Fraunhofer
USA

ANNUAL REPORT 2012

Cover Photo:
Lobby of the newly renovated 5 Channel Center, Boston, MA;
home of the Fraunhofer Center for Sustainable Energy Systems.

About Fraunhofer

Fraunhofer USA is a non-profit research and development organization comprised of six research centers:

- Fraunhofer Center for Sustainable Energy Systems (CSE), Boston, MA
- Fraunhofer Center for Manufacturing Innovation (CMI), Brookline, MA
- Fraunhofer Center for Experimental Software Engineering (CESE), College Park, MD
- Fraunhofer Center for Coatings and Laser Applications (CCL), East Lansing, MI
- Fraunhofer Center for Molecular Biotechnology (CMB), Newark, DE
- Fraunhofer Center for Laser Technology (CLT), Plymouth, MI

Each of the above centers are affiliated with a major research university;

- Boston University
- University of Maryland
- Michigan State University
- University of Michigan
- Massachusetts Institute of Technology
- University of Delaware

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 promotes and supports the products of their respective parent institutes from Germany, namely Fraunhofer IIS and HHI.

To learn more about Fraunhofer USA: **www.fraunhofer.org**
To learn more about Fraunhofer Gesellschaft: **www.fraunhofer.de**

ANNUAL REPORT 2012

Dr. Georg Rosenfeld

Dr. Georg Rosenfeld, President of Fraunhofer USA, Inc.

Dr. Georg Rosenfeld with Prof. Eckhard Beyer, Executive Director of the Fraunhofer Institute for Material and Beam Technology and Dr. William Hartman, Executive Vice President of Fraunhofer USA.

Energy and resource efficiency has become an ecological and economic imperative, and is the key motto of our international research activities under the auspices of the new Fraunhofer President, Prof. Reimund Neugebauer. Fraunhofer USA is well-positioned to address these topics, with specialized expertise in high-performance manufacturing processes and new concepts for lowering the cost of decentralized energy supply. In a recently awarded project from the US Department of Energy's SunShot Initiative, Fraunhofer USA will develop technology solutions that reduce the "soft" costs of residential solar PV systems considerably.

Professor Reimund Neugebauer succeeds Professor Hans-Jörg Bullinger not only as President of Fraunhofer Gesellschaft but also in his role as Chairman of the Board of Fraunhofer USA. As former Executive Director of the Fraunhofer Institute for Machine Tools and Forming Technology, Prof. Neugebauer knows Fraunhofer inside out and is very well connected with the world's leading experts in production engineering research. As Fellow of CIRP, the International Academy for Production Engineering, his network spans across more than one hundred elite research organizations worldwide, many of them in the USA. Fraunhofer USA will benefit tremendously from his support.

After ten years as head of Fraunhofer, Prof. Bullinger stepped down in October, 2012. During his tenure, Fraunhofer USA experienced strong growth in the fields of life sciences and energy, and we are happy that he continues to serve on the Board of Fraunhofer USA as Vice Chairman. Another change in leadership was the departure of Dr. Stefan Heinemann, Director of the Center for Laser Technology CLT. He accepted an offer to become the Chief Technology Officer at DirectPhotonics Industries in Berlin, Germany, a manufacturer of high brightness diode lasers and licensee of CLT's diode laser technology. During his tenure, CLT spun off four companies. We are grateful for Dr. Heinemann's commitment to Fraunhofer and very glad that Mr. Hans Herfurth immediately took over as new Center Director.

In April 2012, Prof. Eckhard Beyer, Executive Director of the Fraunhofer Institute for Material and Beam Technology IWS, was awarded the Fraunhofer Medal for his outstanding service to the Fraunhofer Gesellschaft. As Institute Director, Prof. Beyer was instrumental in reinforcing the close collaboration between Fraunhofer and the Technical University of Dresden, Germany. He also initiated and supported the Fraunhofer Center for Coatings and Laser Applications CCL in Michigan. Over the past 15 years, Fraunhofer CCL has established itself as an integral part of the scientific and economic community in its field. Our sincere thanks and congratulations to Prof. Beyer.

Fraunhofer USA has sustained its very successful intern program which attracts many students from different parts of the world. Last year, we hosted over 150 interns from sixteen different countries. At the end of December, Fraunhofer USA had 200 employees not including the interns.

Our research centers continue to perform at the highest level with projects ranging from software tools for law enforcement, single crystal diamond materials for high power electronics, a multi-beam laser processing head, durability testing of PV modules, a 3-D Bio Printer for synthetic organ production and plant-based vaccines for Influenza, Malaria, Anthrax and Yellow Fever. Together with our partners in universities, government and industry, we look forward to another year serving the needs of society.

Georg Rosenfeld

MESSAGE FROM THE EXECUTIVE VICE PRESIDENT

Dr. William Hartman

Prof. Reimund Neugebauer, Dr. William Hartman (center) and Prof. Hans Jörg Bullinger

The new Fraunhofer Center for Energy Innovation will be at the University of Connecticut.

Fraunhofer USA Headquarter staff

Transitions

Congratulations to Professor Reimund Neugebauer on his appointment as the President of Fraunhofer Gesellschaft and Chairman of Fraunhofer USA. Fraunhofer USA wishes him great success and we look forward to benefitting from his leadership for many years.

We are privileged to also have a new Vice Chairman, the former president of Fraunhofer Gesellschaft, Prof. Hans Jörg Bullinger. Over the past ten years, his meetings with US senators, congressmen, governors, and university presidents enhanced the identity of Fraunhofer USA as an important link of transatlantic cooperation in deploying evolving technology. During his tenure as Chairman of Fraunhofer USA, the phrase "Fraunhofer Model" has been recognized worldwide as a very successful method for innovative applied research; and in recent years several agencies of the US government, including the White House, have referenced and praised the Fraunhofer Model as something to be imitated.

We wish Prof. Bullinger good health and continued success and look forward to seeing him for many more years at our board meetings.

Brand Recognition

Throughout the year Fraunhofer was invited to participate in U.S. meetings and conferences on policy subjects such as nurturing innovation and reviving manufacturing. Examples are presentations to the National Academies of Science, the Department of Energy, the White House Office of Science and Technology Policy, the U.S. Department of Commerce, the Information Technology and Innovation Foundation, and the Department of Defense. In all of these events, the interest in Fraunhofer was related to its flexible and entrepreneurial approach to translational research. The resulting benefits to industry are seen as resulting from cost effective public-private partnerships.

Internal R&D

Spending internal funding on exploratory projects assists the centers with their growth. Since 2007, a total of $4M of special funding has led to over $25 million in additional funding from government, foundations and industry. The following titles represent both the variety and market relevance of current Special Projects: Laser-Based Additive Manufacturing; DNA Delivery into Plants; Three-Dimensional Tissue Printing; Software for Law Enforcement, and Diamond Based Semiconductor Devices. Such projects are seeds for future opportunities that keep our applied research on the leading edge.

New Facility

The front cover shows the lobby of the new home of the Fraunhofer Center for Sustainable Energy Systems, CSE in Boston, MA. The 100 year old building is located in the Innovation District near the Boston Harbor where near-by buildings are also being renovated into office space and condominiums. The successful renovation of 5 Channel Center represents the tireless efforts of multiple partners, funding agencies and dedicated employees who worked countless hours to make this happen. Manufacturers and suppliers donated many of the systems being showcased at CSE for the purpose of demonstrating the feasibility of renovating decades-old buildings with energy efficient systems using advanced building technologies. Technologies contributed by industry partners range from building-integrated solar photovoltaics to radiant flooring; high-efficiency building envelope components such as roof membrane, windows, doors, and insulation; an advanced, efficient 200-ton chiller system; and others. Fraunhofer CSE is displaying these technologies in a state-of-the-art exhibition and educational space open to the public, using innovative applications to call attention to energy saving and/or sustainable construction attributes.

Expansion

Negotiations begun in early 2012 led to the planned startup of a seventh research center. The Fraunhofer Institute for Ceramic Technologies and Systems (IKTS) and the University of Connecticut (UConn) School of Engineering, including its Center for Clean Energy Engineering, will create the Fraunhofer USA Center for Energy Innovation (CEI) to develop advanced technologies related to energy storage, fuel cells, power management and distribution through contract research. The center will receive base funding from Fraunhofer, UConn, and the State of Connecticut Department of Energy and Environmental Protection. Operations are planned to begin in mid-2013.

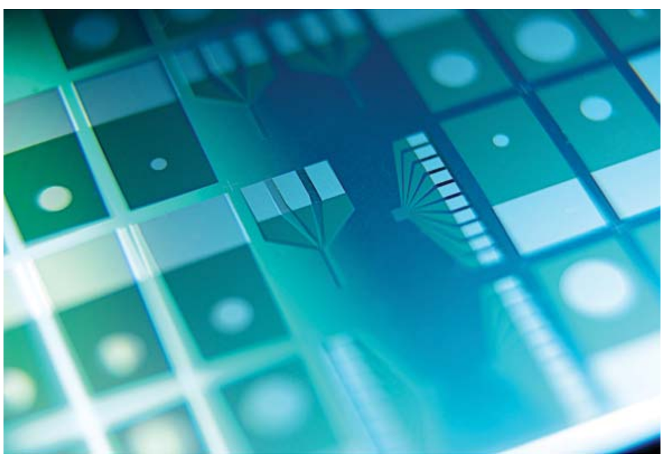
Appreciation

I want to acknowledge the dedication of the employees at Fraunhofer USA Headquarters. They provide the research centers and offices with the important functions of accounting, human resources, and corporate communications. That is comparable to administering operational support to nine distinct companies. The combined years worked by the headquarters staff is 126 years, or more than 10 years each. I extend a special thank you to the Headquarters employees who are pictured on page 6.

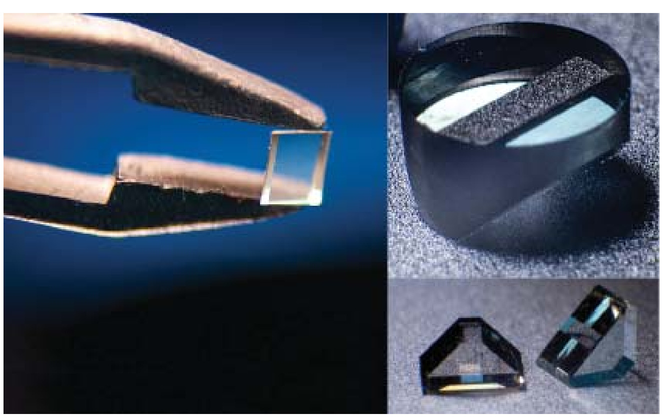
William F. Hartman

FRAUNHOFER CENTER FOR COATINGS AND LASER APPLICATIONS

LaserArc® equipped industrial coating machine to deposit Diamor® coatings



Silicon wafer with boron-doped diamond macro electrode chips and microarray sensor chips



Customized optical diamond crystals

Fraunhofer USA's Center for Coatings and Laser Applications (CCL) has two separately located divisions. The Coatings Technology Division is situated East Lansing, Michigan, and collaborates with Michigan State University. CCL's Laser Applications Division operates a laboratory in Plymouth, Michigan. CCL offers access to advanced technology solutions in thin film coatings and power laser applications. CCL's quality management system is certified according to the ISO9001:2008 standard ensuring efficient, documented and traceable project performance and high quality customer interactions.

Coating Technology Division

Diamor® - CO2 Emission Reduction and Improved Gas Mileage with Energy Efficient Tribological Coatings

In automobiles, 10-15% of the fuel is spent to overcome friction in the engine, axles and transmissions. Reducing friction does not only reduce fuel consumption and increase gas mileage but also reduces CO2 emissions. The potential to reduce CO2 emissions by coating valve trains, transmissions, bearings and chain drives is about 6%.

The auto industry is using surface coatings to reduce friction and wear. Each generation of coatings has become more efficient and wear resistant. Fraunhofer offers the latest coating technology solution to increase engine performance while reducing manufacturing costs. Diamor® is a tetrahedrally bonded amorphous carbon coating that drastically improves engine performance leading to significantly increased gas mileage and reduced CO2 emissions.

Fraunhofer offers the entire manufacturing technology to deposit Diamor® including processes and systems. This technology package includes a medium sized industrial vacuum coating machine and Fraunhofer's LaserArc® deposition module (top left photo). Furthermore, Fraunhofer engineers provide services such as application testing, process development and installation support. Customers interested in this technology receive one-stop-solution services from Fraunhofer, whether they want to install their own in-house coating capability or contract for coating service.

