Fraunhofer USA

FRAUNHOFER USA 20TH ANNIVERSARY

20 YEARS OF TRANSATLANTIC INNOVATION ALLIANCE

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FRAUNHOFER USA: 1994 - 2014

20 years ago, Germany's Fraunhofer-Gesellschaft, the largest European organization for applied research, established its first subsidiary abroad in the United States. With a dynamic manufacturing sector, the U.S. market closely aligned with Fraunhofer's research expertise, and its own goals of becoming a global provider of quality solutions to technical problems. Having achieved considerable success within Germany, Fraunhofer established its first U.S. centers in Massachusetts and Michigan.

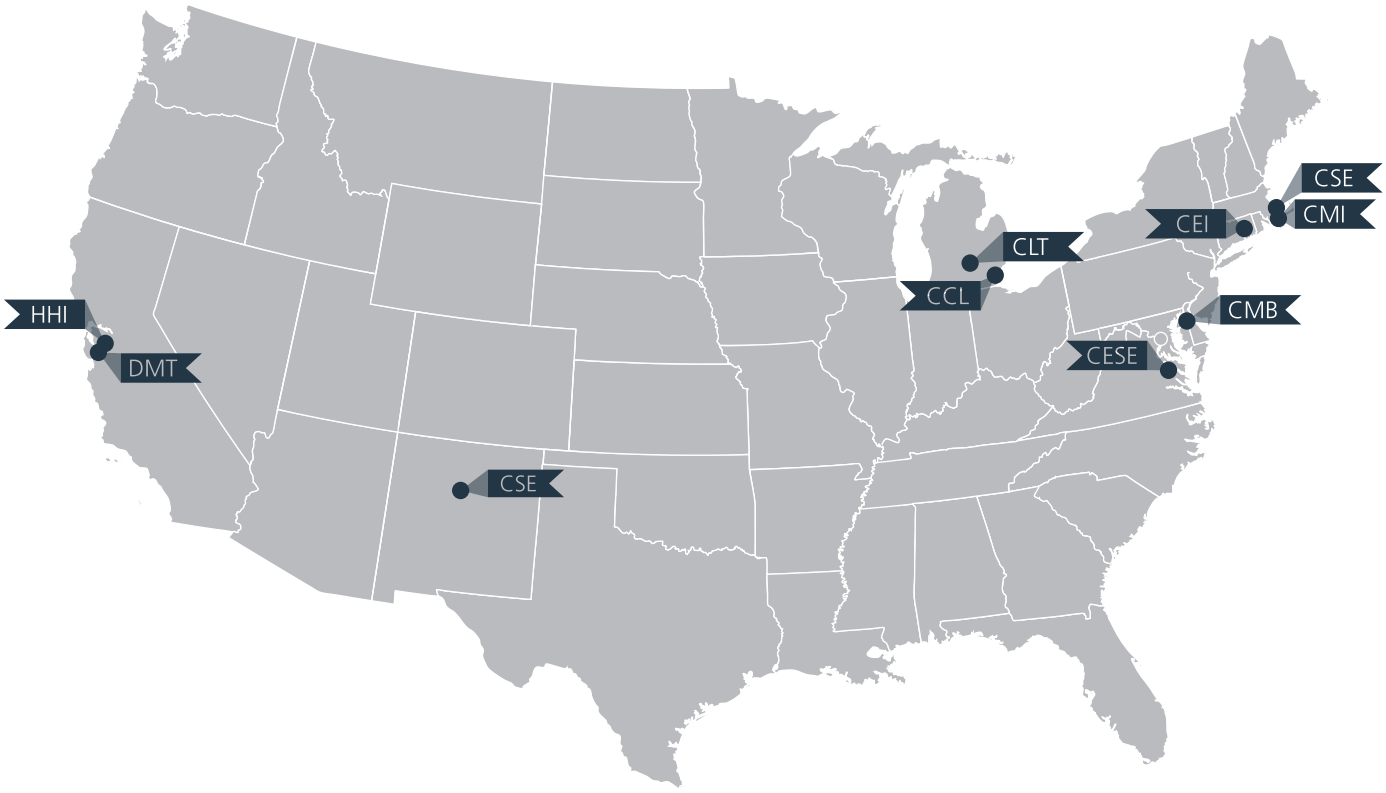
Today, Fraunhofer USA boasts seven research facilities and two marketing offices in the United States. With a staff of some 180 technical specialists, Fraunhofer USA designs and develops new technologies and commercially viable solutions for customers in the U.S. and abroad. In 2013, Fraunhofer USA had a turnover of almost $39 million. The Fraunhofer Centers are closely aligned with renowned universities like University of Maryland, Michigan State University and Boston University. Together, they engineer new production techniques, materials, medical solutions and software tools and contribute to some of the most challenging federal research programs, like the US Department of Energy's "SunShot" Initiative, the DARPA "Accelerated Manufacture of Pharmaceuticals" program, or NASA's "Software Assurance Research Program".

The story of Fraunhofer USA is one of success: thanks to a strong network of collaborative partners – from renowned American research universities that ensure a steady supply of fresh ideas and talented young scientists, to prominent industry partners focused on the commercialization of new technologies - Fraunhofer's strength to bring to market key technologies is of proven benefit to the economy and society.

EST. 1994

$39M

turnover by Fraunhofer USA in 2013.



7

RESEARCH CENTERS

2

MARKETING OFFICES

Fraunhofer USA

20 YEARS

180+

TECHINCAL SPECIALISTS

UNIVERSITY PARTNERSHIPS

6

100+

INTERNS YEARLY

TRANSATLANTIC ALLIANCE FOR INNOVATION

Fraunhofer has been successfully driving innovation in Germany and Europe for 65 years, and now for over 20 years in the U.S. as well. Fraunhofer USA was founded September 14, 1994, as a subsidiary of Germany's Fraunhofer-Gesellschaft, Europe's leading organization for applied research. About 23,000 Fraunhofer employees work at 67 institutes in Germany, plus multiple subsidiaries and locations throughout Europe, Asia and North and South America. Its annual research volume amounts to over two billion euros. This achievement was built on the fact that Fraunhofer established itself as a strategic partner for creating value, especially among clients in industrial sectors. Our scientific excellence is prized as highly as our expertise in transferring research results into useful applications.

Fraunhofer is highly sought after as a partner in the international community, and has been involved in activities outside of Germany for decades. After all, the bulk of the world's research is conducted outside of Germany, and more and more companies are operating on a global basis. Fraunhofer seeks out and stays in close contact with the most important current and future centers of knowledge and business, because working with the best enables Fraunhofer to maintain and expand its own capacity to innovate, and is the only way to ensure we remain an attractive partner for innovative projects.

With that in mind, the Fraunhofer-Gesellschaft's internationalization strategy follows clear principles: all our strategic international collaborations have to deliver scientific value for Fraunhofer as well as positive effects both for Germany's economy and for that of the partner country.

This is what underpins the transatlantic cooperation between the Fraunhofer Institutes in Germany, Fraunhofer USA, the Centers and many excellent universities, including the University of Maryland, Michigan State University and Boston University. Together, engineers and scientists develop new manufacturing processes, materials, medical technology applications and software solutions. This network of outstanding partners ensures a constant influx of new ideas and talented up-and-coming scientists.

Fraunhofer USA also participates in a host of highly ambitious research programs, such as the U.S. Department of Energy's SunShot initiative, NASA's Software Assurance Research Program, and the Accelerated Manufacture of Pharmaceuticals Program.

