Fraunhofer USA

# Focus 2024

# Fraunhofer USA Focus 2024

# Foreword

### Thirty Year Anniversary

This year we celebrate thirty years of generating innovative science and engineering in the United States. In 1994, our founding partner, Europe's largest applied research and development organization Fraunhofer-Gesellschaft, set up Fraunhofer USA as an independently incorporated non-profit entity in the world's largest R&D economy. The concept was simple, partner with universities of excellence in the United States and jointly operate research centers that offer technology solutions and applied research and development services to our partners from industry and the public. We believe that innovative technology solutions are one of the enabling backbones for the continued wellbeing and growth of our society, providing advancements in areas of health, environment, sustainable energy, efficient transportation and so much more.

Over the course of the last 30 years, we have been privileged to work with many amazing people who make up the U.S. and indeed global R&D landscape that moves the progress of applied research and development and contributes to the progress of humanity and its future. I would like to take this opportunity to thank our founding and steadfast partner, Fraunhofer-Gesellschaft, for their strong and unwavering support and cooperation. Through Fraunhofer-Gesellschaft's vision and guidance, Fraunhofer USA has thrived and is a valuable partner supporting the goals and mission of ensuring scientific and engineering progress in areas of bilateral concern to both, the Unites States and Germany, for now and in the future. I would also like to thank our long-term partner universities, Michigan State University, Boston University and the University of Maryland. The collaborative and exchange relationships with these prestigious research universities have proven to be a strong basis for the success of the organization and that targeted and comprehensive strategic planning is addressing the most critical challenges in applied science and engineering. I would like to thank our customers, who bring interesting challenges to us. We utilize our expertise to support them solving those challenges. We are privileged to have the trust of our customers and take pride in the thousands of successful projects that have been executed over the last 30 years. Of course, I also thank our employees, past and present, who have contributed their expertise, talent, and innovation to the organization. Our employees are the heart and soul of the organization.

Moving forward we continue to acknowledge that we are part of a vast interconnected chain of life on the planet, and we need to find ways to not only coexist with nature, but help, support and nurture it. It is not just sustainability we must achieve, but also recognize our obligation to each other and other life on earth to do our part to heal and repair some of the damage that has been caused and continues to be caused.

Sincerely,

*Thomas Schuelke*

Thomas Schuelke
*President, Fraunhofer USA, Inc.*

# Contents

## Mission

Fraunhofer USA offers customized, advanced technology research, development and deployment. Fraunhofer USA shall serve market-driven technology needs; promote international cooperation in business; establish strategic alliances with industry, government and academic partners.

## Vision

Fraunhofer USA, like its founder and funding partner Fraunhofer-Gesellschaft, is a national and international leader of applied research. As an innovation driver, we lead strategic initiatives to master future challenges and thus achieve technological breakthroughs.

# About Fraunhofer USA

Founded in 1994 by Fraunhofer-Gesellschaft, Europe's largest applied research and development organization, Fraunhofer USA conducts applied research and development for customers in industry and for state and federal government.

## What is Applied Research?

Applied research is the systematic investigation of solving practical problems or developing new technologies, products, or processes for specific real-world applications. By bridging the gap between theoretical knowledge and practical implementation, we facilitate applied research and technology transfer by collaborating closely with industry, government and academic partners. As a legally independent affiliate of Germany's Fraunhofer-Gesellschaft, Europe's largest applied research and development organization, Fraunhofer USA fosters innovation by conducting research that aligns with market needs, providing access to advanced facilities and resources, and enabling technology transfer through partnerships pursuing shared societal goals. By bridging academia and industry, it accelerates the translation of cutting-edge research into practical solutions, thus enhancing technology adoption, economic competitiveness and societal development.

## Societal Impact

Our applied research services have a significant societal impact by driving innovation, economic growth, and improved quality of life. By facilitating the transfer of advanced research findings and technologies from the laboratory to the marketplace, Fraunhofer USA can:

### Promote Economic Growth

The technology transfer process generates new products, processes, and services that lead to job creation, increased productivity, and enhanced competitiveness in industries. This contributes to local, regional, and national economic growth.

### Enhance Industry Competitiveness

By enabling industries to adopt cutting-edge technologies and research-driven solutions, Fraunhofer USA helps businesses stay competitive in global markets, driving growth and sustainability across various sectors.

### Address Societal Challenges

Many of Fraunhofer USA's technology transfer outcomes address critical societal challenges, such as healthcare, energy, environment, and transportation. These solutions improve public health, resource efficiency, and overall well-being.

### Catalyze Research Collaboration

Fraunhofer USA's partnerships foster collaboration between academia, research institutions, and industries. This collaborative environment accelerates innovation, encourages knowledge exchange, and creates a ripple effect of positive impacts.

### Provide Education and Workforce Development

The technology transfer process often involves training and upskilling the workforce in new technologies. This contributes to a skilled workforce, supporting employment opportunities and overall societal advancement. The Fraunhofer USA Internship and Research Scholar programs help ensure that the next generation of scientists and engineers receive hands on training, jump-starting their careers and impact.

### Disseminate Knowledge

The transfer of research findings and technologies to practical applications increases the dissemination of scientific knowledge, contributing to public awareness and understanding of complex issues. Fraunhofer Principal Investigators may publish with permission in scientific journals or other professional publications.

# Strategic Research Goals

Fraunhofer USA develops required innovations and core competences to address technological, commercial, and social imperatives of our time. The topics of these projects are a result of two fundamental driving forces – industry and its technology-pull roadmap, and the government and its technology push-roadmap.

These key innovations are then deployed in the U.S. R&D market where Fraunhofer USA engages with industry clients or the public sector in contract R&D projects as well as public-private partnerships (3P) for technology transfer.

As a result of this activity, Fraunhofer USA helps the industry sector to de-risk their technology development investments, improve time-to-market, enhance their competitiveness while reducing capital and operational expense, and improve quality and quantity of the product, enabling scalability and transferability of a process, reducing technology development and device integration costs.

The advantages for the public sector are access to a team of experienced, professional, inter-disciplinary researchers and scientists able to provide scalable and transferable solutions, and access to researchers with both an academic and industrial mindset and experience.

**Topics of strategic relevance for Fraunhofer USA through 2025 include, but are not limited to:**

| | |
|---|---|
| **Future Wireless and Related Technologies** | ■ 5G and 6G<br>■ IIoT and Distributed Manufacturing<br>■ Edge Computing and Mobile Edge Computing (MEC)<br>■ Terahertz Communications<br>■ Ultra-Low Power AI for IoT Devices |
| **Industry 4.0 and Advanced Manufacturing** | ■ Digital Twins<br>■ Additive Manufacturing<br>■ Vision Inspection and Predictive Maintenance<br>■ Process Automation, Robotics<br>■ Collaborative Robots (Cobots)<br>■ Industrial Internet of Things (IIoT) Security<br>■ Design for Disassembly and Recyclability |
| **Electrification and Hydrogen Technologies** | ■ Battery Technologies and Energy Storage<br>■ EVs and Power Semiconductors<br>■ Industrial Electrification and Decarbonization of Industrial Processes<br>■ H2-Technologies (H2-Production Efficiency and Application)<br>■ Smart Grid Technologies<br>■ Green Hydrogen Production<br>■ Solid-State Batteries<br>■ Thermal Energy Storage and Management |
| **Quantum Computing, Communication, Sensing and Imaging** | ■ Quantum Optimization, AI, Numerics<br>■ Advanced Materials and Diamond<br>■ Quantum Communications Systems for Space and Terrestrial Networks<br>■ Quantum Sensors for Precision Measurement |

*Michigan Governor Gretchen Whitmer, attending the Germany pavilion at the North America Battery Show.*

| | |
|---|---|
| **AI and Data Governance** | ■ Trustworthy AI and Ethics<br>■ AI Ergonomics and Human-AI Interaction<br>■ AI Robustness Testing<br>■ Federated Learning<br>■ Explainable AI (XAI)<br>■ AI for Cybersecurity<br>■ Privacy-Preserving AI and Differential Privacy |
| **Climate Technologies, Sustainability and Agriculture** | ■ Carbon Capture and Carbon to X to Y<br>■ Renewable Energies and Storage<br>■ Sustainability in Production and Materials<br>■ Aquaponics, Aeroponics<br>■ Agrophotovoltaics<br>■ Microgrids and Distributed Energy Resources<br>■ Precision Agriculture and AI-driven Farming<br>■ Waste and Toxin Processing (PFAS, etc.)<br>■ Waste-to-Resource Technologies |
| **Bioengineering** | ■ Plant Based Food and Cultivated Meat<br>■ Synthetic Biology and Genetic Engineering<br>■ Biomedical and Neural Engineering<br>■ Organ-on-a-Chip Technology<br>■ Bioinformatics and Computational Biology<br>■ Microbiome Engineering<br>■ Biosensors and Wearable Health Monitoring<br>■ Antibiotic Resistance and Tolerance |

# Fraunhofer USA Research Centers and Offices

# Fraunhofer USA Locations

Fraunhofer USA is headquartered in Plymouth, Michigan, with three dedicated research centers located around the United States. Fraunhofer USA Center Midwest CMW, partnered with Michigan State University, has two locations in Michigan specializing in coatings and diamond technologies and laser applications. Fraunhofer USA Center Mid-Atlantic CMA, partnered with the University of Maryland, is in College Park, Maryland and works on software and software systems with a focus on real world applications of artificial intelligence. Fraunhofer USA Center for Manufacturing Innovation CMI, partnered with Boston University, is in Boston and is active in energy systems, Industry 4.0 style automation and biotechnology applications. Center Directors are professors at our nationally ranked partner research universities. Additional Fraunhofer USA offices are located in California and in South Carolina – the Fraunhofer USA Digital Media Technologies Office DMT and South Carolina Fraunhofer USA Alliance, respectively. Fraunhofer USA employs 100 + full-time staff, university faculty, and student interns. Fraunhofer USA's forecasted revenues for 2024 are expected to be $27 million+.

# Fraunhofer USA Center Mid-Atlantic CMA

## Scientific Focus

Fraunhofer USA CMA develops and uses innovative, effective and scalable approaches to software and systems engineering, delivers powerful testing and verification strategies and tools, uses state of the art measurement and code analysis methods, and develops and tests artificial intelligence based systems for use in manufacturing, health and life sciences applications.

Fraunhofer USA CMA has developed successful collaborations with other Fraunhofer USA centers leading to joint projects utilizing competences in the physical, materials and engineering sciences. Seeking the combination of complementary competences across centers is a key strategy for Fraunhofer USA to create sustainable technology leadership.

The center leverages strategic partnerships with South Carolina, the Applied Research Lab for Intelligence and Security (ARLIS) at the University of Maryland, and the National Institute for innovation in Manufacturing Biopharmaceuticals (NIMBL), among others.

