxidation, hydrolysis, and direct photolysis relatively ineffective. Processes such as granular activated carbon (GAC) adsorption, ion exchange (IX), and reverse osmosis (RO) have proven effective for the removal of PFASs in large water systems. However, these methods generate a concentrated PFASs-impacted regenerate or reject solution that still requires remediation.

As such, researchers at the Fraunhofer USA Center for Coatings and Diamond Technologies CCD are investigating electrochemical oxidation (EO) with boron-doped diamond (BDD) electrodes. The destructive nature of the technology lends itself to applicability in complex media such as IX regenerates, RO rejects, industrial wastewaters, and landfill leachates, among others. Whether as a primary treatment option for complex samples or a secondary treatment option for large-scale remediation, EO with BDD electrodes has shown promise. With the necessary know-how in electrode fabrication, process development, and feasibility assessment, the Fraunhofer USA CCD team is uniquely equipped to solve this emerging problem.



© Fraunhofer USA CCD, Perfluorooctanoic acid (PFOA) degradation overtime in simulated solution using perforated BDD electrodes with 200 mA/cm² in a circulating flow through system.

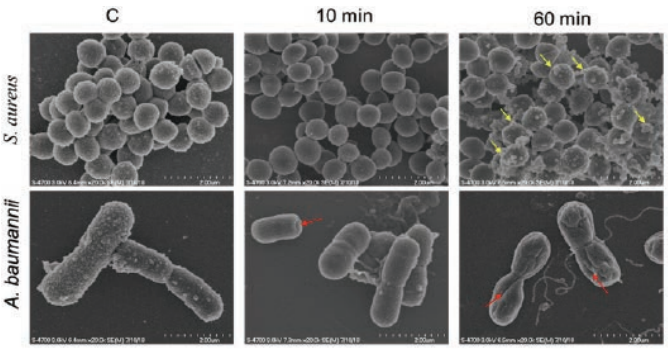
© Fraunhofer USA CCD, Waste Water Treatment System.

Identification and Development of Novel Antimicrobials

Antibiotic resistance is one of the biggest public health challenges of our time. According to the Centers for Disease Control and Prevention (CDC), at least 2 million people get an antibiotic-resistant infection and at least 23,000 people die each year in the US alone. The Fraunhofer USA Center for Molecular Biotechnology CMB continues to discover and develop novel compounds with antimicrobial activity using proprietary screening technologies. Over the last year, a major focus has been to continue development of our lead compound, CMB001, the early development of which was supported by Fraunhofer USA Special Funds project(s). The genome of the producer bacterium was sequenced, and the gene cluster containing a antibiotic-like sequence was identified, along with genes encoding enzymes in the biosynthetic pathway to generate the compound. The three-dimensional structure of the compound was determined using nuclear magnetic resonance (NMR). This analysis revealed a well-defined tertiary structure, unique for CMB001 as compared to published structures. This study provides insights into the uniqueness of the compound's binding site(s) and will allow for molecular modeling of synthetic analogs. In addition, scanning electron microscopy (SEM) reveals significant morphological changes within the cell wall following treatment of bacteria with the compound. Preliminary stability studies revealed exceptional stability of the compound in plasma and in blood. These favorable characteristics of the lead compound warrant its further development. In vivo efficacy studies for treatment of drug-resistant infections are under way, including infections with two critically important pathogens identified by the World Health Organization (WHO): Acinetobacter baumannii and Staphylococcus aureus, as well as drug-resistant Mycobacterium tuberculosis.

Our second lead compound, CMB002, is a broad-spectrum antibiotic effective against many Gram-positive and Gram-negative, drug-resistant bacteria. The biological evaluation of the compound continues in collaboration with the United States Army Medical Research Institute of Infectious Diseases (USAMRIID). NMR structure of the compound is being determined in collaboration with the National Cancer Institute (NCI). The analysis of the genome of the producer bacterium revealed the presence of a cluster typical non-ribosomal peptides (NRPs). In contrast to ribosomally produced peptides, such as CMB001, structural transformations of NRP scaffolds occur at several levels within biosynthetic pathways, allowing development of strategies to rationally engineer non-ribosomal peptides such as CMB002 in order to increase or alter bioactivity.

To identify further compounds of interest, a high throughput screening methodology has been established, significantly decreasing processing time for obtaining pure isolates. Several unique bacterial species and novel antimicrobial compounds have been identified from diverse environmental collection sites, including samples collected from the floor of the Atlantic Ocean and from remote freshwater lakes. The biological and structural analysis of these novel compounds has continued. The incorporation of a mass spectrometry (MS) detector into a liquid chromatography (LC) system has enabled rapid identification and purification of newly recovered antimicrobial compounds.



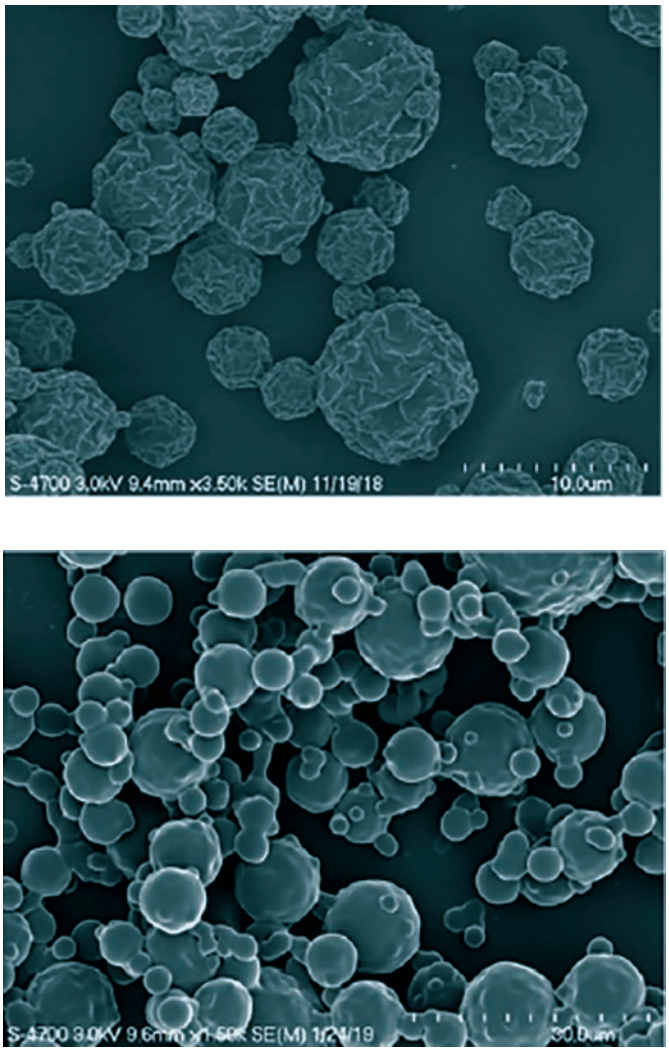
© Fraunhofer USA CMB, Scanning electron microscopy analysis of targeted bacteria (Staphylocccus aureus and Acinetobacter baumannii) treated with antimicrobial compound CMB001. For S. aureus, numerous bleb-like structures and debris on the cell surface were visible after cells were treated for 1 hour. For A. baumannii, dents were apparent after 10 minutes, and undulating deformations and folds were observed after 1 hour. (C = control).

Development of Stable Vaccine Formulations

The Fraunhofer USA Center for Molecular Biotechnology CMB is exploring alternative expression systems such as yeasts and filamentous fungi to produce recombinant proteins for vaccines and therapeutics. The choice of the expression system depends on the target protein and must result in proper folding and post-translational modifications to ensure appropriate maturation of the target. Also, and economically viable level of expression needs to be achieved. Fraunhofer USA CMB is testing and developing systems at laboratory scale and will later scale up to pilot scale, with the potential for GMP production.

