Fraunhofer
USA

Celebrating Twenty Years of Innovative Research

ANNUAL REPORT 2014

About Fraunhofer
www.fraunhofer.org

Fraunhofer USA is a non-profit research and development organization that performs applied research under contract to government and industry. Its customers are federal and state governments, multinational corporations, as well as small to medium-sized companies.

Fraunhofer USA is a subsidiary of Fraunhofer-Gesellschaft, a world leading applied R&D organization with 66 instituites and research units.
www.fraunhofer.de

Fraunhofer USA is comprised of seven research centers:

- Fraunhofer Center for Coatings and Diamond Technologies / Michigan State University
- Fraunhofer Center for Energy Innovation / University of Connecticut
- Fraunhofer Center for Experimental Software Engineering / University of Maryland
- Fraunhofer Center for Manufacturing Innovation / Boston University
- Fraunhofer Center for Molecular Biotechnology / University of Delaware
- Fraunhofer Center for Laser Applications
- Fraunhofer Center for Sustainable Energy Systems

These partnerships serve as a bridge between academic research and industrial needs.

The Fraunhofer USA Digital Media Technologies office and the Fraunhofer Heinrich Hertz Institute, USA office, promote and support the products of their respective parent institutes from Germany, namely the Fraunhofer Institute for Integrated Circuits IIS, and the Fraunhofer Heinrich Hertz Institute HHI.

Cover Photo ©Fraunhofer IIS.
Cingo® a ground-breaking new technology from Fraunhofer IIS and Fraunhofer DMT located in San Jose, CA.

Background image:
Automated growth racks at Fraunhofer CMB

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Celebrating Twenty Years of Innovative Research

MESSAGE FROM THE PRESIDENT

Mr. Frank Treppe

L to R: Dr. Patrick Bressler, Mr. Frank Treppe, Prof. Reimund Neugebauer, Prof. Alfred Gossner, Prof. Georg Rosenfeld and Dr. William Hartman, at the 20th Anniversary Celebration.

Fraunhofer USA celebrated its 20th Anniversary in September, 2014, at the Fraunhofer Center for Sustainable Energy Systems, in Boston, MA.

According to Dr. Dirk Meints Polter, the first President of Fraunhofer USA, the mission was "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."

That sentiment is still true today. Universities in the United States became very interested in the Fraunhofer model and ultimately, through collaborations and partnerships, created Fraunhofer Research Centers. The first such partnership was the University of Michigan. Their partnership with the Fraunhofer Institute for Laser Technology in Aachen, Germany, created the Fraunhofer Center for Laser Technology.

Boston University partnered with the Fraunhofer Institute for Production Technology and created the Fraunhofer Center for Manufacturing Innovation, situated on the campus of Boston University

The University of Maryland partnered with the Fraunhofer Institute for Experimental Software Engineering and created the Center for Experimental Software Engineering - Maryland.

Michigan State University partnered with the Fraunhofer Institute for Material and Beam Technology in Dresden, to form the Fraunhofer Center for Coatings and Laser Applications. This Center became so successful that the two divisions recently split to become the Center for Coatings and Diamond Technologies and the Center for Laser Applications.

The University of Delaware and the Fraunhofer Institute for Molecular Biology are the partners of the Fraunhofer Center for Molecular Biotechnology which sits in the University Research Park.

A collaboration of three entities created the Fraunhofer Center for Energy Innovation: The University of Connecticut, the Fraunhofer Institute for Ceramic Technologies and Systems, and the Connecticut Department of Energy and Environmental Protection.

These partnerships serve as a bridge between academic research and industrial needs. Today, universities continue to be interested in the Fraunhofer model, and even the U.S. government is interested in this model. It is a collaboration of world-class scientists and engineers performing applied research for industry and government clients, for the benefit of society.

The Fraunhofer model is one of the most influential public-private partnerships for technological innovation. Not only does society benefit from the scientifc breakthroughs, but a great number of high-paying jobs are created from the spin-off companies; many of which are still thriving.

Farewell to Prof. Jes Asmussen

In late October, Prof. Jes Asmussen, Executive Director of the Center for Coatings and Laser Applications retired from Fraunhofer. He served as Executive Director for over 10 years and started the collaboration with

Michigan State University in 2002. Dr. Asmussen is an international expert in diamond coatings, plasma system technology and microwave processing of materials.

We wish him all the best in his retirement.

Management Changes

Last year, there were some important changes to senior-level administration:

Executive Vice President

Dr. William Hartman retired after serving 11 years in this capacity. He was responsible for guiding and promoting the strategic development and growth of the Fraunhofer Centers, and fostering expanded cooperation between the Fraunhofer Institutes in Germany and academic, state, federal, and industrial partners in the U.S. In 2010, he received the prestigious Fraunhofer Medal in recognition of his outstanding achievements in the continuing development of Fraunhofer USA.

We thank Dr. Hartman for his years of service and wish him all the best in his retirement.

Dr. Patrick Bressler became Executive Vice President and Chief Operating Officer of Fraunhofer USA on October 1, 2014. He develops technology transfer and innovation partnerships with U.S. companies, and supports transatlantic collaboration in Science and Technology between the U.S. and Europe. He has been a member of several advisory committees to the European Commission on Science and Innovation, in particular the EC's Key Enabling Technologies High Level Group, and has worked in international Expert Groups and Scientific Review Panels for the Commission. He was formerly the Director of Fraunhofer Brussels from 2010 to 2014.

We welcome Dr. Bressler.

President

Dr. Georg Rosenfeld stepped down as President to become the Director of Research for Fraunhofer in Germany. He is responsible for research strategy within the entire Fraunhofer organization. He served as President since 2010 and was instrumental in developing the internal matching funds policy and introducing strategy audits for Fraunhofer USA research Centers. He will continue to serve Fraunhofer USA as Vice Chairman.

And now...

Twenty years ago, I started Fraunhofer USA in Ann Arbor, Michigan. My position was Vice President, serving under then President, Dr. Dirk Polter. In later years, I started small business enterprises and continued working with Fraunhofer in Germany. I am a member of the top Fraunhofer Gesellschaft management team and serve as an Associate Board Member of Fraunhofer Gesellschaft, as well as its Director of International Affairs.

At the end of 2014, I came full circle and returned to Fraunhofer USA as its new President. I look forward to serving in this capacity and helping to grow the business in the USA while adding value for all partners and stakeholders.

Frank Treppe, President
Fraunhofer USA

Dr. Patrick Bressler (left) with President Frank Treppe, at the 20th Anniversary Celebration.

MESSAGE FROM THE EXECUTIVE VICE PRESIDENT

Dr. Patrick Bressler

In terms of technological achievements and project development, 2014 was another highly successful year for Fraunhofer USA and its centers. We celebrated the 20th anniversary and experienced new changes in management. The coming year is a time to take stake, maintain successful operations and strategies while steering Fraunhofer USA to tackle new challenges with new technologies to advance applied research and innovation in the tried and trusted bottom-up public-private partnership. That is what has made the "Fraunhofer model" such a unique global success.

All Fraunhofer USA centers report a highly succesful year 2014, if not the most succesful year in recent history; financially and in terms of new project acquisition. Several technology highlights and promising initiatives for 2015 and the future can be found in the reports by the Fraunhofer Centers.

The cover page of this annual report shows a virtual reality headset that uses Fraunhofer Cingo®, the ground-breaking 3D immersive audio technology developed by Fraunhofer Institute for Integrated Circuits (IIS). Cingo® creates a realistic spatial sound impression and turns mobile devices into true multi-dimensional sound systems. Collaborating with IIS, Fraunhofer USA Digital Media Technologies (San José, CA) was able to support licensing customers, such as Google and Samsung, to launch their new mobile products with the Cingo® audio suite for movies, gaming and virtual environment-based entertainment (details on page 36).

In 2014, we had the Grand Opening of Fraunhofer USA Center for Sustainable Energy Systems (CSE) Boston Headquarters "living laboratory" with several honorable guests from US and Germany. The "living laboratory" houses research and testing facilities for solar module pilot-line production and characterization. CSE's "Plug & Play Photovoltaic (PV) system," was utilized to complete installation and commissioning of a household PV system within 75 minutes – a significant milestone to cutting costs for PV systems. Plug & Play PV is funded through the US Department of Energy's SunShot program. The 75 minute demonstration was well within the 10 hour installation time SunShot had set as the goal.

In a partnership with Consumer Electronics Association (CEA®) CSE began a new project to assess energy savings through e-commerce. Together with academic and industrial partners, CSE developed new bio-based plastic foams to replace more hazardous or more corrosive foam materials.

CSE's Techbridge program supports the advancement of energy technologies by offering early-stage testing, validation and demonstration services to energy companies. The program was expanded to facilitate the participation of larger technology companies (see page 28).

The Fraunhofer Center for Manufacturing Innovation (CMI) in Boston, MA, reports its most successful year with several new projects funded by the National Institute of Health and one funded by the National Science foundation. CMI also grew its industrial research activities with major US and multi-national corporations. Noteworthy is a new project with US Mint to develop alternative technologies for making coins. CMI has also strengthened the cooperation with the Fraunhofer Institute for Production Technologies (IPT), its parent institute in Aachen, Germany. Together, they evaluated manufacturing processes for a large metal container manufacturer with the goal to improve production quality, efficiency and costs.

Together with Boston University, CMI developed new dental implants that eliminate the need for bone augmentation and allow for more precisely fitted and stronger implants (see page 20).

Fraunhofer Center for Molecular Biotechnology (CMB) in Newark, DE, continued to improve its core technology for transient gene expression and applications to new products. With its unique pilot line for protein production, CMB covers the complete range from target gene to final product with quality control and assurance and regulatory management. The facility is the only one of its kind with current Good Manufacturing Practice (cGMP) approval by the Federal Food and Drug Adminstration.

Last year, CMB had milestone achievements in four plant-based vaccine or antibody projects: malaria transmission-blocking vaccine, anthrax vaccine development, yellow fever vaccine, ebola vaccine and antibody development. Phase 1 clinical trials were completed and further trials are scheduled for completion in 2015, (see page 24).

The Fraunhofer USA Center for Experimental Software Engineering (CESE) in College Park, MD, had several new initiatives strengthening strategic partnerships with industry and academia. One such collaboration addresses automotive system security and other software-based security threats. Other projects include mobile health applications, health data management and embedded medical devices that require increasingly more robust and sophisticated software and systems.

The strong collaboration CESE has with the National Aeronautics and Space Administration (NASA), was renewed and strengthened by a multi-year contract with the Space Network Ground Segment Sustainment and a new contract for software services to the Goddard Space Flight Center.

With the departure of CESE's former executive director, Prof. Rance Cleaveland, (who has moved to focus on new academic research projects) at the end of 2014, Fraunhofer USA established an interim leadership team until a new Center Director is appointed. A search committee with the University of Maryland was installed and we foresee the appointment of the new director at CESE by mid-2015. (See page 16).

The Fraunhofer USA Center for Energy Innovation (CEI) in Storrs, CT, was inaugurated in 2013 and is the newest center in Fraunhofer USA. CEI forged its first industrial partnerships and collaborative research projects with its parent institute, Fraunhofer Institute for Ceramic Technologies and Systems (IKTS) in Dresden, the University of Connecticut and Connecticut's Department of Energy and Environmental Protection. Key projects include the development of new glass seals for fuel cells and thermal storage systems, and high temperature stationary battery systems. (See page 32).