Two decades later, Fraunhofer USA has achieved more than just recognition: it has served as an inspiration for pioneering new paths in the American research landscape. For example, President Obama's manufacturing initiative was, in his own words, motivated by European research institutes and by Fraunhofer in particular.

Dedicated employees in Germany and in the U.S. have played a major part in this success story. I wish to thank you and our partners, and wish you all the best for a successful and promising future.

Professor Reimund Neugebauer
President of the Fraunhofer-Gesellschaft

MESSAGE OF GREETING

In Germany, the Fraunhofer brand stands for application-oriented research which is aimed at translating results immediately into new and innovative products, processes, and services. Its Institutes, which are spread across the whole of Germany, thus contribute to the competitiveness of the regions, the country, and Europe.

Characteristic of Fraunhofer is the competitive research it performs on a contractual basis for industry, service providers, and the public sector. With fields of research such as health, security, communication, mobility, energy, and the environment, the Fraunhofer-Gesellschaft is focused on the current needs of our society.

Twenty years ago, the Fraunhofer-Gesellschaft launched its cooperation with American institutions in the U.S., thus enabling it to gain access to the world's most important market for research and innovation. Today, seven centers and two offices have emerged from this endeavor. Each center in the U.S. is also closely affiliated with an American university and at least one Fraunhofer Institute in Germany.

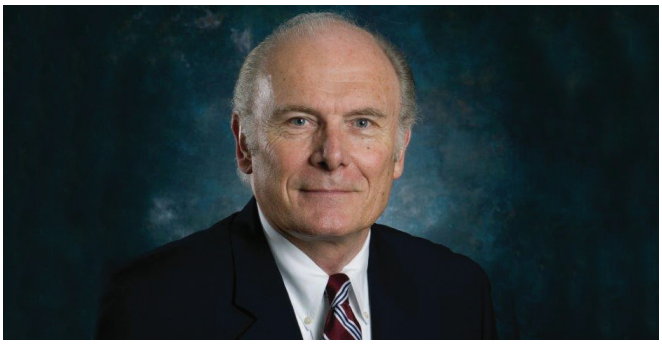
As German Ambassador to the United States, I value the high quality of this cooperation. It is with good reason that Fraunhofer and its partner institutions are engaged in major U.S. research programs. Time and again, experts cite this cooperation as a model for the development and establishment of national strategies for innovation in the U.S.

Joint scientific cooperation creates accepted knowledge about global challenges and thus lends legitimacy to common action. The Fraunhofer-Gesellschaft is making a decisive contribution to this aim in the spirit of our research and academic relations policy.

I warmly congratulate Fraunhofer USA on its anniversary!

Dr. Peter Wittig
Ambassador of the Federal Republic of Germany
to the United States of America

DEDICATION TO INNOVATION

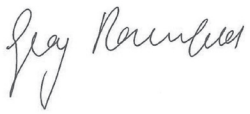


In 1994, Fraunhofer had just experienced a long period of substantial growth and decided to establish the first Fraunhofer subsidiary in the United States, which had a very dynamic manufacturing sector. Fraunhofer wanted to become a global provider of quality solutions to technical problems. While the initial steps were already prepared by late Fraunhofer President Professor Max Syrbe, the deal was closed by his successor Professor Hans-Jürgen Warnecke, an expert in industrial manufacturing and automation, who had just taken office as President of Fraunhofer in 1993. He was applauded by both U.S. and German industry leaders, among them Berthold Leibinger, chairman of laser manufacturer Trumpf and icon of the German "Mittelstand". Dr. Dirk Meints Polter, the first president of Fraunhofer USA, stated: "We wanted to contribute to the U.S. economy, and to benefit our partners and clients in the United States. We feel that our method of conducting research through creating partnerships translates into a win-win situation for our customers and sponsors on both sides of the Atlantic."

From the start, we met U.S. universities that were highly interested in the Fraunhofer model of application-driven research, and open to the idea of close cooperation. At the time, Dr. John Silber – a visionary and excellent leader - was president of Boston University. He was aware of the diversity and distinctiveness of the German research system, as he had been a Fulbright fellow in Germany in his early career. He was convinced that the Fraunhofer concept of having a university professor taking on the directorship of a Fraunhofer research unit would benefit both sides. The resulting partnership produced the Center for Manufacturing Innovation. Later, other universities became our close partners, including the University of Maryland, Michigan State University, the University of Delaware, and the University of Connecticut.
In the early years we developed a portfolio of market-relevant R&D services, and we began establishing brand recognition in the U.S. The most attractive market was the automotive industry with its widespread network of suppliers; but the other markets were quickly evolving. In our first decade, we expanded into the fields of information technology, software engineering, and biotechnology. Our two most recent centers specialize in alternative-energy materials, devices, and systems.

And today, we witness the renaissance of manufacturing, with the growing durable goods manufacturing sector contributing to long-awaited U.S. economic growth. The U.S. government is eager to reinforce this trend, and Germany's innovative manufacturing landscape is seen as a role model. We have come back to an area of expertise that remains a stronghold in Fraunhofer's research profile.

We are well positioned – and recognized - in the U.S. research landscape to play an important role in the innovation system as a bridge between academia and industry. Our continued success, as in the past, will be critically dependent on the excellent capabilities of our employees and the support of the Fraunhofer Institutes.



Professor Georg Rosenfeld
President
Fraunhofer USA, Inc.

Dr. William Hartman
Executive Vice President
Fraunhofer USA, Inc.

CENTER FOR MANUFACTURING INNOVATION

ADVANCED R&D AND ENGINEERING SOLUTIONS FOR A BROAD RANGE OF INDUSTRIES, INCLUDING BIOTECHNOLOGY, PHOTONICS, MANUFACTURING, AND RENEWABLE ENERGY

When the Fraunhofer Center for Manufacturing Innovation opened in 1994, it was one of Fraunhofer USA's first Centers in the U.S. and aimed at addressing the R&D needs of an increasingly global economy. CMI's synergy of life sciences and engineering provides efficient design and fabrication of instrumentation and devices. CMI was one of the early implementers of this new translational research paradigm; it is one of the few places in existence where biologists and engineers work side-by-side, and BioSafety Level 2 (BL2) laboratories are within arm's reach of big milling machines "making chips."

CENTER HIGHLIGHTS AND ACHIEVEMENTS

In 2000, Fraunhofer CMI established the highly successful spin-off kSARIA, a company that produces fiber optic and copper interconnect cables with proprietary automation assembly systems. Focusing on the glass fiber interfaces (an area where most of the processing steps need to be carried out manually), kSARIA developed solutions for fiber-to-fiber attachment and connections between fiber and periphery, as well as glass fiber handling, preparation and packaging. Its products can be found in numerous systems, including the Boeing 787, and the Airbus 380.

The company now employs over 100 people, contributing both to the performance and readiness of U.S. military hardware, as well as the local economy through jobs creation. Impressively, it has been profitable even through the recession. The company has won numerous awards from its customers, demonstrating that U.S. manufacturing can indeed be viable when incorporating the right advanced technologies to make up for the higher cost of labor. All of the

manufacturing takes place in the Commonwealth of Massachusetts. In 2010, only a few months after the outbreak of the H1N1 pandemic, the U.S. government's Defense Advanced Research Projects Agency (DARPA) awarded CMI and CMB researchers a grant to study ways of producing large quantities of vaccines. Drawing from research on tobacco plants, and the plants' genetically engineered mechanisms to produce proteins in their leaves and stalks, CMI and Fraunhofer Center for Molecular Biotechnology CMB developed a fully automated factory that uses tobacco plants to produce large quantities of vaccines and other therapeutic biologics within weeks.