Electrochemical high performance sensor for heavy metal contaminant detection

The reliable and sensitive detection of heavy metal contaminants in water supplies requires long-term stable sensors with an extremely low background noise. Fraunhofer has developed microsensor arrays that tremendously benefit from the chemical and electrochemical properties of boron doped diamond materials.

Boron-doped diamond is a new electrode material, which is deposited as a thin film by chemical vapor deposition. This process uses gases such as methane, hydrogen and boron-containing precursors. Thus the use of low-cost process gases makes this electrode material less expensive than the fabrication of platinum electrodes. Yet boron-doped diamond by far exceeds the electrochemical performance of metal-based electrodes. It offers an expanded electrochemical potential window, which opens access to chemical reactions that are simply out of reach for conventional electrodes.

Fraunhofer's microfabrication process enables the customization of electrode chip designs. For example, highly sensitive heavy metal contaminant detection requires a low background signal. This is especially well achieved when building microarray sensor chips as shown in the middle picture on page 8. Such sensor chips can be acquired from Fraunhofer including recommendations for application integration and testing services.

Technical diamond crystals

The unique combination of physical properties makes diamond an interesting technical material for optical, X-ray optical and electronics applications. Diamond crystals can be used in semiconductor lasers with high power densities to remove heat directly from the site of laser beam generation. Diamond can also be used directly as a laser radiation emitting crystal. Low distortion X-ray monochromators use diamond crystals for high power densities. In addition, diamond crystals are also of great interest for future application in nano (spin) and high power electronics.

Fraunhofer engineers have established a laboratory scale manufacturing line to produce high quality diamond plates and customer specific diamond products in larger quantities. The quality requirements for the diamond crystals are defined by the application. For example, for most optical applications a nitrogen concentration of less than 1 ppm is acceptable. The bottom picture on page 8 shows some crystals of optical quality. First a diamond plate is produced (far left), which is then processed into an optical component. Post diamond growth processing steps at Fraunhofer include plasma etching, laser cutting and polishing. These techniques are used to shape the diamond crystals according to customer specified geometries (bottom picture on right).

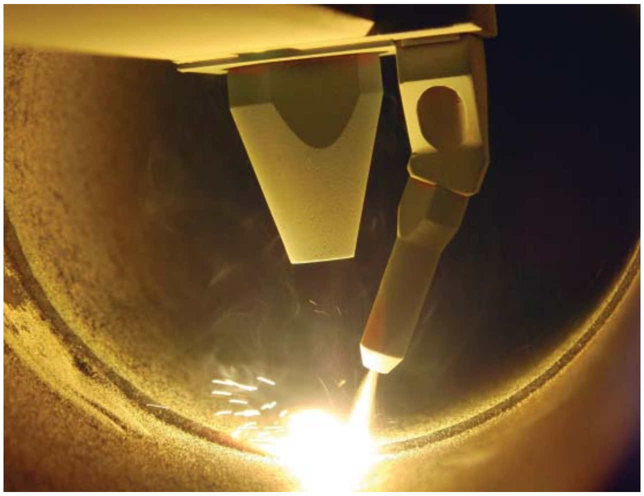
Current research work focuses at the improvement of the reactor and process technologies to further reduce the production costs of single crystal diamond materials by increasing growth rates and high quality crystal yields.

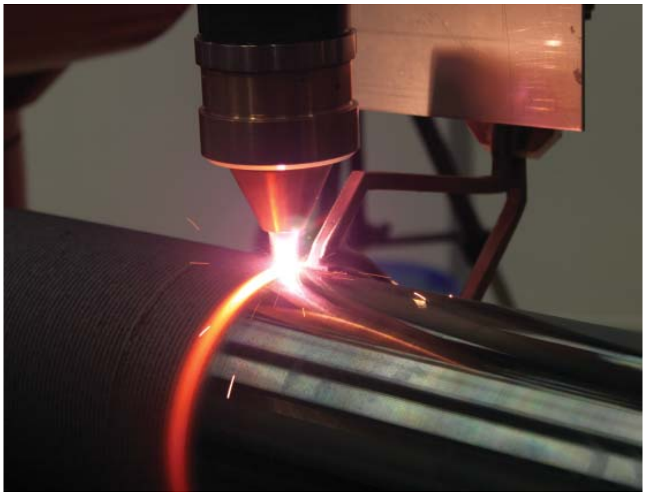
For more information on these technologies, please visit us at www.ccl-coatings.fraunhofer.org

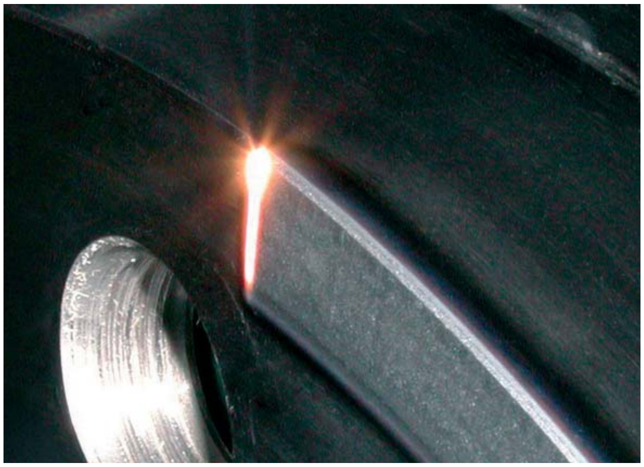
Fraunhofer Center for Coatings and Laser Applicatons

Dr. Jes Asmussen, Center Director
Tel: 517 355 4620
jasmussen@fraunhofer.org

Coatings Division:
Dr. Thomas Schuelke, Director
Tel: 517 432 8173
tschuelke@fraunhofer.org







Laser Applications Division

CCL's Laser Applications Division has extensive know-how and expertise in the field of high power laser applications technology and works in partnership with its German parent institute, Fraunhofer IWS (Dresden).

The laser division's applications facility in Plymouth, Michigan features over 8 state-of-the-art high power lasers from laser manufacturers such as IPG, Laserline, Rofin Sinar and TRUMPF. The center's activities include providing technical support and research and development for these companies in the US market as well as for a variety of industrial end users of laser technology.

The main technology focus is on high power laser applications research and development in technology areas such as laser welding, heat treatment and cladding (including additive manufacturing) for a wide range of industrial customers and government organizations.

Projects and acquisition activities

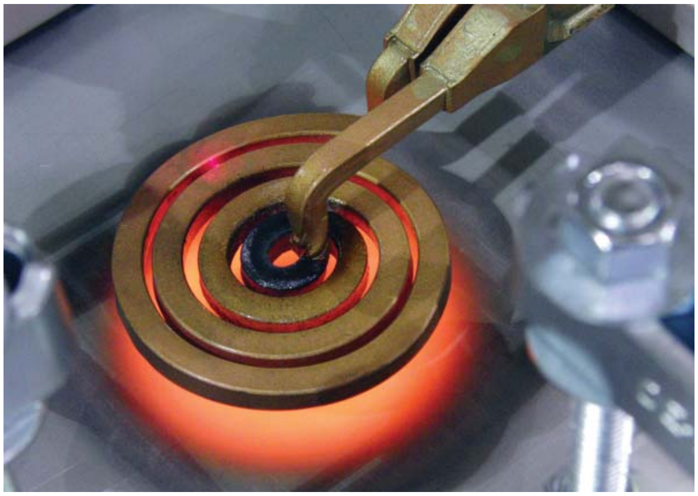
The Laser Applications Division has successfully continued its growth building on its core competence in high power laser applications which resulted in research revenue from US industry of approximately $2.5M for FY 2012.

Approximately 90% of the laser division's revenue is typically obtained from industrial funding and we have a large portfolio of industrial clients who continue to view us as the premier laser applications development facility in North America.

CCL-L remains focused on its successful strategy of developing laser applications technology for markets such as oil and gas, alternative energy, automotive and aerospace. CCL-L secured increased project revenue from all of the above markets in 2012.

In 2012, many new laser applications were developed and transferred into production including a pilot production system which was developed for engine repair and remanufacturing using laser powder metal deposition.

Induction heating technology has been developed for several new industrial applications including induction assisted welding and cladding and also for heat treatment applications in order to improve metallurgical properties.



The laser division 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 division continues to see interest in its laser technology and expertise as major automotive manufacturers look to increase the fuel efficiency of their vehicles by reducing vehicle mass and using advanced manufacturing technology in order to meet future government CAFE regulations which require significant increases in fuel efficiency in the coming years (mandated fleet wide average fuel efficiency target of 54.5 miles per gallon by 2025).

The Laser division also 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 CCL over the last 5 years, and 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 in resulted in the successful transfer of this technology into industrial production for 2 different customers, and projects are continuing in this field in 2013.

CCL-L installed several new lasers and expanded its robotic processing capabilities to offer greater flexibility and the capacity to handle larger, more complex projects.

Outlook for 2013

In 2013, CCL-L will install a new state of the art laser processing machine which will feature new dual core fiber technology that will facilitate rapid process changeovers for different applications and also open up new potential applications on larger scale projects and allow high precision laser processing at extremely high speeds.

We are confident that 2013 will provide further growth opportunities as we continue to expand our Plymouth, Michigan operations to meet the growing demand for our expertise and services in applied research and development for high power laser applications.

The laser division is also proud to report the successful launch of its new website which took place in September 2012. Please visit: www.ccl-laser.fraunhofer.org

Fraunhofer Center for Coatings and Laser Applicatons

Dr. Jes Asmussen, Center Director
Tel: 517 355 4620
jasmussen@fraunhofer.org

Laser Division:
Mr. Craig Bratt, Director
Tel: 734 738 0550
cbratt@fraunhofer.org

The Fraunhofer Center for Experimental Software Engineering, Maryland (CESE) is located in College Park, Maryland and conducts applied research in software engineering processes and technologies. It collaborates with private-sector organizations, government agencies, and academic and research institutions to develop innovative, practical approaches to software development and management issues.

CESE has affiliations with the University of Maryland at College Park and the Fraunhofer Institute for Experimental Software Engineering (IESE) in Kaiserslautern, Germany.

The Center's project portfolio includes a mixture of research efforts into new software technologies and empirical evaluations of existing tools and processes, and service-provision contracts to assist clients with software development and acquisition needs. Customers include government agencies such as the Department of Defense, the US Food and Drug Administration and NASA, and large multi-national companies such as Boeing and Robert Bosch. CESE also supports small and medium-sized companies with software needs in the Washington, D.C. – Baltimore, Maryland corridor.

Competencies

- Measurement and Knowledge Management
  Contact: Dr. Forrest Shull
- Software Management and Process Improvement
  Contact: Ms. Kathleen Dangle
- Software Architecture and Embedded Software
  Contact: Dr. Mikael Lindvall
- Software Verification and Validation
  Contact: Prof. Rance Cleaveland

Business Areas

- Aerospace / Defense
  Contact: Ms. Kathleen Dangle, Mr. Frank Herman
- Automotive
  Contact: Prof. Rance Cleaveland
- Medical
  Contact: Dr. Mikael Lindvall

PROJECTS IN PROGRESS

NASA Space Network Ground Segment Sustainment

CESE is working with NASA on a major overhaul of NASA's space-network communications system.

The NASA Space Network (SN) is a communication signal relay system that provides tracking and data-transfer services between user platforms and user Mission Operations Centers (MOCs). The SN was established in the early 1980s to replace NASA's worldwide network of ground tracking stations and consists of a constellation of data relay and tracking satellites and associated ground systems. This space-based relay system can provide essentially unlimited communication services for altitudes ranging from 73 km to 9000 km, a capability that is unique within the civilian and commercial space industry. In addition, limited communication services can also be provided for customer platforms located on the ground and ocean/sea surfaces (e.g. ships) as well as airborne platforms (e.g. atmospheric balloons). The fleet of Tracking and Data Relay Satellites (TDRS) in geosynchronous orbit serves as a data relay system between SN ground system and user platforms

The SGSS project replaces a majority of the existing SN Ground Segment with modern technology in order to fulfill the following objectives:

1. Monitor and Control the SN Flight and Ground Segments; including management of the configuration, health and safety of the TDRS spacecraft fleet and SN Ground Segment elements.
2. Provide SN user service planning and scheduling.
3. Relay user signals in forward and return directions between the ground and user platforms.
4. Distribute user data on the ground using NASA Integrated Services Network services, user-provided networks, and local interfaces.
5. Provide tracking services for TDRS and user spacecraft.

