

ANNUAL REPORT 2014

THE CREATIVE POWER OF LIGHT

Fraunhofer-Gesellschaft

Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded in 1949, the research organization undertakes applied research that drives economic development and serves the wider benefit of society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration.

At present, the Fraunhofer-Gesellschaft maintains 66 institutes and research units. The majority of the nearly 24,000 staff are qualified scientists and engineers, who work with an annual research budget of more than 2 billion euros. Of this sum, around 1.7 billion euros is generated through contract research. More than 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Almost 30 percent is contributed by the German federal and state governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

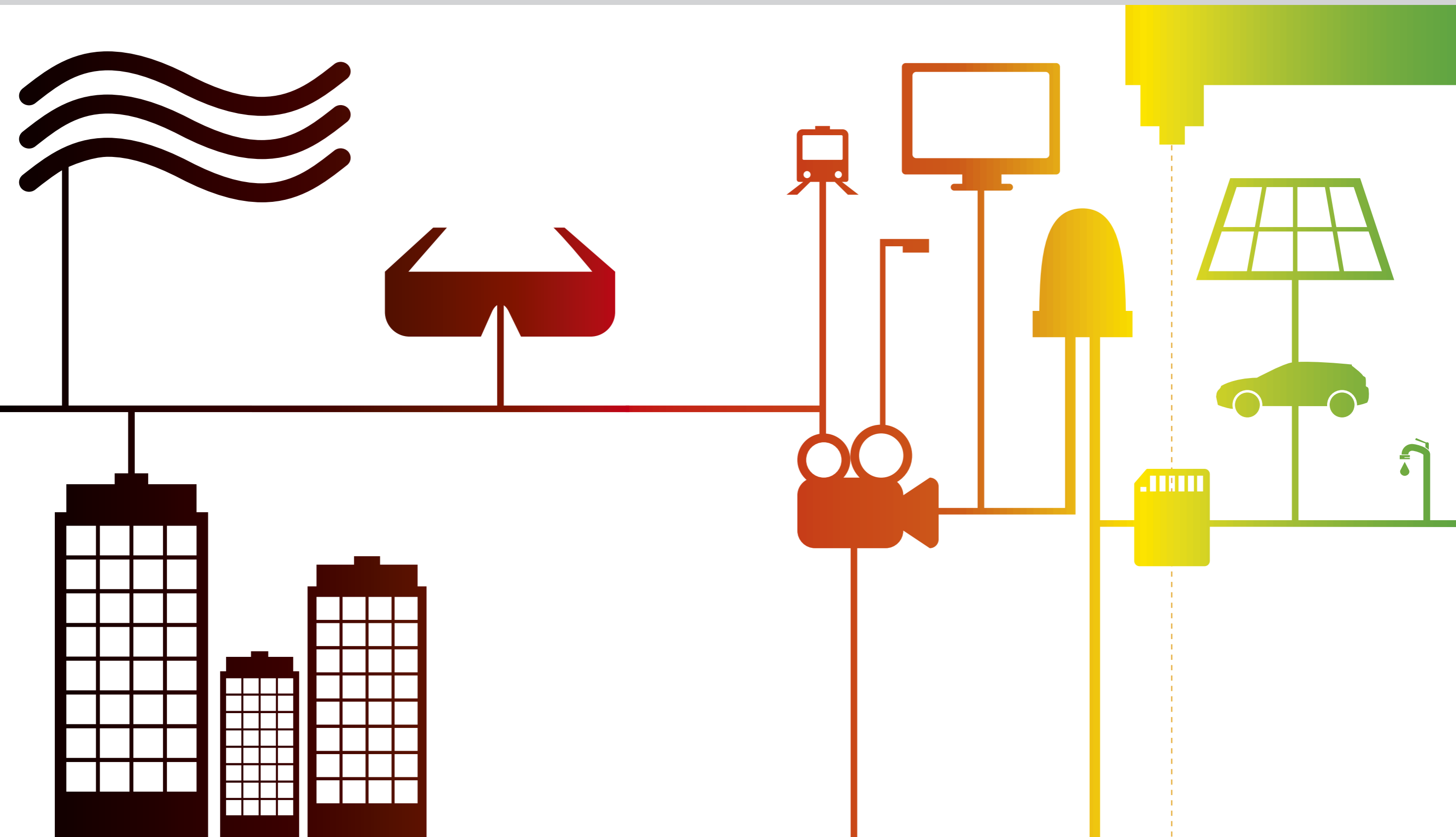
International collaborations with excellent research partners and innovative companies around the world ensure direct access to regions of the greatest importance to present and future scientific progress and economic development.

