Fraunhofer
USA

R & D PORTFOLIO

Fraunhofer USA

Founded in 1994, Fraunhofer USA, Inc. (FhUSA) is a 501 (c) (3) not-for-profit charitable organization incorporated in Rhode Island, dedicated to the advancement of applied research. Fraunhofer USA currently has R & D Centers located in Massachusetts, Delaware, Michigan, Maryland and Connecticut. Our strength lies in our creativity, flexibility and expertise, which allows the centers to work on diversified projects with a large bandwidth of customers across the United States and abroad.

We employ a polytechnical approach to find solutions for our industry and government customers. Our staff is comprised of scientist and engineers with advanced expertise and well-honed innovation skills. These scientists and engineers represent a broad spectrum ranging from the natural and physical sciences to cutting-edge engineering sectors. This diversity and range of know-how leads to superior project outcomes.

In further support of customer requirements, individual Fraunhofer USA centers can work with other Fraunhofer USA centers and with any of our partners to meet unique customer needs. Our partners include renowned academic institutions such as Michigan State University, Boston University, the University of Maryland, University of Connecticut and the University of Delaware. Fraunhofer USA and its centers can also work with Fraunhofer Institutes and Centers in Europe, to provide the most versatile innovative technologies.

Our goal is to bridge the gap from the lab to the real market for our customers and develop and validate scientific applications and technologies for industrial innovation in the USA.

The enclosed information provides an overview of the R & D portfolio offered by Fraunhofer USA. The know-how and expertise listed are not exhaustive, and we welcome "outside of the box" inquiries.

We look forward to working with you!
Fraunhofer USA

Creating a thermocouple to be used as a temperature sensor for building enclosure field research.

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Fraunhofer CESE research assistant conducting embedded system research.

Fraunhofer USA

FRAUNHOFER USA CENTER FOR COATINGS AND DIAMOND TECHNOLOGIES CCD

The Fraunhofer USA Center for Coatings and Diamond Technologies CCD performs applied research and development contracts with industry and government organizations. Customers include companies from industry sectors such as manufacturing, semiconductor, biomedical and energy. CCD is a confident and reliable partner providing proprietary and competitive R&D services based on core competences in diamond and coating technologies. CCD's quality management system is certified according to the standard ISO 9001:2008.

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

Engaging with CCD in Applied Research and Development Work

We work closely with our customers to determine specific project objectives and requirements. Prior to commencing work, every project is structured with mutually agreed upon deliverables, schedules, milestones and costs. Our customers are provided with access to our extensive laboratory and engineering resources. Project results are treated with strict confidentiality. We recognize the need to protect intellectual property rights for our customers and work with them to negotiate mutually acceptable terms and conditions so that the developed solutions can be readily deployed.

Core Competence: Coating Technologies at Fraunhofer CCD

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

Core Competence: Diamond Technologies at Fraunhofer CCD

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

Project Briefs

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

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

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

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

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

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1 *A brilliant cut single crystal diamond on top of a Diamond-like-Carbon coated end mill.*

2 *CCD Engineer prepares to diamond coat silicon wafers in a hot filament diamond system.*

Fraunhofer USA

FRAUNHOFER USA CENTER FOR EXPERIMENTAL SOFTWARE ENGINEERING CESE

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

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

Our Vision

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

Our Mission

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

What We Offer

Model-Based Development and Testing

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

Software Safety and Security Analysis

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

Rapid Prototyping of Mobile and Web Applications

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

Software Engineering Analytics

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

Cybersecurity and Embedded Systems

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

Digital Transformation

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

Project Measurement & Analytics

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

- Risk Assessment
- Regulatory Compliance
- Project Management Consulting
- Strategy Innovation
- Technology & Capability Evaluation
- Process Assessment

Data Protection Policy Effectiveness

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

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Fraunhofer USA

FRAUNHOFER USA CENTER FOR LASER APPLICATIONS CLA

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

With our extensive experience and expertise in laser applications development for processes such as welding, cutting, heat treatment, cladding and additive manufacturing we are your ideal partner for laser applications development.

What We Offer
Contract research and development, process development, prototyping and consulting services, technical support and pilot production systems.

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

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

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

Laser Cutting and Drilling
- 5 Axis 3D laser cutting
- Remote laser cutting
- Micromachining / drilling

Laser Sources
Our state-of-the-art laser application facility features the latest and greatest in laser technology with a wide range of lasers from 1 watt to 16 kilowatt output power.