For its vaccine targets, Fraunhofer USA CMB is developing virus-like particles with improved immunogenicity and efficacy. Specifically, Fraunhofer USA CMB is developing an antigen presenting virus-like particle platform based on a viral coat protein. To present antigens on the surface of this particle, a variety of fusion strategies have been pursued. Fraunhofer USA CMB has shown that while small proteins can be fairly easily displayed, larger proteins are not always tolerated and may interfere with assembly of the VLPs. Fraunhofer USA CMB researchers have developed a molecular engineering strategy to precisely display larger fusion partners at a set ratio to the viral coat protein scaffold that allows for VLP formation. These fusions should allow for the antigen targets to be efficiently presented to immune system on the surface of the VLPs.

Another important aspect of vaccine development is stability during long time storage. Fraunhofer USA CMB has recently developed spray dried formulations with improved stability under an Innovation Fund project. Such formulations are amenable to long-term inexpensive storage of bulk quantities of drug product and, due to elimination of temperature-controlled supply chains, to rapid deployment in emergency situations. These formulations incorporate novel design elements to facilitate repeat dosing with a single administration.



© Fraunhofer USA CMB, Scanning electron microscopy image of microparticles of an anthrax vaccine antigen following spray drying. Microparticles showing a rough surface morphology (top image) or a smooth surface morphology (bottom image) attributed to addition of a non-ionic surfactant. Microparticles are in the size range of 0.6 – 5 micrometers.

SECURITY AND SAFETY

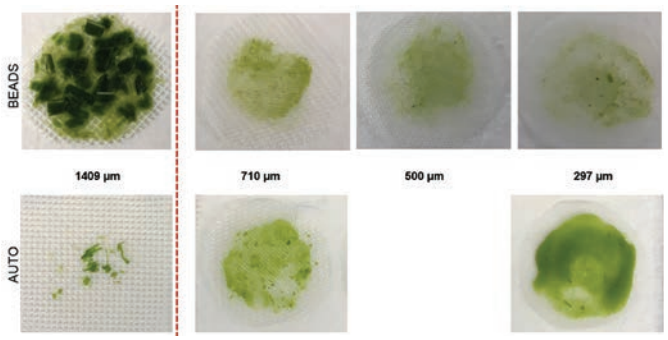
Massively Parallel Tissue Dissociation for Industrial Agriculture

Feeding the estimated 9 billion people that will call planet Earth home by 2050 represents an immediate and critical challenge. Scientists and research teams at agriculture firms, both small and large, are dissecting key crops to discover new ways to generate robust, disease-resistant produce. To access plant cells and sequences, the plants must first be processed down to a fine mulch. Generating this mulch for a single crop is relatively straightforward. Large sample sizes are simply stuck in a blender. But when the goal is to optimize tolerance to drought, salt, and pests for over 25 different sample types, a massively parallel small batch approach is required. This work is currently highly labor intensive with samples processed one at a time with scissors and scalpels.

The shift to small volume, high parallelization is a trend that is seen across the entire bioengineering sector and is particularly sharp in agriculture and personalized medicine. The particular challenge of homogenizing plant tissue versus animal tissue is that plant tissues are far more materially diverse. Tough woody stems, broad soft leaves, and hard seeds must all be quickly broken down. Developing automation that can rapidly pulverize all these tissues presents a unique challenge. However, eliminating the labor costs of these high throughput, big data research efforts is the key to accelerating crop productivity.

Fraunhofer USA Center for Manufacturing Innovation CMI is addressing this need by developing automated instrumentation that rapidly dissociates these diverse plant samples and more in just a few minutes. Modeled after mortar and pestles that efficiently shred plant fibers, the user simply places a small amount of plant material in the bottom of the mortar and turns on the instrument. The pestle can both hammer and cut straight down onto the tissue and shear tissue against the side of the mortar. Within minutes, the tissue is processed into pulp and is ready for single cell studies or deep sequencing. Of particular note is that this approach allows downstream sterilization costs – both in labor and materials – to be substantially reduced.

Having proven out a prototype and broad utility of the approach, Fraunhofer USA CMI will next scale up the instrument to process multiple tissues simultaneously. Such an instrument is projected to reduce labor costs and accelerate research timelines significantly.



© Fraunhofer USA CMI, Corn leaf (1 g) was processed by either commercially available bead beating (top row) or by the automated test fixture at Fraunhofer USA CMI (bottom row). The resulting plant mulch was then sieved and weighed to determine particle size (1409 µm, 710 µm, 500 µm, and 297 µm mesh spacing) as shown. The automated method was far superior in grinding down the tissue to particles that were pipettable by standard p1000 pipette tips (compare material on the 1409 µm mesh to the left of the red dotted line). For the automated process, material on the 297 µm mesh filter represents particles that would be captured on both the 500 µm and 297 µm sieve.

© Fraunhofer USA CMI, Mortar and pestles ready for the primary stage of feasibility exploring the mechanisms and movements required to fully dissociate diverse plant tissues.

MOBILITY AND TRANSPORT

Optimizing Trucking Logistics

Trucking operators face a multitude of daily and long-term challenges. Their role in regional and national logistics environments are adversely affected by increased regulatory oversight, fuel price volatility, rising personnel costs, and diminished interest in trucking as a profession – all factors that serve to drive up costs, increase uncertainty and lower profit. These dynamics also affect other players (e.g., rail, maritime, air transporters) in today's integrated supply chains, posing complex questions about long-term competitiveness for not only these operators, but for economic developers and transportation officials as well.

Through a grant provided by the South Carolina Department of Commerce, Fraunhofer USA Center for Experimental Software Engineering CESE is collaborating with the University of South Carolina, Datos Consulting LLC, and G&P Trucking to devise digital solutions to optimize trucking logistics in the State.

Our team is developing a new cloud-based platform that will provide a variety of services to trucking firms operating in the Palmetto State, including: optimization of business processes; real-time decision making; risk management; and cybersecurity and privacy enforcement. To do this, the platform will collect and integrate data from Internet of Things (IoT) devices and external data systems, providing information on weather, economic factors, fuel prices, real-time traffic conditions and social media activity. The first phase of this project centers on creating real-time planning and tracking software for truckers to optimize pick-ups, deliveries, routing and driver allocation. Over time this project may expand to include other modes of freight movement.

This is one of multiple projects supported by Fraunhofer USA CESE with financial support from the South Carolina Department of Commerce. These projects leverage Fraunhofer USA CESE's technical expertise with that of the State's university researchers and other public and private organizations as project requirements call for.

"South Carolina has built a reputation as a leader in manufacturing, in large part, due to our logistics assets and ability to efficiently transport goods to market. This new project reflects our continued commitment to advancing the state's burgeoning logistics sector, and I look forward to seeing its outcomes as South Carolina remains on the cutting edge of this important industry." – South Carolina Secretary of Commerce, Bobby Hitt

ENERGY AND MATERIALS

Precision Vision System for High Accuracy Laser Processing

In order to manufacture the next generation of energy efficient devices such as heat exchangers for heat pumps and Lithium Ion Battery and Capacitor modules for Electric vehicles, the development of fast and precise welding processes is essential.

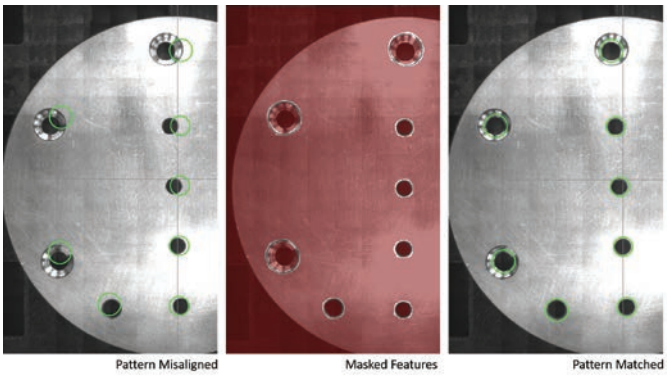
Typically, each part requires 50 to 200 welds per assembly, and only one incorrectly placed weld would render the part unusable which places extremely tight tolerances on the accuracy of the welding process and the part fixturing and location. Fortunately, laser welding has the inherent process advantage of providing a flexible welding solution with minimal heat input and thermal distortion of the materials being welded.