Finally, two new centers have actually been active in their respective fields for quite some time: the Center for Coatings and Diamond Technologies (CCD) in East Lansing, MI, and the Center for Laser Applications (CLA) in Plymouth, MI. The respective center directors are Dr. Thomas Schuelke and Mr. Craig Bratt. I welcome and wish them all the best in their new roles.

The centers emerge as independent centers by the beginning of 2015, out of the former Center for Coatings and Laser Applications (led by Prof. Jes Asmussen).

CCD reports an ARPA-E grant to develop a diamond-based diode operating at high breakdown voltages and high currents. Diamond is a promising material for high-power high temperature electronics. In recent years, much progress has been achieved in monocrystalline growth and device applications based on artificially grown diamond.

Other highlights are anti-reflective coatings to reduce the disturbing glare from windshields at night, and light-weight and inexpensive polymer-films to retrofit windows and improve the thermal insulation properties, saving energy in buildings (see page 8).

The Center for Laser Applications (CLA) reports a very strong and stable performance in the further development of laser-based manufacturing technologies such as laser welding, cutting/drilling, cladding and surface treatment. Innovation in 2014 at the center has been strong with the successful development of direct metal deposition processes and large-scale Additive Manufacturing. New laser welding technology was developed for lithium-ion battery technology and CLA is expanding its customer base with new industrial partners in the aerospace industry. (See on page 12).

As Executive Vice President, I wish to build on these strengths and foster our expertise, visibility and services. We will complement our services to academia and industry to support the needs of knowledge-intensive technologies and provide a platform for joint-projects. Fraunhofer USA already provides entry points in technology markets on both sides of the Atlantic beyond what individual (national) centers and institutes can offer by themselves. Today's grand challenges, such as biotechnology, sustainable energy, sustainable environment and urban living, health care, and materials lifecycle management, to name a few, require much more collaboration than competition. Fraunhofer USA can link German institutes and technologies with US industrial partners and vice versa. The new goal is to connect R&D across the Atlantic with emerging new business models and market strategies - to establish an open innovation bridge and accelerator. Technology and innovation scouting are new tools which are needed: the capability to identify trends in technological development and trends in the strategic focus of companies, to anticipate shifts in private investment and public funding, to offer training and knowledge dissemination and to provide an exhibition space and physical meeting place for partners. These will be the tasks of the Fraunhofer Innovation Forum we hope to establish in the near future.

Patrick Bressler
Executive Vice President
Fraunhofer USA

20th Anniversary of Fraunhofer USA

September 30, 2014

Boston, Massachusetts

Prof. Georg Rosenfeld, former President of Frauhofer USA, addresses the group of attendees at the 20th Anniversary Celebration in Boston.

German Ambassador Peter Wittig discussed the high quality of the cooperation between the Fraunhofer USA research centers and their partner institutes in Germany. "Joint scientific cooperation creates accepted knowledge about global challenges and thus lends legitimacy to common action."

Fraunhofer has been successfully driving innovation in Germany and Europe for 65 years, and now for over 20 years in the U.S. Fraunhofer USA was founded September 14, 1994 as a subsidiary of Germany's Fraunhofer-Gesellschaft. 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. 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.

Fraunhofer's international 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, Boston University, the University of Connecticut and the University of Delaware. 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. The White House's National Network for Manufacturing Innovation was 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 all our partners and wish you all the best for a successful and promising future.

Professor Reimund Neugebauer
President of the Fraunhofer-Gesellschaft

Prof. Reimund Neugebauer introduced the new President and Executive Vice President. He discussed Fraunhofer Gesellschaft's international strategy and recognized Fraunhofer USA's achievements and its dedicated employees.

Prof. Andre Sharon, Executive Director of the Fraunhofer Center for Manufacturing Innovation, took part in the panel discussion on Fraunhofer in Boston. Prof. Rosenfeld is in the background.

FRAUNHOFER CENTER FOR COATINGS AND DIAMOND TECHNOLOGIES

Fraunhofer Center for Coatings and Diamond Technologies

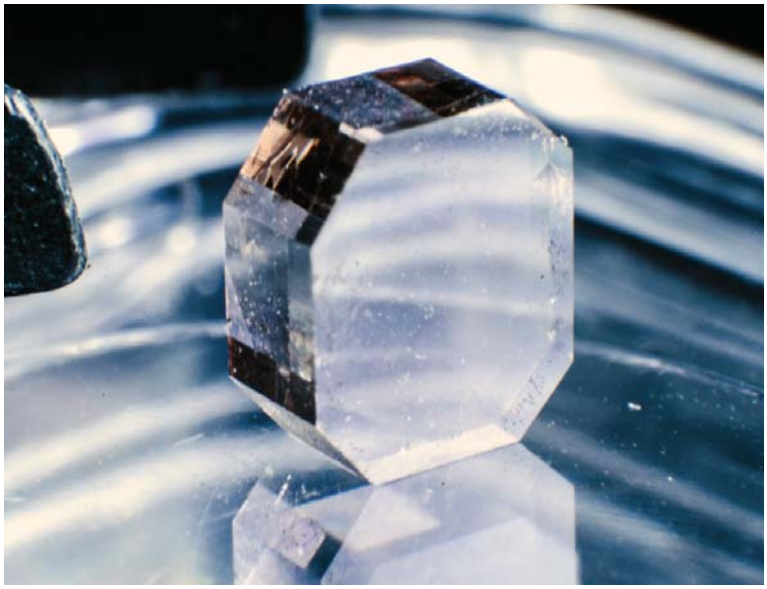


Figure 1. Diamond crystal produced by plasma assisted chemical vapor deposition

Fraunhofer Center for Coatings and Diamond Technologies

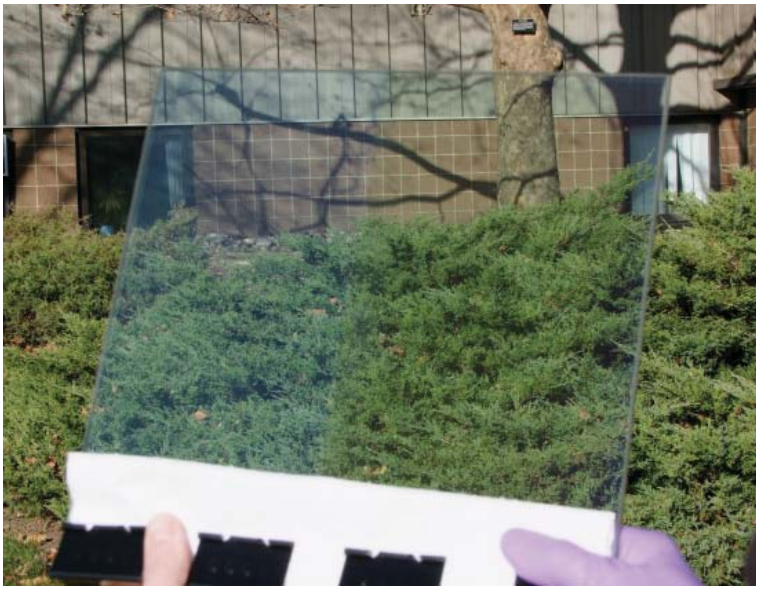
The United States is one of the world's most important innovation drivers. This is a key reason why the Fraunhofer Institute for Materials and Beam Technologies (IWS) in Dresden, Germany, decided to establish an operation in the U.S. research and development market more than fifteen years ago. The Fraunhofer USA Center for Coatings and Diamond Technologies (CCD) is the newest Center created from that initial foray into the US market. This Center is located in East Lansing, Michigan, on the campus of Michigan State University (MSU). For twelve years, MSU and the IWS daughter operation have collaborated on research projects in the fields of thin film coatings and diamond materials. The newly formed CCD will carry on the work, providing customized technology solutions to its industry partners by combining process, materials and systems knowhow with scientific excellence, quality and project management. Some of the 2014 projects are presented here.

Diamond -- The Ultimate Wide Bandgap Semiconductor Material for Power Electronics

Researchers of the Fraunhofer CCD and Michigan State University were awarded an ARPA-E grant in the field of diamond electronics. The project is to develop a diamond-based diode operating at a breakdown voltage of 1200 V and a forward current of 100 A. The proof-of-concept effort started in February of 2014 and will be completed in May, 2015. 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 (Figure 1). Diamond is a unique material with multiple superlative properties, including unmatched thermal conductivity, high charge carrier mobilities, and high electric field breakdown strength. The exceptional semiconductor properties of diamond have enormous potential for high-power electronics technology with applications in transportation, manufacturing, and energy sectors. For a number of power electronics applications, the achievable possibilities with diamond substantially exceed those of other wide bandgap semiconductor materials. The project benefits from the capabilities and expertise gained through the collaborative efforts of Fraunhofer CCD and MSU on diamond material synthesis and fabrication over the last twelve years.

Transportation Safety – Anti-reflective Coatings for Transit Bus Windows

Researchers at the Fraunhofer USA Center for Coatings and Diamond Technologies (CCD), The Mackinac Technology Company



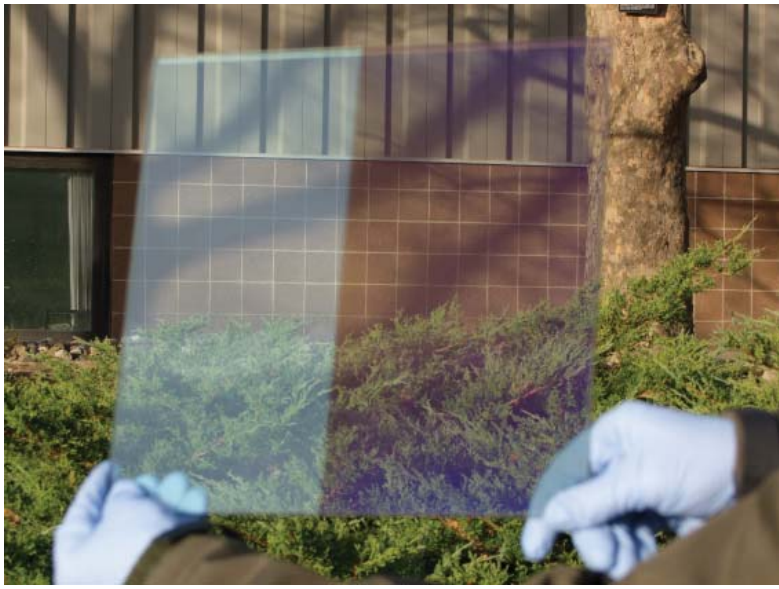


Figure 2. DLC coated transit bus windshield sections. Left side of each sample is uncoated.

(MTC) and the University of Michigan Transportation Research Institute were awarded a Small Business Innovation Research (SBIR) Phase II Department of Transportation grant to develop an anti-reflective windshield coating for transit bus windows. Transit buses operating at night are required to maintain interior illumination whenever passengers are onboard. This interior lighting reflects off the windshield and obscures the driver's vision. The problem of windshield reflection creates a hazardous situation, which is being addressed in this research program. This two-year project aims to develop a thin film coating technology capable of reducing the glare on bus windshields and started in September 2014. During the previously performed Phase I of this project, the team demonstrated that an innovative ultra-low refractive index material made of amorphous "diamond-like" carbon (DLC) could be deposited in nanometer thin layers to the surfaces of windshield glass to significantly reduce reflection of visible light and improve driver vision (Figure 2). The awarded Phase II project will build on this success to advance the technology toward a commercial product by applying the coatings to full size transit bus windows.