With its clearly defined mission of application-oriented research and its focus on key technologies of relevance to the future, the Fraunhofer-Gesellschaft plays a prominent role in the German and European innovation process. Applied research has a knock-on effect that extends beyond the direct benefits perceived by the customer: Through their research and development work, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region, and throughout Germany and Europe. They do so by promoting innovation, strengthening the technological base, improving the acceptance of new technologies, and helping to train the urgently needed future generation of scientists and engineers.

As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop the professional and personal skills that will allow them to take up positions of responsibility within their institute, at universities, in industry and in society. Students who choose to work on projects at the Fraunhofer Institutes have excellent prospects of starting and developing a career in industry by virtue of the practical training and experience they have acquired.

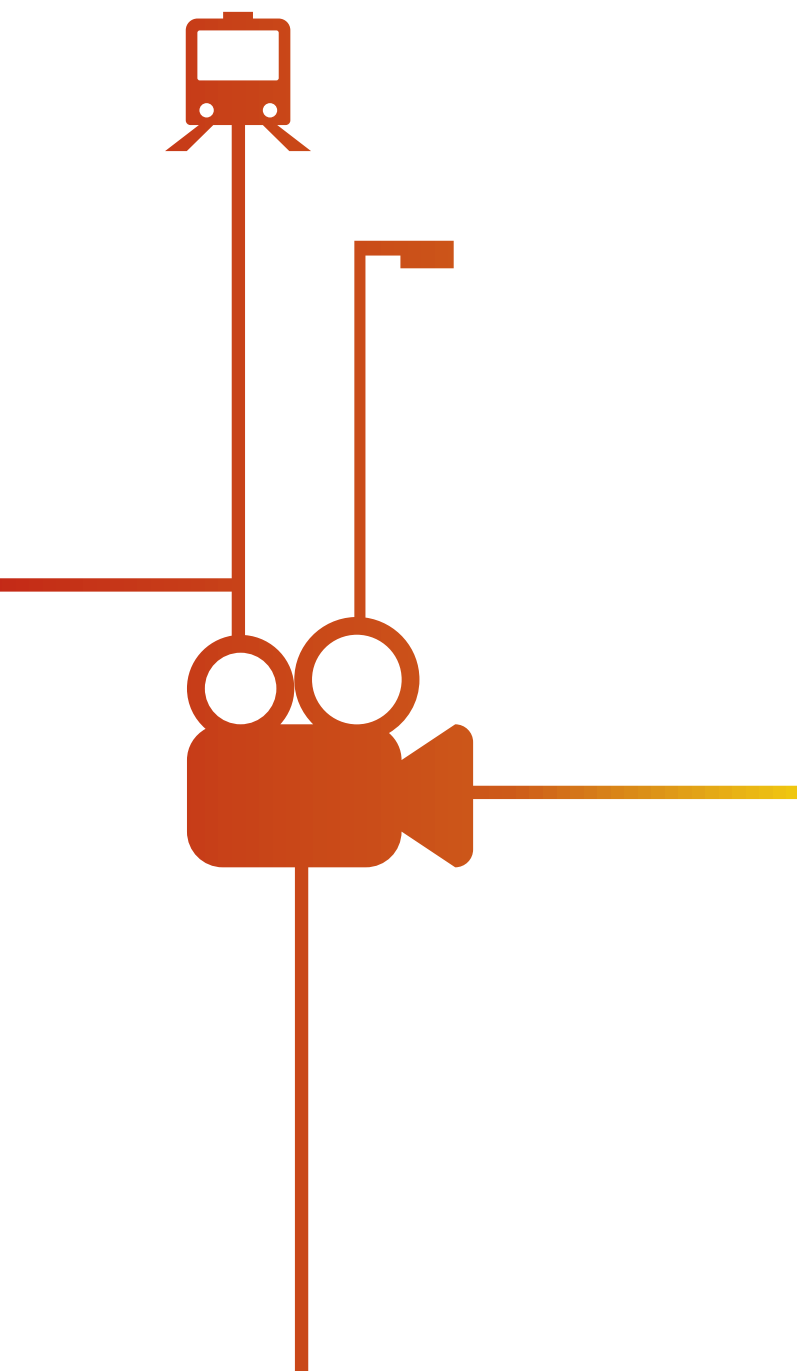
The Fraunhofer-Gesellschaft is a recognized non-profit organization that takes its name from Joseph von Fraunhofer (1787–1826), the illustrious Munich researcher, inventor and entrepreneur.