Remote scanner welding facilitates placing multiple welds with limitless weld geometries with almost zero point to point movement time between welds using a motorized scanning optic.

The process requires no physical contact with the parts to be welded only line of sight from the processing optic which is located around 16 inches away from the part. However, until recently the main issue limiting more widespread use of the technology was the need for precise and repeatable positioning of the part weld locations relative to the processing head.

Fraunhofer USA Center for Laser Applications CLA has recognized this issue and has now integrated remote welding optics which include machine vision capabilities such as our new K-Lab Scout 200 system. The Scout scan head combines precise remote laser weld processing with a vision system that can recognize part features and use them as a reference to ensure accurate and repeatable weld placement.

As can be seen in the example below, the system recognizes the part misalignment relative to the desired weld locations and then adjusts the weld pattern to automatically realign the laser beam process to the part without moving the part or the machine itself.



This system is capable of generating laser focus spot sizes of less than 200 µm which can be advantageous in small electronics applications such as battery welding where small precise welds are required in reflective materials such as copper and aluminum. As shown above, the Scout head can be utilized to search for specific features and align weld patterns based on the features, regardless of part to part placement changes.

Fraunhofer USA CLA is currently running welding trials for a range of different customers on both battery and heat exchanger applications, and the system allows almost any laser beam scan pattern or shape to be accurately placed on the component as can be seen in the process example in header area above.

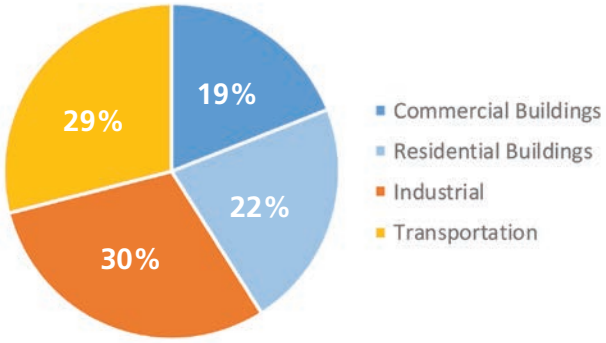
Communicating Thermostats for the Identification of Building Retrofit Opportunities

Buildings account for about 40 percent of US primary energy consumption and greenhouse gas emissions, more than both the industrial and transport sectors (see Figure). In the residential sector, space heating alone accounts for more than 30 percent of primary energy consumption.

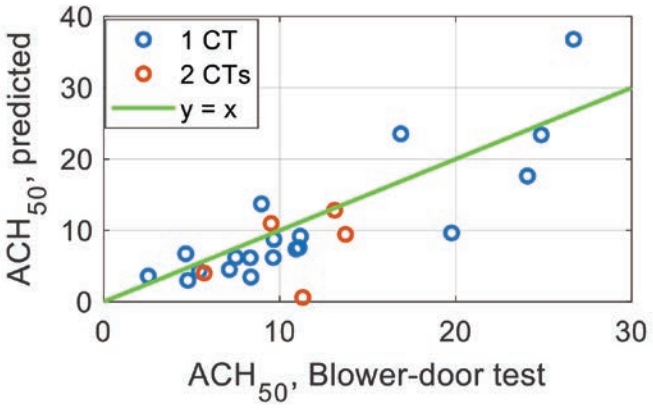
Annual energy savings of up to $4-5 billion could be achieved nationwide through basic insulation and heating system retrofits of existing homes. However, current utility energy efficiency (EE) programs are costly and challenging to scale. Customer acquisition occurs primarily through energy bill mailers, mass media and on-line advertising that lack specificity about particular home retrofit opportunities, expected energy savings, and cost effectiveness. Specific retrofit opportunities are identified via on-site home energy assessments (HEAs) that can be inconvenient to homeowners, expensive, and of variable accuracy.

Staff at the Fraunhofer USA Center for Manufacturing Innovation CMI have developed algorithms that analyze communicating thermostat (CT) data to significantly increase the customer uptake of energy conservation measures (ECMs) by identifying homes with most significant retrofit opportunities, estimating post-retrofit energy savings, and formulating home-specific outreach. The Fraunhofer USA previously developed building model was extended to identify physical building parameters corresponding to the target retrofit opportunities, i.e., whole-home R-value, air leakage characteristics, and heating system efficiency. The estimated R-values and air leakage characteristics compare favorably with the ground truth. The validated algorithms can calculate home-specific energy-savings estimate for each ECM, and the algorithm outputs can be used by utility EE programs to formulate home-specific retrofit offers.

US Primary Energy Consumption [quad]



Sources: DOE/EIA (2012), ecobee.

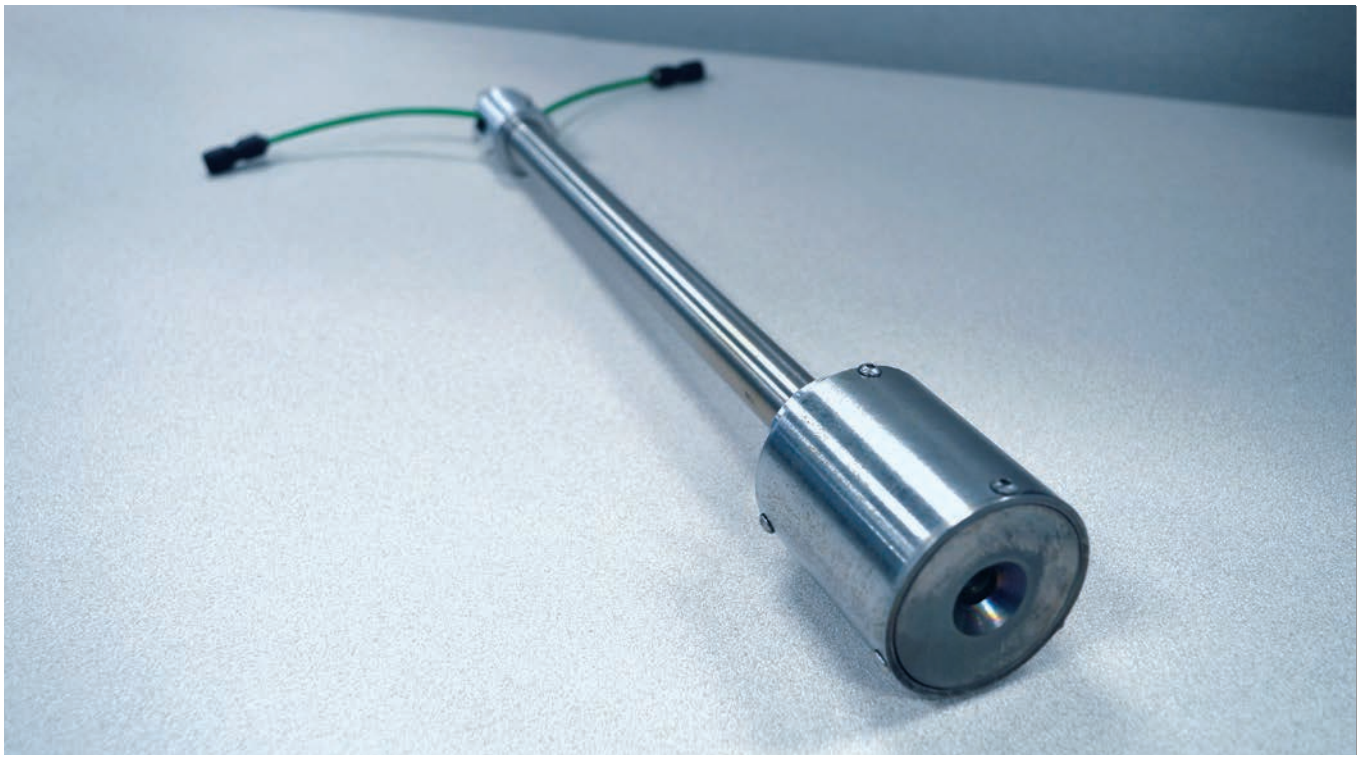


NSF SBIR

Scion Plasma LLC, a spin-off startup company from Michigan State University in collaboration with Fraunhofer USA Center for Coatings and Diamond Technologies CCD, has been awarded a National Science Foundation (NSF) Small Business Innovation Research (SBIR) grant for $225,000 to conduct research and development work on an innovative single beam ion source that overcomes the limitations of conventional ion sources.