Energy efficient window glazing through cost-effective retrofitting

In the United States, architectural glass windows account for 15-20% of the building envelope areas. The US Department of Energy estimates the energy losses through windows to be approximately 50-60%. This means that more than half of all heating and cooling energy gets lost through windows. This energy waste costs the nation approximately 50 billion dollars per year. Currently the best commercial solution to reduce thermal energy losses through windows is to install multi-pane windows with so-called "Low-E" coatings. Low-E or LE glass is coated with a thin and optically transparent film, which features low thermal emission properties in the infrared spectral region. Many applications of LE glass use very thin metal films such as silver. Disadvantages of this solution include the high weight of double or multi-pane windows and the high costs of replacing them when they start to fail. This can happen when air penetrates in-between the panes and corrodes the Low-E coating. Other approaches such as adhesive foils mounted directly to the glass pane are often not effective, hard to install, not attractive optically and in many cases expensive, so that installation costs cannot be recouped by energy savings within 10 years. The task is therefore to develop a simple retrofit solution for already existing windows, which provides substantial energy savings yet does not diminish the optical appearance of the window.

Figure 3. Single Low-E insert retrofit installation of the Low-E polymer film in front of the actual window.

Figure 4. Inserts with several Low-E foils to further reduce thermal energy losses

In collaboration with industry partner MTC in Grand Rapids, MI, scientists at the Fraunhofer Center for Coatings and Diamond Technologies, developed a cost effective and adaptable solution to make already existing windows substantially more energy efficient. The concept is based on a very thin, lightweight, optically transparent and UV stable polymer film that is coated with a wavelength selective and nonmetallic Low-E coating. In the range of visible wavelengths the coated polymer film is completely transparent. This polymer film is not adhering to the glass surface. Instead the film is installed as an insert in a lightweight frame, which attaches to the existing window frame on the inside of the building. It can easily be configured, installed and removed (Figure 3).

This approach allows for retrofitting already existing window installations. The simplicity of the retrofit solution is also suitable for installing several Low-E films with one insert and thus connecting low emissivity functions in series to further reduce thermal transport (Figure 4).

The proposed retrofit solution was selected as a winning idea in a competition addressing the energy efficiency of buildings. This competition was sponsored by US energy giant DTE Energy Company and the winning proposal was awarded funding to demonstrate feasibility and build prototypes. The industry partner used Fraunhofer coated foils and mounted them in inserts, which were then performance tested under real world conditions by an independent third party research institution (Calvin College, Engineering Department in Grand Rapids, Michigan).

Figure 5 is a photo of the test window with four main segments. Figure 5 (right) shows infrared images of the same window. The photo was taken during winter months just prior to sunrise. The outside temperature

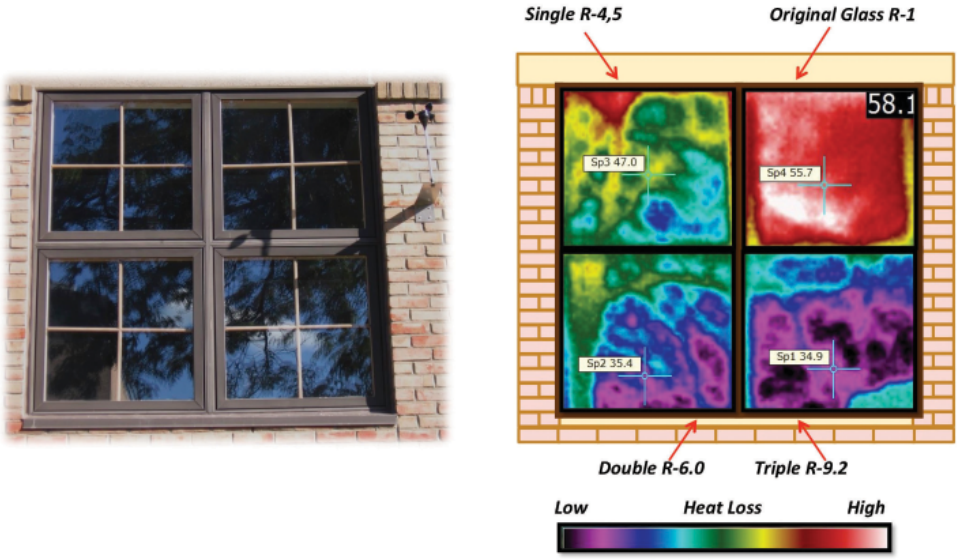


Figure 5. Photo of a test window with four main segments (left) and infrared image of the window with different installed Low-E inserts (right)

Window type	R-Value in BTU/(h °F ft2)
Single pane glass	0.91
Double pane glass, 3/16" spacing	1.61
Double pane glass, 1/2" spacing	2.04
Double pane glass, 1/2" spacing, single Low-E coating	3.13
Triple pane glass, 1/2" spacing	3.23
Fraunhofer single pane glass with single Low-E insert	4.5
Fraunhofer single pane glass with triple Low-E insert	9.2

Table 1. R-values in BTU for typical window glazing

was 24°F (-4.4°C) and the inside temperature was 68.5°F (20.3°C). The heat loss is highest in the upper right segment, which is equipped with just a single glass pane. Much less heat gets lost through the upper left segment. This segment has in addition to the single glass pane a one-foil Low-E coated polymer insert installed. The lower segments are retrofitted with 2 (left) and 3 Low-E polymer foil inserts, which further reduce the energy loss.

The R-values in Figure 5 represent the thermal resistance and are typically used in US units of BTU/(h °F ft2). These can be converted to SI units of W/(m^2 K) by dividing the numerical values by 5.7. The thermal resistance is a typically used measurement in the construction industry and represents the reciprocal value of the heat transfer coefficient. Higher R-values mean better insulation. The US Department of Energy aims for R-values of 10 for windows to achieve energy neutrality with minimal heating and cooling losses while simultaneously maintaining sufficient daylight transmission. This R-value was almost achieved by the triple Low-E insert with Fraunhofer coating (Figure 5, right, lower right window segment R = 9.2). For comparison, Table 1 compiles a list of R-values for various solutions.

For more information:
http://www.ccd.fraunhofer.org/

Fraunhofer Center for Coatings and Diamond Technologies

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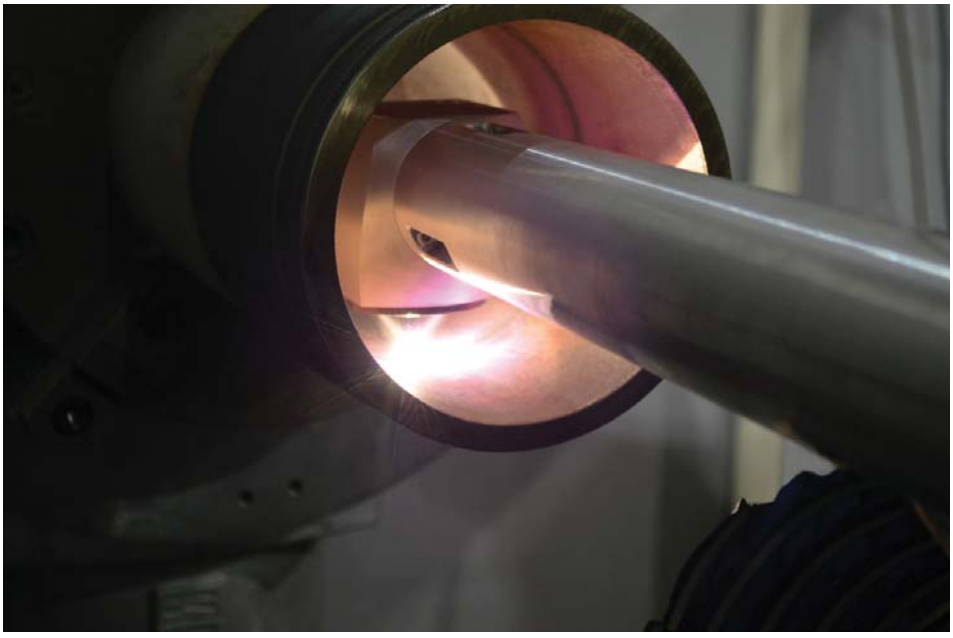
tschuelke@fraunhofer.org

FRAUNHOFER CENTER FOR LASER APPLICATIONS

Center for Laser Applications facility in Plymouth, Michigan



ID-Diode Laser Internal Cladding Head

The Fraunhofer Center for Laser Applications (CLA) was formed as a result of the recent consolidation of Fraunhofer's US laser activities into a new center which is highly focused on providing laser applications oriented research and development solutions.

The CLA research facility is located in Plymouth, Michigan near Detroit and our 13,500 sq. ft. facility houses our state of the art laser applications laboratory.

The CLA mission is to become the leading laser applications research facility in the USA.

Overview of Activities:

Fraunhofer CLA has extensive expertise in laser materials processing and its state-of-the-art laser facility features over 10 lasers from manufacturers such as IPG, Jenoptik, Laserline, Rofin Sinar and TRUMPF as well as 4 robotic and 3 CNC machine cells.

CLA offers a wide range of laser processes including welding, cutting/drilling, cladding, heat treatment and surface marking and modification. Another area of expertise is the development of system technology such as processing heads, process monitoring and control systems.

The CLA works in partnership with its German parent institute, Fraunhofer IWS (Dresden), and there is a close cooperation in a number of technology fields.

The center has built an excellent reputation providing contract R&D services to a wide range of industrial customers and government organizations over the last 20 years and continued to grow its activities in 2014.

New Developments and Expansion in 2014

In 2014, the Center continued to expand its operations and installed additional new state of the art equipment including:

- 6kW IPG fiber laser (50 micron fiber beam delivery capability)
- 4kW Laserline Diode laser (600 micron fiber beam delivery capability)
- 3D Blackbird Scanner (with seam tracking capability for high speed laser welding)
- Kuka Quantec Pro KR90 robot cell.

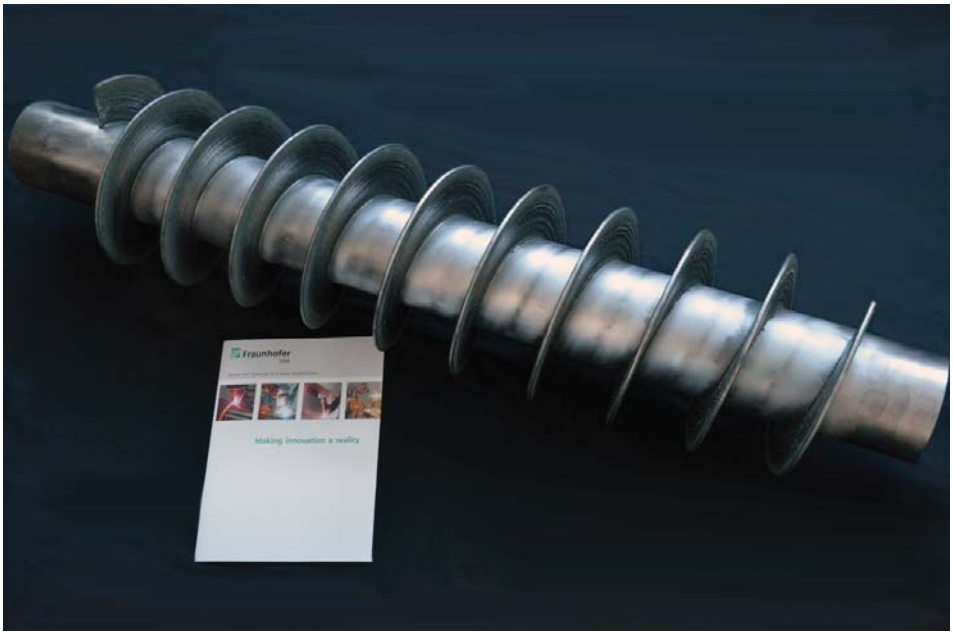
The center has also installed a new central exhaust system for fume and dust removal throughout the facility.