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Ladies and gentlemen,

2014 was yet another successful year for the Fraunhofer-Gesellschaft. The number of employees rose to nearly 24,000 and the total business volume amounted to over two billion euros, with industrial revenues at their highest-ever level. Our researchers received many prestigious national and international awards, testifying to the high regard in which our work is held by leading representatives of public administration and society.

There is one outstanding reason for this continuing success: Not only do we strive to advance applied science and technologies but also our own organization. In a world in which scientific knowledge, government policies and markets are undergoing constant change, it is Fraunhofer's necessary aim to evolve and seek out new ways forward. In 2014, with this aim in mind, we reorganized our structures and processes so that they can be adapted more easily to these dynamic changes and are more suitable for an organization of our present size. Specific aspects include distribution of areas of responsibility, efficient methods, fundamental policy decisions at corporate level, and targeted portfolio management.

In order to fulfill our mandate of providing industry in Germany and Europe with more immediate access to the innovative power of scientific research, we have stepped up our efforts to acquire contracts for industrial projects. The tasks of the new Executive Board function Technology Marketing and Business Models, which has been entrusted to my colleague Alexander Verl, include offering companies more system solutions based on highly original ideas, and working together with customers to set up large, multidisciplinary joint projects financed by a combination of public and private funding.

With regard to German national research policy, we actively contribute to discussions concerning our key areas of expertise such as digital security, resilient infrastructures, sustainable energy, biotechnology and medical devices. We support the German federal government's new High-Tech Strategy by participating in the associated High-Tech Forum and in the "Innovation Dialog" between the German federal government, industry and science. In this way we aim to play a role in promoting value creation.

The United Nations has proclaimed 2015 as the International Year of Light and Light-based Technologies. It was logical for us to adopt this as the theme of our latest annual report, given that the name of our organization stems from Joseph von Fraunhofer, whose pioneering work in optical research is renowned throughout the world. A further reason is that light-based technologies play a central role in innovations derived from applied research in a wide variety of fields – ranging from test and measurement equipment to production methods and from IT to quality assurance systems. Indeed, one of the feature articles in this Annual Report is devoted to the use of light as an industrial manufacturing tool.

Fraunhofer has a special affinity with the subject of sustainable development. Our researchers have long been devoting their efforts to issues such as combating climate change, conserving natural resources, the transition to renewable energy systems, and technologies to boost efficiency. Another of our goals is to perpetuate an approach to research based on excellence that not only meets the immediate need for application-oriented solutions but also and above all has a durable impact on industrial progress. In 2014, we were the

first non-university research institution in Germany to publish a sustainability report, in which we approach the subject from our specific point of view. This report received high accolades both in Germany and abroad, and has since been widely copied by other organizations.

We owe our success to the skills and motivation of our entire workforce. I would like to take this opportunity to thank them for their outstanding work in the past year, and at the same time to thank our customers, the members of the Senate and the governing boards for their enduring confidence in our work.

Sincerely,

A handwritten signature in black ink, appearing to read 'R. Neugebauer', with a long horizontal flourish extending to the right.

Reimund Neugebauer
President of the Fraunhofer-Gesellschaft



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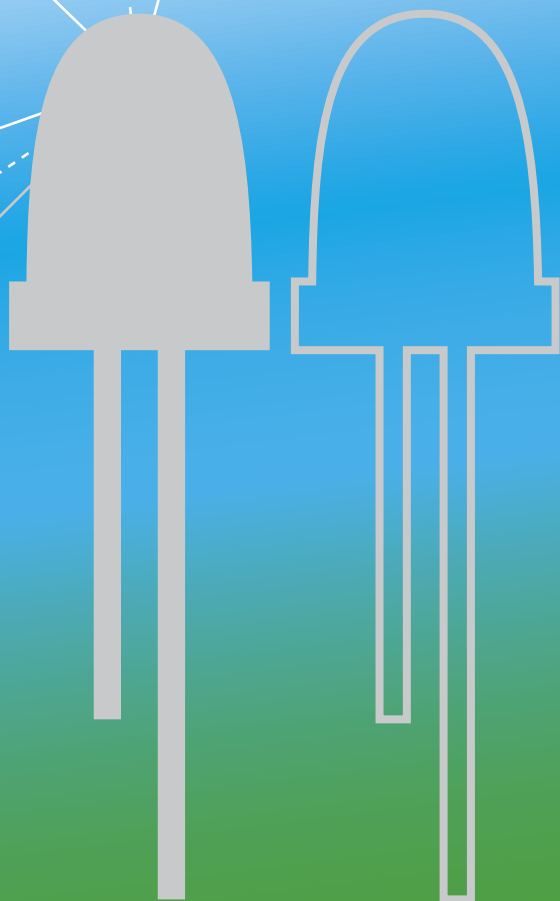
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REPORT OF THE EXECUTIVE BOARD