## Core Competences

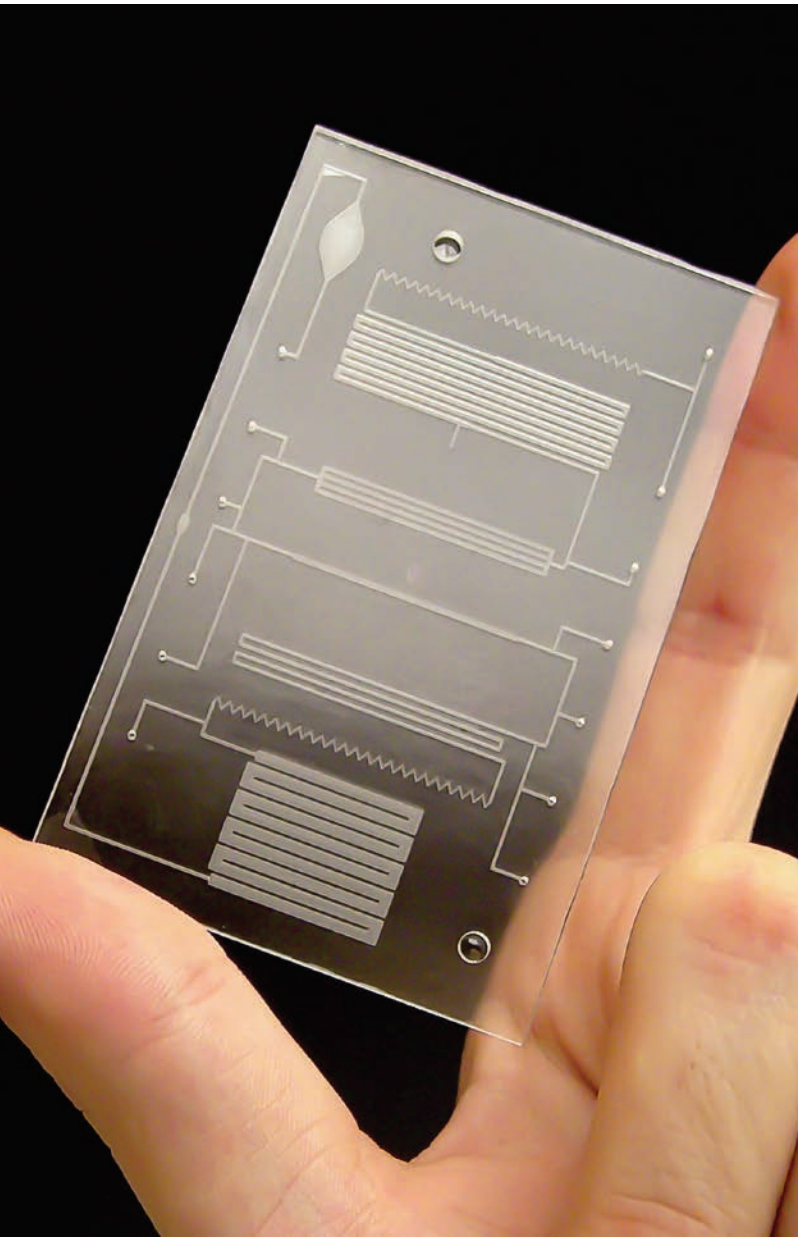
### Information and Communication Technologies

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

## Research Fields

- Applications, software, and systems infrastructure of AI-based systems
- Internet of Things
- Autonomy

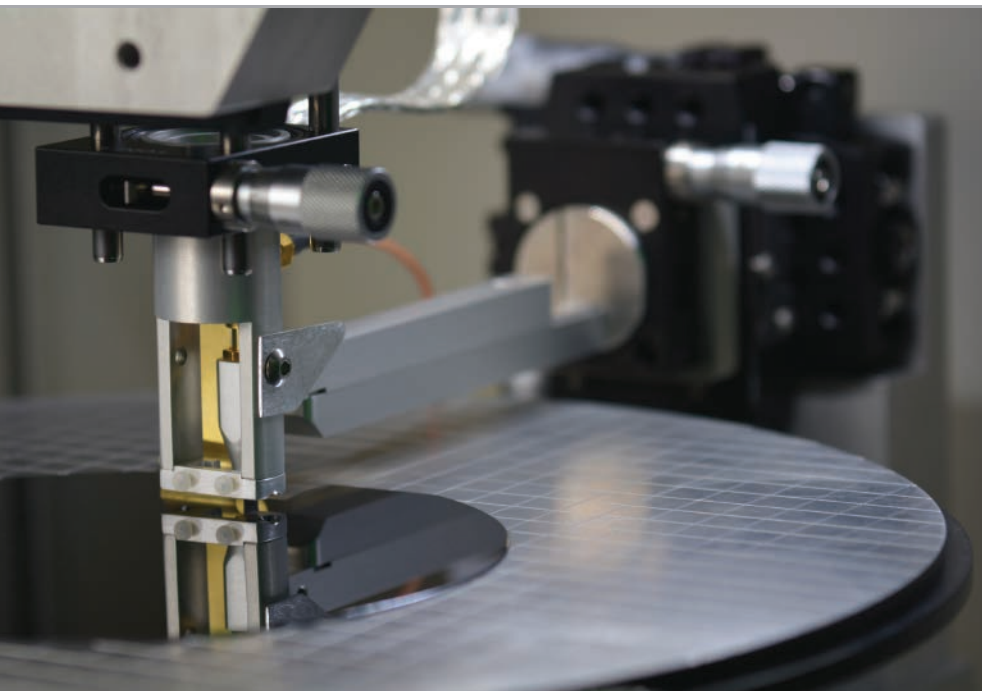
# Fraunhofer USA Center for Manufacturing Innovation CMI

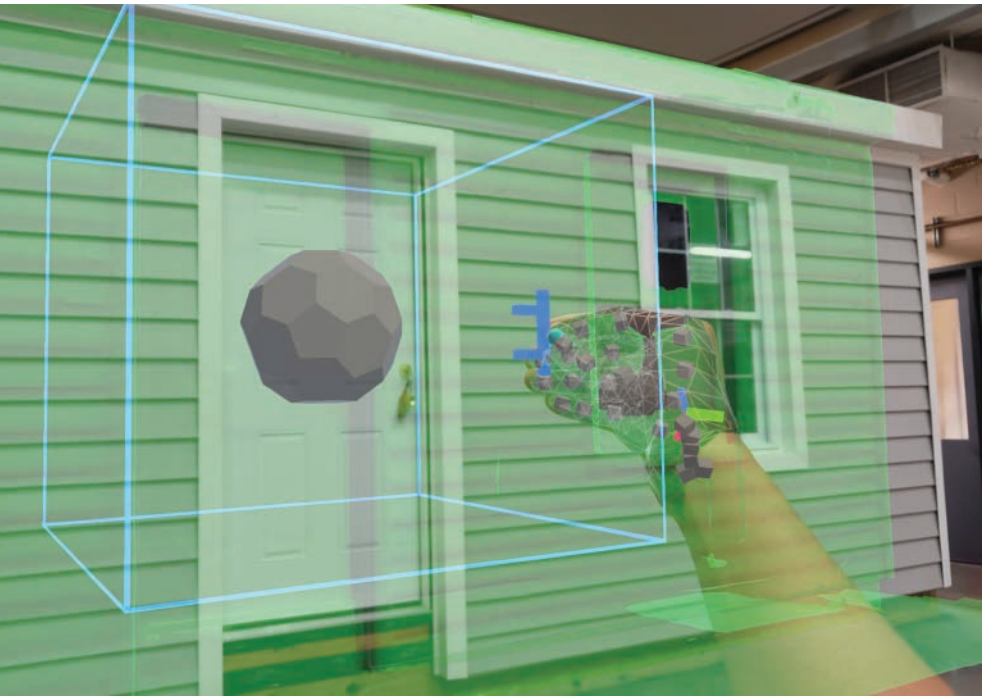


## Scientific Focus

Fraunhofer USA CMI focuses on three pillars of our economy: Industrial systems, sustainable energy systems and biomedical systems. Within industrial systems, CMI develops next-generation automation solutions for a variety of industries, including aerospace, photonics, consumer products manufacturing, automotive, materials processing, and others necessitating high precision and intelligence. Within the biomedical space, engineers and biologists work side-by-side, leveraging our combined expertise in engineering design and biological sciences to develop biosensors and medical devices, microfluidics, laboratory automation, and micro assays.

Our focus in sustainable energy is on reduction in energy consumption in buildings, and efficient grid integration. More specifically, our work in building energy reduction focuses on creative and quantitative means of analyzing and using data generated by an ever-increasing number of communicating sensors, combined with thermal modeling, to reduce energy consumption. In the area of grid integration, Fraunhofer USA CMI is focused on the development of efficient algorithms for integration of distributed energy resources (DERs), such as solar, wind, hydro, storage, etc. into the grid, as well as reduction of strain on the grid through load balancing. A unique advantage of our center is the combination of energy, manufacturing, and biomedical competences. For example, the center leverages its automation and manufacturing expertise to facilitate cost-effective sustainable energy solutions to meet our decarbonization goals as a nation.





## Core Competences

### Industrial Systems

- Turn-key next-generation automation systems
- Control systems
- Real-time control software development
- Precision motion
- Mechatronics

### Energy and Climate

- Building performance assessment
- Building control algorithms
- Power grid integration of distributed energy resources
- Cost-effective construction techniques
- Deep energy retrofits

### Biomedical Systems

- Lab automation and instrumentation
- Massively parallel sample preparation
- Point-of-care diagnostics compatible with high-volume manufacturing
- Microfluidics
- Tissue engineering

### Research Fields

- High-precision motion
- Tissue engineering
- Antibiotic susceptibility
- Model-based building optimization
- Deep energy retrofits
- Production of low-cost biosensors
- Grid load balancing

# Fraunhofer USA Center Midwest CMW


## Scientific Focus

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


## Core Competences

### Light and Surfaces

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

### Materials

- Coating materials
- Diamond materials and applications
- Materials characterization

### Microelectronics

- Electrochemical sensors and methods
- Microfabrication

### Research Fields

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

# Fraunhofer USA Digital Media Technologies Office DMT

Fraunhofer USA's Digital Media Technologies Office DMT promotes state-of-the-art technologies in this field. Fraunhofer USA DMT supports the Audio and Media Technologies division of Fraunhofer Institute for Integrated Circuits IIS in the United States.

For more than 35 years, the Fraunhofer Institute for Integrated Circuits IIS has been shaping the globally deployed standards and technologies in the fields of audio coding and moving picture production. Fraunhofer IIS systems and tools help create, transmit and provide excellent audio and video content as well as enable high-quality, real-time communication. Today, almost all computers, mobile phones and consumer electronic devices are equipped with Fraunhofer IIS technologies and are used by billions of people around the world every day.

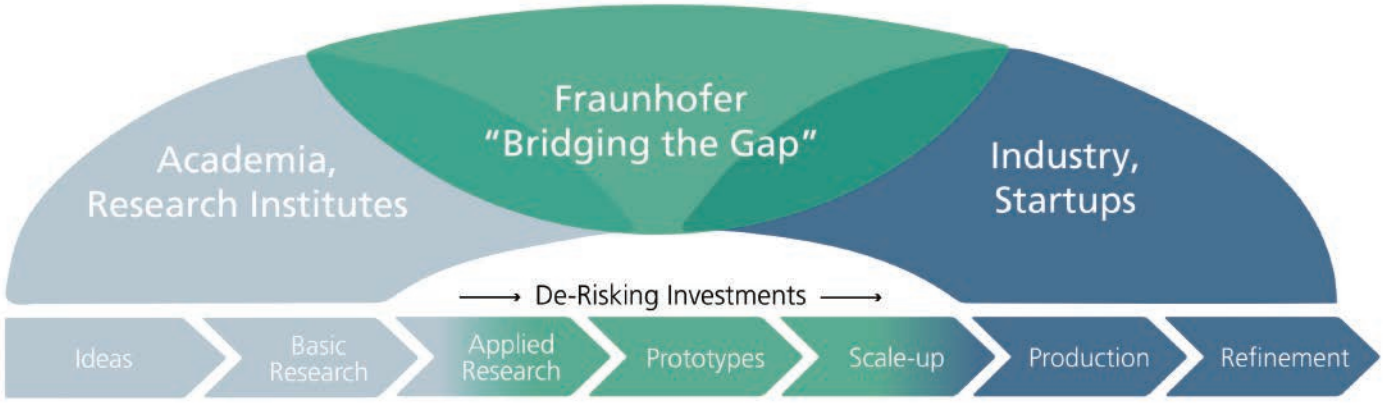
It all started with the creation of mp3, then evolved with the co-development of AAC and HE-AAC. Now, the fourth generation of best-in-class audio technologies – MPEG-H Audio, EVS, LC3/ LC3plus and xHE-AAC – elevates the media experience to new heights. In terms of audio signal processing, Symphoria and the Sonamic product family provide enveloping and enhanced sound in cars, while the upHear product family dramatically improves 3D audio playback or recording quality of professional and consumer devices. Fraunhofer technologies also power digital radio in the form of the ContentServer, which combines audio encoding, multi-media data management and multiplexing. In the field of moving picture technologies, establishing the Digital Cinema Initiative test plan boosted the creation of professional tools for digital film and media production, such as easyDCP. The JPEG XS solutions facilitate the transfer to all-IP workflows.


Welcome to the MAS Codec Demo
Target Reference Level: -19 LKFS
DRC Effect Type:


Fraunhofer
IIS
FRAUNHOFER INSTITUTE FOR INTEGRATED CIRCUITS IIS
EXCELLENCE IN AUDIO ENGINEERING

# Work with Us

Fraunhofer USA brings cutting-edge research and development and a highly trained staff to tackle the toughest problems for our customers. We bridge the gap between academic research and industrial needs, and leverage both in doing so. Our industrial clients include large multi-national companies, SMEs, and startups, in addition to government organizations. We also collaborate with renowned research organizations, universities, and other networks to fulfill our mission of improving the world through the application of advanced technologies. Our creative and enthusiastic team of scientists and engineers are solution driven.