A new innovation in 2014 was the development of a high deposition rate Internal Diameter Cladding head for Diode lasers up to 6kW laser power. This high power laser powder deposition head is for internal bore cladding of pipes and tubes up to 1m (39") deep.

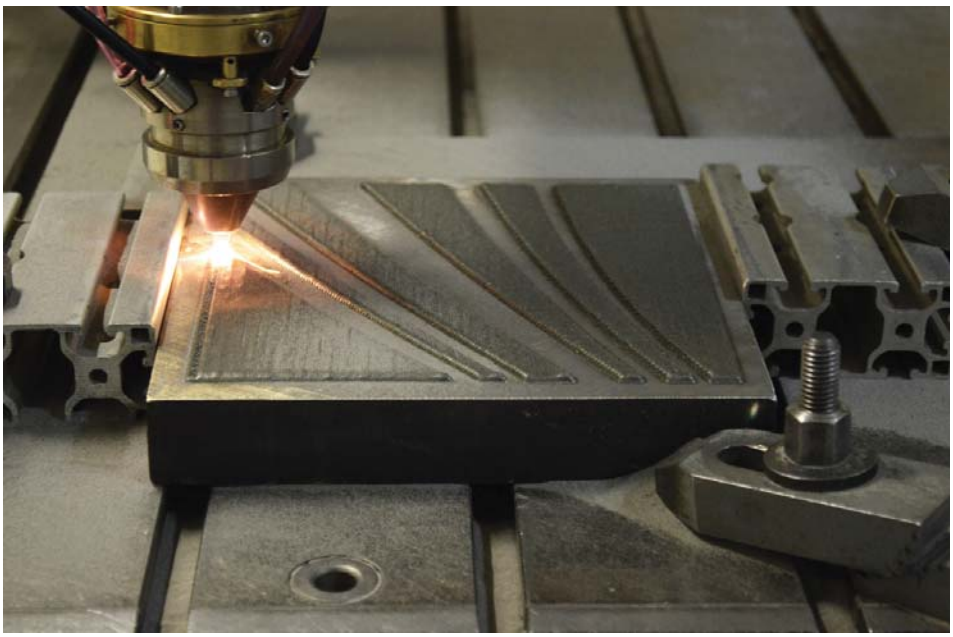
CLA has successfully developed processes for large scale Additive Manufacturing using robotic and CNC motion systems in combination with IWS powder nozzle technology. The use of direct metal deposition processes compared to powder bed machines offers the advantage of being able to produce large scale parts faster with fewer restrictions on part size.

These processes offer potential for a wide range of industrial applications and some of the demonstration parts produced to date can be seen in the following photos.

Laser Additive Manufacturing of Nozzle Demonstration Component at CLA



Extruder barrel demonstrator (final completed assembly) Dimensions: 4' long, 10 turns to 4" high



Display Sample: CLA Metal Construction of Fraunhofer Logo

Fraunhofer CLA also carried out a project for Fraunhofer CMI in 2014 on process development for laser cutting of a variety of coin materials. This project required the use of CLA's state-of-the-art 5 axis Trumpf 7040 disk laser cutting machine in order to evaluate the feasibility of high-speed cutting of typical coin materials used by the US Mint to the required quality standards.

Performance 2014

The 2014 performance of the center set a new record; with 3rd party revenues exceeding $3m for the first time as CLA's industrial clients continue to view them as the premier laser applications development facility in North America.

The center completed approximately 100 industrial projects by year end for their growing customer portfolio of leading blue chip companies in North America.

The center remains engaged in developing laser applications technology for markets such as oil and gas, alternative energy, automotive and aerospace.

CLA continues to work closely together with a large number of automotive companies in the Detroit area, and to develop new laser technologies and applications for advanced light weight vehicle structures and for electric vehicle applications.

The center continued to expand into the non-automotive advanced manufacturing sector with several projects involving the aerospace industry working on laser process development for aluminum, titanium, and nickel-based super alloy materials for both laser welding and laser metal deposition processes.

Lithium-Ion battery technology has been a core competence of CLA over the last 7

High Speed Laser Cutting at Fraunhofer CLA

years. The laser division has been working extensively on developing laser welding technology for several major industrial customers in the lithium Ion battery sector which has already resulted in the successful transfer of this technology into industrial production for two different customers, and projects continued in this field in 2014.

Outlook for 2015

With the recent expansion of its facility and introduction of new state-of-the-art equipment, CLA plans to add additional resources in 2015 in order to meet their objectives for the coming year.

CLA is confident that 2015 will provide further growth opportunities as it continues to expand the Plymouth, Michigan operations to meet the growing demand for its expertise and services in applied research and development for laser applications.

For more information:
www.cla.fraunhofer.org

Fraunhofer Center for Laser Applicatons

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FRAUNHOFER CENTER FOR EXPERIMENTAL SOFTWARE ENGINEERING

Introduction

The Fraunhofer Center for Experimental Software Engineering, Maryland (CESE) conducts applied research to support software-enabled innovations developed by our customers in industry, government, and academia. CESE is affiliated with the University of Maryland at College Park and with the Fraunhofer Institute for Experimental Software Engineering (IESE) in Kaiserslautern, Germany. Together with these strategic partners, CESE develops and uses innovative, effective and scalable approaches to software and systems development, delivers powerful testing and certification strategies and tools, and uses state of the art measurement and analysis methods to support its customers' management challenges.

Business Domains and Competencies

Throughout 2014, CESE worked closely with customers in the aerospace, automotive, and medical industries, with government offices and agencies, and with government research organizations. For instance, major customers included organizations such as Ford, Johnson & Johnson, NASA, the FDA, and the US National Science Foundation.

For these and other customers, CESE investigated, developed, and used state-of-the-art tools and techniques to support customer decision-making and action in systems, software, and acquisition areas, to help them ensure the viability and reliability of their systems and software, and to enable them to identify and prevent security-related vulnerabilities. In addition to this applied research, CESE also conducted innovative basic research projects supported by the US National Science Foundation, as well as by research grants from other basic research institutions.

To support all of these efforts, Fraunhofer CESE relies on demonstrated competencies in the following areas:

- Model Based Development and Testing
- Safety and Security Requirements and Analysis for Highly-Regulated Environments
- Rapid Prototyping of Mobile and Web Applications

Project Snapshots:

Automotive System Security

The modern car is as much a software system as it a physical machine. As a result, traditional computer security concerns are becoming increasingly critical to car manufacturers. For instance, hackers armed with simple wireless networking tools technology have demonstrated their ability to take unauthorized control of car's functions. Of course, once inside, a malicious hacker can control safety-related functions, such as disabling a car's brakes. In short, an insecure car is now an unsafe car.

To prevent some of these attacks, car manufacturers can employ the same security techniques that traditional software systems use. However, in many other cases, standard countermeasures simply don't work because of commercial and engineering constraints unique to the automotive industry, such as cost considerations and "right to repair" laws common in the US.

In addition, with automotive production shifting more and more to hybrid and full electric vehicles, and research moving towards self-driving cars and vehicle-to-vehicle and vehicle-to-infrastructure coordination, new and different attack paths continue to be discovered. Such attack paths will become more and more sophisticated as the transportation network becomes more

sophisticated, and so defense methods and resiliency strategies must become more sophisticated as well.

To address these problems, Fraunhofer CESE has entered into a strategic collaboration with another non-profit research organization to support a major North American automobile manufacturer as it works to defend itself against these issues.

To this collaboration CESE brings knowledge of software security techniques, requirements engineering, and a deep understanding of the automotive industry's needs and constraints. Specifically, CESE has been analyzing vehicle sub-systems in order to give this customer a clear and measured understanding of the vulnerabilities of their systems, as well as possible attack paths. CESE's scientists have matched this vital information with clear solutions for designing and restructuring the customer's software systems to best prevent these vulnerabilities from being exploited. By leveraging its extensive software safety requirements experience, CESE has been able to propose innovative solutions in terms of engineering and design requirements.

CESE's team has also played the role of attacker, attempting to 'hack' into the customer's automotive code. By doing so,

CESE is able to offer its customer a much deeper understanding of the specific issues and challenges they face. By finding existing security holes and vulnerabilities, CESE has been able to recommend not only solutions for existing issues, but also ways to prevent future vulnerabilities.

Mobile Health Applications

Type II Diabetes, also known as Adult-Onset Diabetes, or Non-Insulin Dependent Diabetes, affects 6% of the adult population of the world. The traditional model of diabetes management for Type II involves semi-annual checkups, including lab work to perform the A1C test, which measures average blood glucose over the previous 3 months. Many patients also elect instead to take blood glucose readings every day, and to visit their doctor only once a year. In either case, doctors propose lifestyle advice and/or medication changes based on an interaction that spans only a handful of minutes, based on a single lab test – not an ideal model.

A central problem here is that doctors may tend to treat the 'average' patient, not the individual in front of them. Not because they are bad doctors, but because they don't have access to accurate and reliable data on an individual level. Having access to such data would allow for better and more personalized patient care.

Right now, however, there is no mechanism to collect this data and present it to doctors. That is where Fraunhofer CESE is stepping in. In particular, CESE has worked with a research team from the Robert H. Smith School of Business at the University of Maryland to develop a mobile data collection application called Diasocial. This app provides great benefits to the patients themselves; not only does its data collection allow for better patient treatment, but it also can prevent the need for frequent and costly office visits. For example, a doctor using CESE's software can pull up data on a patient and send a message to their phone that reads, "Your blood glucose reading is higher on mornings after you've eaten dinner at 8:00 p.m. rather than 6:00 p.m. You may consider moving meals back to an earlier time to correct this."

Patient data can also be used to motivate patients to continue leading healthy lifestyles – integrating gaming and social media aspects into the software helps reward positive health measures (e.g., maintaining your diet or working out regularly wins achievement points), much in the way video games reward specific player behaviors. Social media can be integrated in the form of high scores – publicizing who maintained their diet the best this week, who worked out the most, etc.

This application is targeted towards older adults suffering from diabetes, and is currently undergoing a user-study at the Veteran's Affairs Hospital in Baltimore, Maryland.

Embedded Medical Devices

Before a medical device can be sold in the US, the US Food and Drug Administration (FDA) must approve it for sale. As these devices depend ever more on software to deliver their clinical functions, the FDA approval process has begun to rely more and more on sophisticated software assurance and analysis techniques. Device manufacturers therefore often need expert assistance in order to understand and implement this new aspect of FDA approval.

Leveraging its deep expertise in Food and Drug Administration (FDA) approval processes, CESE has been helping a major medical device manufacturer improve the software in one of its medical device products. Specifically, CESE scientists conducted an independent review of the medical device's source

code. One analysis involved reconstructing the software system's architecture from the source code in order to analyze the software from a maintainability and testability perspective. This analysis relied on the CESE SAVE approach and static analysis toolset. In addition, CESE performed targeted source code inspections for the device's safety critical components to ensure alignment between the device's requirements and its implementation. In addition, CESE also analyzed the software system's thread safety and signal handling implementation.