The vaccines produced in the Delaware facility are currently undergoing clinical trials in the U.S. For their development of the fully-automated factory for plant-based pharmaceuticals, Fraunhofer CMI's Center Director, Professor Andre Sharon, and CMB's Center Director, Dr. Vidadi Yusibov, were awarded the 2013 Joseph von Fraunhofer Prize for Science and Innovation.

KEY TECHNOLOGIES

- Disruptive Automation for the Manufacture of Fiber Optic Gyroscopes Used in Airplanes, Satellites, and Ships
- Transformative Automation for the Production of Plant-Based Vaccines and Pharmaceuticals
- Rapid Identification of Antibiotic Susceptibility

STRATEGIC PARTNERSHIPS

The long-standing collaboration with Boston University has led to the creation of the Boston University-Fraunhofer Alliance for Medical Instrumentation, Devices, and Diagnostics. This Alliance has been accelerating the process of taking medical innovations from the laboratory to the patient point-of-care. It has led to several National Institutes of Health-funded activities in the areas of rapid identification of antibiotic susceptibility, rapid molecular diagnostics, and future cancer care technologies.

"Fraunhofer CMI has become our 'go-to' R&D partner when it comes to automating difficult-to-solve processes and unique manufacturing challenges. Their innovative solutions and commitment to getting problems solved are unparalleled. And, when a 'follow-up' is needed, they are back in a heartbeat to ensure sustainability of new and unique processes. They have been a strong, innovative partner to Avery Dennison's Fastening operations." – Craig Smith , Plant Manager - Retail Branding and Information Solutions, Avery Dennison.

PARENT INSTITUTE

Fraunhofer Institute for Production Technology IPT
Director: Prof. Fritz Klocke

CONTACT INFORMATION

www.fhcmi.org
Executive Director: Prof. Andre Sharon

Established in: **1994**

1ST Fraunhofer center in the U.S.

2013 AWARD RECIPIENT

JOSEPH VON FRAUNHOFER PRIZE FOR SCIENCE & INNOVATION
for Fraunhofer CMI's and Fraunhofer CMB's work on plant-based vaccine production.

Development of:

HIGH PRECISION AUTOMATION SYSTEMS

Development of Devices & Instruments for:

BIOTECH / BIOMEDICAL

PHOTONICS

ADVANCED MANUFACTURING

SUSTAINABLE ENERGY

"When we've had trouble finding a partner for some of our more unique and challenging machine design applications, we've found that Fraunhofer CMI tends to always be a good fit. Their breadth of expertise across numerous core competencies is unmatched.

DONNELL E. CREAR
GE GLOBAL RESEARCH

CENTER FOR LASER TECHNOLOGY

APPLIED RESEARCH TO FOSTER THE USE OF LASER TECHNOLOGY ACROSS INDUSTRIES

When it opened in 1994, the Fraunhofer Center for Laser Technologies CLT was the first institution to settle in the Detroit area with the goal to bring the benefits of laser intensive manufacturing to the American automotive industry. Since then, all renowned laser companies have opened either a sales and service center or even their headquarters (e.g., Rofin Sinar) in the area. Fraunhofer continues to be a valuable partner to these companies.

CLT's main focus areas are high-brightness diode lasers for the defense industry and industrial manufacturing and laser micromachining application development. Utilizing lasers, Fraunhofer CLT's manufacturing technologies for batteries and solar cells provided higher performance, cost-effective manufacturing, and micromachining application development for drilling and ablation.

KEY BUSINESS FIELDS

CLT's expertise serves the markets of alternative energy, automotive, medical and homeland security. The main focus is laser processing for batteries and solar cells, thereby enabling higher performance and cost-effective manufacturing, micromachining application development for drilling and ablation, and high-brightness diode lasers for the defense industry and industrial manufacturing. Some of CLT's representative technologies include:

- High Power, High Brightness Diode Lasers
- Packaging Technologies for Advanced Batteries
- Manufacturing Technologies for PV Panels
- Laser Micromachining

CENTER HIGHLIGHTS AND ACHIEVEMENTS

Fraunhofer CLT spun off 4 companies, all of which are successful operating businesses today. Two of these companies are located in the greater Detroit area, one was purchased by a Washington firm and one is located in Berlin, Germany.

In 2002, CLT was the first Fraunhofer Center to secure a significant (> $1 million) federal grant from the Department of Defense (DoD). Funding from this grant was used to establish the new research field of high power diode lasers that has developed into the most important business area for the center over the years.

In 2012, CLT and the University of Michigan created the Clean Transportation Innovation Cluster (CTIC) to advance research of alternative energy sources for automotive transportation. The CTIC partnership supports technological advances needed to drive e-mobility by developing advanced electrical storage systems.

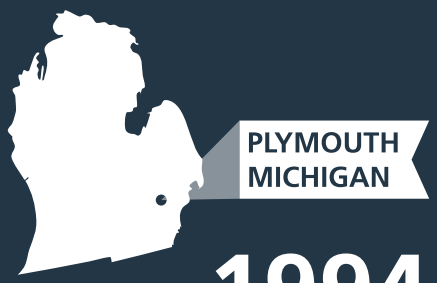
Funded by Fraunhofer and the University of Michigan with more than $2 million, the partnership has yielded considerable scientific advancements, several papers, one patent and one spin-off (Inmatech), which is focused on bringing innovative low-cost and safe power management solutions to key energy storage channels.

PARENT INSTITUTE

Fraunhofer Institute for Laser Technology ILT
Direcor: Prof. Reinhart Poprawe

CONTACT INFORMATION

www.clt.fraunhofer.com
Acting Center Director: Dr. Ingomar Kelbassa



Established in: **1994**

Research & Manufacturing Solutions with Light:

PROCESS DEVELOPMENT

SPECIAL COMPONENTS & LASERS

PROTOTYPING & RUN-OFF PRODUCTION

4 successful spin-off companies started in one decade.

8 patents filed and issued.

❝ Fraunhofer CLT has been an invaluable partner over the past 20 years and we have successfully collaborated through various strategic alliances, research projects and faculty connections. Their in-depth knowledge and experience and attention to detail exemplifies their deep understanding of cutting edge research and innovation.

DR. JYOTI MAZUMDER
DIRECTOR - CENTER FOR LASER-AIDED INTELLIGENT MANUFACTURING
MECHANICAL ENGINEERING
UNIVERSITY OF MICHIGAN

CENTER FOR COATINGS & LASER APPLICATIONS

APPLIED RESEARCH AND DEVELOPMENT OF LASER MATERIALS PROCESSING SOLUTIONS & NEXT GENERATION COATING SOLUTIONS

The core expertise of the Coatings Technology Division includes the development of diamond materials, the associated synthesis technology and advanced diamond-based applications and products. CCL's diamond-related activities present a multimillion dollar investment contributed jointly by Michigan State University (MSU) and Fraunhofer. They jointly pursue technology development to create diamond materials for advanced industrial applications, and their team of researchers is considered to be one of the elite research groups in the field of diamond electronics.

CCL's main focus areas in the Laser Applications Division are laser welding, heat treatment and cladding (including additive manufacturing) for a wide range of industrial customers and government organizations. CCL has built a reputation of being the premier laser applications development activity in the U.S. Up to 90% of the laser division's revenue comes from industrial funding.