# Bridging the Gap: How to Engage with Fraunhofer USA

Fraunhofer USA employs several strategies to bring technology to market for our government and industry customers. By partnering with industry leaders to identify market needs and co-develop solutions, our joint collaborations often lead to the commercialization of technology by integrating it into existing products or launching new products altogether. We can support startup companies based on promising technologies developed in their labs and showcase our research outcomes at industry events or trade shows. We are also actively engaged in technology transfer programs that aim to transition research findings into practical applications, often with government support and grants. We often generate intellectual property through the work of our research scientists and this technology is also available for licensing to interested companies. By offering our collective expertise in market analysis, business planning, and technology validation, we bridge the gap between research and commercialization, further fostering innovation and economic growth.

### Information for Industrial Clients

For 30 years, large and small companies have turned to Fraunhofer USA for assistance in solving their most challenging problems. Through our structured and rigorous approach, we mix emerging research with state-of-the-art technologies to develop custom solutions not available in the marketplace. We work in many industry sectors, including but not limited to: biotech/biomedical, consumer products, aerospace, materials, additive and advanced manufacturing, automation, energy and any other sectors interested in Industry 4.0 technology solutions. Our clients typically engage with us in two ways:

### Joint Government Funding

Fraunhofer USA can support companies applying for government funding, in the form of joint proposals or as R&D subcontractors with letters of support. We participate in both large-scale government programs as well as SBIRs and are in compliance with all pertaining government regulations for such funding.

### Contract Research and Development

We offer a free-of-charge assessment as to whether our organization can help address your needs and then provide a proposal as to how we can be of service, typically under a non-disclosure agreement. All of our proposals include a phased approach to mitigate risk, a clear statement of deliverables, milestones, and cost. We have a flexible and transparent intellectual property policy which works well for both large and small companies.


## South Carolina Fraunhofer USA Alliance

After years of fruitful partnership with the State of South Carolina, including state funding of three research projects between Fraunhofer IESE and selected state universities, the South Carolina Fraunhofer USA Alliance was formally established in 2019 by the South Carolina Department of Commerce. The Alliance is a collaboration of the Council on Competitiveness ("SC Competes"), a statewide non-profit organization that provides administration, industry and academic engagement, and management to the Alliance, Fraunhofer USA, representatives from key industries, and South Carolina academic partners such as Clemson University, College of Charleston, and the University of South Carolina.

The State of South Carolina has provided support which also advances the Fraunhofer USA corporate mission of providing cutting-edge technologies and advanced applied research to companies and organizations of all sizes in order to support them in being as globally competitive as possible. This program, now in its fifth year, offers state governments, economic development agencies and academic institutions the opportunity to develop technical assistance programs based on the Alliance template and is tailored to the states' specific needs and interests.

The program works to assist local businesses with the challenges and opportunities presented by rapid technological changes. Initially targeting manufacturing processes, product development and service delivery, the Alliance has now also reached the life sciences and the material sciences. The State of South Carolina provides approximately $2 million to the South Carolina Fraunhofer USA Alliance per year in 1:1 funding to match industrial monies. To date, more than 30 projects have been co-funded with matching monies for the automotive, energy, aerospace, life science and logistics sectors of the state. South Carolina is home to more than 220 German companies such as BMW, Bosch, Continental, Schaeffler, MTU, Mercedes Benz Vans and more. Representatives from BMW and KION (Linde Group) currently both serve on the South Carolina Fraunhofer USA Alliance Review Board providing "voice of industry" perspective.

Since its inception, the Alliance Program team has worked with companies involved in aircraft subsystems, bicycle manufacturing, thermoplastics, appliances, shipping and logistics, telemedicine, auto assembly, and many others. Projects have focused on reducing defects in assembly operations, image analysis, workforce training and onboarding process improvements, capturing data and integration of data sets for better insights into operations, automation of manual production tasks to allow workers to focus on higher value, growing enzymes for health care, reducing operational costs to be able to reshore operations from Asia, supporting and guiding companies during the transition from the traditional automotive to the EV industry.

The variety of industries and challenges addressed speaks to the Alliance Program team's capacity and capability to take on tough issues facing companies large and small, and delivering success where off-the-shelf solutions do not exist. The technical areas include artificial intelligence for manufacturing, Industry 4.0, advanced quality management, production technology, sustainability, advanced materials, and automation and robotics.

For more information on the South Carolina Fraunhofer USA Alliance contact Dr. Marcel Schaefer at mschaefer@fraunhofer.org.

## Fraunhofer USA TechBridge Program

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

The current TechBridge program, known as the Carbon to Value Initiative (C2V Initiative), is a unique partnership between Fraunhofer USA, Greentown Labs, and the Urban Future Lab at New York University-Tandon. The C2V Initiative drives the creation of a thriving innovation ecosystem for the commercialization of carbontech solutions that capture, convert, and sequester carbon dioxide ($CO_2$) into valuable end products or services.

Now entering its fourth year, the C2V Initiative has supported 26 groundbreaking startups that have raised over $410 million in follow-on funding, leading to numerous successful partnerships and 200+ new business relationships, technology advancement, and industry growth. The initiative connects innovative young companies with industry leaders in chemicals, advanced materials, energy, and other sectors that can provide resources and market access necessary to enable rapid commercialization of carbontech.

A key component of the C2V Initiative is the Carbontech Leadership Council (CLC), an invitation-only group of executive leaders across diverse industry sectors driving the future of carbontech. Startups selected to participate gain access to the CLC, benefiting from customized workshop programming and access to resources and mentorship from the Urban Future Lab, Greentown Labs, Fraunhofer USA and Fraunhofer-Gesellschaft networks.

The C2V Initiative creates a first-of-its-kind collaborative ecosystem among carbontech innovators and leading corporations with the end goal of making carbontech cost-effective and achieving its deployment at scale. Through participation in the CLC, corporations both advance their sustainability goals and take a leadership role at the forefront of a new industry, as the world seeks to rapidly decarbonize in response to climate change.

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

### Applied Research Consortia (ARC) Project

Industry-led R&D consortia are a proven approach to productive pre-competitive collaboration among multinational businesses, large and small. In such consortia, intellectual property and know-how can be protected even as it is shared among partners and consor-tium members. The most effective pre-competitive R&D consortia are hosted by, or adjacent to, major research universities. They are structured to be amenable to supporting public R&D investments and promoting the participation of university-based researchers, and engaging undergraduate and graduate students in industry-defined research.

The ARC Project will develop, and advocate for, industry-led cross-border R&D consortia across a range of pre-competitive challenges and opportunities.

In launching the ARC Project, Fraunhofer USA draws upon decades of successful experience, both in the U.S. as well as globally, in contract R&D for industry and governments. Fraunhofer's experience includes both multiclient R&D projects and industrial applied research consortia. That breadth and depth of experience means that Fraunhofer USA, independently and drawing on the 76 institutes of Fraunhofer-Gesellschaft, can serve as start-up organizational host and interim steward for industry-led consortia across an unparalleled range of pre-competitive R&D challenges.

### Research Scholar Program

Fraunhofer USA offers a research scholar program. International researchers can come to the United States through our J-1 Research Scholar program and perform applied research at Fraunhofer USA for a period of 1 to 3 years. This program offers Post-Doc positions and provides opportunities for early career scientists and engineers to obtain hands-on experience, which can facilitate knowledge transfer and support the progress of science and technology to the greater benefit of society.

### Intern Program

Fraunhofer USA is committed to offering opportunities for mean-ingful, hands-on internships for both international and domestic students studying in STEM fields. Over the last 30 years, Fraunhofer USA has hosted thousands of interns from many countries and backgrounds, supporting and encouraging curious minds as they lay a solid foundation to help support the critical STEM fields that we all rely upon. Internships are available for U.S. and international interns at our three research centers. Interns are closely mentored and find the experience very rewarding. Fraunhofer USA has a J-1 Visa program that provides us with the capability to obtain an intern's visa if the intern is not authorized to work in the U.S..

# Select R&D Projects

Highlighted research showcases Fraunhofer USA's ability to bring technology to market, collaborations with university and government partners, and our efforts to progress transatlantic collaboration in science and technology.

# Bringing Technology to Market

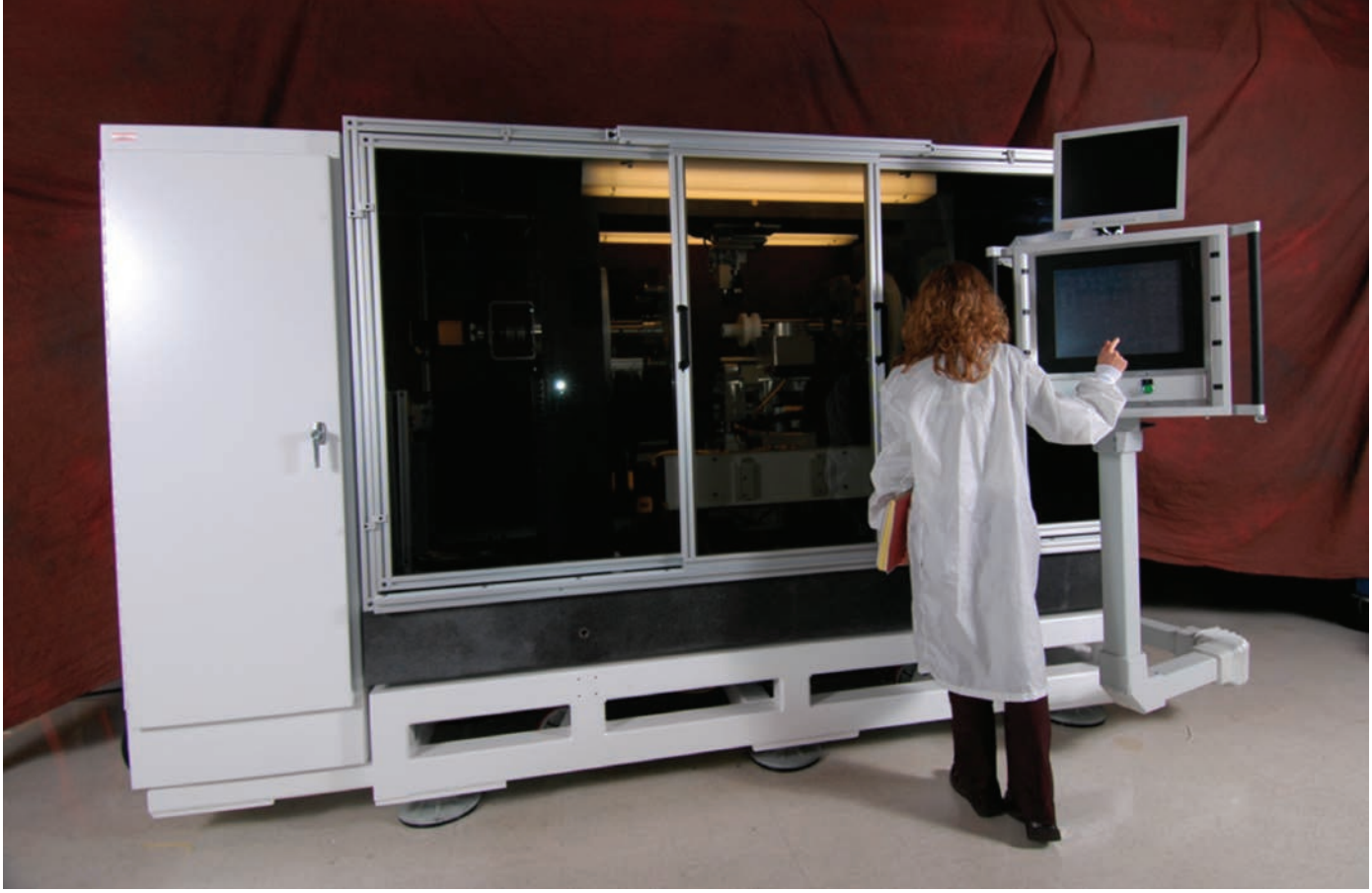
## Application of AI to Verify Weld Quality in the Automotive Industry

**Fraunhofer USA Center Mid-Atlantic CMA**

In the automotive industry, vehicle body production requires from about 3,500 to 14,000 individual resistance welds, known as spot welds, per vehicle to join sheet metal components. These welds must be verified for quality and structural integrity. Current inspection processes rely on static inspection methods, where all welds are manually checked over several shifts using ultrasound. Additionally, weld integrity is periodically verified through destructive testing, providing critical data on weld quality but further adding to the delay between the production of a weld and confirmation of its quality. The overall process flow for the quality checking of spot welds is highly time consuming and labor intensive, making it a focus point for improvements in efficiency in the automotive industry. Advances in machine learning offer an approach to greatly reduce this inspection effort and the duration of the feedback process to approve welds and thus optimize the entire welding and associated quality assurance endeavor.