The focused single beam of ions generated without a filament has widely tunable ion energies for optimal ion-surface interactions. The ion source can be operated over a wide range of pressure that is compatible with most of the physical and chemical vapor deposition systems. The low-cost and simple design allows drop-in installation in existing vacuum systems and long-term stable operation in thin-film processing environment. Maheshwar Shrestha, Principal Research Scientist, commented, "This funding allows us to develop a very unique ion beam source for the next generation of thin-film technology."

Once a small business is awarded a Phase I SBIR/STTR grant (up to $225,000), it becomes eligible to apply for a Phase II grant (up to $750,000). Small businesses with Phase II grants are eligible to receive up to $500,000 in additional matching funds with qualifying third-party investment or sales.



© Fraunhofer USA CCD, A prototype round single beam ion source suitable for lab-scale processing of thin films.

FRAUNHOFER USA CENTERS

FRAUNHOFER USA CENTER FOR MANUFACTURING INNOVATION CMI

The Fraunhofer USA Center for Manufacturing Innovation CMI, in collaboration with Boston University, conducts applied research and development leading to the deployment of technological solutions that enhance the productivity and competitive position of our customers, while educating engineering students in the process. With a strong focus on automation and instrumentation, Fraunhofer USA CMI's activities span three sectors: Industrial Systems, Energy Systems, and Biomedical Systems.

Fraunhofer USA CMI Conducts R&D Leading to the Deployment of

- Custom Automation Solutions
- Sustainable Energy Technologies
- Biomedical Instruments and Devices
- Process Management and Consulting

Custom Automation Systems

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

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

Examples:

Fiberoptic Gyroscope Winding

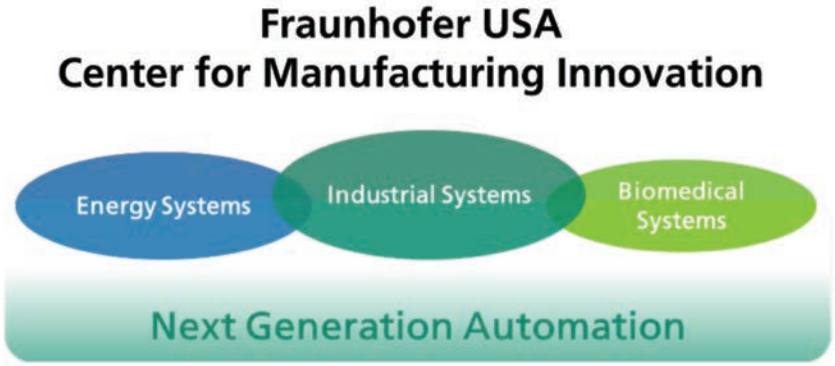
While fiberoptic gyroscopes (FOGs) have several advantages over ring-laser gyroscopes, the difficulties of cost-effectively winding a high-performance sensing coil has kept the cost of FOGs excessively high. In order to cost-reduce the manufacture of FOGs, Fraunhofer USA CMI developed a high-precision, computer-controlled winder for the production of sensing coils. With over 15 coordinated servo-controlled axes, the winder is capable of cost-effectively winding – with minimal touch-labor-tactical, navigation and strategic grade coils for long-range navigation and space applications.

Sustainable Energy Technologies

Fraunhofer CMI's interdisciplinary Energy Systems Team performs applied R&D on building technologies, and distributed energy resources (DERs) to help achieve a sustainable energy future.

We engage in projects with industry and government clients to:

- Test and evaluate the real-world performance of building energy systems and DERs
- Develop building performance assessment and control algorithms
- Develop and demonstrate technologies that optimize dispatch of distributed electric generation and loads
- Increase the hosting capacity of the utility grid for renewable generation
- Facilitate the deployment of DER Systems at scale
- Characterize building energy consumption to inform policy decisions
- Assess building technologies to identify high-impact energy savings opportunities



Examples:

Communicating Thermostats for the Identification of Building Retrofit Opportunities

Annual energy savings of up to $4-5 billion could be achieved nationwide through basic insulation and heating system retrofits of existing homes. However, current utility energy efficiency (EE) programs are costly and challenging to scale. We have developed algorithms that analyze communicating thermostat (CT) data to significantly increase the customer uptake of energy conservation measures (ECMs) by identifying homes with most significant retrofit opportunities, estimating post-retrofit energy savings, and formulating home-specific outreach.

Enabling High Penetration Solar with Integrated Energy Storage, Demand Management, and Forecasting

Fraunhofer USA CMI's SunDial Project is a collaboration with National Grid and IPKeys, which explores how an integrated portfolio of solar PV, grid-tied energy storage, demand-side management (DSM), advanced inverter functions, and advanced forecasting can optimize power flow on the distribution system. Using DER assets as a portfolio, we have developed a vendor-agnostic control platform that optimally shapes the net load for a feeder based on user-defined policy objectives, regardless of whether these assets are owned and operated by different entities.

Biomedical Instruments and Devices

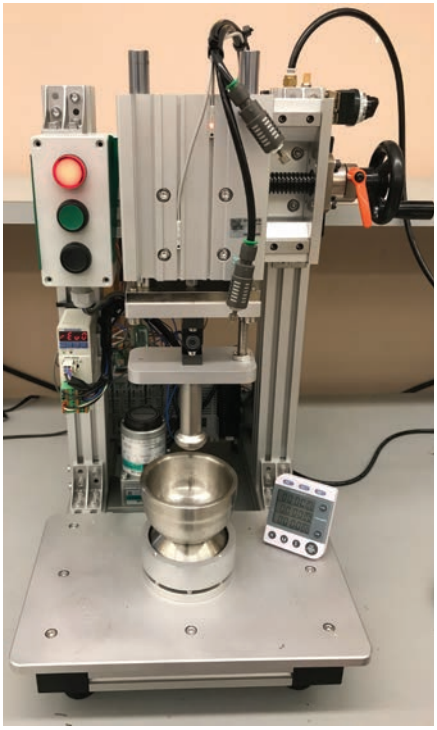
One of Fraunhofer USA CMI's core strengths is the application of advanced engineering to biological problems. Fraunhofer USA CMI combines multiple engineering and scientific disciplines in tackling such problems, and is trusted by leading pharmaceutical and medical device companies and research collaborators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

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

Examples:

Low-Cost, Real-Time, Continuous fl PCR System for Pathogen Detection

Bacterial resistance to antibiotics is escalating, and represents a significant health threat to the human population. To address the need of rapid, portable and low-cost pathogen identification, Fraunhofer USA CMI has partnered with Fraunhofer Institute for Production Technology IPT in Germany to create diagnostics that combines microfluidic and electronic layers into a single device.



© Fraunhofer USA CMI, The semi-automated test fixture built by Fraunhofer USA CMI to prove out the feasibility of the approach. The team is currently adapting the system for use with disposable 50-mL conical vials – maximizing sample containment while minimizing waste.

This microfluidic chip for nucleic acid testing (NAT) can identify pathogens within 20 minutes and is compatible with roll-to-roll embossing for large-scale, low cost production. Fluorescence is monitored in real-time for the quantitative detection of pathogens at concentrations as low as 10 DNA copies per microliter. (Fernández-Carballo et al. Biomed. Microdevices 2016, 18, 34).

Bioprinted Hydrogels Developed to Improve Implant Integration

Fraunhofer USA CMI's custom-designed bio-printer is able to print multiple materials (or multiple cell types in the same material) concurrently with various feature sizes (Campbell et al. J. Nanotechnol. Eng. Med. 2015, 6, 021005).