The heart of CESE's research in the SGSS project is the collection and analysis of software progress and quality metrics from the SGSS development contractors. Software progress metrics include measures such as requirements decomposed, requirements volatility, components designed coded and tested, etc. Software quality measures include defects found, defects corrected, etc. The analysis of these metrics permits CESE to identify areas of risk and opportunities for improvement of contractor outputs delivered to NASA. CESE also uses the metrics analysis to research new technologies and to infuse those that demonstrate risk reduction, better cost/

schedule adherence or software technology improvement into both the NASA Project Team and the SGSS development contractors. Specific technologies that CESE is researching include software cost and schedule estimation and tracking, software defect detection and Reliability Growth Models, Service Oriented Architectures, and software metrics presentation techniques.

In 2012, CESE has played key roles in various critical design reviews for the SGSS project, and it has also been instrumental in using its metrics-based performance research to provide feedback and insight to NASA staffers on the performance of the main software subcontractor.

The Fraunhofer Approach for Software Testing (FAST)

In 2012, Fraunhofer CESE received additional special funding from Fraunhofer USA to support the ongoing development of the Fraunhofer Approach for Software Testing (FAST). FAST is now a method for testing software from many domains, including aerospace, medical device, and web software. Highlights during the year include the following:

1. CESE further developed technical collateral, including a model-based software testing architecture, a "design for testability" knowledge base, reusable testing models, and a testing process and best practices. These assets constitute the main intellectual property for Fraunhofer and are already being used in several third party projects.
2. Center researchers continued to uncover previously unknown critical issues in NASA communications sysems and to development further improvements of the FAST. These testing projects were documented and used as tutorials and presentations that have been used to demonstrate the capabilities to interested parties.
3. Center staff also continued to use the FAST to test several commercial software systems, resulting in different types of detected software errors. The FAST may also be used to check how testable a software system is; this capability is due to the structured approach to software testing that the tool enables.

The FAST is based on two fundamental technical principles:

The first is *Design for Testability*:

Based on extensive experience in working on large-scale software systems, CESE staff members have collected an informal corpus of knowledge encompassing principles that are used by the best software engineers at NASA and JHU/APL to enhance the ease of testing software. These best-practices dramatically improve the testability of the final product.

The second technical foundation for the FAST is *Model-Based Testing* (MBT):

MBT is a new technology developed in the research community that has attracted attention among practitioners. In MBT, tests are specified as abstract, programming-language-independent models. A translator maps abstract test specifications to concrete tests. The advantages of this approach are as follows:

1. Such test models are insulated from changes in the source code, thus radically reducing maintenance costs.
2. One creates a test specification only once in terms of a model and executable test cases are automatically generated without programmer intervention.
3. Models are much easier to understand than code for humans and allow all stakeholders to understand how the software is being tested.
4. Tests automatically generated from behavioral models cover aspects of system behavior in a much more complete manner compared to manually written tests.

GQM+Strategies®

Scientists from Fraunhofer CESE and IESE have continued applying the GQM+Strategies® methodology, which was jointly developed by the two organizations to provide a framework for connecting business-level goals with software-project-specific technical metrics and management artifacts. The main project partner has been EcoPetrol, a Colombian oil company.

Fraunhofer CESE continues to collaborate with Fraunhofer IESE to refine the GQM+Strategies® methodology, and to package the technology so that it can be used to improve staff efficiency in the measurement-related project work that is a core capability for both CESE and IESE. The collaboration continues to build a unique and marketable Fraunhofer capability, which will address one of the organizations' business areas and facilitate projects at both CESE and IESE.

Both CESE and IESE have developed a set of assets that are reusable for both centers, including: a training course for use with customers and collaborators, process description, tool for visualizing the GQM+Strategies® outputs, and case studies – all of which stem from the knowledge, experience, and expertise resulting from the various engagements between CESE and IESE with customers.

Medical-Device Software Security

CESE has been developing a technical competence in cybersecurity; as part of this effort, CESE staff members have been focusing on issues related to the security of embedded software in medical devices, such as insulin pumps, which are software controlled and also possess capabilities for network connections. Such devices have been subject to highly publicized hacker attacks that have attracted the attention of regulatory agencies in the U.S., in particular.

As part of this research effort, CESE has developed an instrument for assessing the security vulnerabilities within these devices. The tool builds on the typical regulatory hazard analysis that medical devices undergo; specifically, it combines information about hazards with information about system interfaces in order to focus engineering attention on the different ways that hazards may be triggered. Using this instrument, the Center has conducted security analyses of two insulin pumps and an implantable infusion pump made by subsidiaries of a major multinational medical device company, and it has been in discussions with technical staff at the US Food and Drug Administration on approaches for incorporating security considerations into the approval of medical devices prior to their release into the marketplace.

InViz: Real-Time Visualization of Cybersecurity Attacks

Also in the cybersecurity realm, CESE has continued to develop its InViz (Instant Visualization) tool, which enables network administrators and other technical staff to visualize cyber-attacks on network infrastructure as they are occurring. InViz gives human experts as well as novices the capability to identify cybersecurity attacks by means of novel information visualization techniques. The tool allows users to observe network traffic in real-time. The focus of CESE's ongoing research is to understand how to effectively present information to enable efficient identification of attack patterns in the large amounts of data typically produced by today's network devices.

The current prototype tool is proving to allow quick detection of different attack patterns, such as denial of service attacks (an attempt to make the target computer unresponsive), backdoor exploits (an attempt to use known security leaks in installed server software), and vulnerability scanners (an attempt to identify specific weaknesses of network devices and servers, such as open ports).

CESE in Figures

CESE experienced significant growth in its revenues in 2012 vis à vis 2011. In part this was due to the slight dip in the Center's performance in 2011 because of turmoil in the US federal budget. The relative stability of the US government's finances in 2012 permitted agencies to reinvest in their missions, and this led to significant growth in CESE project revenues. Based on projections, 3rd-party revenues for 2012 should be approximately 15% larger than those for 2011. CESE is budgeted a 10% increase for 2013 over 2012 in these figures.

Important new project wins in 2012 included various efforts in the medical-device sector, both industrial and governmental; research projects through NASA's Software Assurance Research Program; and new research efforts in cybersecurity for medical-device and law-enforcement applications.

University Partners

- University of Maryland at College Park
- University of Maryland at Baltimore County
- Stevens Institute of Technology
- University of Kaiserslautern

Other Partners

- Axiom Resource Management, Inc.
- Johns Hopkins University Applied Physics Laboratory
- NASA IV&V Center

CESE staff

For more information on all these technologies, please visit:
http://www.fc-md.umd.edu

Fraunhofer Center for
Experimental Software Engineering

W. Rance Cleaveland, II, Ph.D.
Executive and Scientific Director
Tel: +1 240 487 2920
rcleaveland@fc-md.umd.edu

The Center for Laser Technology (CLT) located in Plymouth, Michigan, focuses on research and manufacturing solutions with light comprising the core expertise of processing, special components and lasers. It mainly serves the markets of alternative energy, automotive, medical and homeland security. Laser processing for batteries and solar cells enabling higher performance and cost effective manufacturing, micromachining application development for drilling and ablation and high brightness diode lasers for the defense industry and industrial manufacturing are the main focus. Solutions reaching from optimized processes and real time quality control to customized processing systems are provided.

Packaging Technology for Energy Storage Devices

CLT is developing new packaging technology tailored to the specific requirements of advanced supercapacitors in a strategic partnership with Inmatech Inc., located in Ann Arbor, Michigan. Supercapacitors store electricity based on charge separation and not based on chemical processes as in batteries. Therefore supercapacitors can provide high peak power, but they are limited in energy storage, while batteries store high energies and are limited in peak power. Large surfaces of the active material accessible by the electrolyte along with minimum electrical impedance, are necessary for high performance supercapacitors. Inmatech's technology is based on metal nitrides as active electrode material. CLT has developed reliable laser cutting for the sizing of the electrodes using a pulsed solid state laser and galvanometer scanner for beam steering. Compared to a die cut, the scanning laser beam provides the highest flexibility with regard to the electrode shape. First prototype batches were cut and successfully tested. In addition, laser tab welding is currently being developed to join a stack of electrodes based on infiltrated metal foam. High welding speeds and good repeatability are key benefits of the laser process.

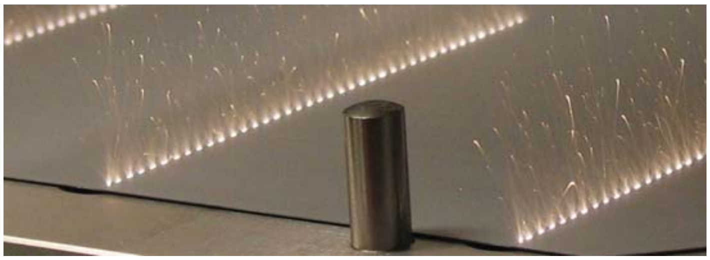
Package for 3-Cell Supercapacitor

CLT has also designed prototype packages for supercapacitor cells. The initial design is based on a machined polymer housing with integrated terminals and venting. This approach allows for quick alternations while the performance of the supercapacitor is being optimized. Single-cell and 3-cell prototypes were produced and tested. High peak power and good energy storage could be demonstrated and further work will optimize the performance and manufacturing processes. The next development phase will also evaluate stamped metal casings with laser welded lids and injection molded polymer casings. Both represent cost efficient packaging approaches for future mass production.

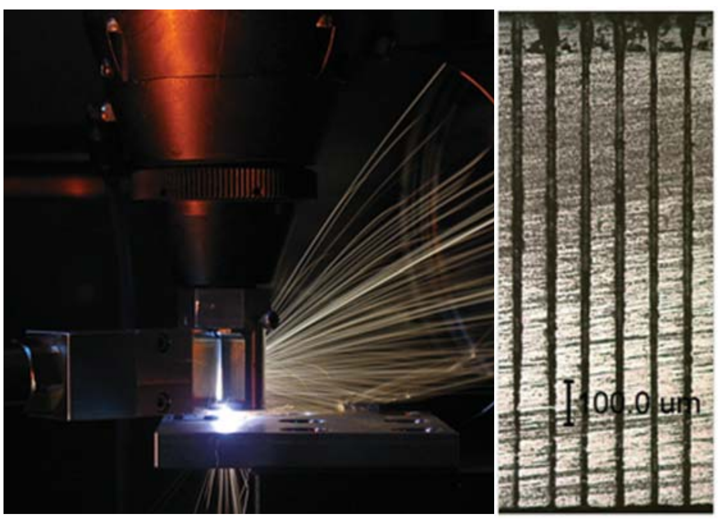
Cost Effective Manufacturing Processes for Solar Cells

CLT's advanced laser processes develops new and more efficient solar cell designs and reduces manufacturing costs. Examples include surface texturing where a pulsed laser beam creates 450,000 dimples per second that are enlarged with subsequent etching or high rate drilling for emitter wrap through (EWT) cells. Together with a laser manufacturer, process and components were developed resulting in >6,000 holes per second in 200μm wafers with only 18W of laser power – a 3x productivity improvement compared to the state of the art. Fast controls with 50ns loop time were developed for both operations to accurately synchronize the laser with the scanner, which allows percussion drilling of holes in multiple sweeps or surface texturing in a single sweep.

CLT is working in partnership with a solar cell manufacturer in a DOE funded program under the PV manufacturing initiative to adapt the technology to metal wrap through (MWT) cells with larger hole size and shallow emitter. CLT has optimized



Laser drilling of silicon wafer for MWT-solar cell design



Drilling of 25µm holes in 1mm thick tantalum

the drilling process for a range of hole sizes and wafer thicknesses. Laser-drilled prototype wafers with a specific drill patterns are the precursor for applying and testing newly developed metallization processes that enable significantly narrower conductive lines on the front side of the wafer. Material savings and increased active area result in higher efficiency and cost reduction. Selective laser doping is the second focus of the program. The goal is to locally increase the dopant concentration underneath the metallization lines to reduce the resistance and enable a more efficient charge collection. Using the controlled heat input of a pulsed 532nm laser, CLT has demonstrated that sheet resistance can be locally lowered by a factor of 2 – 3 without causing significant damage to the surface structure.