Engineers at Fraunhofer USA CMA have worked with colleagues at the Fraunhofer Institute for Manufacturing Engineering and Automation IPA in Stuttgart, Germany and Clemson University to address this opportunity with a major automative manufacturer by collecting extensive data directly from the welding equipment and manual verification systems during production. The team trained artificial intelligence (AI) models on historical data to be able to predict weld quality with high precision in real-time, allowing for targeted manual inspections specifically focused on high-risk welds. This approach also allowed for continuous improvement by refining weld parameter settings to enhance their quality. The outcome of this project was to significantly reduce the time and resources required for manual quality checks while maintaining overall production quality. This effort targets at least a 15% reduction in labor hours dedicated to manual inspections and an estimated return on investment for the manufacturer in under a year. The approach undertaken here should also be applicable to optimizing other production processes requiring inspection and validation, in particular other joining technologies used in the automotive and other manufacturing industries.

*Spot welding (left) in progress on an automotive assembly line (right).*



*Coil winding machine for production of fiber optic gyroscopes.*

## Automated Fiber Optic Winder for Producing Fiber Optic Gyroscopes

**Fraunhofer USA Center for Manufacturing Innovation CMI**

Fiber optic gyroscopes are highly precise and accurate rotation sensors. They are used extensively in navigation and guidance systems installed in aircraft, ships, spacecraft and other complex vehicles. Lower performance range applications include turret stabilization systems, in helmet display stabilization and even the first down marker used in National Football League broadcasts. Such gyroscopes can also be used for research in combined quantum and classical navigation systems such as those envisioned for underwater autonomous vehicles. One of the advantages of fiber-optic gyroscopes over other inertial sensors is low noise emittance, which is important for military applications. The performance of these fiber-optic gyroscopes is closely related to the length of the fiber-optic coil and the accuracy of the winding pattern for that coil. Higher accuracy applications, require coils that can be multiple kilometers in length and successful winding of them requires motion control at the micron level, image processing and high-resolution tension control. Current practices require up to two weeks of highly-skilled manual labor to wind such a coil.

Fraunhofer USA CMI engineers are developing a computer-controlled machine for coil winding that employs 17 coordinated servo axes that control its moving parts, allowing for micron level placement of the optical fiber in the required pattern configuration and precise tension control. The coils are wound from the inside out, meaning that the supplied length of fiber is divided into two connected spools before the winding process begins. Based on the required winding pattern the system then winds individual layers from each supply spool while fixing the inactive spool on the winding axis to prevent unwinding. Such an automated system with in-process image processing allows for highly accurate coil winding without physical intervention by operators. This enables strategic grade coils and gyroscopes with the key performance features of low cross-talk between signals in adjacent channels and very low thermal drift. Such high accuracy coil winding results in a low coil rejection rate. Furthermore, the automated system reduces labor costs and increases throughput. Fraunhofer USA is deploying this system to wind coils for various customers in multiple industries, including for an Asian aerospace company.

*High performance bipolar plate demonstrators.*

*Polymer electrolyte membrane (PEM) fuel cell.*

## Production of Metallic Bipolar Plates for Proton-Exchange Membrane Fuel Cells

**Fraunhofer USA Center Midwest CMW**

Transition to a hydrogen economy is viewed as a key strategy to reduce emissions of greenhouse gases and to reduce global warming. The use of hydrogen as a fuel requires fuel cells, typically proton-exchange membrane fuel cells, that are electrochemical cells capable of converting chemical energy into electricity through redox reactions. They utilize hydrogen and oxygen to sustain a chemical reaction to produce electricity continuously. Metallic bipolar plates are integral components of fuel cells, where they evenly distribute fuel and oxidant and collect the electric current that is generated. In a fuel stack, they connect individual fuel cells in series, conducting electricity from the anode of one cell to the cathode of the next.

Energy efficient fuel cells require high performance bipolar plates that have several key attributes, including adequate fuel flow, fluid impermeability, hydrophobicity, mechanical stability, thermal transmission, and electrical conductance. These attributes define the design of the metallic bipolar plates, including the overall dimensions of the plates, the layout of the flow field, channel width and depth, and the degree of curvature of channels. Thus, precise channel geometries and tight manufacturing tolerances are essential for fuel cell efficiency. Maximum surface area at minimum weight requires complex plate designs and use of thin metals, typically less than 0.1 mm thick, which must be formed without tearing. High-volume production thereof is challenging.

Engineers at Fraunhofer USA CMW have worked with colleagues at Clemson University and the Fraunhofer Institute for Production Technology IPT in Aachen, Germany to optimize approaches for the design and manufacturing of metallic bipolar plates for proton-exchange membrane fuel cells. Firstly, flow field and channel geometries were optimized regarding fuel distribution, tooling capabilities and press capacities. Following the forming, processes and fixturing tools were developed for precision laser cutting of external and internal plate features and uniform laser joining of anode and cathode half plates. Assembled plates were coated by physical vapor deposition techniques. The coatings met key U.S. Department of Energy targets for corrosion resistance and interfacial contact resistance. Finally, gaskets were applied by screen printing around the outer periphery and media ports to complete bipolar plate demonstrators.

These metallic bipolar plates were developed under a project supported by the South Carolina Department of Commerce and a global manufacturer of automotive components. The plates have applications for a wide range of vehicles and industrial equipment.

# University and Government Collaboration

"We are pleased to have been selected as one of three partner universities for Fraunhofer USA. Over the past three decades, our collaboration has resulted in the advancement of medical devices, optimized residential energy consumption algorithms, and a successful spinoff that is providing fiber optic interconnect solutions to the aerospace and defense industries."

– Prof. Thomas Bifano,
*Vice President and Associate Provost ad interim for Research, Boston University*

## University Partnerships

### University of Maryland

The University of Maryland (UMD), College Park is a public land grant university that was founded in 1856. UMD ranks among the top 20 U.S. Research institutions in the National Science Foundation's higher Education and Research Development (HERD) Survey. The HERD survey ranks universities engaged in sponsored research.

The Fraunhofer USA Center Mid-Atlantic CMA has collaborated with the University of Maryland since 1997, specifically within the College of Computer, Mathematical and Natural Sciences. The College of Computer, Mathematical, and Natural Sciences at the University of Maryland educates 8,000 + future scientific leaders in its undergraduate and graduate programs each year. The ten departments and nine interdisciplinary research centers in the college support and develop scientific discovery with annual sponsored research funding exceeding $250 million.

### Boston University

The Fraunhofer USA Center for Manufacturing Innovation CMI has collaborated closely with Boston University (BU) since the center's inception in 1995. The center is located on the BU Charles River campus. Boston University is identified as an institution of "very high research activity" in the Carnegie classification of Institutions of higher education.

Fraunhofer USA CMI collaborates directly with several of BU's schools and colleges, including the College of Engineering, the Medical School, the Business School, and the College of Arts & Sciences. Boston University has a student body of more than 34,000 students of which circa 16,000 are graduate students. As a leading global research institution, BU has been awarded more than $645 million in research awards in FY 2023.

### Michigan State University

Since 2003, the Fraunhofer USA Center Midwest CMW and Michigan State University (MSU) have closely collaborated on applied research and development projects in the areas of diamond and coatings technologies. Michigan State University, founded in 1855, has 50,000+ students, with more than 10,000 graduate students. Michigan State University is a top 100 global research university, with total research expenditures for MSU totaled approximately $844 million in 2023. Fraunhofer USA CMW collaborates closely with the College of Engineering and Natural Sciences.

## Human Agent Teaming for Intelligence Tasks

**Fraunhofer USA Center Mid-Atlantic CMA**

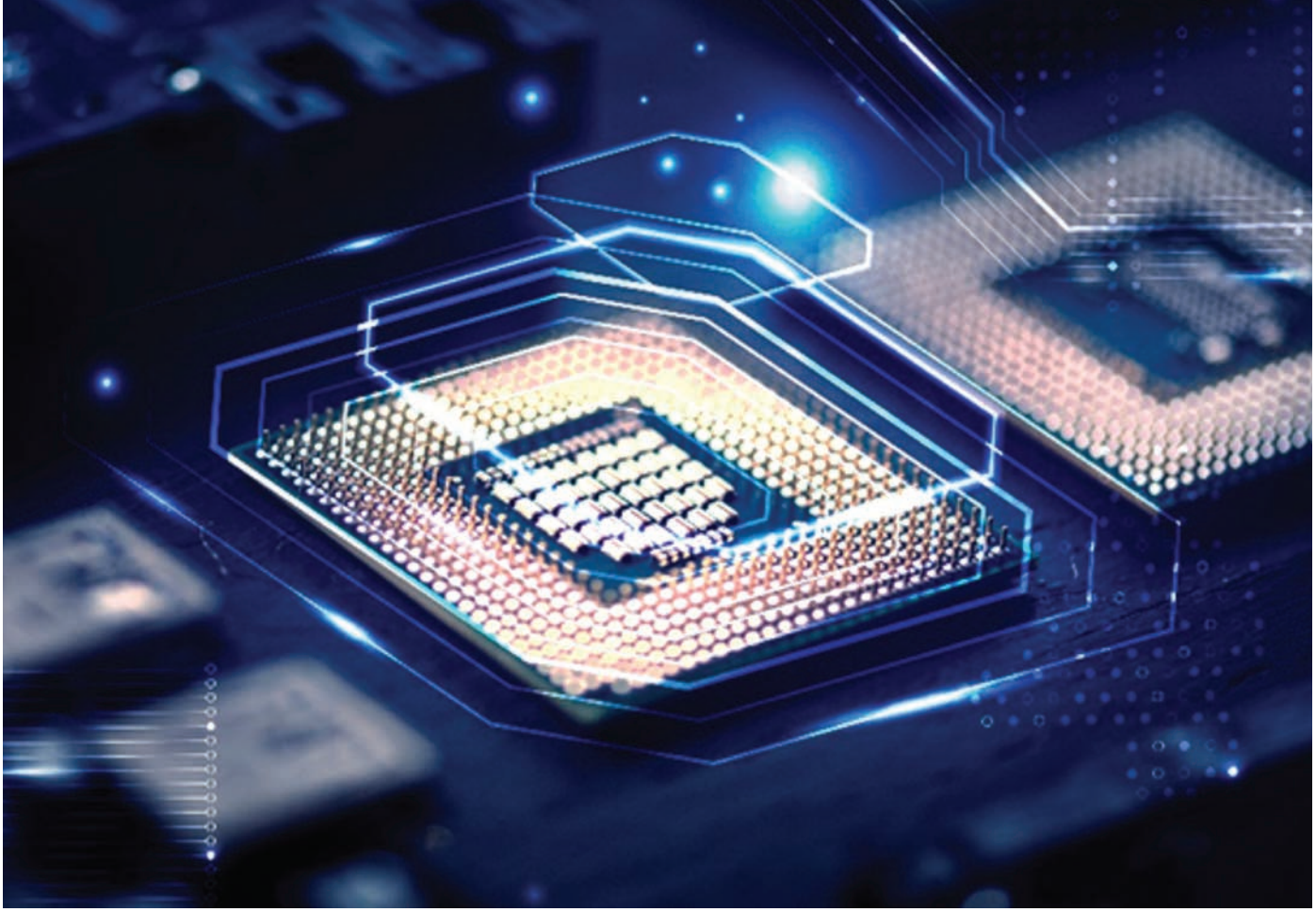
Team communication and coordination is of critical importance for intelligence gathering by the military and government security agencies, with weaknesses in gathering and processing information often associated with shift handovers, resulting in team cognition challenges. These challenges include inaccuracy blindness, group sharing and storing of knowledge, known as transactive memory systems, and shared mental models. Artificial intelligence (AI) has often been proposed as a possible solution to these problems, since, for example, AI can support teaming by augmenting individuals' production capabilities, summarize machine read documents and convert them to summary output text, and organize intelligence analysis around entities, such as people and places, rather than freeform text. However, it is not clear how to best align rapidly developing AI technologies with intelligence analysis work.

Engineers at Fraunhofer USA CMA have worked on a project with colleagues at the University of Maryland and Duquesne University for the United States Army Research Office to assess the application of AI and machine language analysis to mitigate team communication and coordination problems such as information overload, ignoring potentially relevant data and erosion of trust between team members. The goal of the project was to provide much needed insight into how human teams can work together with AI, especially AI that provides sensemaking support, to improve outcomes in intelligence analysis and avoid exacerbating team interactions.