In collaboration with Fraunhofer IPT, Fraunhofer USA CMI has generated novel scaffolds that seek to improve the biological compatibility of titanium implants, which although generally tolerated by the body, fail to adequately interface with the bone. To provide an ideal biologically-based adhesion between bone and metal, Fraunhofer USA CMI used its 3D bioprinter to create a hydrogel scaffold that could be grafted to the implant. The scaffold was able to mimic the bone and trigger bone-producing cells to deposit new calcium directly onto titanium. These biologically-inspired engineering solutions pave the way towards better surgical outcomes for patients world-wide (McBeth et al. Biofabrication 2017, 9, 015009).

Process Management and Consulting

When faced with production challenges, established companies, startups, and governmental institutions engage Fraunhofer USA CMI to benchmark their current process, and introduce new technologies that will address their challenges. Staff begin the process by reviewing the client's current operation and identifying challenge areas in need of improvement.

Technology scouting is used to bring together possible solutions from internal expertise, university contacts, industry experts, journal, and the scientific literature. The ideas are tabulated into technology data sheets showing the evaluation criteria including: maturity of technology, costs (investment and operational), maintenance/service, and effort of implementation. Final evaluation is performed using a two-dimensional technology assessment technique. The down-selected solutions are then proposed for implementation.

Examples:

Coin Manufacturing Assessment and Technology Development

Fraunhofer USA CMI has worked with a several coin mints to assess their current manufacturing operations and wear integrity of their coins to develop alternative manufacturing technologies for higher production efficiency.

Following evaluation of the current coin production facilities and methods, Fraunhofer USA CMI proposed alternative technologies and evaluated the financial and technical impact of the proposed technologies. Staff then prototyped solutions and tested the quality of the coin blanks produced with these alternative solutions. Technologies explored included laser processing as a means of streamlining coin blanking.

Industries Served

- Aerospace
- Biotech/Biomedical
- Consumer products
- Energy
- Fiber optics/photonics

The Fraunhofer USA Center for Coatings and Diamond Technologies CCD performs applied research and development contracts with industry and government organizations. Customers include companies from industry sectors such as manufacturing, semiconductor, biomedical and energy. Fraunhofer USA CCD is a confident and reliable partner providing proprietary and competitive R&D services based on core competences in diamond and coating technologies. Fraunhofer USA CCD's quality management system is certified according to the standard ISO 9001:2015.

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

Engaging with Fraunhofer USA CCD in Applied Research and Development Work

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

Core Competence: Coating Technologies at Fraunhofer USA CCD

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

Core Competence: Diamond Technologies at Fraunhofer USA CCD

Diamond is a crystalline allotrope of carbon and the material with the highest atomic density found in nature. As such it is an extraordinary material with a unique com- bination of extreme properties such as highest hardness, highest thermal conductivity and highest dielectric breakdown strength, to name a few. The field of diamond synthesis and applications is undergoing a spectacular period of transformation as the ability to deposit high-quality monocrystalline diamond materials advances. Fraunhofer USA CCD develops processes and systems to synthesize diamond and to make it accessible to customers for integrating it in applications in optics, electronics and electrochemistry. Diamond is not expensive. In fact, at Fraunhofer USA CCD the material is synthesized by chemical vapor deposition using a process very like depositing coatings from other materials.

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

It is used by our customers in the form of coatings such as poly- and nanocrystalline diamond fields or a poly- or monocrystalline bulk material.

Project Briefs

Boron-doped diamond electrochemistry: Boron-doped diamond (BDD) is a new electrode material for electrochemical applications. Due to the fabrication from methane and hydrogen gases boron-doped diamond electrodes are less expensive than platinum electrodes. Yet BDD by far exceeds the electrochemical performance of metal-based electrodes. The wide electrochemical potential window, the low background current and the low adsorption make BDD electrodes particularly valuable for electrochemical trace analysis and neuro-chemistry. The material can be applied to a variety of substrates and shapes made from silicon, quartz, metals, and diamond. Fraunhofer USA CCD researchers developed fabrication processes to reliably custom tailor BDD electrodes for applications ranging from heavy metal detection in tap water to building flexible diamond-polymer thin film electronics for electrical and chemical sensing of brain signals (NIH funded).

Increased gas mileage and reduced emissions due to powertrain coatings: Fraunhofer USA CCD researchers developed a carbon-based coating to lastingly reduce friction and wear for powertrain components that experience highly loaded contact situations. By coating engine components, Fraunhofer USA engineers demonstrated a 3% horsepower increase across the usable speed range thus enabling the engine to achieve the same performance at lower revolutions per minute. These results demonstrate the tremendous potential to conserve fuel and reduce carbon dioxide emissions.

Diamond for power and high temperature electronics: Fraunhofer USA CCD and Michigan State University researchers develop diamond-based power electronics. The exceptional semiconductor properties of diamond have enormous potential for high-power electronics technology with applications in transportation, manufacturing, and energy sectors. The team develops synthesis processes for doped and intrinsic electronic-grade wide bandgap diamond materials and works on manufacturing process flows to build power electronic devices such as vertical Schottky diodes.

Manufacturing cost savings through 300% increase in tool life: Meritor Inc., a global leader in providing advanced drivetrain, mobility, and braking and aftermarket solutions for commercial vehicle and industrial markets, collaborated with Fraunhofer USA CCD engineers to test new high-performance ceramic coatings for high temperature forming processes. Spindle punches were coated using a physical vapor deposition process developed in collaboration with the Fraunhofer Institute for Materials and Beam Technology IWS in Dresden, Germany. The punches are used for hot forging of steel parts at an operating temperature of 1950 °F (1065 °C). Compared to uncoated spindle punches, the best performing coated tools lasted three times as long while enabling tool changes once a day rather than every shift

Anti-reflective coatings for transit bus windshield: Fraunhofer USA CCD researchers work with The Mackinac Technology Company (MTC) and the University of Michigan Transportation Research Institute on developing an anti-reflective windshield coating for transit bus windows. Interior lighting reflects off the windshield and obscures the driver's vision. The team demonstrated that an innovative ultra-low refractive index material made of amorphous carbon could be deposited in nanometer thin layers to the surfaces of windshield glass to significantly reduce reflection of visible light and improve driver vision.

The Fraunhofer USA Center for Coatings and Diamond Technologies CCD is the go to location for your materials technology needs.

© Fraunhofer USA, View inside Hot Filament Diamond System.

FRAUNHOFER TECHBRIDGE PROGRAM

Promising early-stage energy technologies typically experience many barriers to commercialization such as high capital costs, long sales cycles and complex frameworks of industrial integration. Furthermore, the alignment of the varying needs of the investor, startup a corporate partner can be multi-variate and a highly complicated process. The core offering of TechBridge is applied, industry-focused 'projects' performed for entrepreneurs by the greater Fraunhofer USA/Fraunhofer network technical staff from all around the world with the express goal of de-risking novel technologies for the private sector. The combination of technical and business expertise and multi-stakeholder demonstration projects, along with the deep experience of working with startup companies and larger corporations provide the basis for de-risked startup partnerships with larger corporations.

TechBridge designs and executes these 'projects' for startups and entrepreneurs which can take the form of developing and testing prototypes, deploying field demonstrations, performing third-party validation, generating test data in an industry context, or manufacturability studies. These projects, have proven to bring promising technologies closer to market and make them more attractive for private sector investment, industry adoption, and scale-up funding, ultimately leading to the accelerated success of high growth entrepreneurs and businesses. This 'project' work is the core of what makes TechBridge different from other entrepreneur support programs. This difference stems from Fraunhofer's primary role as one of the world's leading R&D providers to industry. The TechBridge team therefore has access to the deep industry knowledge at Fraunhofer to design and execute targeted, low-cost projects from an industry perspective that move entrepreneurs' concepts toward successful commercialization.

Programmatically, TechBridge runs "TechBridge Challenges" with our partners to perform technical validation projects that prepare the startup(s) for partnership and provide the sponsor with actionable information about the latest innovations in relevant areas. By doing this, TechBridge has helped launch more than 18 companies to date with a survival rate of over 95%, raised $186 million follow-on funding, helped create 367+ jobs and helped facilitate 3 successful acquisitions.