Finally, CESE has also been assisting this organization with assessing, defining, and improving its overall software and product development capability to quantitatively improve the maintainability and testability of their product and processes. Specifically these activities have included requirements practice assessment, requirements specification improvement, as well as developing requirements definition training and guidelines to assist with technology transfer to client personnel.

CESE in Review

2014 was an extremely strong year for CESE. Yearly revenue continued to rise with strong investments from both industry and government. CESE enjoyed several important project wins this year. In addition to the projects outlined above, NASA Goddard Space Flight Center (GSFC) awarded Fraunhofer CESE a multi-year follow on contract to continue its successful work on the Space Network Ground Segment Sustainment (SGSS), led by Managing Director, Frank Herman.

Another key victory this year included an additional NASA contract to provide software services and support at the GSFC.

In addition to the multiple new project wins, last year CESE researchers proudly mentored and trained 28 interns, who provided invaluable assistance in a wide variety of center projects. These interns hailed from several countries and nationalities, reinforcing Fraunhofer CESE's international flavor. The interns traveled to America for 6-month stays, coming from Reykjavik University in Iceland and the Universities of Mannheim and Kaiserslautern in Germany. CESE also hosted several local interns from the University of Maryland.

NASA Goddard Space Flight Center awarded Fraunhofer CESE a multi-year follow on contract to continue its successful work on the Space Network Ground Segment Sustainment.

The staff at Fraunhofer CESE.

Outlook for 2015 and Beyond

During this year, Fraunhofer CESE significantly strengthened its strategic partnerships with the University of Maryland and with its parent institute, Fraunhofer IESE, in Kaiserslautern, Germany. Looking forward, CESE will continue working hard to develop, refine and package its own competencies, but also to combine them with complementary competencies provided by its strategic partners. The goal is to be able to provide a wider array of cutting edge services to a broader and more international customer base. This work is now underway and CESE expects to see multiple new joint projects in place by the end of 2015.

For more information:
http://www.fc-md.umd.edu

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FRAUNHOFER CENTER FOR MANUFACTURING INNOVATION

The PiezoImplant system

The Fraunhofer Center for Manufacturing Innovation (CMI), together with its partners, Boston University and the Fraunhofer Institute for Production Technology, conducts advanced research and development leading to engineering solutions for a broad range of industries, including biotech/biomedical, photonics, and renewable energy. Fraunhofer engineers, faculty and students scale up basic research into advanced technologies for client companies in the U.S. and abroad. CMI's primary focus is on next-generation, high-precision automation systems as well as medical devices and instruments that lie at the intersection of engineering and biology.

Last year was CMI's most successful year, both financially and technologically. In the life-sciences area, during 2014, CMI has worked on a number of NIH-funded projects, including "Rapid Antibiotic Susceptibility Testing," "Bacterial Drug Susceptibility Identification by Surface Enhanced Raman Microscopy," and "NIH Center for the Future Technologies of Cancer Care." In addition, CMI also worked on an NSF-funded project, "Charge-Assisted Protein Sensing." CMI continues to establish itself as a key player in the biotech/biomedical areas with the U.S. government funding agencies.

On the industrial front, CMI has acquired repeat business from industry leaders, as well as new key $1M+ accounts from major U.S. and multi-national corporations. Also, as a "preferred vendor" of the US Mint, CMI acquired a new a project to develop alternative technologies for making coins (money).

Finally, CMI has further enhanced its reputation in the scientific community with several journal publications in 2014.

Representative Projects at CMI during 2014 included:

Technology Evaluation Study for a Large Metal Container Manufacturer

Fraunhofer CMI partnered with Fraunhofer IPT, its parent institute in Aachen, Germany to evaluate manufacturing practices of a large metal container manufacturer and propose new technologies that will improve production efficiency, quality, and cost. In addition, Fraunhofer facilitated a technology innovation session for executives from the company. The initial process consisted of on-site visits to several of the client's large manufacturing operations, each with multiple different production lines. The production processes were evaluated and potential areas of improvement noted. Line managers were interviewed to contribute their experiences and provide productivity, reliability, and capacity data. Fraunhofer distilled that information and researched state-of-the-art technologies and novel concepts that might yield either incremental or game changing results. Each idea was developed into a Technology Data Sheet to be reviewed with the client.

Fraunhofer then guided an Innovation Session with the company leaders. The innovation session started with review of the Technology Data Sheets proposed by Fraunhofer, and then continued with the company leaders contributing their own ideas to the list of possibilities. All the ideas were ranked according to the potential impact as well as fit into the client's production processes. This drove a down-selection process to focus on a few key ideas that are currently being pursued in follow-on projects.

Novel Dental Implants

Tooth loss leads to local resorption of the jaw bone. The longer the tooth is missing, the more bone is lost. When using dental implants, bone augmentation with cadaver bone is the most common solution to

enlarge the jawbone at the desired implant site. More than 50% of patients require bone augmentation before or during dental implant placement.

The PiezoImplant system, jointly developed by the Fraunhofer CMI and the Boston University Dental School, is based on the concept that the implant should match the shape of the available bone, thus eliminating the need for bone augmentation. A piezotome is a miniature bone saw vibrating at ultrasonic frequencies and sub-millimeter amplitudes. The piezotome is capable of creating various shapes of non-round cuts, thus for narrow bone ridges narrow bone cuts can be made and flat implants may be precisely fitted. The non-round nature of the newly developed implants allows for a stronger implant to be placed into the narrow ridge of the recessed jaw bone.

During the design of the piezotomes, CMI employed advanced finite element and modal analysis tools to match the natural frequency of the piezotome tool to that of the instrument. A number of successive tools were developed to facilitate the step-by-step shaping of the implant site, beginning with a traditional round drill, continuing with a course roughing tool and finishing with a fine finishing tool. Prototypes for both implants and piezotomes have been fabricated and tested. The PiezoImplants were examined with respect to fatigue and stress distribution during and after placement. In vivo testing is currently in progress to assess the integration and functionality of the PiezoImplant. This is accomplished by placing PiezoImplants in the mouth of mini pigs and monitoring the success of the implant.

Laser Eye Scanner for Early Detection of Alzheimer's Disease

Alzheimer's disease (AD) is the leading cause of death in the United States. Unfortunately, there currently is no cure or even a means of slowing down the disease. Despite numerous drugs in development, and numerous clinical trials, the disease remains incurable once it become symptomatic. To be effective, therepeutic treatment must be initiated before the appearance of cognitive symptomos and irrevrsible brain damage. Thus, early detection is the key to a cure, and has been recognized as a national healthcre priority.

Fraunhofer CMI and Boston University have engineered an innovative laser eye scanner that enables noninvasive detection and tracking of AD-linked pathology in the lens of the eye, which is present and detectable even at the presymptomatic stage. It has been shown that accumulation of β-amyloid peptides (Aβ) in the brain and in the lens of the eye is linked to AD. While detection of accumulation of AD-linked Aβ in the brain may be too late within the window of effective treatment, the accumulation in the lens of the eye can be detected early using special purpose confocal laser opththalmoscopes with quasi-elastic scattering (QLS) autocorrelation spectroscopy. This technology has been developed and validated by Boston University, using a proof-of-concept system, over the past several years.

In this project, CMI and Boston University developed the first-generation clinical instrument suitable for clinical testing on human subjects. This full-function, user-friendly instrument will be deployed in a multi-center clinical trial in the coming months.

Sheet Metal Forming Using High Speed, Automated Hammering

Traditionally, sheet metal may be formed into various shapes by hammering the metal on various anvils. This labor intensive, physical process requires master craftsmen

Laser Eye Scanner for Early Detection of Alzheimer's Disease

Automated High-Speed Hammering Machine

and is normally only suited to low volume production or prototype work. As products transition to higher volume, stamping dies are fabricated to greatly speed the process and reduce cost in quantity. However, there are some products which can benefit greatly from the unique metallurgy that is produced by individual hammer strikes. Applying automation to this labor intensive process has been difficult due to the wide variation in the size, shape, and weight of products that are manufactured. The different hammer patterns require a flexible holding system to allow nearly all of the sheet metal surface to be reached. Furthermore, the hammering can cause some metal to deform in process in an unpredictable way. This form is corrected in subsequent processes, but an automated hammering system must accommodate this changing shape.

Fraunhofer CMI has developed a new impact hammer system for the production of a wide variety of sheet metal shapes. Two impact hammers are incorporated into a workcell serviced by one loading robot. The workcell allows unattended processing, with the robot loading incoming metal blanks from material handling carts, and outputting processed parts on similar carts. The hammers themselves use a high performance hydraulic ram system for the hammering action. The hammer can cycle in excess of 10 strikes per second, limited by the amount of positioning required between each strike. Interchangeable anvils can provide different hammering characteristics. The hammering force is programmable, as are all crucial process parameters such as the pattern and metal thickness. The operator needs to only select the appropriate program from a menu of choices. Manipulation of the sheet metal blank is accomplished with a robust, multi-axis positioning system using linear and rotary axes to provide full access to the metal surface for multiple shapes while withstanding the intense vibration and

forces of the hammering operation. The workcell successfully processes the products while greatly reducing the required labor.

Artificial Hand for Minimally Invasive Surgery

Over the past several decades, minimally invasive surgery has become more prevalent because it does not require major incisions to the patient, allows for quicker healing, reduces post-operative pain, and may reduce wound complications. However, in comparison to open surgery, existing laparoscopic tools still limit the surgeon's dexterity significantly. In contrast, during open surgery or hand-assisted laparoscopic surgery, the surgeon has the ability to easily grasp, retract, and manipulate organs as necessary. Typically, the surgeon's non-dominant hand is used mainly to retract, palpate, and expose tissue, while the dominant hand manipulates instruments to conduct surgical dissection.

Laparoscopic, single incision, natural orifice and robotic approaches each hold their own appeal. However, they lack the ability to manipulate organs as easily as the human hand. Advances in minimally invasive surgical techniques require new tools with increased functionality of the end effectors. Multifunctional tools with greater dexterity than those currently available are highly desired.

To address this need, CMI designed, fabricated, and tested the first prototype of a laparoscopic tool that provides the dexterity of a hand. The "hand" has two jointed fingers and a jointed thumb attached to a laparoscopic sheath that can be collapsed to fit through a 12 mm trocar or small orifice. The handle provides control for three independent degrees of freedom: finger motion (bending/spreading), finger tip bending, and thumb bending. The tool can be used for pinching, grasping, and spreading motions. Furthermore, the thumb is "double jointed" so that the tool can be converted to a rake configuration to allow lifting motions. The initial prototype has been tested in a cadaver lab to demonstrate its utility. The "Lap-Hand" was used to complete standard surgical tasks in a simulation device in a time comparable to open and laparoscopic approaches, including "bowel" manipulation and peg movement. Cadaver testing confirmed the ability to grasp, elevate and move liver, stomach, colon and small bowel in a fashion expected by the hand. During the cadaver testing, various surgeons tested the device for its ability to grasp, elevate and move liver, stomach, colon and small bowel. Three surgeons, who had not had any prior training in its use, tested the device. No adverse events were noted and no bowel injury or perforation resulted from over-grasping. Use of such tools could both reduce the number of hand-incisions required and potentially transition more patients to undergo their abdominal procedures laparoscopically.

CMI Internship Program

CMI's internship program continues to thrive, providing a global experience to 12 interns per year. Since its inception, the program has hosted over 150 interns, mostly from Europe. Interns are provided with housing and a stipend, and are encouraged to experience not only the American workplace, but the American culture as well. The program has been tremendously successful, receiving rave reviews from all involved. These students are subsequently highly recruited in Europe, as they bring a global perspective to the job.