CENTER HIGHLIGHTS: COATINGS DIVISION

In 2003, CCL combined research and engineering forces with MSU to jointly pursue technology development to create diamond materials for advanced industrial applications. Fraunhofer CCL and MSU invested in a joint laboratory located at the university and focused on the development of a new generation of diamond synthesis reactors, which are capable of producing high-quality diamond for applications in optics and electronics. Only a decade later, the Fraunhofer-MSU team has achieved an impressive level of success: the new diamond reactor technology proved to be among the best systems in the world; the joint intellectual property was licensed to a U.S. equipment manufacturer; and systems are being sold around the world. With thirty joint journal publications and three issued U.S. patents, the team is now considered as one of the leading diamond electronics research groups in the world. In 2014, the team was awarded a Department of Energy grant to demonstrate feasibility of diamond as an electronic device material. This project now starts the next phase of joint Fraunhofer-MSU activities: to research, develop and deploy technologies, thereby supporting economic growth in the U.S.

CENTER HIGHLIGHTS: LASER DIVISION

Fraunhofer USA has been instrumental in helping to commercialize new laser technology for a wide range of new industrial applications and has witnessed a rapid growth in industrial use of laser technology during this time.

CCL has taken many projects through concept, development, prototyping, and finally into production for industrial customers as they look to utilize automated high-speed laser processes in order to increase efficiency. Projects include developing laser welding technology for new aluminum intensive vehicles for automotive OEMs (production starting in 2014); laser welding technology for lithium ion batteries (now in production at 3 major OEMs); and developing remote welding processes for automotive seat frame assemblies (now in production). Fraunhofer CCL has also developed new ID Laser cladding technology for cladding pipes and tubes (now in production in the oil and gas industry); laser cladding technology for the remanufacturing industry (now in production); laser powder metal deposition technology for additive manufacturing (currently being commercialized by large CNC machine OEM); and welding and cladding technology for major aerospace customers (currently in pilot production stage).

FUTURE DEVELOPMENT: FORMATION OF TWO CENTERS

As of January 2015, the two divisions will become separate Fraunhofer Centers: the Center for Coatings and Diamond Technologies (CCD) and the Center for Laser Applications (CLA).

KEY TECHNOLOGIES

Development of Laser Applications:

- Lithium-Ion Battery Technology
- Internal Diameter Laser Cladding Technology
- Laser Powder Metal Deposition

Development of Coating Solutions:

- Diamor® Diamond-like Carbon (DLC) Coatings
- LaserArc® Coating Depositing Module
- Manufacturing Technologies for PV Panels

PARENT INSTITUTE

Fraunhofer Institute for Material and Beam Technology IWS
Director: Prof. Eckhard Beyer

CONTACT INFORMATION

www.ccl-laser.fraunhofer.org | www.ccl-coatings.fraunhofer.org
Center Director: Prof. Jes Asmussen
Director, Laser Division: Mr. Craig Bratt
Director, Coatings Division: Dr. Thomas Schuelke

Coatings Division
EAST LANSING MICHIGAN est.: **2003**

Laser Division
PLYMOUTH MICHIGAN est.: **1997**

HENRY FORD TECHNOLOGY AWARD
in recognition for the development of a laser beam welding process to improve the roof strength of the Ford F150 truck in 2007.

225+
interns trained since center's inception.

R&D 100 AWARD

R&D Magazine selected the LAwave as one the 100 most technologically significant products of 2001.

Development of Coating Solutions:

- **APPLICATIONS AND PRODUCTS FOR CVD DIAMOND MATERIALS**
- **NOVEL & PROPRIETARY COATING SOLUTIONS**
- **DIAMOND-LIKE CARBON AND CERAMIC COATINGS FOR TOOLING AND COMPONENT APPLICATIONS**

Development of Laser Applications:

- **LASER HEAT TREATMENT**
- **LASER CLADDING**
- **LASER WELDING**

"Working with Fraunhofer provides credibility to the efforts of our company, since, as one prospect said, 'You are working with the best.'

GEORGE WILSON, PRESIDENT
NEW TECH CERAMICS INC.
BOONE, IOWA

CENTER FOR EXPERIMENTAL SOFTWARE ENGINEERING

ADVANCING REAL-WORLD SOFTWARE PRACTICES VIA EMPIRICALLY VALIDATED RESEARCH INTO SOFTWARE-ENGINEERING TECHNOLOGIES AND PROCESSES

Photo courtesy of NASA depicts White Sands Complex (WSC) antennas.

The Fraunhofer Center for Experimental Software Engineering CESE conducts applied research in software engineering processes and technologies. It collaborates with its customers and partners to develop innovative, practical approaches to software development and to address management challenges. CESE's technologies primarily serve the aerospace, defense, automotive and medical industries.

Since its founding in 1998, CESE has been working closely with commercial clients and many federal offices and agencies, ranging from the U.S. Department of Defense (DoD), to NASA, to the U.S. Food and Drug Administration (FDA). CESE researches and applies state-of-the-art best practices to assist with decision-making in systems, software, and acquisition areas, to ensure the viability and reliability of systems and software as well as to identify security-related vulnerabilities.

CENTER HIGHLIGHTS AND ACHIEVEMENTS

CESE has been working on NASA's Space Network Ground Segment Sustainment (SGSS) project since 2011 and was recently awarded a 5-year grant to continue its work through 2019. The objective of SGSS is modernizing the space agency's ground infrastructure systems for their Space Network. Fraunhofer CESE team's role in this project is to provide software acquisition management and metric reporting leadership, thereby ensuring the quality of the software controlling the SN Ground Segment for decades to come.

CESE provides expertise, methods and tools to another NASA Program, the Software Assurance Research Program (SARP), which focuses on research in software assurance and transfers this research into NASA missions. Specifically, Fraunhofer researchers developed Process Risk Indicator (PRI), a method to identify and measure software safety risks during system development to support Software Reliability and Quality Assurance management on the NASA Constellation program. In addition, CESE is building tool support to apply state-of-the-art practices in software architecture analysis and automated software testing.

CESE is also developing an open-source Hazard Tracking System (HTS) plugin for the popular Atlassian JIRA Issue & Project Tracking System and provided subject matter expertise and facilitated the development of NASA's software inspection standard (NASA SDD-8739 Software Formal Inspections Standard).

For more than 10 years, CESE has assisted the technology and creative services company, Keymind, by improving the quality of products using Carnegie Mellon University's CMMI© framework. CMMI is a performance improvement and appraisal program administered and marketed by the CMMI Institute and required by many DOD and U.S. Government contracts, especially in software development. CESE has helped Keymind achieve CMMI Maturity Level 5, which is the highest level in the defining quality standard for software development. Only 5% of organizations worldwide attain this benchmark.

Since 2010, CESE has collaborated with Johnson and Johnson (J&J) Operating Companies to enhance software quality in the Medical Device and Diagnostics business segment, specifically by identifying software-related product issues including security vulnerabilities and attack pathways. This work has led to the development of a technical information report (TIR) which may evolve into a Security Standard for the American Association for Medical Instrumentation (AAMI), the premier standards body for the medical device industry.

Most recently, CESE has been working to advance the science of sustained behavior change for managing chronic health conditions, especially older adults suffering from diabetes. The direct result of CESE's research is the Motivational Psychology-based Smart Engagement System (MOSE). MOSE is an integrated system between a patient, peer patients, and health providers that provides tight integration between patient behavior, current patient health status, and clinical input.

CESE is an affiliate of the University of Maryland and conducts joint research projects with several of its departments, including computer science, business, criminology, and engineering. Additionally, CESE collaborates with Fraunhofer IESE, its sister institute in Kaiserslautern, Germany.