Fraunhofer TechBridge Program
Administered by Fraunhofer USA, 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.

Fraunhofer TechBridge Program – Technology Commercialization

- Optimizing and testing prototypes according to industry-standard protocols
- Providing third-party validation of economic viability and performance
- Fielding demonstrations of prototypes in real-world conditions
- Integrating components into a system-level environment
- Evaluating for manufacturability

© Fraunhofer USA, H2Refuel Accelerator Launch at SXSW. Left to-right: Nick Rancis, Fraunhofer USA; Katie MacDonald, Greentown Labs; Joe Silver, Urban Future Lab.

FRAUNHOFER USA CENTER FOR LASER APPLICATIONS CLA

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

With extensive experience and expertise in laser applications development for processes such as welding, cutting, and additive manufacturing, Fraunhofer USA CLA is your ideal partner for laser applications development.

Fraunhofer USA CLA offers contract research and development, process development, prototyping and consulting services, technical support and pilot production systems.

Laser Cladding and Additive Manufacturing

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

Laser Welding and Joining

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

Laser Heat Treatment

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

Laser Cutting and Drilling

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

Laser Sources

Fraunhofer USA CLA's state-of-the-art laser application facility features the latest and greatest in laser technology with a wide range of lasers from 1 watt to 16 kilowatt output power.

High Power CW and Pulsed Lasers:

- 16kW Laserline fiber coupled diode laser
- 10kW Laserline fiber coupled diode laser
- 4kW Laserline fiber coupled diode laser
- 8kW TRUMPF TruDisk 8001 disc laser (100 micron fiber capable)
- 6kW TRUMPF TruDisk 6001 disc laser (100 micron fiber capable)
- 6kW IPG YLS 6000 fiber laser (100 micron fiber capable)
- 6kW Rofin Sinar DC060W slab CO_2 laser

Low Power Pulsed and CW Lasers:

- 850W / 1030nm Trumpf TruMicro 7060
- 70W pulsed 1030 nm Jenoptik IR70 Disc
- 17W @1064nm and 5W @ 355nm pulsed Spectra-Physics HIPPO
- 200W / 1064 nm LASAG KLS 246 YAG
- 100W pulsed Rofin Sinar SCx10 CO_2
- 500W 1070 nm IPG YLR Single mode
- 25W cw 1070 nm JDSU Single mode fiber
- 20W cw 430 nm Fraunhofer Blue diode

Additional Equipment

The Fraunhofer USA Center for Laser Applications CLA utilizes additional robotic systems (Kuka) and multiple CNC machines and an onsite metallographic laboratory.

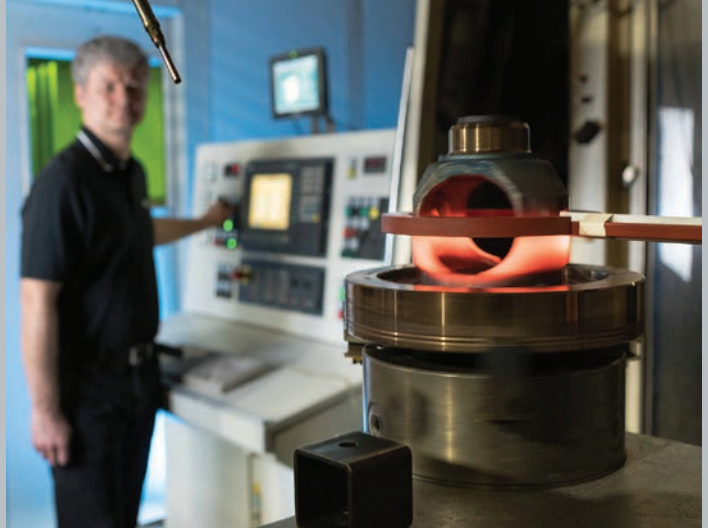
Industries Served

- Automotive
- Aerospace / Space
- Oil and Gas
- Power Generation
- Agricultural and Mining Equipment

Application Examples

Laser Welding

Laser welding offers the potential to join parts with high speed and precision with minimal heat input and distortion.



Difficult to weld materials such as higher carbon steels and cast irons can now be successfully laser welded. Filler wire and / or induction preheating can be used to change the microstructure of the weld metal, preventing the formation of hard and brittle phases. A conventional bolting process was replaced with laser welding for an automotive gear component. Significant cost savings were achieved through reduced material and processing costs and an overall part weight reduction was accomplished with a more efficient production method using laser technology.

Remote laser welding is another laser welding process which dramatically reduces welding cycle times compared to conventional welding. Motorized optics are utilized in order to rapidly scan the laser beam across the workpiece over large distances both for high speed and for high precision point to point movement.

Process Monitoring

Fraunhofer USA CLA has developed a high-speed camera vision system which can record the welding process in high clarity and provide both image and video data from the process. Using customized image processing software algorithms, it is possible to detect many common welding defects automatically. Fraunhofer USA CLA is also working together in partnership with Fraunhofer IWS to develop new applications for their 'EMAQS' camera-based process monitoring system. In particular, this is now being developed into an extremely useful tool for laser cladding and additive manufacturing processes where the melt pool size can be continually monitored, and the laser power can then be closed loop controlled in order to maintain constant build quality of each deposited metallic layer.

Additive Manufacturing and Cladding

In the Laser Metal Deposition process (LMD) metal powder is fed coaxially through a nozzle and then melted by the laser beam to form a fully bonded metallic layer. The deposited layer has a small heat affected zone with minimal dilution. It has been developed for production of wear and corrosion resistant coatings and for repairs and remanufacturing applications. The same process can also be used for generation of complete components from scratch in the form of additive manufacturing where parts are built using layer by layer deposition.

Two other variations of LMD – hot / cold wire cladding and internal diameter cladding – have now evolved into successful industrial processes and are now widely used in industry.

Micromachining

The latest generation of lasers with pulse lengths from millisecond all the way to femtosecond has led to a rich pipeline of innovations impacting virtually every manufacturing industry. One such innovation is large area coating removal for paint stripping, deoxidization, cleaning or localized removal of special coatings. Another example of innovation is the ability to drill high aspect ratio holes at extremely high speeds. One such application developed by Fraunhofer USA was able to achieve drilling of up to 15,000 per second in a silicon wafer material.

The Fraunhofer USA Center for Laser Applications CLA utilizes its expertise and state-of-the-art equipment to maximize the quality of the customer deliverables.

© Fraunhofer USA, Induction heating of automotive part.

FRAUNHOFER USA CENTER FOR EXPERIMENTAL SOFTWARE ENGINEERING CESE

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

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

Fraunhofer USA CESE Vision

Fraunhofer USA CESE accelerates its customers' economic and industrial development by using innovative model-based methods to develop and assure complex software intensive systems.