High Power CW and Pulsed Lasers:
- 16kW Laserline fiber coupled diode laser
- 10kW Laserline fiber coupled diode laser
- 4kW Laserline fiber coupled diode laser
- 8kW TRUMPF TruDisk 8001 disc laser (100 micron fiber capable)
- 6kW TRUMPF TruDisk 6001 disc laser (100 micron fiber capable)
- 6kW IPG YLS 6000 fiber laser (100 micron fiber capable)
- 6kW Rofin Sinar DC060W slab CO2 laser

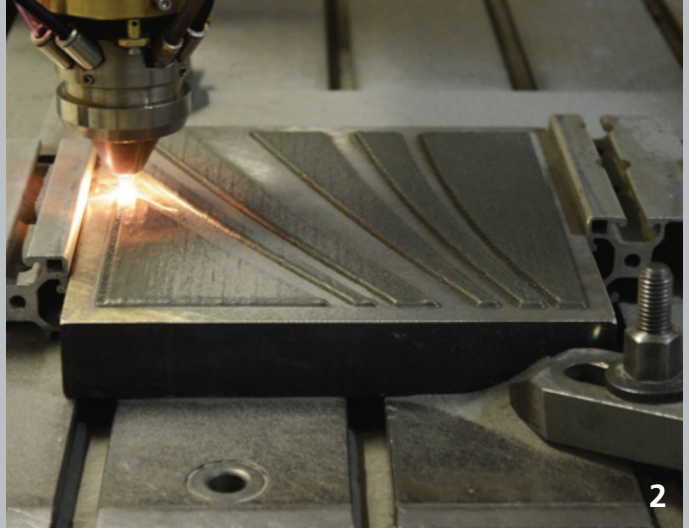
Low Power Pulsed and CW Lasers:
- 850W / 1030nm Trumpf TruMicro 7060
- 70W pulsed 1030 nm Jenoptik IR70 Disc
- 17W @1064nm and 5W @ 355nm pulsed Spectra-Physics HIPPO
- 200W / 1064 nm LASAG KLS 246 YAG
- 100W pulsed Rofin Sinar SCx10 CO2
- 500W 1070 nm IPG YLR Single mode
- 25W cw 1070 nm JDSU Single mode fiber
- 20W cw 430 nm Fraunhofer Blue diode

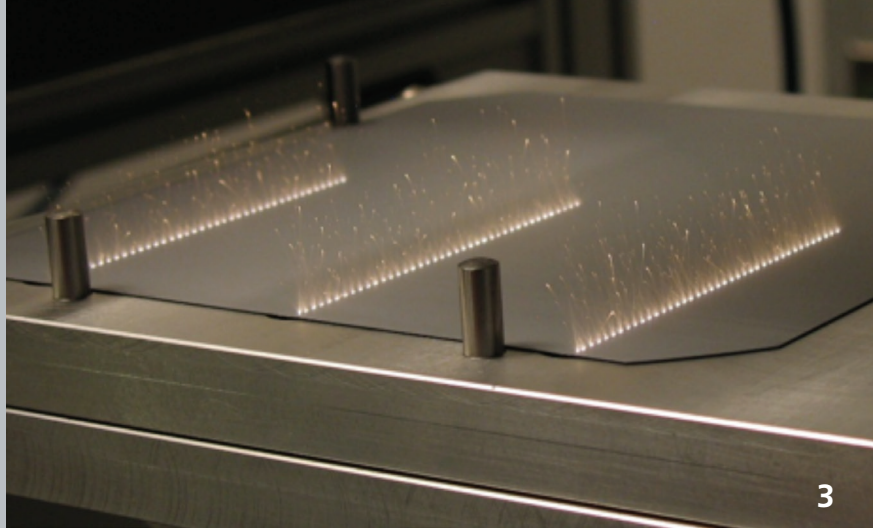
Additional Equipment
The Center for Laser Applications utilizes additional robotic systems (Kuka) and multiple CNC machines and an onsite metallographic laboratory.

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

Application Examples

Laser Welding
Laser welding offers the potential to join parts with high speed and precision with minimal heat input and distortion. Difficult to weld materials such as higher carbon steels and cast irons can now be successfully laser welded. Filler wire and / or induction preheating can be used to change the microstructure of the weld metal, preventing the formation of hard and brittle phases. A conventional bolting





process was replaced with laser welding for an automotive gear component. Significant cost savings were achieved through reduced material and processing costs and an overall part weight reduction was accomplished with a more efficient production method using laser technology.