Based on insights gathered from interviews with intelligence analysts, the team developed a software platform and an experimental infrastructure testbed to experimentally study the role of different types of AI during intelligence analyst shift handovers. They also conducted controlled immersive behavioral experiments to test the effect of AI manipulations on sensemaking, problem solving, workload, and transactive memory systems. The testbed consisted of task-relevant input materials, such as mission descriptions and source documents, simulated team members, activity recording tools, such as search tools and scratchpads, experimental monitoring capabilities, such as recording and survey systems, and AI support tools for human analysts, such as AI that can summarize large quantities of information by, for example, constructing topic models. The experiments simulated the 5Vs challenges associated with big data: a high volume of material, a wide variety of material sources, a rapid velocity of information accrual, questionable veracity of some sources, and extractable value being dependent on linking information from multiple sources.

The testbed was most recently applied to analyze interactive shift-handovers, comparing relatively simple AI tools with an entity-based AI drawing on developments with ChatGPT and theories on information science and intelligence analysis. The approach shows great promise for assessing AI tools being applied with the goal of improving the efficacy of intelligence analysis.

*AI can assist intelligence teams.*



*A typical computer chip where a diamond-based heterogeneously integrated device can be incorporated to improve electric performance.*

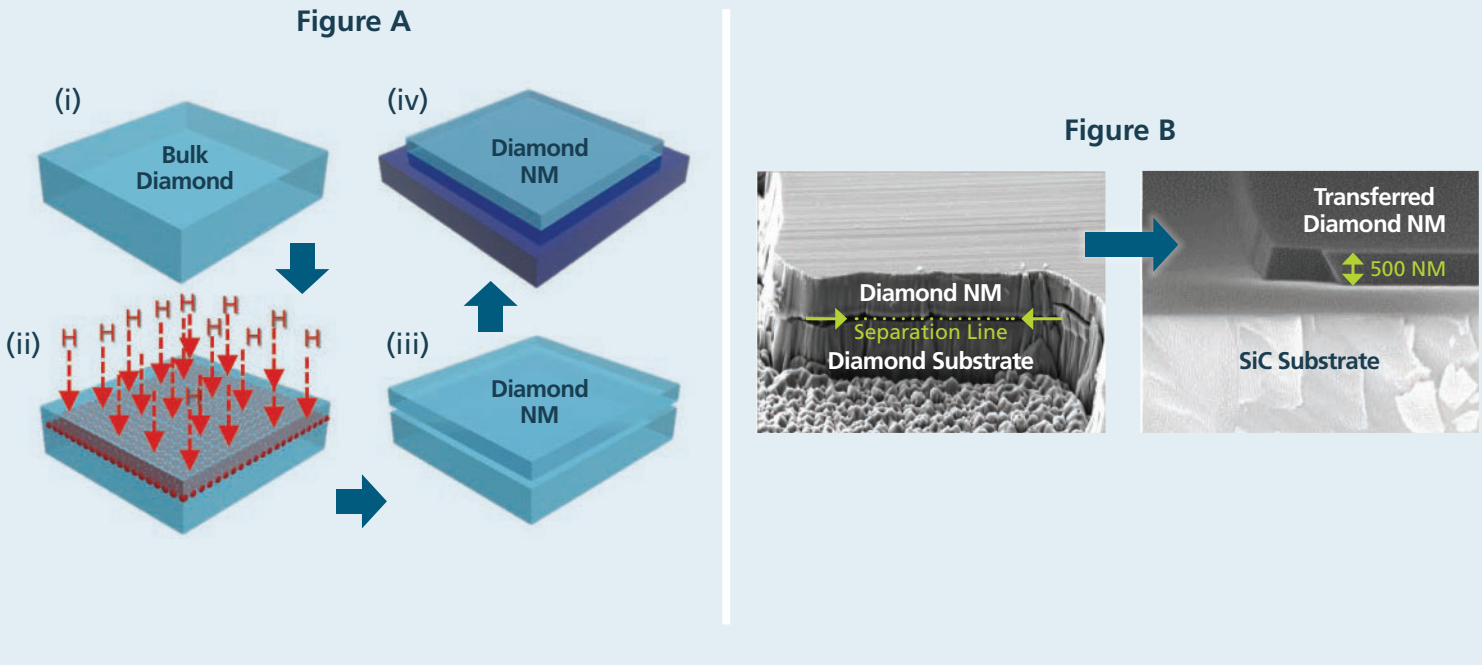
## Diamond Membranes as a Device Layer for Next Generation Semiconductors

**Fraunhofer USA Center Midwest CMW**

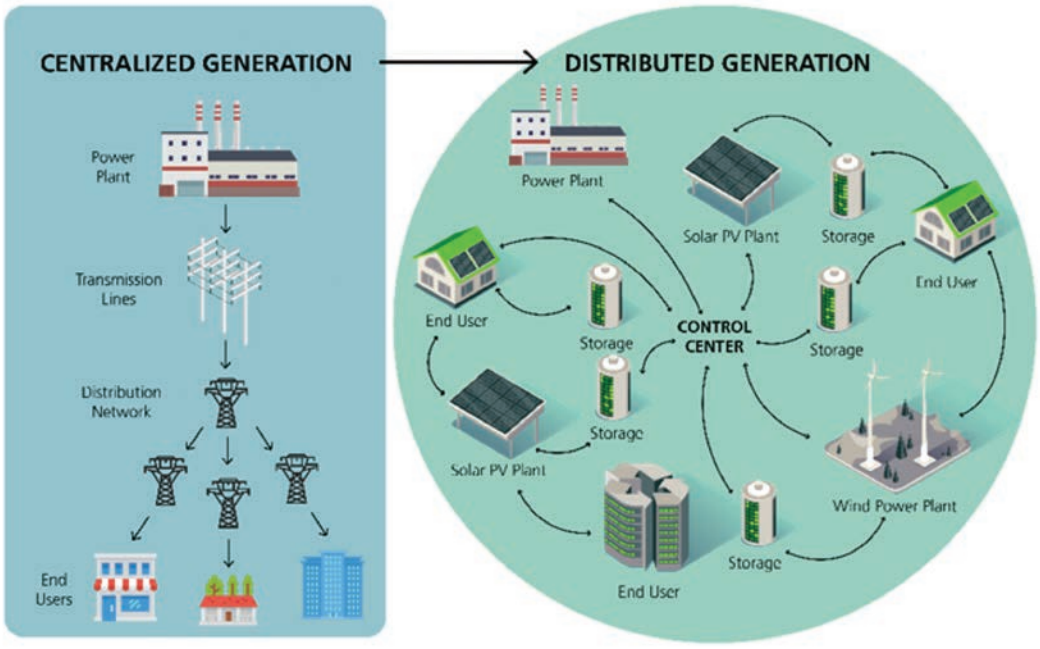
There is an increasing need for higher power devices that are more efficient, reduce strain on the electrical infrastructure, and are required for specialized industrial systems. To address this need, new high-power electronic devices are under development for application in a wide range of systems, including telecommunications, motor drives, power grids, electric vehicles, and industrial and locomotive traction control. These new devices require ultra-wide bandgap semiconductors with performance characteristics that are beyond the capabilities of the silicon carbide and gallium nitride materials used in electronic devices today. Various materials, including aluminum gallium nitride alloys, boron nitride, and diamond, are being tested for use in these new semiconductors, as are composites, combining multiple materials, where each material offers unique and necessary performance characteristics to the semiconductor.

Engineers at Fraunhofer USA CMW have worked with colleagues at the Fraunhofer Institute for Microstructure of Materials and Systems IMWS in Halle, Germany to develop a technique to create single crystalline diamond nanomembranes that can be integrated with other semiconductor materials to create diodes with improved performance (see schematic figures A and B). The diamond nanomembranes are exfoliated from (i) bulk material via (ii) an ion implantation and (iii) separation process. These nanomembranes can then be transferred and further processed via a commercialized micro-transfer printing process (iv). Early prototypes showed an over ten-fold higher increased forward current density compared to traditional all-diamond diodes. Integration of diamond into these heterogeneous diodes also allowed for improved thermal management. Furthermore, the team demonstrated that chemical-mechanical polishing lowered surface roughness on the diamond nanomembranes, a prerequisite for including them in stacked devices such as thyristors, which are robust and operate like switchable diodes that are commonly used in high-voltage applications to control electric power flow.

Under a program funded by the Defense Advanced Research Project Agency (DARPA), the Fraunhofer USA CMW engineers are now working with an industry partner to incorporate these diamond nanomembranes with other ultra-wide bandgap semiconductors that will allow devices to operate at higher voltages, frequencies and temperatures than what can currently be achieved with traditional materials, such as silicon carbide and gallium nitride. Access to such devices will be critical for a transition from a centralized to a distributed power grid. Interfacing renewables, such as solar and wind, as well as battery storage, with the grid at large requires the use of these devices.




*(Figure A) A schematic illustration of the ion-cut process to create diamond nanomembranes on semiconductor substrates, and (Figure B) cross-sectional scanning electron microscopy images of steps (iii) and (iv) of the process.*




*New devices will facilitate the transition from a centralized to an interconnected, distributed power grid system that relies on renewable energy generation sources, like solar and wind, as well as localized energy storage.*

## Pathogen Biosensors for Rapid Healthcare Screening

**Fraunhofer USA Center for Manufacturing Innovation CMI**

As dramatically demonstrated by the coronavirus disease 2019 (COVID-19) pandemic, current diagnostic assays are ill-equipped to deal with the rapid global spread of emerging and reemerging pathogens. These quantitative assays are incompatible with rapid point-of-infection testing. Rather they require biological samples to be collected and then transported to a testing laboratory for the isolation of nucleic acids and the performance of amplification tests to identify the presence and abundance of a specific pathogen. By contrast, crude antigen lateral flow, or strip, tests can be completed at the point of infection but are not quantitative and have higher error rates. Thus, there is considerable demand for accurate nucleic acid-based assays that can be performed at the point-of-infection.

Scientists at Fraunhofer USA CMI have worked with colleagues at Boston University Medical Center, the Fraunhofer Institute for Production Technology IPT in Aachen, Germany and the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB in Stuttgart, Germany to incorporate printed hydrogels into fluorescent arrays. These arrays combine the accuracy of nucleic acid amplification tests with the simplicity, speed and convenience of lateral flow assays and are thus suitable for rapid, point-of-infection tests to detect viral pathogens.

This platform has the added advantages of long-term stable storage of thermolabile reagents within the hydrogel matrix and multiplexing of outputs from multiple pathogens. The sensors detect the presence of specific pathogens in the samples through biological assays based on DNA amplification. Current development with Fraunhofer USA CMW focuses on integration of hydrogels with boron-doped diamond microelectrode arrays. The outcomes of these assays are thus converted into electrochemical signals.

The research team initially developed this technology for the detection of four respiratory disease pathogens, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), influenza virus A, influenza virus B and human rhinovirus. In addition to developing the relevant assays and the hydrogel matrix in which the assay components are encased, the team developed manufacturing processes for the printing of these hydrogel embedded arrays, including defining surface modifications of manufacturing-compatible plastics. Furthermore, the team designed a low-cost, portable reader for the assays and developed algorithms to process the output images to allow for automated analysis.

Under a recently awarded grant with the National Institutes of Health (NIH), the research team is now extending this approach to blood borne pathogens, specifically to develop a diagnostic assay to detect human immunodeficiency virus (HIV), the causative agent of acquired immunodeficiency syndrome.


Photos: Daniel Reibert

*Instrument for reading the output of the assays (left) and insertion of a printed array into this instrument (right).*

# Transatlantic Collaboration

Fraunhofer USA exemplifies the power of transatlantic cooperation in applied research and development. Through our unique partnership with Fraunhofer-Gesellschaft in Germany, we create a vital bridge between two of the world's leading innovation ecosystems. This collaboration goes far beyond traditional institutional partnerships – it represents a strategic alliance that accelerates technological advancement and creates lasting positive impact for both continents.

The strength of our model lies in its ability to combine German engineering excellence with American entrepreneurial spirit and market dynamics. By leveraging the vast capabilities of Fraunhofer-Gesellschaft's network in Germany while maintaining deep connections to U.S. industry and research communities, we create unique opportunities for breakthrough innovations that benefit society on both sides of the Atlantic.

Our transatlantic collaboration model enables rapid deployment of cutting-edge technologies and expertise where they are needed most. Whether addressing global challenges in sustainable energy, advanced manufacturing, or digital transformation, this partnership allows us to pool resources, share knowledge, and accelerate the development of practical solutions.

The impact of this collaboration extends far beyond our immediate institutional boundaries. By fostering deep connections between European and American innovation ecosystems, we help strengthen the broader transatlantic relationship, contributing to economic growth and technological advancement in both regions. This international cooperation is particularly crucial in today's interconnected world, where the most pressing challenges require global solutions and coordinated efforts.