KEY TECHNOLOGIES

- Software Architecture Visualization and Evaluation (SAVE)
- Model-Based Testing (MBT)
- Technical Debt Analyzer

PARENT INSTITUTE

Fraunhofer Institute for Experimental Software Engineering IESE
Executive Director: Prof. Dieter Rombach
Scientific Director: Prof. Peter Liggesmeyer

CONTACT INFORMATION

www.fc-md.umd.edu
Center Director: Prof. Rance Cleaveland

Established in: **1998**

NASA GROUP ACHIEVEMENT AWARD

For an outstanding group accomplishment that has contributed substantially to NASA's mission. CESE received this award in 2012 for work with the Office of Safety and Mission Assurance (OSMA).

150+

interns trained since center's inception.

In 2007, CESE co-founder Vic Basili was awarded the

FRAUNHOFER SILVER MEDAL

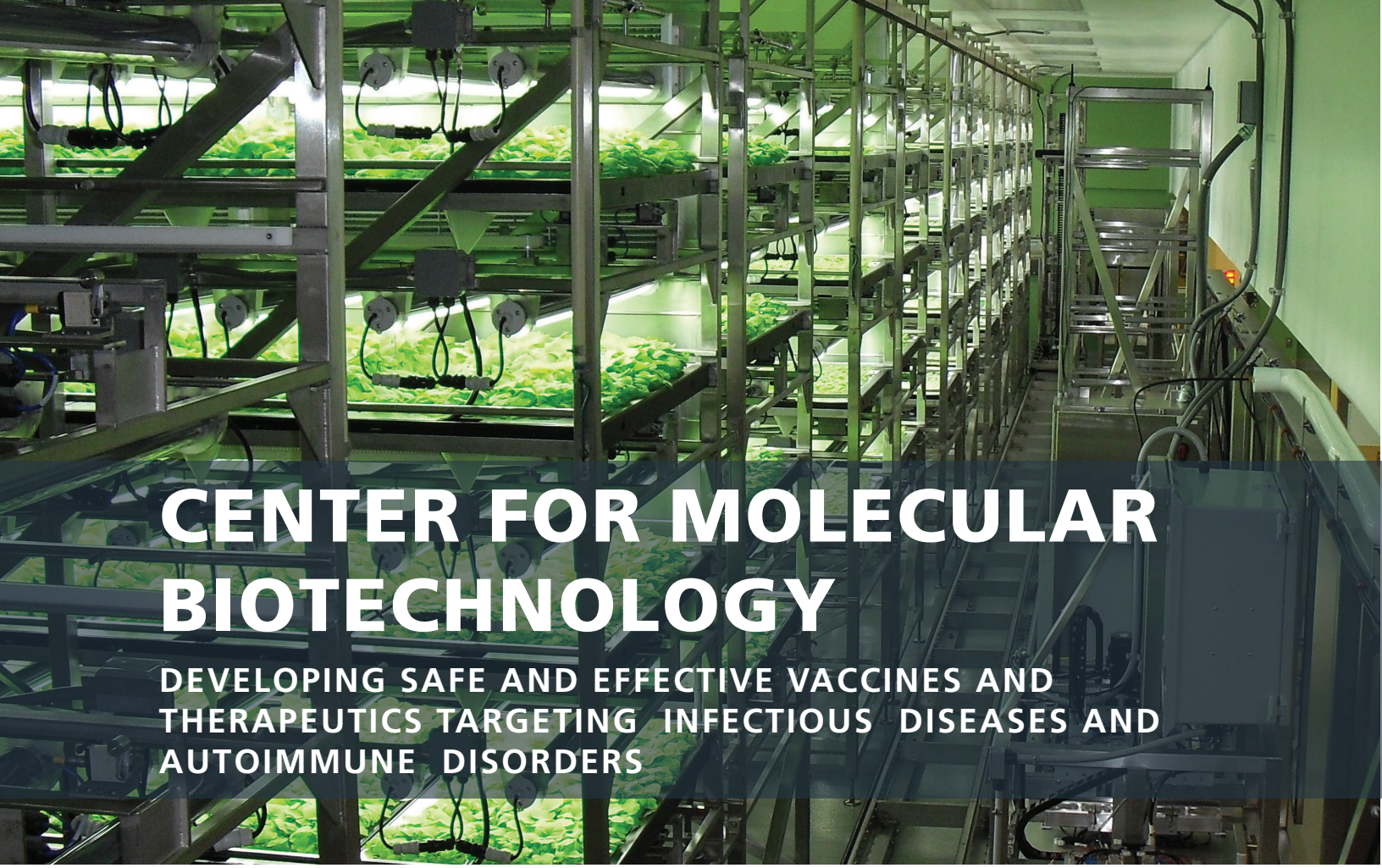
for Exemplary Collaboration with Outstanding Results in Applied Research.

Areas of Focus Include Software:

- **DESIGN & REQUIREMENTS ANALYSIS**
- **ANALYSIS, TESTING, VERIFICATION & VALIDATION**
- **MEASUREMENT, PROJECT MANAGEMENT & PROCESS IMPROVEMENT**

> Your teams embody all that the [NASA SARP] Program values: collegial collaboration, innovation, determination, and an unshakeable focus on making NASA software and missions safer and more effective.

LISA MONTGOMERY
NASA SOFTWARE ASSURANCE RESEARCH PROGRAM
DELEGATED PROGRAM MANAGER



CENTER FOR MOLECULAR BIOTECHNOLOGY

DEVELOPING SAFE AND EFFECTIVE VACCINES AND THERAPEUTICS TARGETING INFECTIOUS DISEASES AND AUTOIMMUNE DISORDERS

Established in 2001 as a partnership between Fraunhofer-Gesellschaft and the State of Delaware, the Fraunhofer Center for Molecular Biotechnology CMB is a unique institution conducting translational research in the area of pharmaceutical biotechnology, utilizing cutting-edge technologies to advance products for prevention, diagnosis and treatment of infectious diseases and autoimmune disorders. CMB has assembled a dedicated and expert work force of over ninety full-time employees with extensive experience in research and development, GMP manufacturing, QA/QC, regulatory/clinical affairs and technology transfer. Lead scientists at the Center have published widely on recombinant protein production and are inventors of key enabling patents.

CENTER HIGHLIGHTS AND ACHIEVEMENTS

Since its inception in 2001, CMB has advanced its innovative protein production technology from concept, through process development and pre-clinical evaluation, to establish a fully automated, GMP compliant, biopharmaceutical production facility. CMB's plant-based protein production platform has been validated by the successful completion of several clinical trials.

In 2009, CMB received its third grant from the Bill & Melinda Gates Foundation, supporting the development of vaccines using its plant-based platform, for the development of a new approach to fight malaria - a transmission blocking vaccine (TBV). The work from this grant utilized the center's Good Manufacturing Practice (GMP) bioprocessing facility, which is a validated Phase I and II compliant pilot plant for the production of biopharmaceuticals using CMB's proprietary plant-based expression platform.

In February 2014, CMB launched a clinical trial of the plant-derived malaria TBV. As part of the planned collaboration strategy, CMB, the PATH Malaria Vaccine Initiative and Accelovance, entered into an agreement to conduct a Phase 1 clinical trial. Development of this malaria TBV is an effort to improve global health by supporting the development of critical platform technologies for delivering vaccines to malaria-endemic countries.

STRATEGIC PARTNERSHIP: UNIVERSITY OF DELAWARE

Since 2011, CMB and University of Delaware (UD) have been collaborating through a life science partnership that aims to close the gap between academic and industry research. Leveraging CMB's expertise in applied translational research and UD's strengths in basic research, the two parties have increased investment into interdisciplinary programs and contributed to the growth of the State of Delaware's innovation economy.