Fraunhofer USA CESE Mission

- Serve as a trusted source for technology transfer and innovation to our government, academic and industrial customers across the nation
- Maintain a workplace culture of innovation that supports, rewards, and holds our team members accountable for creating new ideas that work

Fraunhofer USA CESE Offers: Model-Based Development and Testing

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

Software Safety and Security Analysis

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

Rapid Prototyping of Mobile and Web Applications

- Design and facilitate user focus groups and empirical experiments to validate customer innovations
- Conduct technology evaluations in cloud, mobile, and other emerging platforms and suggest solutions based upon discovery

- Provide project management support including agile and scrum methodologies – to mitigate risk, manage cost and schedule, and ensure delivery
- Evaluate and create software engineering approaches and tools to improve software development productivity

Software Engineering Analytics

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

Cybersecurity and Embedded Systems

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

Digital Transformation

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

Project Measurement and Analytics

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

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

Data Protection Policy Effectiveness

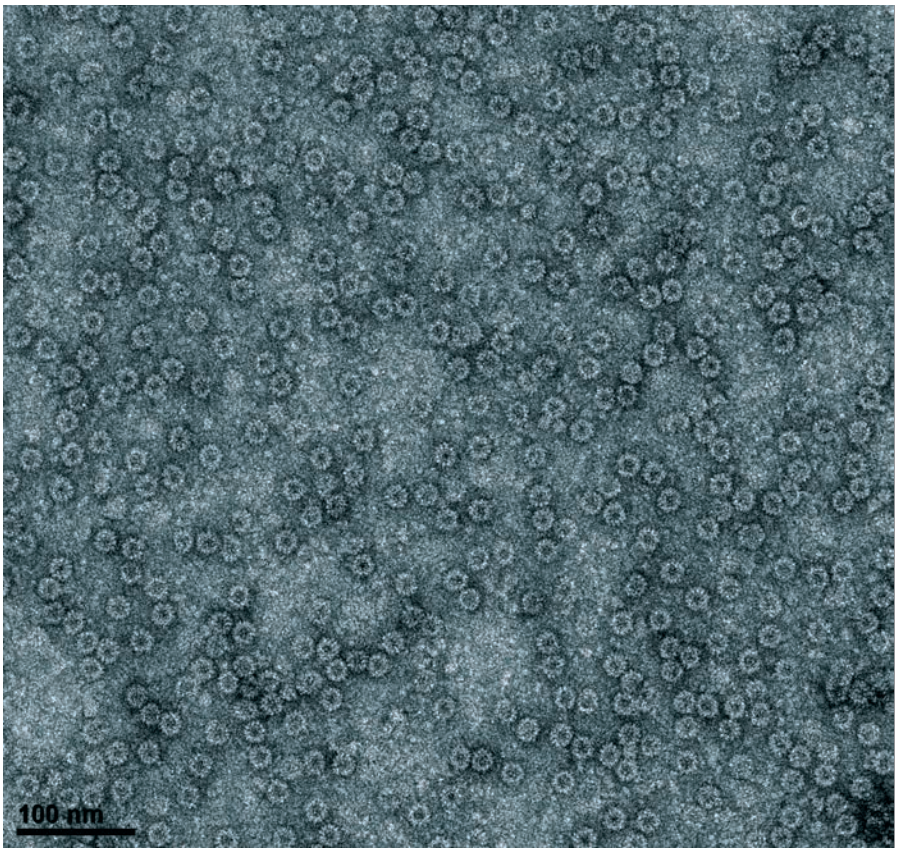
- Craft data protection and privacy policies to satisfy corporate and regulatory needs
- Analyze data protection processes for effectiveness and improvement
- Create executive-level dashboards on data protection effectiveness across the enterprise
- Identify data protection policy gaps and recommend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

FRAUNHOFER USA CENTER FOR MOLECULAR BIOTECHNOLOGY CMB

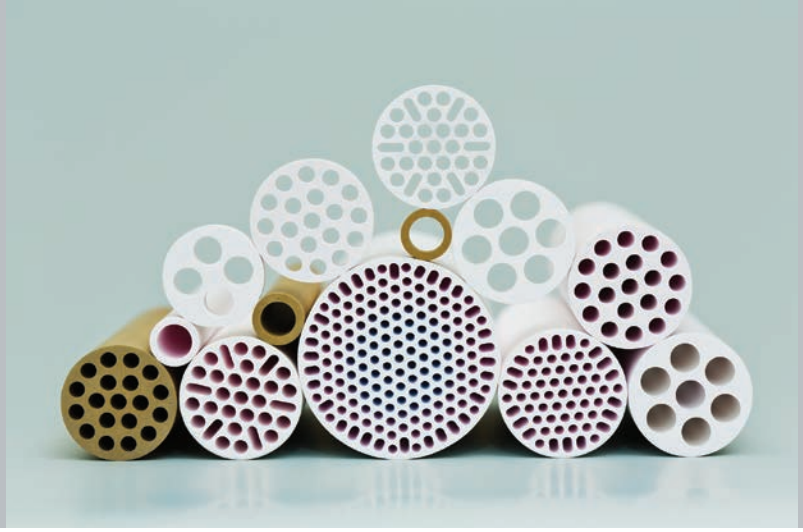
The Fraunhofer USA Center for Molecular Biotechnology CMB is working in the area of biotechnology development, primarily emphasizing applications in human health. The Center is currently focusing on the discovery of novel anti-microbials and on the development of thermostable formulations for vaccines.

Despite ongoing efforts, the number of new antibiotics approved annually in the United States continues to decline. In addition, fewer new antibiotics are in late-phase clinical trials, and nearly all of them belong to existing classes. At the same time, infections caused by multi-drug resistant-pathogens are continually on the rise. This is a world-wide threat, with diseases that have long been held at bay again having potential to affect the health of millions.

Over the last year, Fraunhofer USA CMB has continued to expand its microbial library, using the quarum quenching technology for which Fraunhofer owns the IP to culture previously uncultured microbes. Screening of this library has identified some lead components with anti-microbial activity and these are being assessed for efficacy through in vitro and in vivo studies. In addition, their structures are being elucidated.



© Fraunhofer USA CMB, Transmission electron microscopy image of purified virus-like particles formed by a protein fusion of a viral coat protein (acting as a carrier molecule) with an antigen from a surface lipoprotein from Borrelia burgdorferi, the causative agent of Lyme disease. (nm = nanometers).



FRAUNHOFER USA CENTER FOR ENERGY INNOVATION CEI

The Fraunhofer USA Center for Energy Innovation CEI performs a range of services to assist with the development, demonstration and deployment of separations technologies across a myriad of industries.. These services range from laboratory, pilot scale to full scale demonstration testing of liquid and gas separation applications.

Fraunhofer USA CEI Offers Customized Separations Solutions for:

- Water treatment and reuse
- Membrane process engineering
- Resource recovery
- Membranes for energy efficiency and production
- Non-aqueous liquid separations
- Vapor and gas separations

Technology Platforms

- Ceramic membranes
- Polymeric membranes

Ceramic Membranes

Ceramic membranes offer capabilities for separation applications where polymeric membranes cannot operate at like high temperatures, pressures, pH levels. Fraunhofer USA CEI, together with its collaborative partner, Fraunhofer IKTS, has the knowledge and resources to demonstrate the capabilities of ceramic membranes for aqueous and organic filtration applications as well as other inorganic membranes including ezeolites, carbon materials, and perovskites.

Polymeric Membranes

Fraunhofer USA CEI has extensive expertise with polymeric membranes for liquid separation applications. Application experience includes desalination, water treatment, reuse, water softening, dewatering processes and organic solvent purification. The team has experience in reverse osmosis, forward osmosis, nanofiltration, and membrane distillation.

Contract research and consulting services Fraunhofer USA CEI provides are:

- Solutions for separations needs across disciplines (water, solvent, vapor, gas)
- Membrane characterization, innovation, development, validation and synthesis (performance, longevity) for any separations need
- Lab, prototype, pilot scale testing of membrane process
- Design and construction of separations prototype / systems
- Comparison/benchmarking of commercial options for tailored separations needs
- Development of standard operating procedures for customized systems and membrane elements
- Techno-economic assessment for specific separations processes
- Analysis of mass transfer processes and membrane separation mechanisms
- Joint development of membrane and systems technology for energy and separations needs
- Scale-up and techno-economic assessment/feasibility studies

Joint Development Opportunities

Fraunhofer USA CEI welcomes joint development projects with industrial and governmental clients. Types of project include, but are not limited to, membrane design/ modification, module prototyping, systems design/ piloting, applications testing, feasibility studies, bench-marking studies etc. We work with a range of companies who are in start up/proof of concept phase to fortune 500 companies to government agencies like the Department of Energy and US Bureau of Reclamation to help serve their separation needs.

Separation Equipment and Analytical Resources

Fraunhofer USA CEI has access to state-of-the-art separations test equipment designed for aqueous, organic, vapor, and gas separations processes for different types of membranes and modules.

There also is access to the state-of-the-art research infrastructure at the University of Connecticut for a variety of analytical testing. available for a fee.