At its core, Fraunhofer USA's mission is driven by the belief that transatlantic cooperation in applied research and development is essential for advancing society's wellbeing. By bridging the innovation landscapes of Europe and North America, we help ensure that groundbreaking research translates into tangible benefits for people on both continents and beyond.

## AI-assisted Laser Material Processing

### Fraunhofer USA Center Mid-Atlantic CMA

There are several challenges with laser welding of metal materials and laser cutting of thick metal materials. These include handling materials of diverse thicknesses and qualities, achieving the required detailing and precision in the product, meeting efficiency and time constraint targets, and limiting material wastage. New technologies are being developed to overcome these challenges, including new laser sources with increased power and tailored attributes, high-frequency power modulation of the laser beam, high-frequency oscillation of the laser beam and the focal plane of the laser, and plasma keyhole welding, which allows for the welding of high-alloy and unalloyed materials in a single pass of the laser. However, these new technologies are of high complexity, involving interacting non-linear effects, resulting in unstable processes when they are combined. Therefore, to incorporate these new technologies into a reliable operation requires comprehensive monitoring and control, best achieved through real-time monitoring and computer control guided by artificial intelligence (AI) to recognize deviations from the desired quality attributes and issue commands to promptly rectify deviations and maintain process stability.

Engineers at Fraunhofer USA CMA have worked with colleagues at the Fraunhofer Institute for Material and Beam Technology IWS in Dresden, Germany and the Fraunhofer Institute for Applied Optics and Precision Engineering IOF in Jena, Germany to develop controlled optimized laser material processing assisted by AI. The team implemented multimodal process monitoring equipment that provided input data for AI-based process evaluation that then allowed for AI-based closed-loop feedback control. This AI-based solution reduced energy consumption, increased processing speed, improved weld strength, and reduced distortion. Through this project, the team achieved the seamless integration of diverse monitoring technologies, including input from high-speed cameras and microphones, and ultra-fast data processing to provide real-time process control, allowing for dynamic adjustment of laser cutting and welding parameters during operation. The integrated system targets up to 30% higher speeds and up to 40% lower energy use for laser cutting and welding, while it also reduces the risk of cutting and welding failures. It is suitable for a range of materials, including the cutting of thick metal sheets and the welding together of different materials. The built systems are adaptable and scalable to various industrial needs and have broad application potential.

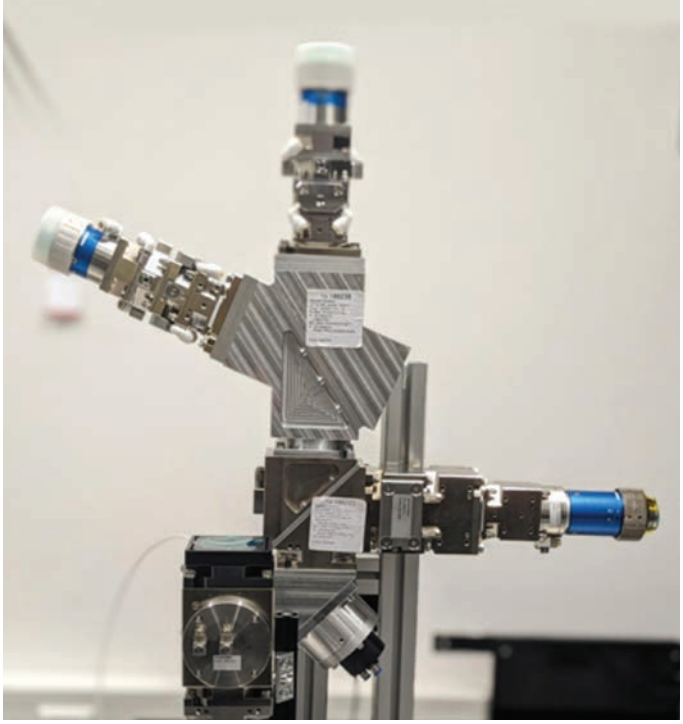


Photo: © Fraunhofer IWS

*Prototype for AI-assisted laser welding.*

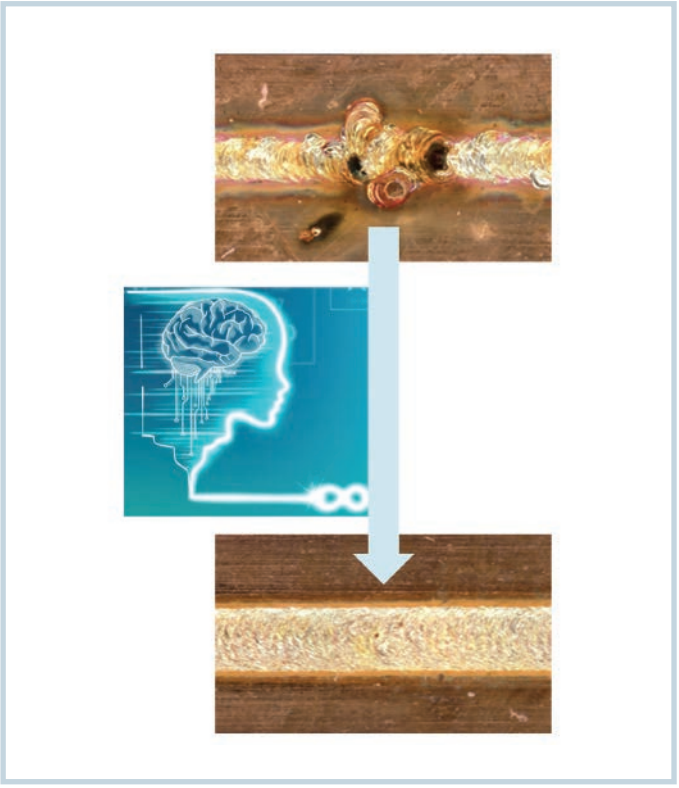


Photo: © Fraunhofer IWS

*Improvements in the welding process that can be realized through an AI-assisted approach.*

## Flexible Bioreactors for Cultured Meat

**Fraunhofer USA Center for Manufacturing Innovation CMI**

Meat, mainly beef, pork, mutton, lamb and poultry, is consumed by humans worldwide and contributes a large proportion of the calorific intake in many countries. This is rapidly increasing as the middle class swells in nations with rapidly rising gross domestic product (GDP). Indeed, the average annual per capita consumption of meat worldwide is more than 40 kg, but this rises to 120 kg in the relatively affluent U.S.. The environmental consequences of such rising meat consumption, both in terms of land usage and greenhouse gas emissions, are considerable and contribute significantly to global concerns over limited availability of arable land and climate change. The generation of antibiotic resistant microbes is a further hazard of the large-scale cultivation of animals for meat. However, cultural drivers make it highly likely that meat consumption will continue to be viewed as aspirational by many human populations for decades to come.

One leading potential solution to the land use and environmental consequences of meat consumption is to develop and use animal cell culture techniques to culture meat in bioreactors. However, the economical production of high-quality meat in bioreactors faces several hurdles, including the development of high yielding cell lines, the mass propagation of these cell lines, the fabrication of appropriate scaffolds upon which the cells can adhere, grow and divide to generate meat-like tissue, and appropriate bioreactor design for large-scale culturing, including allowing for flexing of the growing tissue to simulate the exercising of muscle in an animal.

Scientists at Fraunhofer USA CMI have worked with colleagues at the Fraunhofer Institute for Molecular Biology and Applied Ecology IME in Aachen, Germany to address the issues of a lack of suitable scaffolds and bioreactors for cultured meat production by developing a wet spinner, a circular braider and a tension bioreactor. This has allowed for the wet spinning of plant based polymers to tensile strengths compatible with cultured meat production. The team also developed porous sponges for compression-based scaffolds and

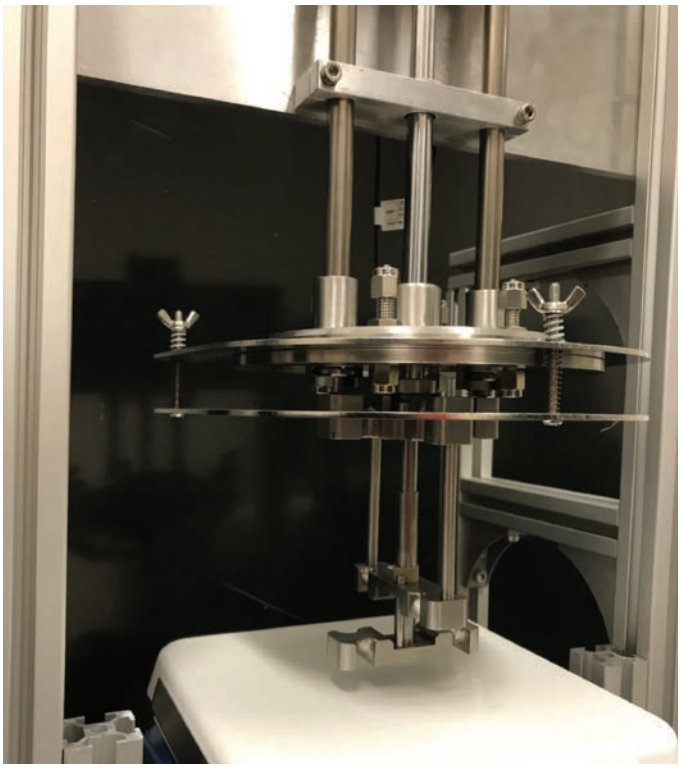


Photo: Daniel Dwiggins

*Tensioned bioreactor for cultured meat.*

showed them to have compression strengths compatible with the culturing of meat products. In addition, muscle satellite cells were isolated from samples biopsied from cattle. These cells were shown to be able to attach to the fiber scaffolds, where they were induced to form myotubes, a developmental precursor of muscle. The cells could also attach to the sponge-like scaffolds. The team is also optimizing the growth medium for muscle satellite cell cultivation and differentiation. To avoid the use of fetal bovine serum, which is expensive and of animal origin, the necessary growth factors are being produced in a cell-free plant expression system. Together, these developments are highly promising for advancing the cultured meat industry.

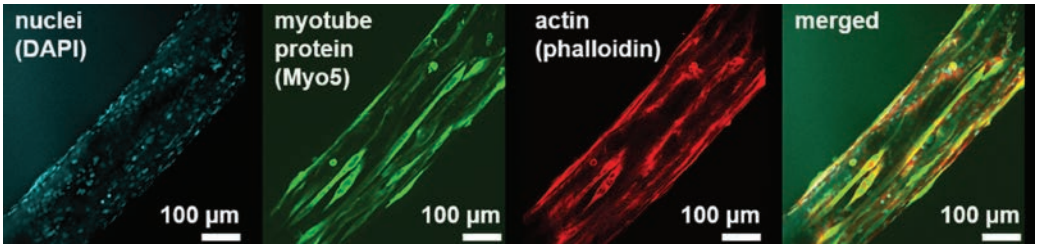



Photo: David Pietri

*Differentiated, multi-nucleated muscle cells (myotubes) growing on plant based fibers, stained for their nuclei (blue), a muscle protein (green) and a cell cytoskeleton protein (red). The scale bar shows 100 micrometers.*

## Biosensors for Infectious Pathogen Detection

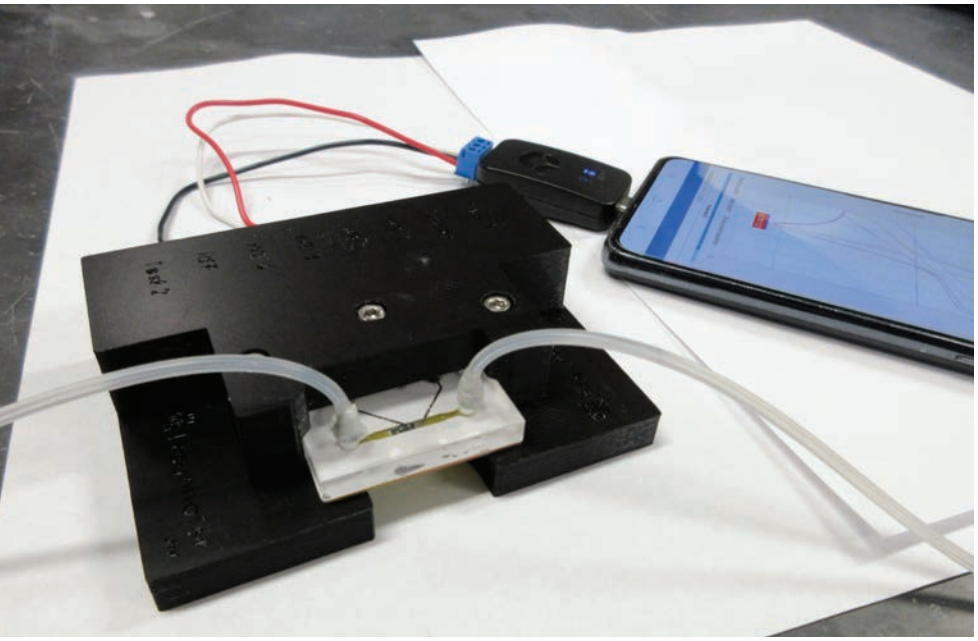
**Fraunhofer USA Center Midwest CMW**

Accurate and rapid detection of specific biomolecules is vital in biomedical research and for the development of effective diagnostics. Current methods for rapid biomarker detection include testing for protein antigens and antibodies using lateral flow assays and testing for DNA and RNA using nucleic acid amplification techniques. The former can be rapidly performed at the point-of-sampling but have relatively high error rates, low sensitivity and poor selectivity. By contrast, the latter have relatively high accuracy, selectivity and sensitivity but need to be conducted by trained technicians in a laboratory and are relatively expensive and time consuming. Thus, there is a market need for diagnostics for a range of biomarkers that are both rapid to perform and inexpensive but that also have a high degree of accuracy and sensitivity and that are highly selective.