THE EXECUTIVE BOARD

MANAGEMENT REPORT 2014

**REPORT OF THE SENATE
ON THE FINANCIAL YEAR 2014**



THE EXECUTIVE BOARD





MANAGEMENT REPORT 2014

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Prof. Dr. Alexander Verl

Prof. Dr. Reimund Neugebauer
President of the
Fraunhofer-Gesellschaft

Prof. Dr. Alexander Kurz

Prof. (Univ. Stellenbosch)
Dr. Alfred Gossner

Summary of the Fraunhofer-Gesellschaft's business development in 2014

	2013	2014	Change	
Business volume in € million	2010	2060	+50	+2%
Contract research	1661	1716	+55	+3%
Defense research	114	118	+4	+4%
Major infrastructure capital expenditure	235	226	-9	-4%
Breakdown of expenditure in %				
Personnel expense ratio	50	53	+3	
Non-personnel expense ratio	29	28	-1	
Capital expenditure ratio	21	19	-2	
Contract research funding in € million				
Project revenue	1200	1272	+72	+6%
Industrial revenue	578	618	+40	+7%
Public-sector revenue ¹	622	654	+32	+5%
Base funding ²	461	444	-17	-4%
Sources of contract research funding in %³				
Projects	72	73	+1	
Industry	37	37	0	
Public sector ¹	35	36	+1	
Base funding ²	28	27	-1	
International revenue in € million⁴	250	276	+26	+10%
Patent applications per year	603	564	-39	-6%
Active patent families at year end	6407	6618	+211	+3%
Employees at year end	23 236	23 786	550	+2%

- 1 Public-sector funding includes Germany's federal and state governments, the European Commission and other revenue (research grants, other R&D, non-R&D).
- 2 In 2013, this item included changes in Fraunhofer-Gesellschaft's reserves.
- 3 Funding sources for the operating budget including imputed depreciation of investments (excluding institutions in start-up phase and change in reserve).
- 4 Revenue from work with international customers and partners (including income generated by international subsidiaries with third parties).

STRATEGIC DEVELOPMENT

Business model

Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded in 1949 and based in Munich, the Fraunhofer-Gesellschaft is a non-profit research organization that undertakes **applied research and development (R&D)** in areas of the natural and engineering sciences that are of importance to Germany's economic competitiveness. It currently operates 66 Fraunhofer Institutes and Research Institutions across Germany, whose mission is to develop innovative solutions **of direct benefit to industry and society as a whole**. Fraunhofer's research portfolio covers a broad spectrum of topical areas, which also feature in the German government's latest High-Tech Strategy, including resource-efficient manufacturing, transportation and mobility, energy and housing, information and communication technologies (ICT), protection and security, as well as health-care, nutrition and the environment.

The majority of the nearly 24,000 people who work for Fraunhofer hold academic degrees in the natural or engineering sciences. Together they generate an annual business volume of over €2 billion. Of this sum, more than €1.7 billion is generated through contract research, the main focus of the Fraunhofer-Gesellschaft's activities. More than 70 percent of the Fraunhofer-Gesellschaft's **contract research** revenue derives from contracts with industry and from publicly financed research projects. Together with their customers and project partners, the Fraunhofer Institutes develop and optimize processes, products or equipment to the point of industrial maturity/marketability. Around 30 percent of Fraunhofer's contract research budget is accounted for by base funding provided by the German Federal Ministry of Education and Research (BMBF) and the state governments in a ratio of 90:10 for the internal use of the organization at its own discretion.

To assure the quality of its planning processes, Fraunhofer aligns the composition of its broad research portfolio with the dynamically changing conditions of the research market. The organization's R&D strategy is planned on three interconnected levels.