Drilling of High Aspect Ratio Holes

Pulsed lasers are excellent tools for drilling small holes (diameter <100µm) with high aspect ratio (>1:10) in metal substrates. Examples include cooling holes in turbine blades for jet engines and fuel injectors for automotive engines. CLT recently secured a program from the Navy Research Lab on drilling of up to 3mm thick tantalum sheet. The application is an x-ray collimator optic that is comprised of a large quantity of perforated sheets. The goal is to drill holes with a diameter of less than 50µm and achieve a depth to diameter ratio of 60:1. CLT used a pulsed disc laser (wavelength 1070nm) with adjustable pulse length to optimize the drilling parameters for shortest drill time and small and consistent hole size. A special cross-jet was developed to prevent small melt particles that are ejected from the hole with high kinetic energy from contaminating the drilling optic. The shortest drill time for 45µm diameter holes in 2.0mm tantalum sheet is 200ms. Sheets with a thickness of 1mm are drilled in 65ms achieving average hole sizes of 25-30µm. In both cases, subsequent etching can be applied to further increase the hole diameter and to reach an open area fraction of 70%.

Laser

High brightness diode lasers have been a main research field of CLT for the past decade. CLT developed and patented a novel packaging technique allowing 3x higher brightness than commercial products and opens the door to use diode laser for cutting and welding. This led to multiple federal programs from different funding agencies and high scientific visibility as well as extended industrial network. Applications are in pumping of advanced solid state lasers and material processing. In cooperation with the University of Michigan a unique system was developed that delivers more than 600W from a 0.2mm fiber. An integrated beam switch allows redirecting the beam to six 0.1mm fibers and 130W are delivered from each of the fibers. The system is used at the University as pump source to develop novel high power fiber lasers.

The technology was licensed to Direct Photonics Industries (DPI), which focuses on the >$1billion market for cutting and welding. In close collaboration, CLT developed the next generation prototype laser platform designed to deliver 500W out of a 0.1mm fiber using advanced dense spectral beam combining technology. This platform achieves peak efficiency of 44% and represents the basis for scaling up power to the 2kW level.

The medical industry continues to be interested in wavelengths above 1.5 µm because of their high absorption in water and are considered much safer for materials processing since the allowable exposure to the human eye is three orders of magnitude higher compared to lasers operating in the 1µm and below wavelength range. The challenge with long wavelength diode lasers is their limited output power and electro-optical efficiency. Sophisticated packaging technologies and excellent cooling are required to realize high power and good beam quality.

CLT developed customized 1530nm packages that deliver up to 40W from a 0.2mm fiber, far exceeding specifications of commercial devices currently available. First prototypes were delivered to the Army Research Laboratories and the Technical University of Berlin in support of their development work of resonantly pumped eyesafe lasers.

Components

Design and manufacturing of components delivering the laser light to the work piece are a core expertise of CLT. This includes special optics, advanced process monitoring and tooling that are designed and built based upon proven process capabilities. Automation is not included, but together with our approach "from process to components," a clear interface to system integrators is defined.

CLT has developed ablation systems for roll-to-roll processing of thin film products, such as RFID in the past. The ablation quality and efficiency was investigated for a variety of different lasers in the spectral range from 500nm to 1100nm with the goal to identify the system with the lowest cost of ownership. In collaboration with a system integrator diode lasers were proven to meet the requirements and multiple systems are installed today at customer sites worldwide.

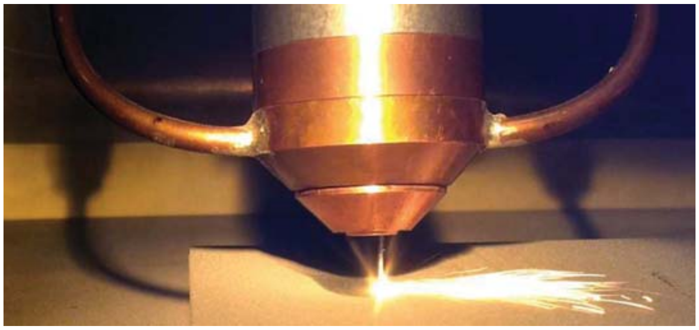
Individual product marking becomes increasingly important in mass production for the purpose of product identification, quality control and counterfeit prevention. It's a specially challenging task for thin film products that require small features and are manufactured at high speeds. CLT currently leverages its expertise in diode laser integration, ablation processes and special controls to develop a marking system without any moving parts. The goal is a diode laser based 2D barcode marker for on-the-fly processing at speeds in excess of 1m/s.

The availability of compact and highly efficient high brightness diode lasers also enabled the development of a multibeam processing head for laser additive manufacturing. In conventional laser material deposition, the energy is applied by a single beam. The associated high heat input and limited process control hamper tight manufacturing tolerances and the applicable material spectrum. The multi-beam approach aims at significantly improved control of the energy input by using at least two laser beams that meet at the work piece surface. The concept comprises a stationary center beam and a movable beam that can be steered within a specific distance of the center beam. Flexible and fast beam steering will allow establishing specific temperature profiles in the interaction zone of laser beam and material.

The individual beams either work in parallel to scale productivity without sacrificing precision, or are fully or partially superposed in a single spot creating material and application specific tailored heat profiles that will significantly expand the applicable material spectrum. Precise control of the heat cycle during material deposition will allow expansion of the spectrum of materials and include alloys that are currently difficult to process and tend to exhibit defects such as cracking. This includes high-strength steels and superalloys used in jet engines and gas turbines. Further advantages of the multibeam approach are expected for the deposition of gradient materials.

CLT completed the development of the multi-beam processing head and has successfully completed the initial devise testing. The processing head has a compact design (425mm x 175mm x 125mm) and weighs approximately 10kg. It comprises 4 high brightness laser platforms, each providing power of 100W. The beams of 2 platforms are optically combined to a single beams. One of the two beams is guided via a reflective mirror that can be steered in 3 directions allowing control of the laser spot position on the work piece surface relative to the stationary beam. The movable beam can be set at a constant off-set to the stationary beam. It can also be oscillated within a defined range at frequencies up to

800Hz. The beam position, amplitude and direction of oscillation is freely programmable. The high flexibility in beam positioning enables pre-heating and post heating regimes as well as creating distinct temperature profile independent of the direction of motion. The design and build of a very compact coaxial powder delivery nozzle was part of the development effort which was supported by the University of Michigan; a collaborator on this program.



Multi-beam Laser deposition head

To learn more about these technologies, please visit www.clt.fraunhofer.com

Fraunhofer Center for Laser Technology CLT
Hans J. Herfurth, Director
Tel: 734 738-0503
hherfurth@clt.fraunhofer.com

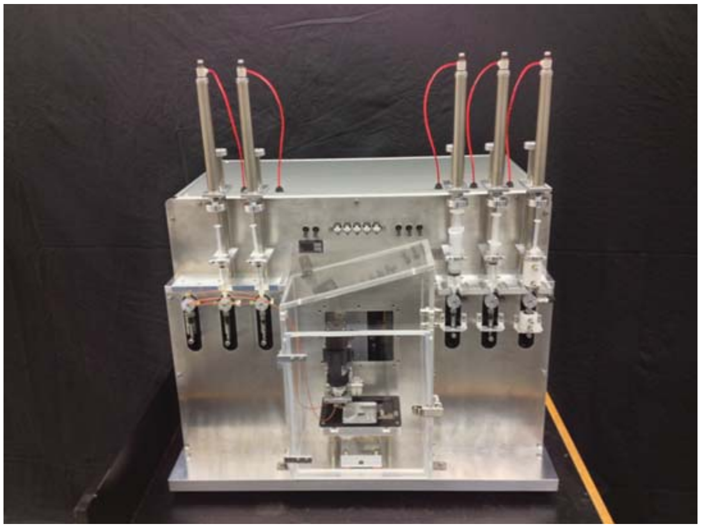


Figure 1. Completed 3-D BioPrinter

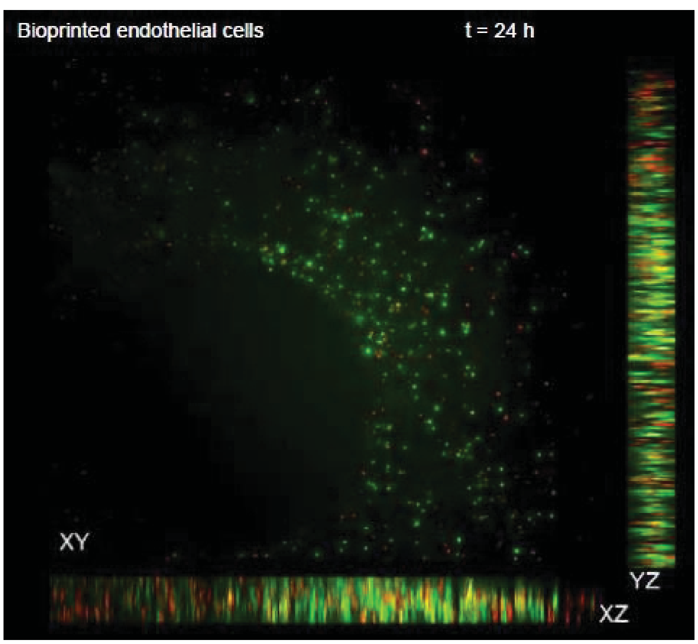


Figure 2. Endothelial cells

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.

During 2012, CMI won its first National Science Foundation research grant entitled "Charge Assisted Protein Sensing." Additionally, CMI participated on the Boston University-led team that was awarded a translational NIH grant for the creation of a Center for Innovation in Point of Care Technologies for the Future of Cancer Care. CMI will serve as the engineering partner for this multi-organization, multi-year program. With on-going NIH grants on Bacterial Drug Susceptibility Identification by Surface Enhance Raman Spectroscopy, CMI is establishing itself as a key player in the biotech/biomedical areas with the U.S. government funding agencies.

On the industrial front, during 2012, CMI has acquired and/or delivered a number of automation systems and instruments to major U.S. corporations. Specific applications ranged from high speed manufacture of disposable products, to highly sophisticated, intelligent automation for genetically engineered products, to novel automated processes for the manufacture of aircraft engine components.

Finally, CMI has further enhanced its reputation in the scientific community with five new journal publications, including one in the prestigious **Science Translational Medicine**.

Representative systems under development at CMI:

3-D BioPrinter

CMI has developed a 3D additive manufacturing system capable of multi-material and multi-scale deposition of biological materials, enabling the next-generation of bottom-up tissue engineering and synthetic organ production. This new area for CMI is an exciting and important scientific endeavor that resides at the interface of manufacturing engineering and

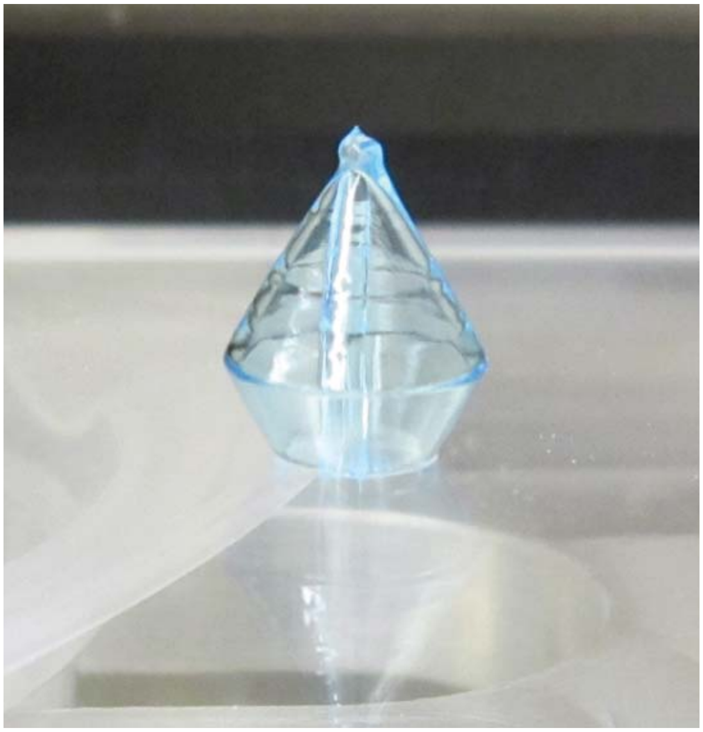


Figure 3. Hollow diamond test structure

life sciences. As such, it entails four diverse elements: a novel hydrogel-based bioink, a 3D bioprinter, software to drive the printer, and mammalian cell culturing.