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

Process Monitoring

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

Additive Manufacturing and Cladding

In the Laser Metal Deposition process (LMD) metal powder is fed coaxially through a nozzle and then melted by the laser beam to form a fully bonded metallic layer (FIG 2).The deposited layer has a small heat affected zone with minimal dilution. It has been developed for production of wear and corrosion resistant coatings and for repairs and remanufacturing applications. The same process can also be used for generation of complete components from scratch in the form of additive manufacturing where parts are built using layer by layer deposition.

Two other variations of LMD – hot/cold wire cladding and internal diameter cladding – have now evolved into successful industrial processes and are now widely used in industry. A recent key development by Fraunhofer IWS is a new coaxial wire deposition head COAXwire (FIG 1) which provides omni-directional welding using metallic wire as the filler material which is of particular use for additive manufacturing of metallic components.

MicroMachining

The latest generation of lasers with pulse lengths from millisecond all the way to femtosecond has led to a rich pipeline of innovations impacting virtually every manufacturing industry. One such innovation is large area coating removal for paint stripping, deoxidization, cleaning or localized removal of special coatings. Another example of innovation is the ability to drill high aspect ratio holes at extremely high speeds. One application developed by Fraunhofer was able to achieve drilling of up to 15,000 per second in a silicon wafer material (FIG 3).

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1 *Coaxial Wire deposition head.*
© Fraunhofer CLA

2 *Coaxial powder metal deposition process.*
© Fraunhofer CLA

3 *High speed laser drilling of silicon.*
© Fraunhofer CLA

Fraunhofer USA

FRAUNHOFER USA CENTER FOR MANUFACTURING INNOVATION CMI

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

What We Offer

- Custom Automation Systems
- Biomedical Instruments and Devices
- Process Management and Consulting

Custom Automation Systems

Manufacturing automation begins with a thorough understanding of the requirements of the process, followed by a review of available state-of-the-art technologies that may be incorporated. When commercially available technology does not suffice, we develop new custom automation systems, based on the latest emerging academic research, and provide our clients with a turnkey solution.

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

Examples:

Fiber optic gyroscope winding

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

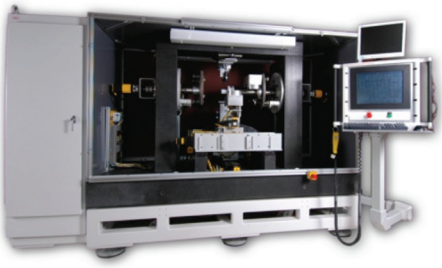


Figure: A custom-designed automated machine for rapid fiber optic coil winding for strategic, navigation, and tactical grade gyroscopes.
© Fraunhofer USA CMI

Biomedical Instruments and Devices

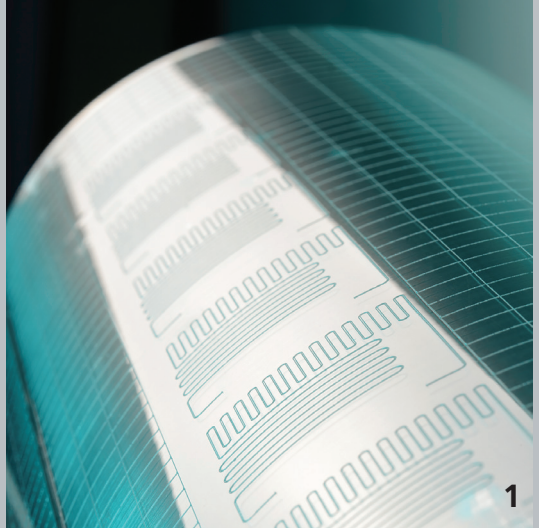
One of our core strengths is the application of advanced engineering to biological problems. We combine multiple engineering and scientific disciplines in tackling such problems, and are trusted by leading pharmaceutical and medical device companies and research collaborators to successfully carry out their project goals.