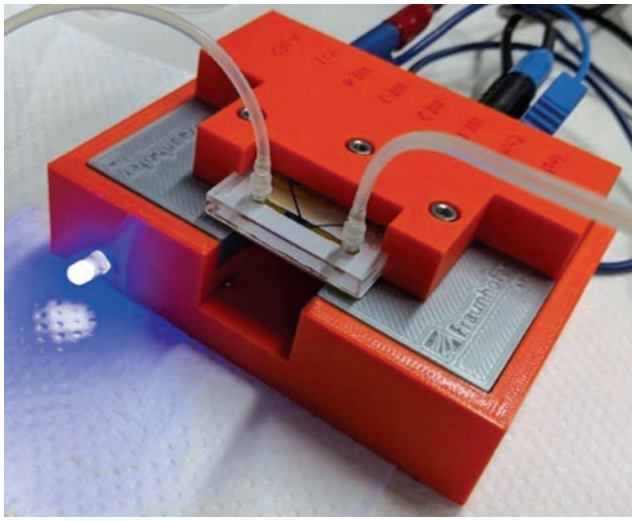
Scientists at Fraunhofer USA CMW have worked with colleagues at the Fraunhofer Institute for Reliability and Microintegration IZM in Berlin, Germany and the Fraunhofer Institute for Cell Therapy and Immunology IZI in Leipzig, Germany to develop an alternative biosensor technology based on electrochemical detection of proteins binding to a functionalized electrode surface. For initial development of this tool, the team focused on detecting antibodies to the major spike protein antigen of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which is indicative of viral infection, and to the human c-MYC protein, which is indicative of cancer.

The team developed a sensor in which a boron-doped diamond surface acting as an electrode was functionalized by click chemistry with known peptide targets of the relevant antibody. Since this mode of functionalizing the sensor surface is modular, it can be tailored to detect any antibody and thus has applications across a wide range of diseases. Differential pulse voltammetry was deployed to measure antibodies in a human serum sample binding to the peptides on the diamond electrode surface. This resulted in a highly selective and quantitative signal. The diamond-based sensor was packaged with a standard microfluidic system to allow for sample flow over its surface, with electrical connections to the electrode made through the back side of the resulting device. The device plugs into a standard cartridge to allow fluid flow through a syringe pump and provides connection to a potentiostat to record the output signal. This packaging scheme allows for a portable and disposable sensor that could be mass produced and read using standard recording equipment at the point-of-sampling.

This detection platform is now being further developed with multiple microfluidic channels to allow for internal controls and the analysis of multiple variables within samples. It is also being further validated with various human samples.



*Packaged cartridge with inlet and outlet channels and hooked up to a quick-change interface for connection to a cell phone based potentiostat.*



*Packaged cartridge with inlet and outlet channels for rapid testing.*

# Engagement with Fraunhofer Institutes

Fraunhofer USA engages with Fraunhofer Institutes primarily through joint projects, through prime and subcontractor project relationships, and through permitted scientific and technology know-how exchange and personnel exchange. These projects help ensure that the applied science and technology being developed that is not subject to restrictions can be translated into products and innovation that benefit society.

Fraunhofer USA continues to jointly represent the Fraunhofer-Gesellschaft network in the U.S. and has rapidly proven its institutional value as an expert in the U.S. market. Our joint program for internal strategic pre-competitive research continues to prove beneficial for transatlantic knowledge and technology transfer. This program facilitates our readiness to deploy resources across the Atlantic where and when needed. Our continued outreach with Fraunhofer institutes has led to Fraunhofer USA working with about 50 of the 76 research institutes in Germany at a time, to conduct joint project development activities in the U.S., engage in joint pre-competitive strategic technology development projects, executing on U.S.-industry projects or publicly funded projects.

Some recent highlights of this transatlantic collaboration include a joint presence at the SC Battery Symposium and the U.S. Battery Show in Detroit with eight different Fraunhofer Institutes from Germany, Fraunhofer IFAM, Fraunhofer IGCV, Fraunhofer ILT, Fraunhofer IPA, Fraunhofer IPT, Fraunhofer ISC, Fraunhofer ISIT, and Fraunhofer IWS, contributing and engaging with local industry stakeholders. Fraunhofer Institutes were supporting delegation trips to the U.S. facilitated through the German Ministry for Economic Affairs and Climate Action BMWK as well.

Fraunhofer USA additionally supports the Fraunhofer Institutes though joint engagements and activities with the German Embassy in Washington D.C. and the German Chambers of Commerce Abroad (AHK). Recent examples of these joint activities include "Germany on Campus", an on-campus university event showcasing collaboration between the United States and Germany, and joint participation as a community partner.

Other opportunities for Fraunhofer USA-Fraunhofer Institute engagement include personnel exchange though the Fraunhofer USA Research Scholar Program and the Fraunhofer Innovation Mobility program, which permits Fraunhofer-Gesellschaft staff to work in markets such as the U.S. to better align the science and technology activities and streamline transatlantic collaboration.

# Q&A with Nina Baule Ph.D. awardee

**Q:** ***You have just been awarded your Ph.D. in Materials Science, Congratulations! What was your thesis all about?***

**A:** Diamond-like carbons (DLC) are widely recognized for their exceptional toughness, comparable to that of diamonds. They are commonly employed in the automotive industry to enhance the durability of components such as piston rings and to reduce friction. During my Ph.D., I investigated a modified variant of this material known as nitrogen-incorporated tetrahedral amorphous carbon (ta-C:N) for applications in electrochemical sensors. This material is particularly promising because it can be deposited at room temperature, cost-effectively, and on a large scale, enabling the development of flexible and disposable sensors.

A significant focus of my research was on elucidating the material properties of ta-C:N. In the field of materials science, a comprehensive understanding of a material's behavior is essential for its successful application in real-world contexts. This deeper insight facilitates innovation and allows for the effective implementation of materials in impactful ways.

**Q:** ***What was your favorite part of discovery in the work that you have done for your Ph.D. thesis?***

**A:** I noticed that ta-C:N's functionality did not work as expected when applied to insulating materials, like flexible or transparent surfaces, compared to electrically conductive ones. This was an important finding because many of the materials we use today, such as in flexible or transparent electronics, are naturally insulating. To solve this, I introduced a conductive layer between the two materials, which restored the functionality.

What excites me about this discovery is that it highlights how critical it is to understand materials and surfaces. Whenever you transfer a coating from one material to another, it usually requires some engineering adjustments to ensure it works properly. This process taught me a lot about the importance of surface engineering in making advanced technologies work seamlessly.

**Q:** ***Where does the work go from here?***

**A:** During my Ph.D., I focused on electrochemical electrodes, but my larger goal is to explore new uses for amorphous carbon coatings. The tools we have to produce these coatings are really promising and can help bring new applications to life. What makes DLC coatings especially exciting is that we can create materials with diamond-like qualities at room temperature, which is a remarkable feature that opens up many possibilities for future technologies.

Moving forward, I aim to investigate applications in areas such as flexible electronics, energy transition and storage, and highly functional coatings for various industries. By collaborating with industry partners and leveraging cutting-edge research, I hope to accelerate the transition of these materials from the lab to real-world applications.

**Q:** ***To acquire the Ph.D. while working full time at Fraunhofer USA, it required collaboration between Fraunhofer USA, the University of Technology in Dresden Germany, Michigan State University and several professors. Can you explain how this worked?***

**A:** In Germany, it is quite common for Ph.D. candidates to conduct their research at external institutions or within industry, especially since every candidate must already hold a Master's degree and does not attend additional classes during their Ph.D..

At Fraunhofer USA, I focused on the practical, application-driven aspects of my research, gaining real-world insights and hands-on experience. My primary academic affiliation was with the University of Technology in Dresden, where my doctoral advisor provided guidance on the theoretical foundation of my work to ensure it met academic standards. Michigan State University supported my research by providing access to specific resources and expertise.

Coordinating across these institutions required regular communication with my advisors at both organizations while fulfilling my responsibilities at Fraunhofer USA. Although balancing full-time employment with a Ph.D. can be challenging, I truly value this setup. It encourages greater independence in research and allows candidates to gain practical, professional experience alongside their studies. Ultimately, this experience helped me bridge the gap between academia and industry, offering both academic depth and practical insights.

**Q:** ***You dedicated your thesis to women: To all female engineers and scientists – be the change you want to see. What advice or words of encouragement do you have for other women considering to pursue a Ph.D.?***

**A:** The one sentence I keep telling myself is, "You have the right to be here." I know my strengths and my limits, and I do not need to prove myself to anyone. Confidence in your abilities is key, and believing in yourself is what truly matters. Your gender, religion, or background should not define your potential or path. If this is the career you are passionate about, set clear goals and approach them with resilience, confidence, and strength.

Along the way, I've also stayed focused on my personal well-being. Pursuing hobbies like strength training and outdoor activities has been essential in helping me stay centered, maintain focus, and remain calm when tackling challenges.

In the STEM field, women are still often seen as "exotic" or stand out in a way that makes them feel singled out. I have reflected a lot on this and believe that, for us to achieve true equality, we need to stop placing so much emphasis on our gender. When I walk into a business meeting, often filled with men, I do not think of myself as different. My professional achievements speak for themselves, and that is where my focus lies.

"Confidence in your abilities is key, and believing in yourself is what truly matters. Your gender, religion, or background should not define your potential or path."

# Celebrating 30 Years of Innovation and Technology Transfer at Fraunhofer USA

As we mark the 30th anniversary of Fraunhofer USA, we celebrate three decades of groundbreaking research, technological advancements, and unwavering commitment to innovation and technology transfer with our partners. Since our inception in 1994, Fraunhofer USA has stood at the forefront of applied research, bridging the gap between academic discovery and industrial application.

## The Mission

At the heart of Fraunhofer USA's mission is the drive to foster innovation across various industries. We are dedicated to developing cutting-edge solutions that address real-world challenges, pushing the boundaries of what's possible in manufacturing, energy, healthcare, information technology, and beyond. Crucially, we are committed to making innovation accessible to businesses of all sizes, from industry giants to small and medium-sized enterprises.

## The Impact

Applied research and technology transfer play a pivotal role in driving economic growth, enhancing industrial competitiveness, and addressing societal challenges. At Fraunhofer USA, we're dedicated to bridging the gap between fundamental research and practical applications, ensuring that groundbreaking discoveries translate into tangible benefits for businesses and communities alike.

Our impact extends far beyond individual projects or technologies. Through our work, we've fostered a robust innovation ecosystem that spans across industry sectors, company sizes, and academic institutions. We've completed numerous projects with small and medium-sized businesses, bringing cutting-edge innovation opportunities within reach of companies that might otherwise lack access to advanced research and development resources. Our collaborations, involving thousands of industry partnerships and strong ties with leading universities, have created synergies that propel technologies from our labs to markets, thus making innovation happen.

The breadth of our impact is reflected in our intellectual property portfolio, with numerous patents and publications contributing to the global knowledge base and benefiting businesses of all sizes. By making innovation accessible and applicable, we've empowered companies to leverage cutting-edge technologies, enhancing their competitiveness in an increasingly technology-driven marketplace.