©Fraunhofer IKTS, Porous ceramic membrane support tubes.

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

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

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

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

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

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

Equipment and Infrastructure

Fraunhofer USA facilities have a total combined working space of over 173,000 square feet and more than $47 million in equipment and infrastructure. The Centers also have access to additional equipment and resources through the partnerships with universities and the network of the 72 institutes and research locations at our partner organization, Fraunhofer-Gesellschaft, in Germany.

Fraunhofer USA has been able to expand its machine portfolio due to generous equipment donations from current and former customers. Several current customers of Fraunhofer USA have located their equipment on-site at the Centers to showcase the machines being used in the development of specific technologies.

University Partnerships

Fraunhofer USA has excellent and mutually beneficial partnerships with several U.S. universities. Like Fraunhofer-Gesellschaft in Germany, Fraunhofer USA understands the benefits of partnering with academic institutions of excellence and fostering integrated and enduring relationships. The research and development universe is enriched as each entity adds value. The university partnerships provide mutually beneficial synergies in many ways that increase the value and usefulness of both organizations.

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

Boston University has a student body of approximately 34,000 students of which circa 15,000 are graduate students. Boston University ranked #42 in national universities in US News and World Report for 2019. As a leading global research institution, BU has been awarded over $400M in grants and contract awards in 2018.

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. Faculty and students participate in a number of joint research programs funded by both government and industry.

University of Maryland: The Fraunhofer USA Center for Experimental Software Engineering CESE 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 40,000 students, of which circa 10,000 are graduate students. The University of Maryland has become one of the nation's leading public research and innovation universities, receiving $545,314,107 in research awards in 2018.

Michigan State University: Since 2003, the Fraunhofer USA Center for Coatings and Diamond Technologies CCD and Michigan State University 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. External researching funding for MSU totaled approximately $600M in 2016-2017

The Fraunhofer USA Center for Coatings and Diamond Technologies CCD, in collaboration with Michigan State University and its College of Engineering, provides innovative research and development services based on its expertise in coatings and diamond technology.

University of Delaware: The Fraunhofer USA Center for Molecular Biotechnology CMB partners with the University of Delaware to expand the innovation pipeline by enhancing technology and product development activities.

One of the oldest universities in the US, the University of Delaware traces its roots to 1743. Currently the enrollment is made up of circa 24,000 enrolled students. UDEL received $145M in sponsored research projects in 2018

University of Connecticut: The Fraunhofer USA Center for Energy Innovation CEI is located on the campus of the University of Connecticut (UConn) and just recently moved into brand new research space at the state-of-the-art UConn Tech Park.

UConn, founded in 1881, has a rich history of excellence in energy innovation with more than 30,000 students currently enrolled.

State Support and Collaborations

Several Fraunhofer USA Centers receive financial support from the states in which they operate directly or through state agencies.

Delaware: Fraunhofer USA Center for Molecular Biotechnology CMB
Maryland: Fraunhofer USA Center for Experimental Software Engineering CESE
Connecticut: Fraunhofer USA Center for Energy Innovation CEI

Fraunhofer USA Partner Institutes

Fraunhofer USA Center for	*Fraunhofer Institute for*
Coatings and Diamond Technologies CCD	Material and Beam Technology IWS
Laser Applications CLA	Material and Beam Technology IWS
Experimental Software Engineering CESE	Experimental Software Engineering IESE
Manufacturing Innovation CMI	Production Technology IPT
Energy Innovation CEI	Ceramics Technologies and Systems IKTS
Molecular Biotechnology CMB	Molecular Biology and Applied Ecology IME
Digital Media Technologies Office DMT	Integrated Circuits IIS

Fraunhofer USA Centers also work and collaborate with other institutes in the 72 institutes and research unit network of the Fraunhofer-Gesellschaft in Germany.

More than 20 federal agencies fund R&D in the United States. Funding is generally broken down into categories of basic research, applied research, experimental development, research and development equipment and research and development facilities. In the 2020 White House Budget document, improving the transfer of Federally Funded Technologies from Lab to Market has been listed as one of its cross-agency priority goals. The document states "This goal will strengthen the ability of federally funded innovations to transition from discovery in the laboratory to impact in the marketplace, including by reducing regulatory burden, strengthening partnerships, and enhancing how to measure return on federal investment."

Highlights of the budget include "$688 million for the national institute of standards and technology to conduct cutting edge research, including quantum computing, artificial intelligence, and microelectronics." $1.2 billion allocated for satellite system development, $718 billion for the Department of Defense, with key areas of focus in autonomous systems, hypersonics and artificial intelligence. The budget is requesting "more than $59 billion in research, engineering and prototyping activities... ". The budget requests more than $9.6 billion in investments in cyber security. A portion of the proposed funding for the Department of Energy is $2.3 billion to support early stage R&D to enable the private sector to "deploy the next generation of technologies and energy services".

Source: www.whitehouse.gov/wp-content/uploads/2019/03/budget-fy2020.pdf.

Fraunhofer USA benefits from these expenditures and programs. In 2018 the main agency funders for Fraunhofer USA included the Department of Defense (DoD), the Department of Health and Human Services (HHS), the Department of Energy (DoE), the National Science Foundation (NSF), and the National Aeronautics Space Administration (NASA). We are confident that our strategic technology areas will continue to be attractors to federal government agencies.

Fraunhofer USA, Inc.

Balance Sheet
As of December 31, 2018

Assets	
Current Assets	
Cash and Cash Equivalents	$ 22,300,883
Accounts Receivable	8,686,950
Investments	705,160
Prepaid Expenses and Other Current Assets	1,316,088
Total Current Assets	**33,009,081**
Property and Equipment - Net	**41,841,215**
Intangible Assets	**152,138**
Long-Term Receivable	**2,726,784**
Total Assets	**$ 77,729,218**
Liabilities and Net Assets	
Current Liabilities	
Accounts Payable	$ 2,045,997
Deferred Revenue	1,365,743
Accrued Liabilities and Other	21,084,535
Total Current Liabilities	**24,496,275**
Long-Term Obligation	**15,146,786**
Total Liabilities	**39,643,061**
Net Assets	
Unrestricted	
Undesignated	**3,849,275**
Increase (Decrease) in Undesignated Assets	**(43,678)**
Designated	**28,845,099**
Increase (Decrease) in Designated Assets	**(737,693)**
Temporarily Restricted	
Temporarily Restricted	**3,826,653**
Increase (Decrease) in Temporarily Restricted Assets	**2,346,501**
Total Net Assets	**38,086,157**
Total Liabilities and Net Assets	**$ 77,729,218**

Fraunhofer USA, Inc.

Statement of Activities and Changes in Net Assets
Year Ending December 31, 2018

Contract Revenue	
Industry	$ 8,047,964
Government & Universities	7,887,489
Fraunhofer Institutes	1,956,965
Miscellaneous	714,325
Total Contract Revenue	**18,606,743**
Support	
Base Funding	13,442,184
In-Kind Contributions	3,091,093
Other	618,998
Total Support	**17,152,275**
Funds Released from Restrictions	**405,211**
Total Undesignated Revenue, Support and Released Funds	**36,164,229**
Labor Costs	**17,437,176**
Undesignated Other Expenses	
Administrative Expenses	**13,186,720**
Cost of Goods Sold - Excluding Labor	**5,386,513**
Depreciation and Amortization	**197,498**
Total Undesignated Other Expenses	**18,770,731**
Total Labor Costs and Undesignated Other Expenses	**36,207,907**
Increase (Decrease) in Undesignated Assets	**(43,678)**
Undesignated Net Assets	**3,849,275**
Designated Revenue	**1,645,626**
Designated Expenses	**(2,383,319)**
Increase (Decrease) in Designated Assets	**(737,693)**
Designated Net Assets	**28,845,099**
Temporarily Restricted Revenue	**2,751,712**
Funds Released from Temporary Restriction	**(405,211)**
Increase (Decrease) in Temporarily Restricted Assets	**2,346,501**
Temporarily Restricted Net Assets	**3,826,653**

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