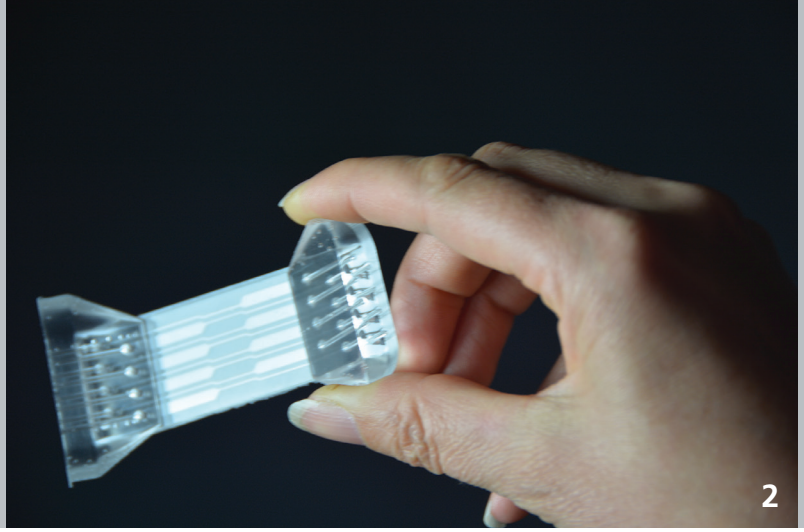
To meet these needs, we have over 16,000 square feet of fully equipped laboratories including five CNC machines, which are housed adjacent to our on-site BL1 and BL2 laboratories that are capable of bacterial, viral and mammalian cell culturing. Our major activities include developing rapid diagnostics,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

Examples:

Low-cost, real-time, continuous flow PCR system for pathogen detection

Bacterial resistance to antibiotics is esca- lating, and represents a significant health threat to the human population. To address the need of rapid, portable and low-cost pathogen identification, we have partnered with Fraunhofer IPT to create diagnostics that combines microfluidic and electronic layers into a single device. This microfluidic chip for nucleic acid testing (NAT) can identify pathogens within 20 minutes and is compatible with roll-to- roll embossing for large-scale, low cost production.





Fluorescence is monitored in real-time for the quantitative detection of pathogens at concentrations as low as 10 DNA copies per microliter. (Fernández-Carballo et al. Biomed. Microdevices 2016, 18, 34).

Bioprinted hydrogels developed to improve implant integration

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

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

Process Management and Consulting

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

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

Examples:

Coin manufacturing assessment and technology development

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

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

Industries Served

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

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1 *Roll-to-roll manufacturing of lab-on-a-chip devices. © Fraunhofer IPT*

2 *Microfluidic platform for rapid antibiotic susceptibility diagnostics. © Fraunhofer CMI*

Fraunhofer USA

FRAUNHOFER USA CENTER FOR SUSTAINABLE ENERGY SYSTEMS CSE

Applied R&D Services for the Sustainable Energy Industry

Fraunhofer CSE is an applied research and development laboratory dedicated to building tomorrow's energy future today. Our staff's expertise in solar photovoltaics, smart energy-efficient buildings, and grid technologies provides a platform for deeply integrating distributed energy resources through collaborative R&D with private companies, government entities, and academic institutions.

Fraunhofer CSE's mission is to secure America's clean energy future and drive economic development by supporting the commercialization of technologies that will fundamentally transform the energy industry.

We offer comprehensive support for development, testing, evaluation, education, and marketing around new technologies, with considerable flexibility for project structure and intellectual property concerns. Fraunhofer CSE works with a wide variety of customers, ranging from Fortune 500 companies and national labs to university spin-outs and start-ups.

Building Energy Systems Research Facilities

- Data Acquisition Lab
- Human Behavior Lab

Building Enclosures and Materials Research Facilities

- Thermal and Hygrothermal Test Labs
- Outdoor Exposure Facility
- Material Characterization Lab
- Two Field Testing Sites (Boston, MA; Albuquerque, NM)

Solar PV Research Facilities

- PV Module Fabrication Lab
- PV Durability Lab
- Rooftop Mockup
- Outdoor Test Sites
- Building Integrated Photovoltaics (BIPV) Lab

Grid Integration Research Facilities

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

Inside the Living Lab

Fraunhofer CSE and its industry partners established a Living Lab for energy efficient building technologies in Boston's Seaport District. The retrofitted 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 Lab houses CSE's research facilities, including a pilot solar module fabrication line, extensive characterization / environmental testing resources and a platform for evaluating energy storage systems in residential and light commercial applications.

Fraunhofer TechBridge Program

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


1

Building Energy Systems

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

Building Enclosures and Materials

- Applied R&D of novel energy-efficient materials and systems, including advanced thermal insulations and environmental barriers, phase change materials (PCMs), advanced ventilation strategies, and systems to control radiation heat transfer
- Deployment and integration of these technologies
- Development and testing of novel building-integrated solar systems
- Advanced thermal, hygrothermal modeling
- Whole building energy analysis
- Laboratory thermal / hygrothermal testing
- In situ performance, monitoring and long-term evaluations

Photovoltaic (PV) Technologies

- Module and system performance assessment, based on outdoor exposure testing and characterization
- Module reliability, including accelerated stress tests
- Failure analysis and materials characterization
- Assessment of new module materials for conventional and lightweight modules
- Module prototyping
- Novel approaches to power electronics
- PV system integration
- Novel PV mounting approaches
- Demonstrations and pilots