## The Technologies

Our work spans a wide range of sectors and business sizes, showcasing our commitment to fostering innovation at all levels. While our list of accomplishments is extensive, here are just a few highlights that demonstrate the breadth and depth of our work:

- **Advancing Artificial Intelligence:** We've developed innovative tools and methodologies to enhance the robustness and reliability of AI systems, particularly in image recognition. Our work has focused on optimizing testing processes for AI applications, identifying factors that lead to classification errors, and providing recommendations to improve system performance. This research is crucial for ensuring the safety and reliability of AI in critical, real-world applications, especially in autonomous and decision-making systems.
- **Pioneering Laser Technologies:** We've developed state-of-the-art laser processes and applications for various industries, including additive manufacturing, automotive, medical, energy, and defense sectors. Our innovations in laser technology have enabled advancements in manufacturing processes, material processing, and product development across these diverse fields.

- **Biotechnology Breakthroughs**: Our work in biotechnology has led to significant advancements across multiple areas. In biomedical device manufacturing, we've developed innovative processes and materials that enhance the functionality and reliability of medical implants and diagnostic tool all while making these technologies work at scale.

- **Custom Manufacturing Solutions:** We've developed and deployed a wide range of innovative manufacturing solutions, from novel surface coatings for consumer goods and advanced forming tools to world-class fiber winders for fiber optic gyroscope production. These diverse applications showcase our ability to adapt cutting-edge technologies to meet specific industry needs.

- **Advanced Materials:** We've pioneered the development of world-leading materials with far-reaching applications across multiple industries. Diamond materials for example are set to revolutionize the semiconductor industry, enhance the performance of electric vehicles, and enable new possibilities in medical treatments and devices. Our work in this field demonstrates our commitment to pushing the boundaries of material science and creating technologies with broad, transformative potential.

## The Future

As we step into our fourth decade, Fraunhofer USA remains committed to driving technological progress and societal impact. Our focus areas for the future include:

- **Artificial Intelligence:** Advancing the development and deployment of reliable AI systems, particularly in manufacturing, to enhance productivity, quality control, and operational efficiency across industries.

- **Sustainability:** Developing green technologies and sustainable manufacturing processes to address global environmental challenges.

- **Digital Transformation:** Advancing and deploying Industry 4.0 technologies to revolutionize industrial processes.

- **Healthcare Innovation:** Continuing to push the boundaries in medical technology and biotechnology to improve patient care and outcomes.

- **Interdisciplinary Collaboration:** Fostering partnerships across different fields to tackle larger and more complex challenges.

- **Empowering SMEs:** Further expanding our support for small and medium-sized enterprises, ensuring that cutting-edge innovation remains accessible to businesses of all sizes.


## A Heartfelt Thank You

Our journey of innovation would not have been possible without the dedication of our talented team members, the trust of our partners and clients – from multinational corporations to local small businesses – and the invaluable collaboration with our university partners. The partnership between industry, academia, and our organization has been a cornerstone of our success.

We extend our deepest gratitude to Fraunhofer-Gesellschaft, our founding organization and funding partner, whose unwavering support and shared vision have been instrumental in our growth and success over these three decades. Our thanks also go to our industry partners, both large and small, who have trusted us with their challenges and collaborated with us to find innovative solutions. We are grateful to the academic institutions and researchers who have worked alongside us, pushing the boundaries of scientific knowledge and helping to translate cutting-edge research into practical applications. We are particularly grateful for our longstanding partnerships with Michigan State University, Boston University, and the University of Maryland, whose collaboration has been instrumental in driving forward-thinking research and innovation. Lastly, and most importantly, we are immensely grateful to our dedicated team members, whose expertise, creativity, and hard work have been the driving force behind our achievements. Our strength is our people, and we want to thank everyone who has been on our side along the way.

As we celebrate this milestone, we recognize that our success is a testament to the power of collaboration and the shared commitment to innovation that unites us all.

Here's to 30 years of turning ideas into innovations, and to many more years of groundbreaking research and impactful solutions. Together, we'll continue to shape the future of applied research and technology and to our partners, ensuring that businesses of all sizes can thrive in our proven innovation ecosystem.

Join us in celebrating three decades of Fraunhofer USA. Follow us on our social media channels and website for updates on projects, events and initiatives. Here's to the next chapter of innovation at Fraunhofer USA!

# Financials

## Fraunhofer USA, Inc.

**Balance Sheet**
**As of December 31, 2023**

| | |
|---|---|
| **Assets** | |
| **Current Assets** | |
| Cash and Cash Equivalents | $ 1,306,081 |
| Accounts Receivable | 3,018,225 |
| Investments | 5,675,275 |
| Costs and estimated earnings in excess of billings on uncompleted contracts | 1,422,985 |
| Prepaid Expenses and Other Current Assets | 679,979 |
| **Total Current Assets** | **12,102,545** |
| **Property and Equipment - Net** | **2,412,319** |
| **Right-of-use Operating Lease Assets** | **1,790,553** |
| **Intangible Assets** | **1,237,545** |
| **Total Assets** | **$ 17,542,962** |
| **Liabilities and Net Assets** | |
| **Current Liabilities** | |
| Accounts Payable | $ 675,401 |
| Current portion of lease liabilities - Operating | 425,146 |
| Accrued Liabilities | 1,650,933 |
| Deferred Revenue | 1,180 |
| Billings in excess of costs and estimated earning on uncompleted contracts | 963,763 |
| Accrued Liabilities and Other | 106,243 |
| **Total Current Liabilities** | **3,822,666** |
| **Lease Liabilities - Operating** | **1,571,384** |
| **Total Liabilities** | **5,394,050** |
| **Net Assets** | |
| **Unrestricted** | |
| **Undesignated** | **3,549,150** |
| **Increase (Decrease) in Undesignated Net Assets** | **565,584** |
| **Designated** | **3,699,991** |
| **Increase (Decrease) in Designated Net Assets** | **(398,048)** |
| **Predetermined** | |
| **Predetermined** | **10,730,383** |
| **Increase (Decrease) in Predetermined Net Assets** | **(5,998,148)** |
| **Total Net Assets** | **12,148,912** |
| **Total Liabilities and Net Assets** | **$ 17,542,962** |

## Fraunhofer USA, Inc.

### Statement of Activities and Changes in Net Assets
### Year Ending December 31, 2023

| | | |
|---|---|---|
| **Contract Revenue** | | |
| Industry | $ | 3,451,093 |
| Government & Universities | | 7,970,008 |
| Fraunhofer Institutes | | 2,674,993 |
| Miscellaneous | | 430,711 |
| **Total Contract Revenue** | | **14,526,805** |
| **Support** | | |
| Base Funding | | 625,305 |
| In-Kind Contributions | | 776,639 |
| Other | | 619,189 |
| **Total Support** | | **2,021,133** |
| **Funds Transferred from Predetermined Funding** | | **7,311,812** |
| **Total Undesignated Revenue, Support and Predetermined Funds** | | **23,859,750** |
| **Labor Costs** | | **14,548,380** |
| **Undesignated Other Expenses** | | |
| Administrative Expenses | | **6,124,459** |
| Cost of Goods Sold - Excluding Labor | | **2,433,130** |
| Depreciation and Amortization | | **188,198** |
| **Total Undesignated Other Expenses** | | **8,745,787** |
| **Total Labor Costs and Undesignated Other Expenses** | | **23,294,167** |
| **Increase (Decrease) in Undesignated Net Assets** | | **565,583** |
| **Undesignated Net Assets** | | **3,549,150** |
| **Designated Revenue** | | **45,699** |
| **Funds Transferred from Predetermined Funding** | | **375,000** |
| **Designated Expenses** | | **(818,747)** |
| **Increase (Decrease) in Designated Net Assets** | | **(398,048)** |
| **Designated Net Assets** | | **3,699,992** |
| **Predetermined Funding** | | **1,688,664** |
| **Net assets transferred to other support** | | **(7,686,812)** |
| **Increase (Decrease) in Predetermined Net Assets** | | **(5,998,148)** |
| **Predetermined Net Assets** | | **10,730,383** |

# Outlook

In addition to industry, more than 20 Federal agencies fund R&D in the Unites States. The U.S. government has been increasing research and development funding since 2012. The top five largest agency spending for fiscal year 2022 was the Department of Defense, the Department of Health and Human Services, the Department of Energy, the National Aeronautics and Space Administration, and the National Science Foundation. The 2024 budget includes $209.7 billion for federal R&D including an investment in facilities and equipment, which represents an $8.9 billion increase over the 2023 level. The budgeted amounts align with the administration's view of research and development's role as a driving force in the innovation ecosystem. The government has also learned from the successful Defense Advanced Research Projects Agency (DARPA) model, wherein the agency has established new and innovative approaches to selecting and executing projects, staffing and personnel management, contracting and intellectual property management. The lessons learned are applied to advance other agencies and to enhance the return on investments funded by the U.S. taxpayer.

The government has enacted recent legislation like the CHIPS and Science Act to help ensure innovation and make supply chains more resilient, supporting the overarching goal to remain a world leader in technology creation and deployment. It has also identified priorities, including cutting the rate of death by cancer in half over the next 25 years, addressing climate change in profound and meaningful ways through investments in clean energy and climate technology and infrastructure, advancing national security and technological competitiveness, ensuring equity in R&D spending and funding, and cultivating STEM education, engagement and workforce ecosystems.

Industry investments in research and development remain strong with 2021 figures of $528 billion spent in the United States. Of that amount, 7% was spent on basic research, 14% on applied research, and 79% on development. The manufacturing sector comprised the largest portion of the spending (source: https://ncese.nsf.gov).

The research and development goals for the government and industry are aligned, as are the challenges they face. These challenges include finding capable partners, providers, connectors, and innovators. Fraunhofer USA, in partnership with Fraunhofer-Gesellschaft (Europe's largest applied research and development organization) and its university collaborators, is ready, willing, and able to provide the services, connections, and platforms to help face and overcome these challenges. We are committed to providing excellent services to our customers and, through them, to society at large.

Fraunhofer USA's strategic research areas align closely with national priorities and industry trends. Our work in advanced manufacturing and Industry 4.0 technologies is poised to have a significant impact on the U.S. economy. By developing and implementing smart manufacturing solutions, we expect to enhance productivity, reduce waste, and improve the competitiveness of U.S. industries on the global stage. Additionally, our research in climate technologies and sustainability is addressing one of the most pressing challenges of our time. Through innovations in renewable energy systems and sustainable materials, we anticipate contributing to the nation's goals of reducing carbon emissions and creating a more resilient, eco-friendly industrial base.

Our ability to form flexible, interdisciplinary teams and our experience in managing intellectual property in collaborative projects make us an ideal partner for both government and industry initiatives. As we look towards the future, Fraunhofer USA, in close collaboration with our partners, remains committed to staying at the forefront of technological innovation. We continuously evolve our research focus and capabilities to address the most pressing technological and societal challenges facing not just the United States, but the global community. Through our commitment to excellence, our global perspective, and our deep understanding of both scientific and market needs, we play a pivotal role in shaping innovation ecosystems worldwide. Our unique position as a bridge between Fraunhofer-Gesellschaft's extensive European network and the dynamic U.S. market enables us to facilitate international collaboration and knowledge transfer, fostering innovation on a truly global scale.

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*Lawrence Livermore National Laboratory (ret.)*

# Fraunhofer USA Partners and Memberships

### American National Standards Institute (ANSI)

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

### Automation Alley

Automation Alley is a World Economic Forum Advanced Manufacturing Hub (AMHUB) and a nonprofit Industry 4.0 knowledge center with a global outlook and a regional focus. Based in Michigan, Automation Alley is very well connected to manufacturing companies throughout the midwestern U.S. providing its more than 1,400 members the knowledge necessary to adopt new Industry 4.0 technologies. Fraunhofer USA technical experts will have the opportunity to present new technologies to the members of Automation Alley through seminars, presentations, and at their yearly international conference Integr8.

### Association of University Research Parks

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

### German American Chamber of Commerce

Fraunhofer USA is a National Partner of the German American Chamber of Commerce (GACC). The GACC is part of a global network of German Chambers of Commerce Abroad (AHKs) which has 140 offices in 92 countries. In the U.S., more than 2,500 German companies maintain memberships with the GACC. The GACC assists with increasing the awareness of Fraunhofer's presence within the U.S. as well as providing visiting German delegations opportunities to meet with Fraunhofer USA experts.

### German American Business Council of Michigan

The official mission statement of the GABC is "To foster investment and trade while cultivating business between Germany and the State of Michigan through our network of members, corporate partners, companies and business professionals to improve and encourage German-American business relations.

### A3- Association for Advanced Automation

A3 is North America's largest automation trade association representing more than 1,300 organizations involved in robotics, artificial intelligence, machine vision and imaging, motion control and motors and related automation technologies.

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