Stregthening this partnership, CMB initiated a graduate student exchange program, featuring placements at Fraunhofer Institutes and University Departments focusing on biotechnology and energy. It is designed for selected German and UD students to participate in research placements in energy and biotechnology, at the University of Delaware or Fraunhofer in Germany.

In addition to the exchange program, CMB and UD launched the Inaugural Technology Summit - *Solutions for Sustainability* - bringing together over 150 guests, including scientists, researchers, CEOs and entrepreneurs, to collaborate and explore solutions to challenges ranging from energy to human health. The event was held at the University of Delaware and was kicked off by Delaware Governor, Jack Markell, and UD President, Dr. Patrick Harker.

KEY TECHNOLOGIES

- Plant Produced Immunotoxin Demonstrates Toxic Activity
- Development of a Technology That Disrupts Microbial Quorum Sensing in order to Identify Novel Microbes with Unique Industrial and Health Applications
- Precision-Cut Lung Slices as an Alternative System for Evaluating Vaccine Safety

PARENT INSTITUTE

Fraunhofer Institute for Molecular Biology and Applied Ecology IME
Senior Executive Director: Prof. Rainer Fischer

CONTACT INFORMATION

www.fhcmb.org
Center Executive Director: Dr. Vidadi Yusibov

Established in: **2001**

100+

interns trained since center's inception.

COMPLETED SUCCESSFUL
CLINICAL TRIALS

for H1N1 and H5N1 influenza vaccines using its its plant-based protein production platform.

2013 AWARD RECIPIENT

JOSEPH VON FRAUNHOFER PRIZE FOR SCIENCE & INNOVATION
for Fraunhofer CMI's and Fraunhofer CMB's work on plant-based vaccine production.

Areas of Focus Include:

PLANT-BASED BIOTECHNOLOGY

GMP BIOMANUFACTURING

> We are excited to see this promising new vaccine approach advance to clinical testing... Vaccines that can induce immunity to break the cycle malaria parasite transmission between humans and mosquitoes have the potential to be important interventions to accelerate future elimination and eradication efforts.

ASHLEY J. BIRKETT, PHD
DIRECTOR, PATH MALARIA VACCINE INITIATIVE

CENTER FOR SUSTAINABLE ENERGY SYSTEMS

FOSTERING ECONOMIC DEVELOPMENT THROUGH THE COMMERCIALIZATION OF CLEAN ENERGY TECHNOLOGIES

Photo credit: Trent Bell

The Fraunhofer Center for Sustainable Energy Systems CSE focuses on the commercialization of clean energy technologies, specifically in photovoltaics, building energy efficiency, and distributed electrical energy systems (grid technologies). Founded in 2008 with the support of the Massachusetts Clean Energy Center (MassCEC), Fraunhofer-Gesellschaft, Fraunhofer ISE, the US Department of Commerce, National Grid, and an anonymous donor, CSE has created hundreds of direct and indirect jobs in the United States, provided workforce training for more than 140 young technologists and entrepreneurs and supported over 30 early-stage cleantech companies through its TechBridge program.

CENTER HIGHLIGHTS AND ACHIEVEMENTS

The transition to a sustainable energy future is one of the major challenges for our society in the next decades. Fossil energy sources, which emit greenhouse gases, need to be replaced by renewable energy sources such as solar and wind, and the efficiency of our use of energy needs to be increased on a massive scale. CSE was founded in 2008 to help develop solutions for this transition. CSE pursues research and development in in the areas of photovoltaic energy generation, energy efficiency technologies for buildings, and electrical grid integration of photovoltaics and smart buildings. CSE's key strength is its multidisciplinary research team comprised of mechanical and electrical engineers, polymer and silicon materials scientists, chemists and physicists, as well as social scientists. CSE works with industrial and government clients on projects ranging from short tests, which last two weeks, to complex technology development, which include code and standards work that last more than three years. CSE conducts its research from its new Living Laboratory headquarters in Boston, MA, and performs PV testing at its solar module testing laboratory in Albuquerque, New Mexico.

KEY TECHNOLOGIES

Plug and Play PV for American Homes: In 2013, CSE became the Research Team Leader for the Department of Energy's Plug-and-Play Photovoltaic Systems Project, aiming to dramatically reduce costs of residential PV installation and thereby enabling a wider adoption of solar power generation in the U.S. Fraunhofer researchers use a set of advanced technologies to make the installation of PV systems on residential rooftops easier, safer and less expensive, while adhering to all applicable codes and standards. The goal of the project is the installation and commissioning of a complete rooftop system in less than 10 hours and to bring the cost of solar down to $1.50 per watt installed.

EVA Cross Linking Test: In 2011, Fraunhofer CSE developed and patented a new method to measure the degree of cross-linking of PV module encapsulants, a key manufacturing quality metrics. The non-destructive method reduces measurement time from 24 hours to 20 seconds. Fraunhofer CSE licensed its method to LayTec AG, a manufacturer of in-situ metrology systems for thin-film processes. In May 2012, LayTec announced its X Link in-line metrology system, the first commercial application of Fraunhofer CSE's intellectual property.

Smart Meter Data Algorithms: In 2011, CSE developed a non-intrusive load monitoring (NILM) algorithm to efficiently and accurately disaggregate whole-building electricity consumption by individual loads. Using a single sensor at an electric meter, it has the potential to provide much greater insight into building electricity consumption and energy savings potential than whole-building electric data. Building on a Fraunhofer USA project completed in 2013, Fraunhofer has teamed with Fraunhofer IWES and ITWM in Germany in 2014 to develop a commercial NILM system for a German company.

A LIVING LABORATORY

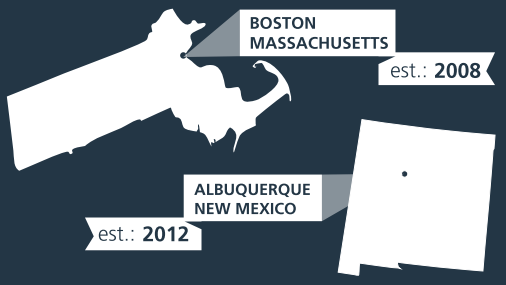
In 2013, CSE and 37 industry partners established a living laboratory for building technologies and energy efficiency at 5 Channel Center in Boston's Innovation District. The building combines the historic architecture of a 100-year-old warehouse with cutting-edge design concepts and energy technologies to drastically reduce the building's energy consumption. The living laboratory houses CSE's research facilities, including a pilot solar module fabrication line, dedicated thermal testing laboratory, and extensive characterization/environmental testing resources.

PARENT INSTITUTE

Fraunhofer Institute for Solar Energy Systems ISE
Director: Prof. Eicke Weber

CONTACT INFORMATION

www.cse.fraunhofer.org
Center Director: Dr. Christian Hoepfner



$77 MILLION

in follow-on funding secured by 16 start-ups after receving technical services from CSE through its TechBridge Program.

140+

interns trained since center's inception.

Areas of Focus:

- PHOTOVOLTAIC TECHNOLOGIES
- BUILDING ENERGY & ENCLOSURES TECHNOLOGIES
- GRID INTEGRATION TECHNOLOGIES
- EARLY STAGE CLEANTECH COMPANY ASSISTANCE

" Dow Corning Corporation has collaborated with the Fraunhofer CSE Photovoltaic Modules group for two years. This interaction has significantly strengthened our understanding of the material requirements in PV modules, especially in areas of overall module durability and performance.