For more information:
www.fhcmi.org

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FRAUNHOFER CENTER FOR MOLECULAR BIOTECHNOLOGY

L to R: Dr. Vidadi Yusibov, Executive Director of Fraunhofer CMB; Mr. Frank Treppe, President of Fraunhofer USA; Dr. Patrick Bressler, Executive Vice President of Fraunhofer USA and Delaware Governor, The Honorable Jack Markell

Automated growth racks at Fraunhofer USA Center for Molecular Biotechnology

The Fraunhofer USA Center for Molecular Biotechnology (CMB) is a unique institution conducting research and development in the areas of plant and microbial biotechnology. Its main focus is on using plant-based systems for rapid, inexpensive production of vaccines, therapeutics and diagnostics. The Center has assembled a diverse staff, with expertise in plant virology, molecular biology, plant biology, biochemistry and immunology, and has core research groups specializing in expression technologies and protein target design, plant tissue culture, engineering and biomass production, downstream processing and analytical biochemistry, immunology and formulation. CMB has continued to improve its core technology for transient gene expression and its application to the development of new products.

CMB occupies a 56,000 square feet facility, of which approximately 14,000 square feet is dedicated to a pilot plant for the production of material under cGMP for early phase clinical trials. The building contains the complete range of equipment to provide protein production services from target expression to final product including quality assurance, quality control and regulatory management.

CMB has moved targets from molecular engineering through to pilot scale manufacturing in plants under good manufacturing practices. The Center's approach has been validated by the successful completion of two phase 1 clinical trials, and two additional trials are currently underway with results expected in 2015.

2014 Project Summary

Malaria transmission blocking vaccine

Malaria is a mosquito-borne infectious disease of humans and other animals caused by parasitic protozoans (a group of single-celled microorganism) belonging to the genus Plasmodium. Malaria causes symptoms that typically include fever, fatigue,

vomiting and headaches. In severe cases it can cause yellow skin, seizures, coma or death. The disease is transmitted by biting mosquitos and symptoms usually begin ten to fifteen days after being bitten.

The disease is widespread in tropical and subtropical regions that are present in a broad band around the equator. This includes much of Sub-Saharan Africa, South America and Asia and has a major negative effect on economic development in those regions.

In 2014, CMB received clearance from the U.S. Food and Drug Administration (FDA) for an investigational new drug (IND), Fraunhofer's plant-derived malaria transmission-blocking vaccine (TBV), which targets the Pfs25 antigen, to proceed into the clinic in a Phase 1 safety and immunogenicity study.

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. 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.

Anthrax

Fraunhofer has received funding for two projects dealing with anthrax. "Development of Dual Agent Countermeasures to Combat Anthrax and Plague" and "Vaccine Technologies to Advance Next Generation Anthrax vaccines." The goal of the first project was to progress a plant-based Anthrax and Plague vaccine through preclinical studies and a phase 1 clinical trial. The Phase 1 trial of a protective antigen (PA)-based vaccine candidate has been completed and analysis of results is underway.

The second project involves developing anthrax vaccine that can mount protective immunity following one or two administrations, is stable during storage, and can be deployed in an emergency situation.

Tray of Nicotiana benthamiana plants about to be placed in vacuum infiltration chamber

Yellow fever

Yellow fever virus is found in tropical and subtropical areas in South America and Africa. The virus is transmitted to humans by the bite of an infected mosquito. Yellow fever is a very rare cause of illness in U.S. travelers. Illness ranges in severity from a self-limited febrile illness to severe liver disease with bleeding. Yellow fever disease is diagnosed based on symptoms, physical findings, laboratory testing, and travel history, including the possibility of exposure to infected mosquitoes. There is no specific treatment for yellow fever; care is based on symptoms. Steps to prevent yellow fever virus infection include using insect repellent, wearing protective clothing, and getting vaccinated.

Bio-Manguinhos, Brazil, is internationally recognized as a yellow fever vaccine manufacturer. Since 1937, vaccine preparations are obtained in their laboratories from the attenuated strain 17D of the Yellow Fever virus which is grown in pathogen free embryonated chicken eggs, according to the standards set by the World Health Organization.

CMB's work with Bio-Manguinhos to develop a plant-based yellow fever vaccine candidate for potential production in Brazil continued throughout 2014. CMB engineered and expressed several constructs, screened them for target production, initiated the development of purification procedures and designed a dose ranging study in mice. Pre-clinical efficacy studies are currently underway at Bio-Manguinhos in Brazil.

German interns Angsgar Flammersfeld and Maike Baues analyze results in CMB's protein biochemistry lab.

L to R: Ms. Than Nguyen, Delaware Technical Community College; Delaware Governor Jack Markell; Ms. Hannah Anderson, University of Delaware; Ms. Margaret Steward, Delaware State University.

Ebola

In response to the global health threat posed by the emerging Ebola virus in Africa, CMB is working on projects to develop Virus-Like Particles to be used as a vaccines that can prevent the disease. Virus-Like Particles will be produced for Zaire, Sudan and Marburg Ebola viruses.

The goal is to develop a trivalent vaccine which would be protective against all 3 strains of Ebola virus.

In another project, Mammalian and Plant-derived Antibody-based Therapies against Sudan Ebola virus, CMB is working in collaboration with USAMRIID to develop an antibody-based therapy for the treatment and management of Sudan virus infection, one of the most common and lethal species of Ebola virus. Plant produced antibodies have been shown to neutralize the virus in vitro.

Education and Outreach
International Interns

In 2014, CMB hosted four international interns: Ms. Maike Baues and Mr. Ansgar Flammersfeld, Master's students from Germany, Ms. Nazgul Kydyralieva, PhD. student from Germany and Ms. Aytan Aghayeva, a master's student from Azerbaijan. Maike was involved in the Center's malaria vaccine development program and while at CMB, she learned and performed a variety of molecular biology and protein purification techniques to further our understanding and optimization of vaccine candidates. Maike worked to develop new versions of these molecules, increasing their antigenic display and potency.

Ansgar was instrumental in developing CMB's anti-fungal screening assays and used this methodology to screen it's bacterial library against the clinically relevant fungal pathogens. In addition, Ansgar worked on the development of potential malaria vaccines.

Aytan has worked to increase the size of CMB's bacterial library by using our quorum quenching technology to isolate diverse bacteria from myriad environmental sources and has screened these bacteria for potential anti-bacterial properties. In addition, Aytan has worked to purify an antimicrobial compound for an in vivo study.

Delaware Governor's Bioscience Fellowships

CMB continues to support local university students pursuing careers in biotechnology and life sciences. Through 2014, thirty students have been awarded Delaware Governor's Bioscience Fellowships.

Undergraduate research has provided students with practical lab experience and opportunities for presenting their research at regional and national competitions.

The program is now supported with contributions from several Delaware bioscience companies and each of the winners is planning to continue their work at the graduate level. The program's visibility helps to highlight the variety of research careers available to students pursuing interests in bioscience and provides them with exposure to many local companies offering internships and post-graduate employment opportunities.

New Technologies, New Vaccines International Conference

CMB, in cooperation with the International Alliance for Biological Standardization (IABS), once again organized this meeting where more than 100 scientists from industry, academia and government regulatory agencies from around the world, meet to share advances in vaccines and vaccine technology. Dr. Michael Kurilla, M.D., Ph.D., Director of the Office of Biodefense, Research Resources and Translational Research as well as Associate Director for Biodefense Product Development for the National Institute of Allergy and Infectious Diseases (NIAID) of the National Institutes of Health (NIH), gave the keynote address.

More than 40 world-leading scientists presented on how these advances significantly impact responsiveness to life-threatening diseases. Over the three-day conference, the following topics were covered: Biomanufacturing and Product Development; Molecular Designs and Formulations; and How New Science is Shaping Regulatory and Business Making Decisions.

Outlook for 2015

CMB anticipates results by the end of the year for Phase I clinical trials for candidate vaccines against anthrax and malaria. The budget for 2015 anticipates nearly $10 million in project revenue, an increase of $2.5 million from 2014 and an increase of $4.0 million since 2013.

A spin-out company, Fourth Dimension Biotechnologies, Inc., is expected to facilitate commercialization of various CMB technologies, including development of novel antimicrobial products.

CMB will once again organize the *New Technologies, New Vaccines Conference* in cooperation with the International Alliance for Biological Standardization (IABS). 2015 will mark the 10th anniversary of the program and the 2015 conference will feature sessions on emerging infectious diseases and therapeutic vaccines.

The second Fraunhofer-University of Delaware Technology Summit will be held in the fall of 2015, and will focus on how nanotechnologies are being used to improve human health. Participation is anticipated from several Fraunhofer institutes in Germany who are doing pioneering work in nanotechnology development and applications.

Dr. Stanley Goldman, Dr. Mark Jones of CMB with Dr. William Egan of Novartis at the New Technologies, New Vaccines conference organized by CMB

For more information:
www.fhcmb.org

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FRAUNHOFER CENTER FOR SUSTAINABLE ENERGY SYSTEMS

Demonstrating the Installation and Commissioning of Fraunhofer CSE's Plug & Play PV Systems

The Fraunhofer Center for Sustainable Energy Systems CSE, located in Boston, Massachusetts, provides collaborative technology research and development in the areas of solar photovoltaics (PV), building technology, and distributed electrical energy systems. In addition, Fraunhofer CSE offers technology commercialization expertise for promising early-stage companies through its TechBridge program.

Installing Solar PV in under 75 Minutes

In November, Fraunhofer CSE successfully installed and commissioned a Plug & Play PV System in the presence of key stakeholders, including the Commonwealth of Massachusetts, the City of Boston, National Grid, Northeast Utilities, and the U.S. Department of Energy. The event was a significant milestone in the 3-year U.S. Dept. of Energy SunShot Initiative funded project, which aims to develop a Plug & Play PV system that can be installed and commissioned within 10 labor hours. Held at Massachusetts Clean Energy Center's Wind Technology Testing Center in Charlestown, MA, the Plug & Play PV Systems demonstration showed a complete system installation, including commissioning, in 75 minutes, well under the 10-hour goal.

Fraunhofer CSE's Plug & Play PV Systems concept revolutionizes the ease of installation, while improving safety during installation and operation. Once commercially available, homeowners will be able to purchase PV systems at their local home improvement store, and install them as easily as a household appliance. The speed of installation and the automated permitting, inspection, and utility interconnection processes designed into the system will drive the installed cost from $4/W down to $1.50/W by 2020. CSE filed a provisional U.S. Patent Application entitled "Plug and Play Solar Energy System," in 2014.

A Grand Opening

In 2014, Fraunhofer CSE celebrated the Grand Opening of its Boston headquarters, a "living laboratory" for studying solar and energy efficiency technologies. The Grand Opening brought together over 200 members of Boston's cleantech and innovation communities. Guests participated in guided building tours of the Living Laboratory and heard remarks from Massachusetts Governor, Deval Patrick; Massachusetts Secretary of Energy & Environmental Affairs, Maeve Vallely Bartlett; Deputy German Ambassador to the U.S., Dr. Philipp Ackermann; Fraunhofer USA President, Prof. Dr. Georg Rosenfeld; and U.S. Department of Energy Director of the Solar Energy Technologies Office, Minh Le.