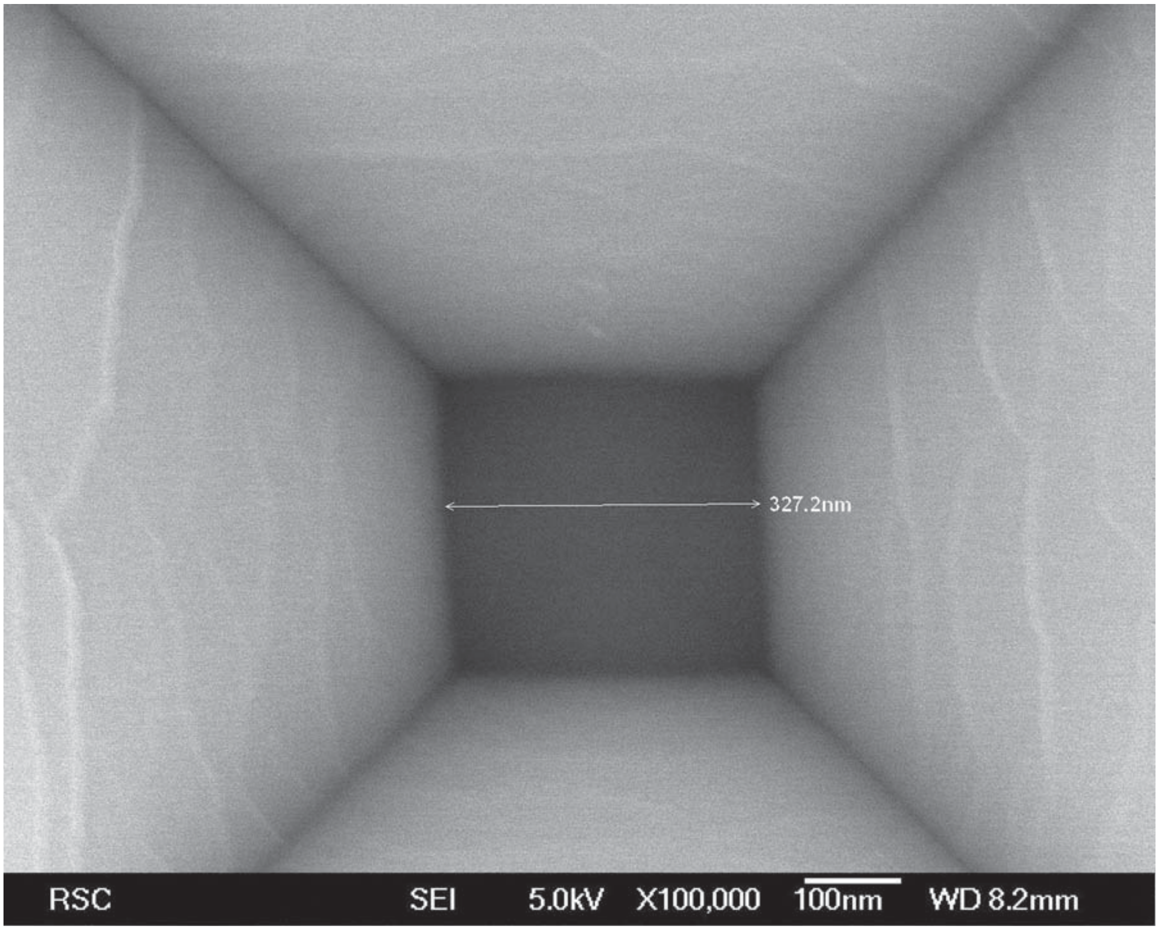
One benefit of a direct writing approach is that one can in principle achieve the multiple length scales found in nature, from that of the microscale (~0.1 mm, e.g. pancreatic islets) to the mesoscale (~10 mm, e.g. large blood vessels) to the macroscale (~100s mm, e.g. length of long bones). Based on concepts from 3D rapid prototyping of non-biological materials, initial forays into 3D printing of biological materials have been met with some initial success. These methods use various types of cell-laden hydrogels that are printed following CAD/CAM procedures. The hydrogels can be photo-polymerizable, thermoreversible, or chemically cross-linked. The surrounding material serves two purposes; to suspend the cells in a matrix that has enough viscosity to maintain a three-dimensional shape and to provide the appropriate chemical environment to support cellular viability and in some cases cell differentiation and outgrowth. These purposes can require compromises in the material choice or geometry when the desired tissue construct is as complex as natural tissues. Moreover, often a trade-off exists between the desired resolution and the manufacturing speed, as viscous materials must be printed slowly to maintain a uniform (and large) line width during extrusion. However, there is a time limitation during which the biological material can sustain the printing conditions (humidity, temperature, etc.), thus this can limit the obtainable geometries.

To address these challenges, CMI designed and built a 3D rapid prototype machine that can both achieve the multiple scales required AND simultaneously print various materials (including biologicals) in order to achieve a level of complexity that actually mimics the intricacies of natural tissues. The system has three components uniquely combined into a comprehensive tool: a multi-nozzle head that allows application of different materials simultaneously with varying viscosities and chemistries (and carrying live cells), a high velocity/high precision x-y-z stage to accommodate the most rapid speeds allowable by the materials to be printed, and a methodology that borrows well-developed methods from traditional rapid prototyping to achieve higher complexity 3D bioprinting.

Figure 1 shows the completed 3-D BioPrinter, while Figure 2 shows printed endothelial cells with the bright dots indicating live cells having survived the printing process. Finally, a hollow diamond test structure on its tip was manufactured on the BioPrinter and is shown in Figure 3.

Charge Assisted Protein Sensing

Next-generation sequencing is providing a wealth of information about the human genome. However, not all proteins in the genome are actually expressed, so the importance of understanding the biological interactions of such proteins is becoming increasingly important. Two-dimensional gel electrophoresis and mass spectrometry are the current technologies of choice, but new technologies are needed to allow label-free analysis of proteins in physiological environments. CMI is developing a new technology that takes advantage of extremely well developed silicon technology that now can make arrays of high-gain sensors with dimensions comparable to single biomolecules (5-20 nanometers). Such devices can be configured to be an analysis tool that senses the charge configuration of individual biomolecules while carried in ionic media through small synthetic pores. This technology could potentially serve to deepen our understanding of biochemical interactions and pathways to elucidate mechanisms of normal and disease states.



Scanning electron micrograph of a pore.

The push to use increasingly smaller biological samples for analysis is driving innovation towards high analytical sensitivity; the ultimate sensitivity being at the single molecule level. Single molecule analysis techniques such as atomic force microscopy, optical tweezers, fluorescence resonance energy transfer (FRET), other types of single molecule spectroscopy (e.g. fluorescence anisotropy), and surface plasmon resonance (SPR) have been providing direct access to biomolecular information. These techniques determine characteristics of molecules without statistical ensemble averaging, including their associated distribution functions and possible subpopulations. Techniques such as nuclear magnetic resonance (NMR) and x-ray crystallography have complemented the dynamic techniques' results with structural information. These single molecule technologies have supplied information about concentrations, structure-function relationships, and interaction kinetics of biological molecules; key requirements for modeling cellular organization and temporal dynamics.

Existing single molecule techniques have several shortcomings, including the fact that they do not allow study of the analytes in their native environment, are not high throughput, are expensive, and are labor-intensive. With current techniques, the molecules of interest must be labeled with a probe (e.g. fluorescence), be crystallized (e.g. x-ray crystallography), or be bound to a surface (e.g. AFM, SPR, optical tweezers). Researchers are careful to minimize the effects of these modifications, but an ideal method would allow study of single molecules without modification in solution phase. Although NMR does allow study of unlabeled molecules in solution, it is limited by the size, purity and concentration of the target molecule. Moreover, the methods developed to study the biophysical properties of single molecules are limited in both their throughput capability and spatial resolution. With the human genome project completed and low cost sequencing on the horizon, a need exists for higher throughput technologies to study the proteome at the single molecule level. This will require parallel methods that are scalable and affordable.

To address these technological shortcomings, CMI is developing a semiconductor nanopore sensor array technology that will enable the high-throughput study of single molecules in solution. It is based on a novel design of integrated FET sensors and microfluidics. Figure 4 shows a scanning electron micrograph image of a pore fabricated for this project. In 2012, CMI received a competitive award from the United States National Science Foundation to develop this technology over three years.

Automated Injection Under Vacuum

Fraunhofer CMI developed a new system for filling and injection of components under vacuum conditions and lower injection pressures. Vacuum can be an important environmental factor for many applications to avoid entrapped air, especially at lower injection pressures required for delicate components. Entrapped air can cause material defects or visible occlusions in the component. The new Fraunhofer system eliminates these issues by enabling filling under vacuum at less than 1 Torr.

The system incorporates an X-Y positioning system to allow an operator to load the machine with a rack of components to be filled. The travel of 200 mm by 180 mm permits a large number of components to be processed in one batch, limited only by component size. After the chamber is pumped down, the system sequentially processes each component. A Z-axis drive engages a fill port on each component and then injects with a positive displacement syringe pump. After all the components are processed, the chamber is vented so another rack can be loaded into the machine and processed in quick succession.

Process parameters, including injection speed, pressure, volume, and dwell are completely customizable to allow a large viscosity range of materials to be processed. Process parameters are stored in recipes which can be recalled by the operator from a menu system to suit different products or components being processed. Data is collected in real-time from each fill and logged for quality control or evaluation.

The system was designed for high reliability in a vacuum environment. All heat generating components are located outside the vacuum chamber. Servomotors for driving the X-Y system, for instance, are located in-air for cooling but coupled inside the chamber with rotary ferromagnetic feedthroughs, while Z axis translation is coupled through a metal bellows seal.

CMI Internship Program

CMI's internship program continues to thrive, providing a global experience to 12 European 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 on all these technologies, please visit:
www.fhcmi.org

Fraunhofer Center for Manufacturing Innovation

Dr. Andre Sharon, Executive Director
Tel: 617 353 8776
asharon@fraunhofer.org

Fraunhofer CMB's plant-based production platform advances

With the addition of cGMP manufacturing capability and the successful completion of two Phase I clinical trials, Fraunhofer CMB's plant-based, protein production technology achieved several important developmental milestones. The advancement of FhCMB's work, as measured by the US Dept. of Defense, has evolved from Level 1- Basic technology research, through proof of feasibility, technology development and demonstration to level 8 – System and subsystem development, which has made CMB eligible for new funding from various government departments including the National Institutes for Health. This is a major accomplishment which both externally validates CMB's innovative technology and enables the organization to move closer to the goal of improving sustainability of its programs.

CMB's plant-based product development continues

H1N1 Influenza Vaccine

CMB confirmed interim results from the first human trial of plant-produced H1N1 influenza vaccine (HAC1) that began 13 September, 2010 and ended 5 May, 2011. This Phase 1, single-blind, placebo-controlled, dose-escalation study was conducted to assess the safety and immunogenicity of CMB's HAC1 influenza vaccine. The trial was supported by funding from the Defense Advanced Research Projects Agency (DARPA) and was conducted at the Walter Reed Army Institute of Research Clinical Trials Center (WRAIR-CTC). Safety and assessments were completed at WRAIR-CTC and immunogenicity evaluation was performed by the Influenza Division of the Centers for Disease Control and Prevention.

The final analyses confirmed results of the 2 June, 2011 announcement of the safety and immunogenicity of the HAC1 vaccine which was found to be safe and well tolerated at all dose levels, with or without adjuvant. There were no reported serious adverse events or dose-limiting toxicities. No subjects withdrew from the study as a consequence of an adverse event. The analyses also showed that the HAC1 vaccine elicited high levels of immune responses which correlated directly with the amount of antigen administered when the vaccine was not adjuvanted. The immune response was the highest in subjects who received the non-adjuvanted highest HAC1 dose which was comparable with the immune response of the licensed, control H1N1 vaccine.

Malaria transmission blocking vaccine

Collaboration with Imperial College, Radboud University, Ehime University and the National Institute of Allergy and Infectious Diseases (NIAID) has resulted in the successful completion of pre-clinical studies and all filings have been completed as required. The project's Scientific Advisory Board selected a target candidate to move forward into clinical trials. A pre-IND meeting was held in the spring and a cGMP 50 kg product run was completed to provide material for clinical trials. The toxicity study was completed in late December and the clinical trials will be conducted in partnership with PATH/Malaria Vaccine Initiative.

Anthrax vaccine

CMB was awarded its first contract from the NIAID, part of the National Institutes of Health, for developing vaccine technologies to advance the next generation of Anthrax vaccines. The contract will support the advanced development of candidate vaccine components and technologies that enhance immune responses for developing a vaccine that require fewer doses then current vaccine against Bacillus Anthracis.