ANDY GOODWIN
GLOBAL SCIENCE & TECHNOLOGY MANAGER
DOW CORNING SOLAR SOLUTIONS

CENTER FOR ENERGY INNOVATION

TRANSFORMING SCIENCE FOR A SECURE ENERGY FUTURE

Founded in 2013, the Fraunhofer Center for Energy Innovation CEI is the 7th Fraunhofer USA Center. Fraunhofer CEI at the University of Connecticut works toward the discovery and development of utility-scale novel energy storage systems; the integration of energy storage systems and renewable energy technologies in flexible microgrid architectures; new materials and methods of integrating, processing and producing biofuels; as well as the development of fuel cells and electrolyzers. Currently, CEI is collaborating with an industry partner in the area of developing technical solutions for liquid filtration by ceramic membranes in the U.S.

CENTER HIGHLIGHTS AND ACHIEVEMENTS

Fraunhofer CEI has substantial expertise in next-generation functional materials development (metals and ceramics, nano and micro structures). CEI researchers developed a capture device chemistry and configuration for capturing gaseous Cr species formed by stainless steels. These chromia forming steels are commonly used as cell stack and balance of plant construction materials in high-temperature electrochemical systems, but form chromium containing vapor species under presence of moisture. Interaction of the Cr vapor with the perovskite-based electrode degrades the performance due to chemical reaction, compound formation and electrochemical deactivation. The chromium capture device chemistry and configuration developed at CEI mitigates this issue by capturing the gaseous Cr species and thus enabling the use of the cost-effective stainless steels.

CEI has also developed cathode materials for Ni-containing batteries, which enable higher energy and power density energy storage. Ni-containing batteries present a viable alternative for high energy and power density energy storage for grid backup and even automotive applications. However, control of the precise (macro-porous) pore morphology of the cathode is required for optimal operation. CEI has developed template fabrication routes that enables the required microstructure, incorporates high-electronic conductivity, and eliminates depassivation of the electrode surfaces, thus yielding higher energy and power density electrochemical energy storage.

In July of 2014, Fraunhofer CEI conducted its 1st *Science-2-Business* workshop at the University of Connecticut campus in Storrs, CT. The workshop provided presentations on the research findings of major projects being conducted at CEI in the field of clean and efficient energy systems, including energy conversion and storage, advanced membranes and bio-fuel cleanup technologies. The workshop also provided a platform to network with technical and domain experts from CEI's parent Institute IKTS (Institute for Ceramic Technologies, Dresden) on technology transfer, product development and doing business in Germany and Europe. The networking session presented opportunities for discussion with industry on advancing energy technologies in the field of science and engineering.

KEY TECHNOLOGIES

- Capture of Gaseous Cr Species
- Cathode Materials for Ni-containing Batteries
- Manganese Oxides / Graphene Nanocomposites, Films, and Membranes and Methods of Making
- Advanced Mesoporous Carbon Adsorbence for Bio-Fuel Clean-up

PARENT INSTITUTE

Fraunhofer Institute for Ceramic Technologies and Systems IKTS
Director: Prof. Alexander Michaelis

CONTACT INFORMATION

www.cei.fraunhofer.org
Center Director: Prof. Prabhakar Singh

Established in: **2013**

YOUNGEST FRAUNHOFER RESEARCH CENTER

The 7th center, Fraunhofer CEI is a partnership between the University of Connecticut, Fraunhofer USA and the State of Connecticut's Department of Energy and Environmental Protection (DEEP) and was officially launched by Governor Dannel D. Malloy on July 25th, 2013.

Areas of Focus:

- **BATTERIES & ENERGY STORAGE**
- **MICROGRID ENGINEERING**
- **ENVIRONMENTAL TECHNOLOGY**
- **FUEL CELLS & ELECTROLYZERS**

FRAUNHOFER DAY

At the inauguration ceremony in 2013, Governor Dannel Malloy proclaimed this day as Fraunhofer Day in the State of Connecticut.

"This partnership between the state, UConn, and Fraunhofer USA is a welcome and important collaboration when it comes to finding solutions to some of the most pressing energy challenges.

DANNEL D. MALLOY
GOVERNOR OF THE
STATE OF CONNECTICUT

FRAUNHOFER USA DIGITAL MEDIA TECHNOLOGIES

PROMOTING STATE-OF-THE-ART AUDIO CODING AND MULTIMEDIA REAL-TIME SYSTEM TECHNOLOGIES

The Fraunhofer USA Digital Media Technologies Office located in San Jose, California, promotes and supports the products of its parent institute, the Fraunhofer Institute for Integrated Circuits, IIS in Erlangen, Germany.

FRAUNHOFER CINGO – GOOGLE'S CHOICE FOR SURROUND SOUND ON SMARTPHONES AND TABLETS

Today, music is sold predominantly online, reaching millions of consumers through user-friendly platforms: from phones to TVs, cars, and a host of media devices. Although it is available everywhere, the audio quality of digital music need not be compromised if music is recorded, produced, and delivered with care from the recording studio to the online store and - ultimately - the consumer. This emotional music experience and the online music business were largely made possible by audio coding algorithms such as mp3, AAC, and the corresponding recording and production tools developed at Fraunhofer IIS in Germany. These open standard audio codecs combine coding efficiency with the highest quality. They power popular download and streaming services that bring artists, labels, and fans together in the most direct manner.

Fraunhofer doesn't just develop codecs, but also provides the recording industry with essential tools that enable dedicated workflows for online music composition, arrangement, recording, mixing, and publishing. In addition, Fraunhofer's codecs are used to share work-in-progress sessions between record-making collaborators that are often in different locations. In its role as audio quality evangelist and R&D powerhouse, Fraunhofer also delivers know-how, software, and expertise to consumer electronics companies and online retailers including Apple, Google, and Sony that combine great content offerings with advanced playback devices.

HE-AAC and other audio codecs are developed and tested in Fraunhofer's advanced sound lab that allows for critical listening and flexible loud speaker arrangement.

Fraunhofer booth at the NAB Broadcast Show in Las Vegas

In online music distribution, the MP3 codec is used by the majority of music download services today, while the AAC codec is the format of choice for iTunes. The open standard nature of the formats allowed Apple and others to continuously improve the quality of music encoding based on input from the recording industry and despite the fact that the standards had been finalized years prior. Fraunhofer was the "behind-the-scenes" technology consultant that supported Apple with its encoding expertise in its quest for high quality digital audio. The iTunes Plus program was the solution that brought 256 kb/s AAC files to consumers that many consider virtually indistinguishable from the original recordings.

Even though online retailers improved the ingest and encoding techniques, recording, mixing, and encoding of music were still separated and rather cumbersome tasks. To address this gap and integrate mixing and encoding into the professional mastering process, Fraunhofer worked with Sonnox and developed the "Sonnox Fraunhofer Pro Codec" DAW plugin. It includes Apple's and Fraunhofer's AAC encoder, which enables the professionals in the studio for the first time to audition the encoded mix in real-time while mixing, making adjustments where necessary and finalizing the mix with the confidence that s/he hears what the consumer would hear once they purchased the song online. The plugin's FFT and NMR display, codec comparisons and ABX listening tests make mixing for online music distribution a fully integrated process.

At Fraunhofer's premises, nearly 300 people never stop innovating and aim for even higher audio quality. Examples include surround music, 24-bit/96 kHz lossless delivery, or adaptive streaming techniques for optimized music delivery over mobile networks. It's all about music indulgence enabled by invisible technology.