Located in the heart of Boston's Innovation District, the Living Laboratory is home to

Celebrating the Grand Opening of Fraunhofer CSE's Living Lab in Boston

Fraunhofer CSE's Massachusetts R&D center for the advancement of sustainable energy systems. Born out of the 2013 energy-retrofit of a 100-year-old building, the Lab leverages cutting-edge design concepts to create in-house research facilities in a historic building, including a pilot solar module fabrication line, dedicated thermal testing laboratory, and extensive characterization / environmental testing resources.

Developing New Bio-Based Plastic Foam

During the 1980-90s, phenolic foam acquired a bad reputation after a large number of U.S. commercial metal roofs failed due to the intensive corrosion caused when phenolic foam insulation came into contact with moisture. Although phenolic foam has higher thermal resistivity and fire resistance than plastic foams, usage declined sharply after these failures. Fraunhofer CSE was selected by the U.S. Department of Energy Building Technologies Office (BTO) to lead a research project dedicated to developing a new bio-based, nonflammable, inexpensive foam for use as building insulation.

Experts from Fraunhofer CSE, the University of Tennessee, Knoxville, and Atlas Roofing Corporation aim to develop a mechanically stronger plastic foam, while using low-cost materials, including biomass lignocelluloses (a biological material derived from plant or plant-based materials). To reduce the risk of foam corrosion, researchers will cut down on the use of sulphonic acid catalyst, a highly acidic component, and replace it with a bio-based, less acidic organic acid catalyst. The team has already started producing the project's first foam samples and will conduct sensitivity studies over the cell size, cell wall thickness, and develop procedures for foaming and increase of the foam pH level.

Testing Two New Insulation Systems in the American Desert

To improve overall energy performance of the U.S. Army's lightweight shelter structures, the insulation manufacturer Aspen Aerogel developed two types of novel insulation products for roof and wall insulation. Aspen Aerogel commissioned Fraunhofer CSE researchers to measure temperature profiles, heat flux, and energy consumption of three near-identical wood-framed test huts in the Center's outdoor testing facilities in Albuquerque, New Mexico. The building enclosure experts assessed the thermal performance benefits associated with the two new insulation systems installed in the huts relative to a baseline. At the time of testing, daily temperatures ranged from about 15 to 33°C (59 to 91°F).

FRAUNHOFER CENTER FOR SUSTAINABLE ENERGY SYSTEMS

Test huts at the Fraunhofer CSE laboratory in Albuquerque, New Mexico

Each of the tested insulation systems was comprised of a layer of Aerogel insulation sandwiched between thin layers of foil facing material. One of the materials had a standard, non-reflective exposed surface, while the other one had a highly reflective exposed surface that was intended to act as a radiant barrier to further reduce radiative heat transfer through the building envelope. Field testing showed that both insulation systems improved thermal performance significantly. Daily cooling energy consumption was reduced by about 70%, while daily peak heat gain was reduced by at least 60%.

Modeling the Energy Efficiency of Residential Attics

U.S. Census Bureau data for homes show 50 to 70% of the existing 116 million residential homes are slab-on-grade – implying that the heating, ventilation, and air-conditioning (HVAC) unit and associated ductwork are all contained in the extreme temperatures of an attic. An analysis by Oak Ridge National Laboratory (ORNL) using AtticSim/EnergyPlus shows the HVAC and ducts in the extreme temperatures of an attic attribute to an added 30 to 50 MBtu/year of lost energy per home, which totals a staggering 2.9 Quads of wasted energy. To help predict potential losses, the U.S. Department of Energy asked Oak Ridge National Laboratory and Fraunhofer CSE to work on a modified version of the Fraunhofer Attic Thermal Model (FATM), which could compute radiation, convection, and thermal losses during both on and off cycles of the comfort conditioning system.

Throughout this multiyear project, CSE is responsible for development and validation of several new components of the FATM framework, including the attic air duct and roof deck level ventilation algorithms. At the same time, ORNL is performing a series of lab-scale experiments serving validation of the FATM's numerical components. After completion of development and validation tasks, the final product will be integrated with EnergyPlus – a widely used whole building energy model – and will become public domain.

Partnering with CEA on Consumer Electronics Energy Consumption

Fraunhofer CSE completed a report for the Consumer Electronics Association (CEA®) to quantify the electricity consumption of consumer electronics (CE) in U.S. households in 2013. CEA engaged Fraunhofer CSE to conduct a comprehensive evaluation of the installed base, power draw, and usage of residential CE. Upon completion, Fraunhofer CSE researchers estimated 169 TWh were consumed in 2013 by 3.8 billion CE in U.S. homes; an amount equal to 12% of residential electricity consumption. This amounts to a 12% decline between 2010 and 2013.The study drew a lot of attention among the consumer electronics industry and journalists, resulting in follow-up articles by *Forbes* and the *MIT Technology Review*.

Fraunhofer CSE also began a new project with CEA to assess energy savings through e-commerce and telecommuting. The report and Fraunhofer CSE's findings will be publicly shared on CEA's website in Spring 2015.

Fraunhofer CSE's Proprietary Home Energy Research Platform

Home energy displays (HEDs) and home energy management (HEM) systems support energy efficiency in homes. To facilitate the development of energy management products features, Fraunhofer CSE created its proprietary Fraunhofer Experimental Smart Home (FRESH) research platform. Using a collection of customizable sensing, control, display, and feedback components in a wireless network, the platform can monitor the indoor environment, how people interact with systems, and how people use spaces. FRESH contains a machine learning module that supports the testing of various algorithms, and data collected from hardware sensors can be applied to improve prediction accuracy for home occupancy and house-

FRESH deployed in a commercial office building

holds' target temperature preference. FRESH can be configured to automatically send surveys, alerts and messages to users when certain conditions are met – for instance, if the system detects that a window is open even though the air conditioning is running.

Fraunhofer CSE and Nest Labs Develop Smart Thermostat Framework

Fraunhofer CSE and Nest Labs co-developed a new data-driven framework for comparing the energy performance of residential thermostats. In the final report to Nest Labs, Fraunhofer CSE researchers identified the key challenges facing thermostat assessment and proposed a framework that can help overcome those challenges. In their framework, the researchers considered both temperature setpoint adjustments by residents as well as more automated HVAC-control based savings. Fraunhofer CSE's researchers demonstrated the framework with an illustrative example of a data-driven whole-building energy simulation approach for quantifying setpoint-based performance using anonymous data from selected Nest thermostat users.

TechBridge Launches the "TechBridge Challenges"

Early-stage technology companies face significant hurdles bringing their products to market, including testing and demonstration of their novel concepts. Since its start in 2010, Fraunhofer CSE's TechBridge program has supported several energy technology companies by carrying out validation, testing, and demonstration projects. The projects often position a company to achieve its first investment round, product launch, or customer relationship. To date, TechBridge project awards have supported 16 early-stage companies, which have raised more than $70 million in follow-on funding and launched 16 commercial products.

TechBridge has expanded its program to meet the needs of industry clients to reduce the barriers large companies face in exploring new technologies. Funded by Fraunhofer CSE's industry clients, the "TechBridge Challenge" enables TechBridge to perform a targeted search among early-stage technologies of interest to the client. After selecting particular technologies, TechBridge works with the selected companies on validating and demonstrating their technologies. TechBridge ran its first two Challenges in 2014: the *TechBridge Microgrid Challenge*, which sought solutions to enable microgrid adoption via innovative technologies or business models, and the *TechBridge Manufacturing Challenge*, which sought technology and process innovations that could improve the energy-, water-, or resource-efficiency of the manufacturing sector. The Microgrid Challenge drew over 70 applications and the winning company was selected for its low-cost, flexible controls system being developed for large commercial and industrial customers. Fraunhofer CSE completed a study that quantified the effects of using such a controls system for a typical industrial user.

The winner of the Manufacturing Challenge was selected from 57 applicants and is developing a simple, cost-effective synthesis method for efficient thermoelectric materials. Fraunhofer CSE is currently conducting a project to evaluate the method's total cost savings on the value chain, and will advise the winner on optimal design parameters for systems that use their materials.

Notable Partners and Clients of 2014

- Aspen Aerogels
- Atlas Roofing Corporation
- Consumer Electronics Association
- Massachusetts Clean Energy Center
- Nest Labs
- New York State Energy Research and Development Authority
- Oak Ridge National Laboratory
- University of Massachusetts, Amherst
- University of Tennessee, Knoxville
- U.S. Department of Energy

Since its inception, Fraunhofer CSE is proud to partner with the Massachusetts Clean Energy Center in Boston, MA, and Fraunhofer ISE in Freiburg, Germany, in its efforts to advance clean energy technologies.

For more information:
www.cse.fraunhofer.org

Fraunhofer Center for Sustainable Energy Systems

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FRAUNHOFER CENTER FOR ENERGY INNOVATION

L to R: UConn Provost Mun Choi; Dr. Patrick Bressler, Fraunhofer USA Executive Vice President; Prof. Alexander Michaelis, Fraunhofer IKTS Institute Executive Director; Dr. Albert Monroe, DEEP Chief of Staff; Dr. Prabhakar Singh, Fraunhofer CEI Executive Director; Dr. Kazem Kazerounian, UConn School of Engineering Dean; and Dr. William Hartman, Executive Vice President (retired), Fraunhofer USA.

The Center for Energy Innovation (CEI) located at the University of Connecticut (UCONN) in Storrs, CT, is in its second year of establishment. CEI is a 4-year partnership between UCONN, Fraunhofer USA, and the Connecticut Department of Energy and Environmental Protection (DEEP) which was launched in July, 2013. CEI provides collaborative technology research and development, testing and implementation of advanced energy systems.

In July of 2014, the Fraunhofer Executive Advisory Board, comprised of Fraunhofer USA, UConn, DEEP, and Fraunhofer IKTS representatives, met to provide guidance and recommend business and scientific strategies for the Center. The Advisory Board meets annually to discuss the state of the business, growth of the center, and collaborative activities.

The Fraunhofer Center for Energy Innovation hosted its first Science-2-Business workshop in July with the focus of connecting science and industry. The areas of energy (conversion and storage) and environmental technology were presented.

The workshop covered the following topics:

- Membrane technology (materials, membranes, and gas/fluid separation)
- Fuel cells (focus on SOFC, MCFC)
- Batteries and energy storage (high temperature batteries)
- Adsorbents

More than 100 interested visitors from small, medium sized and large companies from various industrial sectors as well as academic partners and appointees from the State of Connecticut, participated in the workshop. Scientists from the University of Connecticut, Fraunhofer and industry presented their most recent research results. The workshop prompted discussions for future collaborations and joint projects with industry and academic partners.

Following the workshop, the Industry Advisory Board met to advise on industry trends, network leveraging, and business strategies for the development of new materials to help generate clean and efficient power systems and reveal novel methods and applications for energy storage. A well-defined growth strategy based on input from the Executive Advisory Board and industrial clients, independent market analysis and technology forecasts was the basis of discussion and served as a guide to the development of continued and sustainable growth.

Attendees at the Fraunhofer CEI Science-2-Business workshop.

Dr. Prabhakar Singh, CEI Executive Director, and Dr. Richard Metzler, Managing Director of Rauschert

Partnerships

The Rauschert Group, a company based in Germany that develops and manufactures ceramics, engineering plastics and hybrid components, has partnered with CEI on the development of nano-filtration technology. As a result of this partnership, the installation of Rauschert's pilot filtration unit utilizing Inopor's ceramic membranes was installed at CEI's laboratories in February, 2015. Rauschert has also funded a scholarship for two students annually at the Fraunhofer CEI. The scholarships will enable two graduate or undergraduate students to conduct research and gain hands-on experience in the field of ceramic filtration.