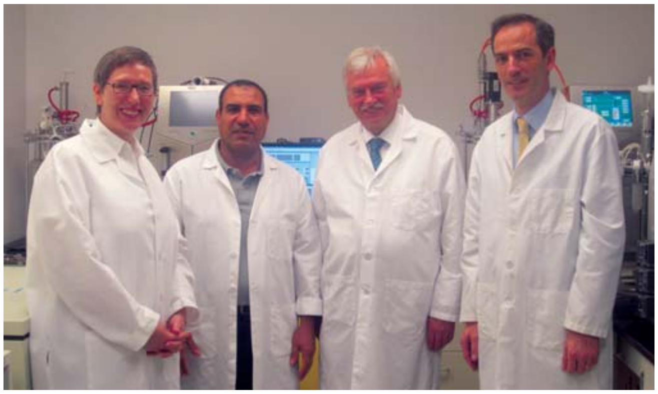
Most disciplines within Fraunhofer will play a part in successfully completing the deliverables as outlined in the contract, from biomass generation, to agro infiltration and protein purification, formulation development and stability, pre-clinical activities, pre-IND activities and IND submission, and ending with the option to conduct a Phase 1 clinical trial.

Yellow fever vaccine

CMB and iBio, Inc. have entered into a collaborative research agreement with the Brazilian Ministry of Health through Bio-Manguinhos (Fiocruz) to develop a plant-based yellow fever vaccine candidate for potential production in Brazil. 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. Initial target candidates have been evaluated and a target has been selected for further evaluation and commencement of pre-clinical studies. Pre-clinical studies are currently in progress at Bio-Manguinhos.

Ebola Reagents

Ebola and Marburg viruses, members of the Filoviridae family, are threat agents with the potential to be used as biological weapons. There are significant efforts and resources dedicated to developing countermeasures against filoviruses. One



Fraunhofer Gesselschaft (FhG) officials visit CMB. *L to R: Dr. Gabriela Schumann, FhG Research Planning-Life Sciences, Dr. Moneim Shamloul, CMB Group Leader for Fermentartion & Expression, Dr. Ulrich Buller, Senior VP for Research Planning, FhG and Joan Bosch, Budget Director, FhG*

limiting factor in advancing this important area of research and development, however, remains the availability of much needed protein reagents.

By the end of December 2012, Fraunhofer successfully met the objectives of this contract which were to engineer and establish a sustainable source for producing glycoproteins from ZEBOV, SEBOV and MARV strains of filovirus, as well as three full-length monoclonal antibodies. In collaboration with United States Army Medical Research Institute of Infectious Diseases, Fraunhofer delivered qualified and well characterized reagents to advance research and clinical development for prevention, early detection and treatment purposes for the Ebola and Marburg viruses.

Hookworm Vaccine

CMB is performing process development work for the Sabin Vaccine Institute to improve the purification method for the hookworm antigen. CMB is also performing clearance studies required by the FDA to support Sabin's IND for their Phase I clinical study.

Collaborations and Partnerships

University of Delaware – Fraunhofer USA CMB - State of Delaware Partnership

Technology Summit

An important part of the University of Delaware-State of Delaware partnership signed in 2011 is the exchange of ideas and development of possible research collaborations between researchers from the University and Fraunhofer. To facilitate this exchange, planning began in 2012 for the first Fraunhofer- University of Delaware Technology Summit. Scheduled for October, 2012, the summit was postponed until March, 2013 due to Superstorm Sandy's devastating impact on the mid-Atlantic region of the United States.

Titled "Energy and Life Science – Solutions for Sustainability," the summit will bring together faculty from the Univ. of Delaware and various Fraunhofer Institutes that are making significant advances in their fields of research. The summit will also include representatives from several U.S. government agencies and from major businesses in the two sectors. The goal of the summit is to develop working relationships that will result in development of new funding opportunities for both partners.

Fraunhofer CMB –University of Delaware Collaborative Research Projects

In another effort to develop closer collaborative research links and leverage the strengths of both institutions that will lead to new funding opportunities, CMB and the University of Delaware are working on several collaborative research projects. Seed funds have been provided both by Fraunhofer and the Univ. of Delaware/State of Delaware Center for Advanced Technology (CAT) program. The projects are: Bioinformatics optimization for recombinant protein expression for vaccines and therapeutics, and Enhancement of TMV – based vaccine expression in Nicotiana benthamiana by altering cell to cell movement capacity and efficacy and stability testing of biologics in novel, biologically inspired matrices.

Fraunhofer –PATH Bend Research

Bend Research Inc., PATH, and Fraunhofer CMB, in collaboration with PATH and Bend Research, Inc. are working together to develop a new technology for the production of thermostable vaccines. Utilizing novel formulation and spray-drying processing methods, the technology has enabled scientists at Bend Research, PATH, and CMB to develop a spray-dried influenza vaccine product that is stable at 50°C for over 2 months. The technology can also be applied to emerging influenza and other vaccines.

Thermostable influenza vaccines hold promise for improving the pandemic preparedness of national immunization programs by extending product shelf life, decreasing the cost of

CMB researchers, Lauren Douglas and Megan Coffin present their work at "New Cells, New Vaccines VI: Target to Market"

Dr. Vidadi Yusibov, Executive Director of CMB and Delaware Governor, Jack Markell.

vaccine stockpiling, and easing the deployment of vaccines against pandemic influenza strains in the United States or developing countries. Thermostable vaccines can also help to ensure vaccine potency in remote areas of the world with limited to no electricity for cold chain refrigeration.

Spray-drying processing methods are well-established for the development and manufacture of pharmaceuticals and dry food products but have rarely been applied to vaccines; until now. The next phase of technical work for the Bend Research Inc., PATH, and FhCMB partnership includes developing a commercially viable process for producing thermostable influenza vaccines using this breakthrough technology.

All research activities under the partnership are supported with a grant from the Defense Threat Reduction Agency of the United States Department of Defense and leverages earlier proof-of-concept work advanced by PATH.

Fraunhofer CMB – Fraunhofer ITEM

Working with technology originally developed by Fraunhofer Institute for Toxicology and Experimental Medicine (ITEM) in Hannover, Germany, CMB is adapting the ITEM technology specifically for vaccine development. The objective of the project is to develop and establish a cost-effective, high throughput, ex-vivo, lung tissue-based system for evaluating vaccine safety and immunogenicity directly in human tissue.

PCLS (Precision Cut Lung Slices) could potentially be an alternative to animal models for evaluating product safety. This undertaking will be useful in enhancing and accelerating CMB's ability to characterize vaccines and therapeutics in humans as well as to reduce the time and cost of developing products. CMB has received funding for the project from the Defense Threat Reduction Agency to move forward on research and development efforts in collaboration with Fraunhofer ITEM.

The three year contract will address one of the largest obstacles in the current system of evaluating vaccine safety and immunogenicity - the lengthy testing in animal models that precedes clinical drug development. By some estimates, as many as 30% of potential new drugs never move on to clinical trials because results of animal testing are not predictive of human response.

Fraunhofer CMB - Fraunhofer IME

CMB was granted a Fraunhofer USA Special Funds grant to work with Fraunhofer IME on the development of immunotherapeutics for the treatment of rheumatoid arthritis. The immunotherapeutic of interest is a toxin fused with a monoclonal antibody fragment. The goal of the project is to engineer and test a recombinant immunotoxin made in plants using CMBs methodology. Recently the target molecule has been produced in plants and purified. In vitro analysis suggests that the molecule binds cellular receptors and has the required enzymatic activity to be active. The next step is to determine that activity of the target molecule in vivo.

Staffing, Educational Support and Outreach

At the end of December, CMB had 93 employees including

77 full-time employees and 16 part time employees. The Center has 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.

German Interns

Mr. Thomas Wolfhart from the University of Fulda, was the first German student to intern in the Quality department and he performed a critical role in several key compliance programs to support the Quality Assurance section, including supplier/service provider qualification, metrology, standard operating procedure development, and identification of raw material specification attributes. His role was focused on developing and/or assisting in the process of revising these compliance programs and this required him to communicate with personnel from other departments.

Lisa Blaschke, from Hochschule Mannheim, worked in the Center's Fermentation and Expression group under the direction of Dr. Moneim Shamloul. The title of her work, which will be the basis for her Master's Thesis, was "Evaluation of Agrobacterium-infiltration efficiency using the GFP reporter gene and Confocal Microscopy"

Working under the supervision of Dr. Tarlan Mammedov in the Technology Development group was Kristina Herschbach, an Applied Chemistry and Biotechnology student from Hochschule Niederrhein. Ms. Herschbach worked on comparing plant produced glycosylated and non-glycosylated forms of PA83 and 48F1.

Finally, Ms. Marion Schwamborn worked in the Center's Assay Development Group under the direction of Dr. Tatiana Golovina. Her work included measurement of alpha-anti-trypsin and alpha-galactosidase activity, isolation of peripheral blood mononuclear cells (PBMC) from human buffy coats and isolation and characterization of monocytes form human PBMCs, developing the protocol for cattle sera acid treatment and also for intracellular protein staining in plant protoplasts.

Delaware Governor's Biotechnology Scholarship

Initiated by Fraunhofer CMB in 2006 as scholarship support for young scientists pursuing studies in the life sciences at Delaware institutions of higher education, the program has provided awards to more than twenty young scientists who plan to pursue studies in the life sciences and biotechnology. 2012 winners were Miss Alexa Bennett of Delaware Technical Community College and Mr. Roderick King from Delaware State University. CMB lead fundraising efforts in the State's biotechnology community to support the scholarships and organized the annual awards luncheon where Delaware Governor Jack Markell honored the students and recognized their academic and personal accomplishments.

The program's advisory committee met and recommended to refine the program in 2013 by targeting support to students working on undergraduate research. The revised program, a research fellowship, will support summer research activities of biotechnology students at the University of Delaware, Delaware Technical Community College and Delaware State University.

New Cells, New Vaccines VI: Target to Market

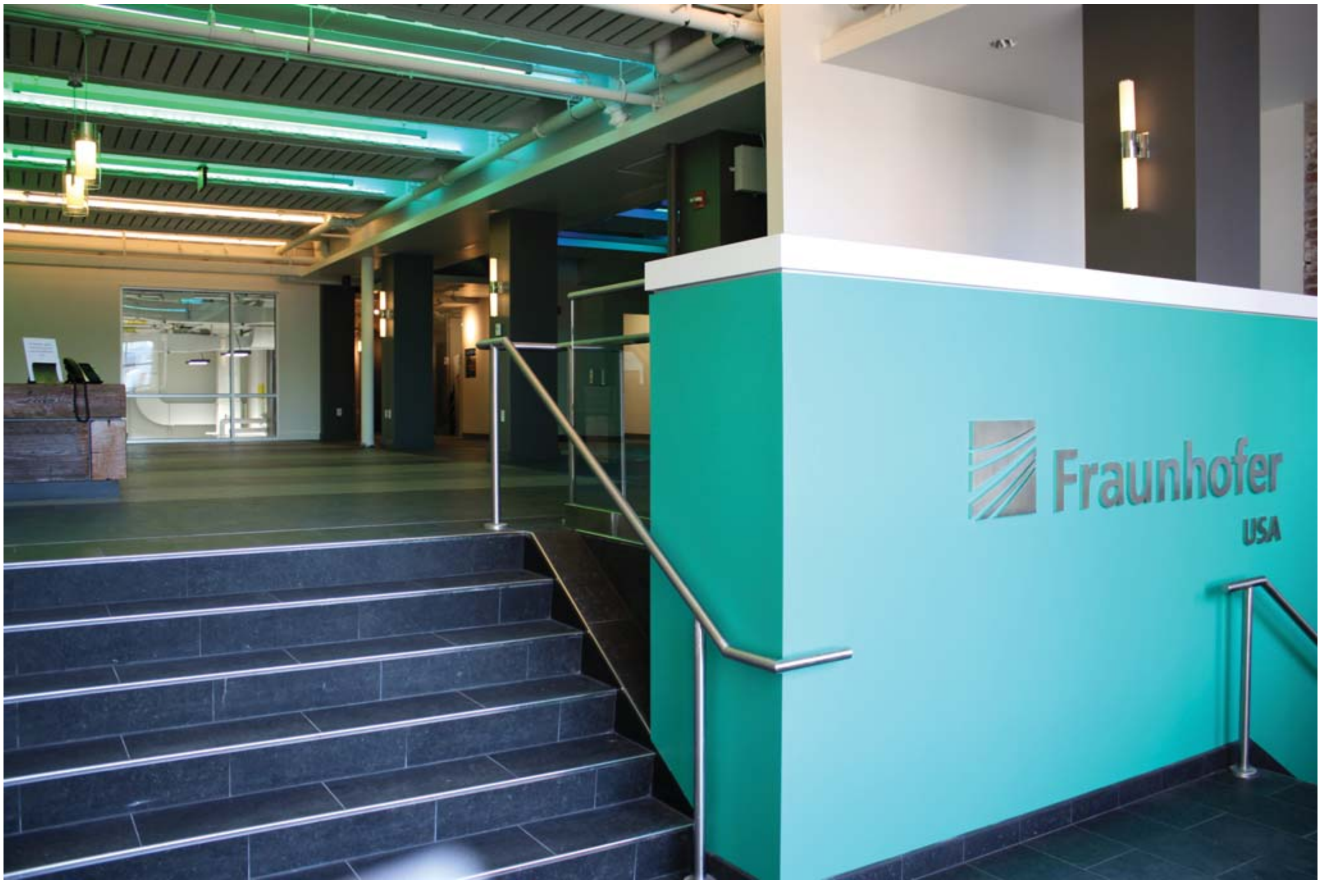
New technologies to produce vaccines more safely, quickly and economically than traditional approaches were presented and discussed at the seventh New Cells, New Vaccines conference organized by Fraunhofer CMB, conducted in cooperation with the International Association for Biological Standardization (IABS), headquartered in Geneva Switzerland and held at the Hotel DuPont in Wilmington, Delaware.