Each Fraunhofer Institute defines its own market orientation and core competencies on the basis of its immediate market environment and its networking ties with the scientific community.

The seven **Fraunhofer Groups** provide a means of developing and coordinating cross-institute collaboration by bringing together institutes with related areas of technological expertise:

- Information and Communication Technology
- Life Sciences
- Light & Surfaces
- Microelectronics
- Production
- Materials and Components – MATERIALS and
- Defense and Security VVS

Moreover, institutes with complementary areas of expertise can join together to form **Fraunhofer Alliances**, enabling them to jointly develop and market solutions for specific business sectors.

At the same time, on an organization-wide level, Fraunhofer identifies innovative technologies with significant market potential and sets up in-house programs to drive them forward.

Seven Fraunhofer Institutes are involved in research projects of interest to the German Federal Ministry of Defence (BMVg). Activities that are funded solely by the BMVg make up the Fraunhofer **defense research** segment, which is reported separately in the Fraunhofer-Gesellschaft's annual accounts.

The Fraunhofer Institutes work in close **collaboration with the universities**. Each party occupies different functions, which extend from teaching and university training to knowledge-based research, technology transfer and contract research. A key feature of this form of collaboration is joint appointments. Nearly all directors of Fraunhofer Institutes hold parallel posts as the chair of a university department. In this way, Fraunhofer plays a prime role in educating the next generation of scientists and engineers.

Fraunhofer has **subsidiaries** in Europe, North America and South America and representative offices in Asia and the Middle East. These form a bridge to the world's main regions of current and future economic and scientific interest. Numerous strategic partnerships with organizations of excellence round off Fraunhofer's international portfolio.

Operating objectives and strategy

The Fraunhofer-Gesellschaft provides research and development services to support innovation-oriented companies, primarily in Germany. The expenses incurred by Fraunhofer in connection with research conducted on behalf of industrial customers are invoiced at full cost, yet Fraunhofer does not pursue any profit or growth objectives per se. A significant measure of the organization's success is the proportion of its operating budget covered by revenues from contract research for industrial customers. The Executive Board has defined this benchmark as at least one third of total revenues. This high proportion of revenues generated by research on behalf of industrial customers sets the Fraunhofer-Gesellschaft apart from other publicly funded research organizations in Germany. This is the essence of the **Fraunhofer model**, in which the work of the Fraunhofer Institutes is financed in three ways: through contract research for industry, publicly funded projects, and base funding that allows them to carry out pre-competitive research. To enable Fraunhofer to continue fulfilling its

mission, the following instruments and processes were implemented in 2014:

- Establishment of the new Executive Board function Technology Marketing and Business Models
- Introduction of an organization-wide sustainability management system
- Support for promising but high-risk research initiatives and interdisciplinary lead projects
- Creation of greater synergies between Fraunhofer Institutes and local universities and business communities
- Initiation of a new collective approach within Fraunhofer Groups to stabilize institutes in financially critical situations

Overall, the Executive Board allocates around 10 percent of base funding to the Fraunhofer Institutes via **internal programs**, each of which pursues a different objective. Two new programs were launched in 2014. "Discover" promotes unconventional and original ideas that involve a high scientific risk and require a short-term implementation horizon. Short project terms, rapid evaluations and multiple requests for proposals per year are all designed to stimulate the discussion of promising, innovative ideas and new areas of business across Fraunhofer as a whole. The second new internal program launched in 2014 is "lighthouse projects", which addresses technological challenges currently facing companies based in Germany. This program takes an interdisciplinary approach in which the participating Fraunhofer Institutes pool their expertise and involve industrial partners at an early stage of the projects. The topics of most interest identified so far are electromobility, E3 production, rare earth elements in critical supply, and theranostic implants.

New concepts for Fraunhofer locations based on the creation of High Performance Centers serve as an instrument to bridge the gap between scientific research and industrial needs. The first stage involves developing a plan in collaboration with universities and businesses in the region to determine

the profile of the location. This includes elements such as sponsored chairs and joint appointments, other joint initiatives in the realms of research, teaching, training and continuing education, technology/knowledge transfer and commercialization, and shared investments in buildings and equipment. Once these elements have been decided upon, the next stage focuses on linking together the locations to form a transregional network. Three such centers are currently in the process of being established, in Freiburg, Erlangen and Dresden.