PARENT INSTITUTE

Fraunhofer Institute for Integrated Circuits IIS
Institute Director: Prof. Albert Heuberger

CONTACT INFORMATION

www.fraunhofer.org/DigitalMediaTechnologies

Division General Manager: Robert Bleidt
Director, Marketing & Business Development:
Jan Nordmann

FRAUNHOFER HEINRICH HERTZ INSTITUTE, BERLIN GERMANY & SILICON VALLEY USA

DEVELOPING KEY TECHNOLOGIES FOR HIGH SPEED WIRELESS AND FIBER OPTIC COMMUNICATIONS NETWORKS, VIDEO & IMAGE PROCESSING, HIGH SPEED COMPUTING, ENVIRONMENTAL SENSING AND ENERGY EFFICIENCY

The U.S. Office of the Fraunhofer Heinrich Hertz Institute (HHI), located in California, promotes and supports the products, technology, and research of its parent institute, HHI, in Berlin, Germany. HHI is a world leader in the development of mobile and fixed broadband communication networks and multimedia systems. The Heinrich Hertz Institute works together with international partners from both research and industry to design the infrastructure necessary for a global "Multi-Gigabit Society".

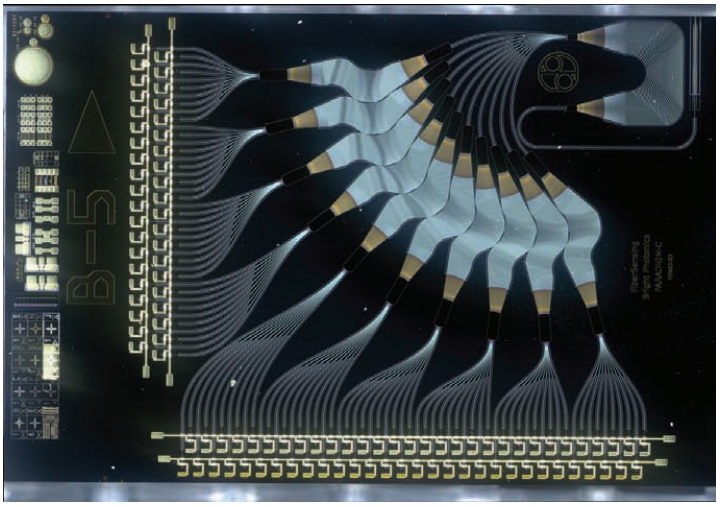
The Institute's core competencies are in the areas of communications, computing, networking, and image processing. HHI's current research and development work focuses on high-speed photonic components; high-capacity fiber optic networks and systems; wireless networksl; broadband systems; fiber optic sensors; and next-generation communications hardware architectures, video processing, and electronic imaging.

INNOVATIONS FOR THE DIGITAL FUTURE

State-of-the-art communications systems and the field of digital media are at the heart of research and development work carried out by the HHI. Activities in photonic networks span a spectrum of activities ranging from high-capacity flexible long haul networks to broadband access networks. In photonic components, HHI makes world-leading fiber optic communication devices including high speed lasers, detectors, and modulators. More than half of all internet bits traveling the world's fiber optic communications links are transmitted or received using optical components from HHI.

HHI's wireless R&D activities are concentrated in the areas of mobile broadband systems, design of future cellular systems, and development of various key parts of the modern wireless communications system. Heinrich Hertz's wireless researchers had the world's first operating LTE based (4G) wireless system. The wireless department is now deeply involved with developing the next generation of wireless, 5G.

Cross-border Research and Development for the Gigabit Society.



This photo shows an example of a result from the PARADIGM project at the Heinrich Hertz Institute. The main objective of the PARADIGM program is to enable a "fabless" model for the design and fabrication of Indium Phosphide based photonic devices and components.

In the areas of multimedia, video, and image processing, the research is centered on development of video encoding / decoding technologies (CODEC) used for efficient transmission of digital video, 3D image processing, video & audio reproduction in virtual environments, tele-immersive systems, auto-stereoscopic displays, and man-machine interactions. Today, nearly all of the video transmitted over the internet and much of modern digital television is powered by the video CODEC developed by HHI.

BUSINESS AREAS

- Communications & Networking: design and development of submarine and ultra long-haul fiber optic systems. Broadband access systems, wireless systems including wireless backhaul, 4G and 5G cellular radio systems, microwave technology, and advanced modeling and simulation for wireless networks.

- Photonics Components: very high speed lasers, high bandwidth detectors and receivers, tunable photonics including tunable lasers, world's fastest and lowest power consumption Mach Zehnder Modulators, silicon - polymer photonic devices, and associated techniques for advanced modulation and detection.

- Image Processing: ongoing development of advanced video CODEC technology, design of immersive video, advanced 3D image processing techniques, along with design of world-leading filming and projection tools and systems.

- Energy Technology: HHI's fiber optic sensor technology can be utilized for a wide range of applications, including condition monitoring of wind power plants, sails, power cables, and structures as well as enhancing energy efficiency of battery systems and modern solar panels.

- Medical Technology: HHI's medical technology research includes solutions for hands-free control of operating theatre devices, automatic image and video recognition for diagnostic support, and auto-stereoscopic 3D displays.

PARENT INSTITUTE

Fraunhofer Heinrich Hertz Institute
Director: Prof. Martin Schnell
Director: Prof. Thomas Wiegand

CONTACT INFORMATION

www.hhi.fraunhofer.org
Director of Business Development: John Aengus

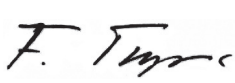
OUTLOOK

Today, Fraunhofer is a well-established brand in the U.S. among scientific experts, technology leaders and entrepreneurs. The Fraunhofer model is recognized as one of the most powerful public-private partnerships for technological innovation. It creates an infrastructure from the lab to the market, linking regional expertise and excellence to global challenges and world-class competitiveness. It is no surprise that the new U.S. manufacturing initiative was also inspired by the European research and technology environment led by Fraunhofer.

Nonetheless, if we look closer we will find that, in public perception, Fraunhofer is not quite that well-known. Past achievements and how Fraunhofer actually serves innovation and regional economic growth are not very visible to the general public. We need to improve on this. It is part of the Fraunhofer model to communicate how applications-oriented research interacts with scientific advancements and commercial entrepreneurship. Fraunhofer USA is a strong partner in the regional innovation ecosystem, helping to create more jobs and growth. Yet, Fraunhofer USA is more than that. Fraunhofer USA is also a bridge to technological competence and excellence in Germany. We need to show and explain better what we can achieve together, and where the benefits lie for the U.S. and German/European economies.

Together we can improve our capabilities and position ourselves as more valuable partners for industry. We intend to enter into more strategic partnerships with the best research institutions in the USA - universities as well as non-university institutions - and to strengthen our existing partnerships. Fraunhofer USA can create unique technological synergies that others cannot. Fields for collaboration will focus on key topics in research and technology such as biotechnology, renewable energy and energy management, environmental technologies, advanced materials and lifecycle management, or initiatives like the "Industry 4.0" initiative, which combines advances in ICT and manufacturing technology.

We also intend to intensify activities at our current locations. For example, the 5 Channel Center Building in Boston, Massachusetts, is a perfect place to present the bandwidth of Fraunhofer technologies and services. A Fraunhofer Innovation Forum here could be more than that: a platform to showcase the most recent advancements in technological innovation, a co-location center to broker new high-tech collaboration, and a training base for dissemination and education services in key technologies in the U.S. We can enhance the visibility of our joint projects, services and deliverables considerably and amplify the benefits of the Fraunhofer model and value added by transatlantic cooperation.



Mr. Frank Treppe
President-Elect
Fraunhofer USA, Inc.

Dr. Patrick Bressler
Vice President-Elect
Fraunhofer USA, Inc.

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