Leading scientists, business leaders and regulatory agency representatives from around the world gathered at the New Cell meeting to exchange information on bringing life-saving vaccines and antibodies to market more quickly through innovative manufacturing processes. At the meeting, participants shared how these advances in technology significantly impact responsiveness to life-threatening infectious disease epidemics and bioterrorism threats and how they can best be used to improve human health around the world.

For more information on all these technologies, please visit:
http://www.fhcmb.org

Fraunhofer Center for Molecular Biotechnology

Dr. Vidadi Yusibov
Tel: 302 369 1708
vyusibov@fraunhofer-cmb.org



The lobby of the Building Technology Showcase will feature an interactive exhibit area and partner showcase dedicated to innovative building systems and materials.

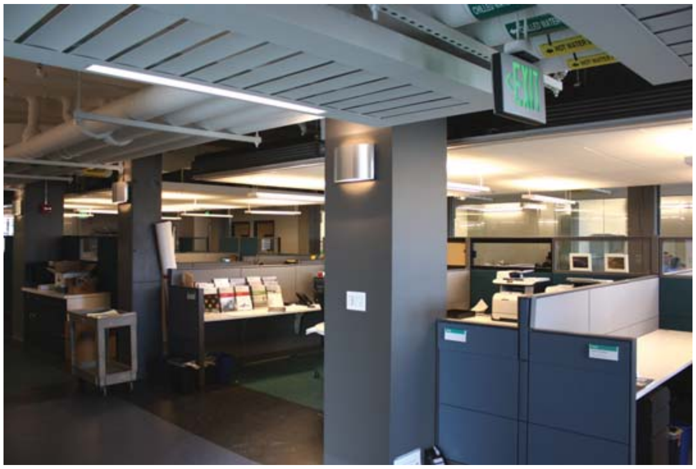
The Fraunhofer Center for Sustainable Energy Systems (CSE), located in Boston, Massachusetts, provides collaborative technology research and development services for the solar photovoltaics (PV), building technology, and distributed electrical energy systems sectors, as well as offering start-up and technology commercialization expertise for promising early-stage companies through its TechBridge program. In recent years, CSE has developed a center of excellence in Massachusetts, with staff recognized as leaders in a number of key technology spaces. During this time, CSE has also been an active contributor to the growth of New England's clean energy economy, providing dozens of jobs and job training opportunities, fostering the development of local cleantech start-ups, and advising state government on energy policy and climate change.

Building Technology Showcase

In 2012, CSE and its partners began renovating a 100-year-old building in the Boston Innovation District to serve as the Center's permanent home in Massachusetts. In addition to providing laboratory and office space for Fraunhofer CSE's scientific teams, the Building Technology Showcase is intended to demonstrate the feasibility of deep energy retrofits in historic building stock. The building will also act as a testing environment for advanced building technologies, both in CSE's laboratories and in the actual building itself.

The Building Technology Showcase leverages over $3M in energy-saving materials, components and systems donated by partners across the building value chain; these include leading manufacturers and suppliers such as Siemens, Philips, Dow Corning, DuPont, and ThyssenKrupp. Among other things,

The historic property that now houses Fraunhofer CSE's headquarters had previously been slated for demolition. To rescue the property, CSE leveraged support from property developers, members of the building industry, and state and federal government agencies. Image courtesy of Kathy Chapman/ThyssenKrupp Elevator Americas.



A deep energy retrofit has transformed the 100-year-old building into a modern, energy-efficient office space.

the building features energy-efficient heating, ventilation, and air conditioning (HVAC); a synergy elevator with regenerative braking technology; advanced insulation solutions like vacuum insulated panels (VIPs); and extensive use of LED lighting.

Additional energy savings are realized through the use of a central building management system that can adjust lighting, heating, cooling, and other essential building services based on expected occupancy levels. This is supplemented by continuous commissioning, which monitors energy consumption over time and can advise building managers on potential problem areas based on data anomalies. Detailed 'dashboards' make it possible to track energy usage on a system-by-system basis providing managers and researchers, with a wealth of real-world data.

The building also features a lobby exhibit area that uses interactive displays and novel technology such as augmented reality (AR) to educate visitors on the energy-efficient systems and measures found within the building. A dedicated conference room serves as a venue for seminars, workshops, and public presentations from CSE and its partners.

Plug-and-Play PV

In December 2012, Fraunhofer CSE was awarded an $11.7M project through the US Department of Energy's SunShot Program, a collaborative national effort to make solar energy cost-competitive with other forms of energy by the end of the decade. The grant will support a 5-year research project focusing on the development of plug-and-play solar PV systems that can be purchased, installed, and connected by homeowners without the need to engage outside consultants or contractors.

Under the scope of the DOE grant, Fraunhofer CSE will develop technologies, components, systems, and standards that reduce the cost and complexity of residential solar PV deployment. To this end, CSE will leverage its R&D capabilities in photovoltaics, building energy efficiency, and distributed electrical energy systems. The project also draws on a multidisciplinary team of equipment manufacturers, utilities, local governments, universities, and research institutions.

This project is part of a larger DOE investment into technology solutions that reduce the "soft" costs of residential solar PV systems – the non-hardware costs such as permitting, inspection, and interconnection that now account for a majority of the total cost of residential PV, and that represent a significant barrier to the wider adoption of solar power in the United States.

CSE Managing Director Nolan Browne (right) with Cambridge Mayor Henrietta Davis (center) and featured guests at the opening of Das Haus, a travelling showcase of building efficiency concepts, at MIT. Image courtesy of GACC.

CSE Scientific Director Christian Hoepfner (left) discusses the Center's research programs with Peter Ammon, Germany's Ambassador to the United States.

Solar modules undergo testing at OTF-1 in Albuquerque, NM

The Photovoltaic Durability Initiative (PVDI)

First announced in 2011, PVDI is a joint venture between Fraunhofer CSE and its German sister institute, the Fraunhofer Institute for Solar Energy Systems (ISE). PVDI aims to reduce the risks and costs involved with PV investment by providing installers, manufacturers, and financiers with better lifetime and durability data. The goal of this initiative is to create a durability assessment protocol that can form the basis of a new international industry standard, one that makes it easier for PV companies to secure the funding needed to advance production and installations.

PVDI's accelerated test protocols go beyond existing standards for module performance and safety; they range from mimicking winter wind stress via low-temperature dynamic loading to simulating hot, dry climates by exposing PV modules to high temperatures and ultraviolet radiation. The tests also include more typical stresses such as temperature cycling, humidity-freeze, and damp heat exposure. Going beyond simple pass/fail ratings, a quantitative scoring system provides a way to rank modules based on their durability.

PV modules may be submitted to PVDI testing by module manufacturers, project developers, and other stakeholders in the PV industry interested in a more comprehensive picture of module performance and reliability. Manufacturers of modules tested through PVDI can opt into revealing the identity of their tested modules, enabling the public to compare their products to others available in the market. The first round of PVDI testing was completed in 2012; the second round of testing will be finished in the summer of 2013.

TechBridge

Technology risk and uncertainty are key challenges for cleantech startups. Fraunhofer CSE's TechBridge program breaks down these barriers by giving innovative startup companies access to the applied R&D and technical resources of the Fraunhofer Society. In addition, TechBridge works closely with investor and industry partners to provide client companies with important sources of capital and channels to markets. To date, TechBridge portfolio companies have raised over $30 million in follow-on funding.

In 2012, TechBridge provided funded service awards to 20 promising early stage start-ups, including $85,000 in awards given out through U-Launch, a grant program supported by the US Department of Energy's Innovation Ecosystem initiative. TechBridge also partnered with the Clean Technology & Sustainable Industries Organization (CTSI) to provide $100,000 in pilot project awards through the Utility Technology Challenge, a national competition that matches promising clean technology solutions with utility and industry partners. Three pilot awards were given out, supported in part by a $50,000 contribution from the Ewing Marion Kauffman Foundation.

Building America

For the past fifteen years, the US Department of Energy's Building America program has drawn on researchers, industry, and the US national lab system to develop and demonstrate market-ready solutions for builders and homeowners that improve durability, comfort, and energy efficiency.

In the summer of 2010, a Fraunhofer CSE-led research team was selected to join this program, investigating technologies and methods that could dramatically increase the scale and depth of home energy efficiency retrofits in the United States. CSE's cross-disciplinary team ultimately drew on 33 partners from across the building value chain, ranging from materials and systems manufacturers like Owens Corning and Mitsubishi Electric to builders, developers, architects, research institutions, and municipal governments.

By the end of 2012, CSE had completed close to a dozen Building America research projects, focusing on subjects as diverse as innovative insulation solutions in cold-climate homes and psychological barriers to the widespread adoption of home energy displays. The results of these projects have since been released into the public domain by the Department of Energy and Oak Ridge National Labs (ORNL).

OTF-1

In 2012, Fraunhofer CSE officially opened Outdoor Test Field 1 (OTF-1), its outdoor solar test site in Albuquerque, New Mexico. The new facility provides performance and durability testing services such as analysis of individual modules and components, strings, or grid-tied systems; stabilization with continuous monitoring under open circuit, short circuit, and/or max power point conditions; and inverter DC/AC power conversion analysis. These capabilities complement existing testing and certification capabilities offered through the co-located CFV Solar Test Laboratory, a joint venture between Fraunhofer CSE, Fraunhofer ISE, CSA International, and the VDE Testing and Certification Institute.

OTF-1's location offers more than 310 days of direct sunshine, a solar spectrum consistent with typical utility-scale PV locations, and a local climate capable of spanning module temperatures greater than 50º C over the course of a single day. To exploit these conditions, the site is equipped with both variable-angle mounting racks and dual-axis trackers. Micro-inverters, string inverters, continuous curve tracers, and state-of-the-art data acquisition and weather monitoring round out the capabilities.

Support for Education

Fraunhofer CSE's industry-facing Fellowship Program is designed to give young scientists, engineers, and business professionals impactful project experience in areas such as PV technologies, building energy technologies, distributed electrical energy systems, and technology commercialization.

To date, CSE has provided opportunities for more than 90 Fellows, many of whom have gone on to R&D positions in leading energy, science, and engineering firms, as well government organizations like the US Department of Energy's ARPA-E program. Others have built on their training by subsequently pursuing advanced degrees at top universities. Overall, the program enjoys a placement rate of 90 percent, and many Fellows credit their time at Fraunhofer as having played an instrumental role in their professional success.

For more information on these technologies, please visit:
www.cse.fraunhofer.org

Fraunhofer Center for Sustainable Energy Systems

Mr. Nolan Browne, Managing Director
nbrowne@fraunhofer.org

Dr. Christian Hoepfner, Scientific Director
choepfner@fraunhofer.org

Full-HD Voice allows for social interaction that feels like being in the same room ©Fraunhofer

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.