For the purpose of accounting, the individual Fraunhofer Institutes are treated as cost units and are managed as profit centers. In certain cases this may mean that one particular institute is exposed to risks affecting its ability to generate enough revenue to cover expenditure – a situation that is detected early by internal controlling. Whereas until now the institute's senior management was responsible for finding its own solution to the problem and turning the situation around, Fraunhofer introduced a **new collective approach** in 2014, whereby the entire Fraunhofer Group to which the institute belongs takes part in developing an appropriate strategy. By way of support, the Executive Board makes additional funds available to the Group to enable institutes in a temporarily adverse risk situation to open up new lines of business.

New Executive Board function Technology Marketing and Business Models

Prof. Dr.-Ing. Alexander Verl has been senior vice president with responsibility for Technology Marketing and Business Models since April 1, 2014. Fraunhofer established this new Executive Board function to meet the demand for system solutions that extend beyond the domain of individual institutes. The purpose of this new board-level function is to serve as an interface between the Fraunhofer Institutes, Groups and Alliances, to provide a single source of technology offers and to create

added value for customers. Moreover, given the increasing restraints on public spending, the new Executive Board function will help to secure the Fraunhofer-Gesellschaft's financial resources in the medium term. The key activities of this central function include developing new business models for Fraunhofer, introducing industry-specific customer contacts, systematically strengthening technology transfer through spin-offs and joint ventures, actively commercializing and managing Fraunhofer's intellectual property rights, and building up a range of opportunities for application-oriented, continuing education. Other responsibilities include cross-cutting activities such as data and case study analysis, with the aim of identifying trends in specific industry sectors or customer groups at an early stage, and using this information to direct the strategic orientation of contract acquisition management.

The tasks of the **Business Models** unit include developing formats for cross-institute acquisition of contracts. One such format is the Fraunhofer Technology Day events, at which Fraunhofer scientists present technologies and conceptual ideas of topical interest, selected according to the specific needs of key customers. The first Technology Day took place in 2014 at a car manufacturing company. A total of 20 Fraunhofer Institutes presented products and services relating to the technological fields of big data analytics, human-robot cooperation, lightweight construction, industry 4.0 in logistics and production, and electromobility. Other formats for cross-institute acquisition of contracts, such as strategic cooperation workshops or support for Fraunhofer Alliances at high-level industry meetings, have been initiated.

The second pillar of the new Executive Board function, alongside business model development, is **Technology Marketing**. The aim here is to help customers quickly find suitable partners in the complex network of Fraunhofer Institutes. Central customer advisors for the energy, ICT, life sciences and automotive sectors have already been appointed. Recruitment of other experts for the microelectronics and production engi-

neering sectors is under way. In addition to this, a central point of contact has been established for new customers seeking advice on projects. From here, their inquiries are directed to the relevant Fraunhofer Institute(s) or central customer advisor.

To strengthen the skills of Fraunhofer Institute employees in acquiring contracts, the new Executive Board function has set up the "Fraunhofer Research Manager" program. Its aim is to train institute staff in their first management post or with responsibility for a technical area to take on the role of "customer advocate". Topics dealt with in the training program include marketing and contract negotiation, marketing strategies and means for bringing IP fruitfully to market, customer communication and network management. The Fraunhofer Institutes have shown considerable interest in this program.

Integration and creation of new entities

As a natural consequence of industry's growing need for applied research, the established Fraunhofer Institutes have been growing continuously over the past years. In addition to this organic growth, the integration of external research institutions and the creation of new departments and project groups have also contributed significantly to the growth of the Fraunhofer-Gesellschaft. As a general rule, the integration or creation of these entities is spread over five years. At the end of this transitional period, the entity is evaluated to determine its suitability with respect to the Fraunhofer model. At the end of this period, if the evaluation is positive, the new entity is fully integrated and becomes eligible for base funding by the federal and state governments in a ratio of 90:10.

Given that the Fraunhofer-Gesellschaft is continuing to grow and that base funding is in increasingly short supply, the challenge for Fraunhofer is to maintain and safeguard its traditional, mixed funding model. To meet this challenge, Fraunhofer takes a proactive approach to portfolio management, in which

the integration and creation of new entities plays an important role. While pursuing its ongoing lobbying activities at the German federal and state government level, with a view to obtaining sufficient base funding to complement its own revenues and fulfill its research mandate, Fraunhofer is now asking for assurance that the federal and state governments are willing to provide long-term financial support for newly integrated or created entities, over and above the resources made available to cover the initial, transitional period.