Dr. Robert Klee, Commissioner for the State of Connecticut's Department of Energy and Environmental Protection (DEEP), visited the Fraunhofer Center and UConn's Center for Clean Energy Engineering (C2E2) in December of 2014, where he listened to researchers discuss their work and the technological advances in energy research that are being made at both C2E2 and CEI.

In the framework of Commissioner Klee's visit, Prabhakar Singh, Executive Director for CEI, explained the collaboration of Fraunhofer USA, UConn, and State of Connecticut's Department of Energy and Environmental Protection (DEEP) and the project work that is being conducted at CEI.

Key Projects and Developments

The Center engaged in five advanced technology development programs which include:

- the formulation of new glass seals,
- development of methodologies to characterize the wettability of solid surfaces at high temperatures,
- characterization of a new class of adsorbents,
- high temperature stationary battery systems,
- membrane reactors for novel liquid and gaseous separation.

Glass Sealing Project

The outcome of the R&D under this program will be utilized to develop glass seals for similar applications in various energy sectors such as fuel cells, thermal storage systems, and thermal power plants. The laboratory facilities developed under this program will also be used for glass R&D for other high temperature applications, such as protective coatings on metals/alloys. Considering the capabilities and research expertize, sponsored research grants from federal agencies

Dr. Robert Klee, DEEP Commissioner for the State of CT and Dr. Prabhakar Singh.

and industries have shown interest in this technology.

Wettability of Solid Surfaces at High Temperatures

The focus of this project is to increase the wettability of sodium and beta alumina because poor wetting reduces the active surface area and limits charging/discharging rates. CEI is developing a proven capability to generate accurate and reproducible data on these materials at temperatures as high as 375°C for Na /beta-alumina and 700°C for molten salt which will position CEI as a leader in this field with proven capabilities for testing and as an analytical lab service provider.

Characterization of a New Class of Adsorbents

The primary goal in this work is to identify new generations of adsorbents that have high adsorption capacity for siloxanes and for organic sulfides like CS2 and COS. The focus is on a variety of porous materials with the goal of controlling the types of pores created during the synthesis process. The value of this technology for industries is more efficient energy generation and reduced costs for changing engine oils, as well as the removal of siloxane from biogas or landfill gas to prevent the damaging effects in combustion engines, heat exchangers, catalytic and exhaust gas treatment systems.

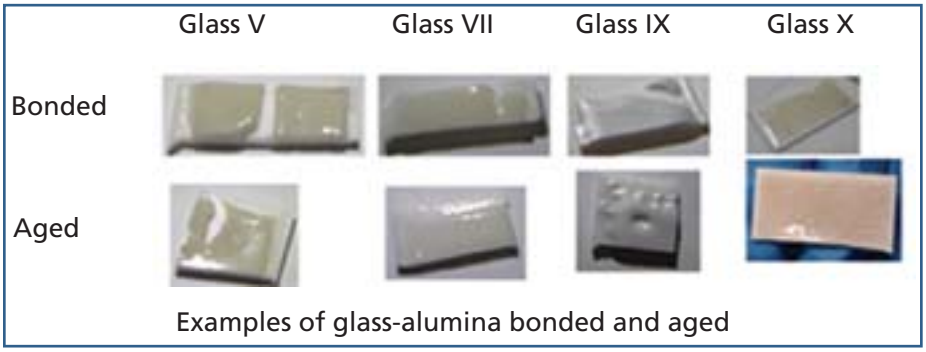
High Temperature Stationary Battery Systems

The focus of this research is to prepare new high temperature stationary battery systems that are inexpensive and efficient. Novel metal materials such as Zebra materials and Durathon-like systems are excellent materials for such batteries. Synthesis strategies for nickel component of these materials have been identified and a scale-up of the modified synthesis is under development. The evaluation of this material in salt test stands at IKTS-Helmsdorf, is in process.

Membrane Reactors for Novel Liquid and Gaseous Separation

The project concerns the synthesis and characterization of unique and excellent membranes, based on microporous manganese oxide materials as well as new unique University of Connecticut mesoporous materials. Applications of such membrane systems are in membrane reactions, such as enhancement of oxygen and hydrogen, catalytic reactions like natural gas reforming, separation of hydrocarbons, water oil separation, dye degradation, and heavy metal adsorption.

In August, CEI filed 5 patent invention disclosures as a result of the novel research work in the five research projects previously mentioned. CEI is continuing to mature these projects for commercialization and will expand on the disclosures already filed.



Examples of glass-alumina bonded and aged

Goal of the Center

The goal of CEI is to continue to develop and commercialize new materials and technologies which will improve and lead to advances in widespread use in energy production and storage. Through collaborative efforts with both industry and state and federal agencies, CEI will continue to expand its breath by advancing energy technologies to commercialization. CEI is on a direct path to developing highly efficient as well as cost-effective energy solutions for battery storage and more efficient energy generation along with reduced costs, by developing cutting-edge technologies in adsorbents and membranes.

Outlook for 2015

In 2015, CEI acquired a well-established water filtration system from Rauschert GmbH that utilizes ceramic membrane technology for conducting water filtration testing. This technology aligns well with the State of Connecticut's interest in water technologies and the removal of oil, bacteria and larger suspended solids from waste water streams.

Also in 2015, CEI will receive the first U.S.-based 100 W eneramic® system developed by CEI's partner institute IKTS. This unit will be installed at the CEI laboratory for demonstration and testing purposes. The unit is a cost-effective alternative for an off-grid power supply and has been demonstrated to have a long life and low maintenance costs. This technology expands the breath of CEI's technical expertise and provides a unique opportunity for industry collaboration in this power range.

CEI has launched two new projects for 2015. The first new project involves catalytic reactions for water purification that will use manganese and other metal oxides. The second project concerns the synthesis, characterization and use of porous metal sulfides. These new projects have target companies interested in their development and commercialization of these materials.

With the two new installed technologies and the new projects launched, CEI plans to add additional resources in 2015, in order to meet the objectives for the coming year. CEI will continue to expand its research areas and portfolio in material characterization and ceramic technologies and identify new potential applications on larger scale projects and commercialization.

For more information:
www.cei.fraunhofer.org

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FRAUNHOFER DIGITAL MEDIA TECHNOLOGIES

Samsung Gear VR© is the first Cingo-enabled device to deliver 3D immersive audio. Photo: ©Samsung.

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

Fraunhofer Cingo® Delivers Immersive Sound Experience on Mobile Devices

On its way from the loudspeakers to our ears, sound is altered in several important ways. By the time it reaches us, it contains information about the listening environment as well as the actual musical or speech content. In addition, sound waves that arrive from different directions are shaped by our head and outer ear. Collectively, this information helps us to identify the distance and direction of a sound source.

When using headphones, this information is absent because the audio content is played back almost directly at our eardrums and therefore appears as if the sound is 'in' our head. This can lead to considerable discomfort during extended periods of listening. But researchers have discovered that these changes in sound waves can be measured and modelled by digital filters. By applying those filters to audio signals when listening on small devices or headphones, we can achieve a spatial sound impression close to the one achieved with 'real' loudspeaker playback. This technology is called binaural audio processing and is just one feature of Fraunhofer's ground-breaking new technology, Cingo.

With Fraunhofer Cingo mobile devices become true multidimensional sound theaters. Plug in your earphones or use the built-in stereo speakers for enveloping sound when enjoying movies, games or any other virtual environment. Fraunhofer Cingo creates a realistic immersive sound impression when

listening to stereo, surround or 3D content and dramatically improves the entertainment experience on mobile devices, delivering natural and clear sound in any given environment. Based on the latest developments in audio technology, Fraunhofer Cingo contains a complete set of tools to deliver an exceptional level of audio quality, unmatched on mobile devices. With the virtual sound mode, each audio channel is presented as a virtual sound source in such a way that it is heard from a specific location and distance; for example, a loudspeaker of a 5.1 or 11.1 speaker setup in a living room. The loudness optimization feature of Cingo delivers a natural and clear sound even in the most challenging situations. Together with the equalizing algorithm, which compensates for the common audio quality deficiencies often encountered with smartphones and tablets, Fraunhofer Cingo ensures significantly improved audio quality in any listening situation.

Industry Adoption

Google was the first OEM that licensed Fraunhofer Cingo, which brings unrivaled surround sound experience to the users of the Nexus family of devices, including the new Nexus 6 and Nexus 9. On the Nexus phones and tablets, Cingo can be used to enjoy movies in surround sound from the Google Play Movie Store or stereo music in the Google Play Music app.

The Samsung Gear VR virtual reality headset, one of the most innovative entertainment products, is the first Samsung device using Fraunhofer Cingo surround sound technology. The new 3D sound capabilities of Cingo enable Samsung Gear VR users to fully immerse themselves in a mobile virtual reality environment. Thanks to Fraunhofer Cingo, the users of the Samsung Gear VR headset can perceive sound elements in front, behind, from above or below and be truly immersed in a movie with a stunning level of reality that creates the experience of "being there". With the advancements of Fraunhofer Cingo that add a height dimension to sound, various elements can be placed anywhere in a virtual space around the listener. The Samsung Gear VR is the first Cingo enabled device that supports rendering of 3D audio content with tracking of head movements.

The leading Korean telcos KT Media Hub, SK Broadband and LGU+ use Fraunhofer Cingo in their mobile video service apps on smartphones and tablets. With the integration of Cingo and adoption of the HE-AAC surround sound audio codec, subscribers to KT's "olleh tv mobile" video on demand service experience unrivaled audio quality with their movies or TV programming while on the move or at home. The LG U+ mobile video service "U-HDTV" provides excellent audio quality delivered by AAC and Fraunhofer's Cingo mobile audio suite for LG U+ subscribers on Android smartphones. SK Broadband's ubiquitous "Btv mobile" (Btv) live broadcast TV and video on demand service features superior audio with Cingo for users of downloadable mobile app through an update that incorporates Cingo. Fraunhofer Cingo is available from Fraunhofer as a product-ready software implementation for mobile device manufacturers, chip set vendors and providers of multimedia services.

For more information about Fraunhofer Cingo, please visit
www.fraunhofer-cingo.com

Fraunhofer at Industry Events and Tradeshows

In 2014, the Audio and Multimedia Office of Fraunhofer USA Digital Media Technologies (DMT) continued its promotional and market development efforts around the latest audio technologies. In close collaboration with Fraunhofer IIS in Erlangen, one of the key objectives of 2014 was to support customers such as Google with the launch of mobile products incorporating the Cingo audio suite. With the initiation of U.S. business deals, Fraunhofer USA helped create increased awareness of Fraunhofer's offerings. During the course of the year, Fraunhofer exhibited at a number of industry events in the U.S. The employees of Fraunhofer USA DMT supported their colleagues from Fraunhofer IIS at a number of occasions including the Audio Engineering Society (AES) Convention and the Streaming Media West Conference in Los Angeles, the NAB Broadcast and CEA Consumer Electronics Shows in Las Vegas. Fraunhofer USA through its employees of the San Jose office also introduced Fraunhofer's audio codecs in various industry specifications such as the DECE UltraViolet Common File Format for Online Video distribution.

For more information:
www.fraunhofer.org/DigitalMediaTechnologies

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Fraunhofer USA Board of Directors Meeting

June 11, 2014, Boston, MA

L to R: Former President Georg Rosenfeld,
New President Frank Treppe,
Former Executive Vice President William Hartman and
New Executive Vice President Patrick Bressler

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Back cover:
High speed cutting at Fraunhofer Center for Laser Applications.