Full-HD Voice: Redefining the Communications Experience

Today, we have grown accustomed to consuming HD content in most aspects of our lives. From TV's, PC's, tablets, video games, home theatres with multichannel sound, and even mobile phones, we expect and get high-fidelity content. The only "white spot" in the HD realm is the humble telephone call, which is still largely tied to the limitations of technologies from the last century. At present, the vast majority of phone calls are restricted to an upper limit of 3.4 kHz, making phone calls sound muffled and behind the times. However, most people are able to hear audio signals up to much higher frequencies, 14 or even 20 kHz, meaning that we are missing at least three quarters of the audible spectrum. The result is speech that is often hard to understand, can even lead to misunderstandings, especially when talking in a foreign language where intelligibility of every phoneme is important, and requires frequent spelling. It is not suitable for music and sounds, and can't really relay an "ambience." Recently, some operators took notice of this shortcoming and worked to improve the call quality for their customers by implementing "HD Voice," using, for example, AMR Wideband (AMR-WB) or G.722. While these emerging HD Voice services provide better quality – the audio bandwidth is around 7 kHz - than our current narrowband phone calls, it still does not come close to matching the quality consumers experience daily with their digital media. In addition, the speech codecs used in mobile telephony are only optimized for generic speech signals and cannot deliver high fidelity audio for music and ambience sounds. As a result, consumers generally agree that music, and even speech, are not really acceptable, especially over mobile phones. For example, the problems associated with differentiating the letters "f" and "s" or "b" and "g", and the resulting "spelling bees".

Introducing "Full-HD Voice"

At Mobile World Congress in Barcelona earlier this year, Fraunhofer IIS introduced Full-HD Voice as a new level of quality for phone calls. Full-HD Voice will finally bring telephony into the 21st century, on par with our quality expectations for digital media. Full-HD Voice creates a natural communication experience, allowing telephone calls to sound as clear as talking to someone in the same room, including the ambience. When making a call from a beach vacation to friends and family, why should the waves and birds in the background sound less real than when recording them with a camcorder? The improved intelligibility and fidelity is possible because Full-HD Voice quadruples the audio spectrum of regular phone calls.

The MPEG audio codec Enhanced Low Delay Advanced Audio Coding (AAC-ELD) is a perfect example of a Full-HD Voice audio codec. It was developed to deliver low bitrate, low coding delay phone calls, offering a perceptually transparent speech and audio quality. The AAC-ELD codec is optimized for bitrates from 24 to 64 kbit/s, which is even lower than landline narrowband calls using G.711, and features an algorithmic delay down to 15 milliseconds. It supports the full audible audio spectrum, up to 20 kHz if desired, and reproduces music, speech and ambient sounds equally well, enabling completely new services and communications experiences.

The audio quality of AAC-ELD has been evaluated in several independent tests comparing it to other codecs including: G.718, G.719, G.722.1, Annex C (Siren 14), G.722.2 (AMR-WB), G.722, Silk, Speex and CELT. In these tests, AAC-ELD was found to deliver excellent quality at lower bit-rates compared to the other codecs under test. Additionally, AAC-ELD can produce high quality audio consistently, even under poor network conditions. The codec has the capability to adapt to changing bitrates and can manage transmission errors efficiently.

As a result, AAC-ELD enables phone services to perform at the same level of fidelity that consumers have come to expect in today's Full-HD world. Only Full-HD Voice allows the delivery and exchange of music (e.g. music on hold, ring back tones), sounds and "ambience" in Hi-Fi quality, thus enabling new services such as integrative music, rich live chat or augmented audio for gaming.

Millions of phone calls are already taking place in Full-HD Voice quality. For example, Apple's FaceTime and most video and teleconference systems from companies such as Cisco and Tandberg already make use of Fraunhofer's Full-HD Voice capable audio codecs. Google recently added AAC-ELD encoding and decoding to the latest version of it's Android operating system, Jelly Bean 4.1. In the near future, consumers might be able to use cross-platform Full-HD Voice applications on the majority of mobile devices.

Implementing Improved Communication

The Full-HD Voice codec AAC-ELD is available as product ready software from Fraunhofer IIS for all major platforms. This allows efficient and straightforward integration into communications applications, such as VoIP, videoconference or telepresence systems. HE-AAC multichannel and AA-ELD encoding and decoding are part of the new Fraunhofer FDK AAC codec library for Android and replaces the previous AAC and HE-AAC software. It is included in Android since version 4.1 and delivers open source Fraunhofer implementations of the ISO MPEG audio codecs AAC, HE-AAC, HE-AACv2, and AAC-ELD to the Android community.

Summary

As the communications industry continues to make major improvements to their networks, including low latency all IP networks such as LTE, and devices, Full-HD Voice is the next, natural step to bring telephony on par with the quality level of state-of-the-art digital media. Compare the codecs firsthand, listen to the differences between "classic" telephone quality, HD Voice and Full-HD Voice by visiting: www.full-hd-voice.com

Fraunhofer at Industry Events and Tradeshows

In 2012, 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 2012 was the insertion of Fraunhofer technologies in Android and application standard bodies for video streaming and Full HD voice communication. 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 in San Francisco, the NAB Broadcast and CEA Consumer Electronics Shows in Las Vegas and the NAMM Show in Los Angeles. Fraunhofer USA also joined a number of application standard bodies such as the DASH Industry Forum and employees of the San Jose office introduced Fraunhofer's audio codecs in various industry specifications.

For more information on these technologies, please visit:
www.fraunhofer.org/DigitalMediaTechnologies

Fraunhofer Digital Media Technologies
Mr. Robert Bleidt,
Division General Manager

Mr. Jan Nordmann,
Director, Marketing and Business Dev.
Tel: +1 408 573 9900
codecs@dmt.fraunhofer.org

About the Fraunhofer Heinrich Hertz Institute

The Fraunhofer Heinrich Hertz Institute is a world leader in the development of mobile and fixed broadband communication networks and multimedia systems. From photonic components and systems to fiber optic sensor systems and high speed hardware architectures, the Heinrich Hertz Institute works together with its international partners from research and industry on the infrastructures for the future Gigabit Society for the international market. At the same time Fraunhofer HHI also develops forward-looking applications for broadband networks with key research foci on 3D TV, 3D displays, HDTV, man-machine interaction through control by gesture, image signal processing and transmission, and use of interactive media.

High-Speed Internet from the Ceiling Lamp

With its "Visible Light Communication," the Fraunhofer Heinrich Hertz Institute HHI has developed a new form of broadband transmission technology – broadband data streams which travel in the visible light from standard off-the-shelf LED lights to the computer or communication-enabled end device.

The HHI opened an office in 2011 with Fraunhofer USA to coordinate collaboration between companies and research institutes in the fields of medical technology, security technology, 3D multimedia, control by gesture, optical sensor technology and also optical wireless transmission. This year, HHI has set a further milestone on the way to high-speed internet from the ceiling lamp. Development of novel components for data transmission over LEDs means that significantly higher bandwidth can now be used in real-time with data throughput rates of up to 3 Gbit/s being reached in laboratory experiments. The newly developed patent protected components have now achieved a transmission of over 1 Gbit/s per single light frequency. As off-the-shelf LEDs mainly use three light frequencies or light colors, speeds of up to 3 Gbit/s are feasible. Development of the components as modules makes them suitable for customized integration in technology developments such as Car-to-X communication. But visible light communication also has a broad array of other possible applications ranging from areas like hospital operating theatres where safety is at a premium, to places like trade shows and factory halls where radio communication is problematic. This new development represents a major step forward towards optical high-speed WLAN.

Johns Hopkins University and Fraunhofer Heinrich Hertz Institute sign Memorandum of Understanding

The Johns Hopkins University (JHU), America's first research university, in Baltimore, MD, and the Fraunhofer Heinrich Hertz Institute HHI, based in Berlin, Germany, have signed a Memorandum of Understanding to jointly research the innovative medical applications of integrated optical sensors: small, highly sensitive devices with disease-recognition capabilities.

Under the terms of this agreement, signed last June at the 2012 BIO International Convention in Boston, Mass., the two entities will study how the technology developed by HHI can be used in the detection, diagnosis and treatment of medical conditions. Johns Hopkins University School of Medicine researchers with clinical expertise in a variety of specialty areas, including oncology and infectious diseases, will collaborate with HHI's scientists and engineers.

Johns Hopkins and HHI are well matched with their medical knowledge and their long tradition of excellence in patient care and research. Their best-in-class abilities will develop new point-of-care clinical tools by fusing Fraunhofer HHI's sensor technologies with Johns Hopkins' clinical experience.

The Fraunhofer Heinrich Hertz Institute offers a broad range of research expertise, from optical communication networks, systems and components, to mobile broadband systems, electronic-imaging technologies and optical-sensor technologies.

The National Science Foundation has ranked Johns Hopkins University as number one among U.S. academic institutions in total science, medical and engineering research and development spending for 32 consecutive years. To date, 36 Nobel Prize winners have been affiliated with JHU, and the university's research is among the most cited in the world.

From left to right:

- *Gregory Bialecki, Secretary of Economic Development, Commonwealth of Massachusetts*
- *Ulrich Gamerdinger, Executive Director, German American Business Council*
- *Lynn Taylor, Senior Vice President Global Government Affairs, EMD Serono Inc.*
- *William Hartman, Executive Vice President, Fraunhofer USA*
- *Peter Ammon, German Ambassador to the USA*
- *Hans-Joachim Grallert, Executive Director, Fraunhofer HHI*
- *Frank Menzler, Senior Director of Sales, Fraunhofer USA / HHI*
- *James Hoyes, President, EMD Serono Inc.*

For more information on these technologies, please visit: www.hhi.fraunhofer.org.

Contact:

Frank Menzler, Senior Director of Sales
Fraunhofer USA - Heinrich Hertz Institute (HHI)
5 Channel Center
Boston, Massachusetts 02210-3400
Tel: 617-714-6529

Officers and Directors

Officers

Dr. Georg Rosenfeld
President

Dr. William Hartman
Executive Vice President

Ms. Erin Simmonds
Treasurer

Mark J. Eby, Esq.
Secretary
Eby, Conner, Smillie & Bourque, PLLC

Directors

Prof. Reimund Neugebauer
Chairman
President of Fraunhofer-Gesellschaft

Prof. Hans-Jörg Bullinger
Vice Chairman
Senator of Fraunhofer-Gesellschaft

Mr. J. Michael Bowman
Chairman and President
Delaware Technology Park

Mr. Marvin Parnes
Associate Vice President for Research
University of Michigan

Mr. Stephen Williams
Regional Vice President for Continental Europe
Lockheed Martin Corp. International

Dr. Brian Darmody
Associate Vice President Research & Economic Development
University of Maryland

Dr. John F. Reid
Director, Enterprise Product Technology & Innovation
John Deere Company

Dr. Dennis A. Ausiello,
Physician-in-Chief
Massachusetts General Hospital

Fraunhofer Partner Institutes

Fraunhofer Institute for Experimental Software Engineering, IESE
Prof. Dieter Rombach, Executive Director
Fraunhofer-Platz 1
67663 Kaiserslautern, Germany
Phone: +49 631 6800 1001

Fraunhofer Institute for Integrated Circuits, IIS
Prof. Albert Heuberger, Executive Director
Am Wolfsmantel 33
91058 Erlangen, Germany
Phone: +49 9131 776-1000

Fraunhofer Institute for Laser Technology, ILT
Prof. Reinhart Poprawe, Executive Director
Steinbachstrasse 15
52074 Aachen, Germany
Phone: +49 241 8906-110

Fraunhofer Institute for Molecular Biology, IME
Prof. Rainer Fischer, Executive Director
Forckenbeckstr. 6
52074 Aachen, Germany
Phone: +49 241 6085-11020

Fraunhofer Institute for Production Technology, IPT
Prof. Fritz Klocke, Executive Director
Steinbachstrasse 17
52074 Aachen, Germany
Phone: +49 241 8904 0

Fraunhofer Institute for Solar Energy Systems, ISE
Prof. Eicke R. Weber, Executive Director
Heidenhofstrasse 2
79110 Freiburg im Breisgau, Germany
Phone: +49 761 4588-5121

Fraunhofer Institute for Material and Beam Technology, IWS
Prof. Eckhart Beyer, Executive Director
Winterbergstrasse 28
01277 Dresden, Germany
Phone: +49 351 83391 3420

Fraunhofer Heinrich Hertz Institute, HHI
Prof. Hans-Joachim Grallert, Executive Director
Einsteinufer 37
10587 Berlin, Germany
Phone: +49 30 31002-427

Fraunhofer USA, Inc.
Headquarters
44792 Helm Street
Plymouth, Michigan 48170
U.S.A.

Frances Roland-Lee, Manager
Corporate Communications
Tel: +734 354 4333

froland@fraunhofer.org

Photo spread on these two pages:

Fraunhofer CMI's hollow diamond test structure. *See page 21.*

For more information, please visit:
www.fhcmi.org

Back Cover:

Fraunhofer CCL-Laser Division develops laser applications technology for the oil and gas industries, alternative energy, automotive and aerospace. *See page 10.*

For more information, please visit:
www.ccl-laser.fraunhofer.org