Grid Integration (Distributed Energy Resources)

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

Fraunhofer TechBridge Program – Technology Commercialization

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

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1 *Fraunhofer CSE's building houses 50,000 ft of lab and office space in an energy-efficient retrofit of a 100-year-old building. © Fraunhofer CSE/Trent Bell*

2 *Fraunhofer CSE Plug and Play PV system installation and commissioning takes less than 1 day. © Fraunhofer CSE*

3 *In addition to contract research, Fraunhofer CSE's scientists conduct extensive engineers and R&D on sustainable technologies. © Fraunhofer CSE/Trent Bell*

Fraunhofer USA

FRAUNHOFER USA CENTER FOR ENERGY INNOVATION CEI

The Fraunhofer USA Center for Energy Innovation CEI performs applied research, feasibility studies, and demonstration testing of membrane separation processes, providing energy effective separation processes and processes integration across industrial sectors. This includes laboratory and pilot scale demonstration testing of liquid and gas separation applications.

What We Offer

Customized Separations Solutions for:

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

We Offer the Following Technology Platforms

- Ceramic membranes
- Polymeric membranes

Ceramic Membranes

Ceramic membranes offer capabilities for separation applications where polymeric membranes cannot operate. For example, ceramic membranes can operate at temperatures, pressures, pH levels, and in abrasive environments where polymeric membranes would fail. CEI has the knowledge and resources to demonstrate the capabilities of ceramic membranes for aqueous and organic filtration applications.

CEI's collaborative partner, Fraunhofer IKTS, fabricates the most selective ceramic filtration membranes on the market. They are the only provider of nanofiltration ceramic membranes. Other inorganic membranes are also available for vapor and gas separations. These include membranes made from zeolites, carbon materials, and perovskites.

Polymeric Membranes

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

Membrane Process Engineering

CEI can assemble customized membrane separations systems that are designed for client needs. Fraunhofer IKTS offers scaled-membrane manufacturing capabilities for element and module design and fabrication.

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Joint Development Opportunities

CEI welcomes joint development projects with industrial clients. These range from membrane design and module prototyping to system piloting.

Separation Equipment & Analytical Resources

Separation Equipment

CEI has access to state of the art separations test equipment designed to accept different types of membranes and modules. These systems are designed for aqueous, organic, vapor, and gas separations processes.

Analytical Resources

CEI has access to the state of the art research infrastructure at the University of Connecticut to perform a variety of analytical testing. Extensive materials characterization and liquids/gas analysis facilities are available for a fee.

Examples of Applications

Water treatment and reuse: CEI can offer a variety of water treatment options using both off-the-shelf and customized membrane solutions for industrial and municipal reuse.

Produced water and mining wastewater treatment: Wastewater from oil and gas exploration and mineral mining can be treated with high durability MF, UF, and NF ceramic membranes.

Organic solvent purification and recycling: For filtering solvents and oils that might damage delicate polymeric materials, we offer a suite of membrane options that are resilient in the presence of non-aqueous fluids.

Fuels dewatering: For biofuels production, we offer membranes for dewatering that can lower the energy use of fuel production and replace distillation.

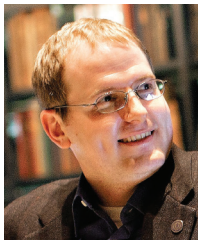
Gas dewatering: Zeolite membrane technology is available for high temperature water removal from gas streams.

Biogas upgrading: Carbon-ceramic composite membranes are available that can remove CO2 from biogas as well as other gas separations.

Perovskite membranes for oxygen separations: Oxygen generation is possible at competitive costs and energy use to traditional technologies.

A close partnership with Fraunhofer IKTS

The Fraunhofer Institute for Ceramic Technologies and Systems IKTS is the parent institute of Fraunhofer CEI. CEI has access to the facilities and expertise of Fraunhofer IKTS, which employs over 600 staff working on advancing ceramic technology in numerous fields.



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1 *High temperature membranes for catalysis and oxygen generation. © Fraunhofer IKTS*

2 *Ceramic membranes available in numerous geometries for liquid and gas separations. © Fraunhofer IKTS*

3 *Pilot and full-scale system design capability. © Fraunhofer IKTS*

Fraunhofer USA

FRAUNHOFER USA DIGITAL MEDIA TECHNOLOGIES DMT

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

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

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

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

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1 *MPEG-H allows viewers to select different audio mixes from a menu or even make their own mix.*
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