In 2014, the planned integration of the Research Establishment for Applied Science (FGAN) received a positive evaluation. Its three institutes have been operating since 2009 in the contract research sector as the Fraunhofer Institute for Optoelectronics, System Technologies and Image Exploitation IOSB, the Fraunhofer Institute for Communication, Information Processing and Ergonomics FKIE and the Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR. The proposal to integrate them in the Fraunhofer-Gesellschaft resulted from the restructuring of research and technology activities funded by the German Federal Ministry of Defence (BMVg), on the recommendation of the German Science Council. The performance of the former FGAN institutes has far exceeded the original expectations. Consequently, it was decided that their civil-sector contract research activities would be entitled to mixed funding according to the Fraunhofer model from 2015 onward.

The Hermsdorf branch of the Fraunhofer Institute for Ceramic Technologies and Systems IKTS was similarly evaluated in 2014, five years after its provisional integration. The evaluation committee reported favorably on the exceedingly positive results of its work on joint projects with the parent institute and the synergy effects ensuing from the expansion of activities in the field of energy and environmental technologies at the Hermsdorf facility. Its entitlement to mixed funding according to the Fraunhofer model was approved.

In addition to these institutes, base funding was approved for five Fraunhofer Project Groups that were evaluated in 2014. These groups were created as a means of expanding the portfolio of five existing Fraunhofer Institutes.

Only one new entity was created in 2014 with a view to integration, namely the ScreeningPort department of the Fraunhofer Institute for Molecular Biology and Applied Ecology IME, which took over the operative business of European ScreeningPort GmbH with effect of July 1, 2014. The new location in Hamburg will enable Fraunhofer IME to optimize its activities in the field of advanced drug development by drawing on ScreeningPort's expertise in the development of biological assay systems and high-throughput, automated drug discovery. The Free and Hanseatic City of Hamburg has promised to provide initial funding for a period of five years.

Sustainability

Knowing that Fraunhofer's research helps to meet social needs is a powerful motivating force for the organization's employees. The general public is also convinced of Fraunhofer's commitment to sustainable development, thanks to its work in socially relevant areas such as medicine, renewable energies and efficient use of natural resources. To emphasize that these goals are respected throughout the organization, the Fraunhofer-Gesellschaft published its first **Sustainability Report** in 2014. With contributions by all Executive Board functions, and reviewed at two-year intervals, it describes the measures taken to promote sustainability and provides details of the corresponding strategies. The transparent manner in which these goals and measures are communicated and the voluntary nature of the commitment underline the sense of responsibility assumed with regard to the organization's forward-looking strategy. Current projects on the sustainability management agenda include ways to achieve sustainable growth and widening the meaning of "innovation" beyond

the narrow technological sense to include a social dimension, for instance by involving representatives of social institutions in various phases of the innovation process. Fraunhofer is one of the first German research organizations to publish this kind of report, and intends to pursue this pioneering role further by establishing an organization-wide sustainability management system and systematically implementing the goals it has set.

Research at Fraunhofer encompasses many environmental, economic and social aspects that are reflected in the holistic approach to systems research, especially in in-house, pre-competitive research projects. Implementing the principles of sustainability calls for a proactive management strategy and continuous optimization of business processes. Examples include the creation of the new Executive Board function Technology Marketing and Business Models to facilitate knowledge transfer to markets and businesses, and more intensive participation in the dialog between the government, industry and science by the Fraunhofer-Gesellschaft's science policy department. Another currently ongoing project at Fraunhofer is the internal debate concerning ethical research conduct and scientists' responsibilities in this respect.

Science policy framework

As a key player in the German research and education system, the Fraunhofer-Gesellschaft is obliged to operate within a complex science policy framework. The second period of the **Joint Initiative for Research and Innovation** comes to an end in 2015 and will be renewed for a third period starting in 2016. In this new pact, the German Chancellor and the prime ministers of the states agreed that the base funding granted to non-university research organizations would be subject to an annual increase of 3 percent between 2016 and 2020. Given that the annual rate of increase in the previous periods was 5 percent, this means that the base funding received by the Fraunhofer-Gesellschaft will grow more slowly than in the past.

In its declaration stating the measures it plans to take to achieve the research policy goals defined for the third period of the Joint Initiative for Research and Innovation, the Fraunhofer-Gesellschaft formulated its six key mission objectives as follows:

- Trigger dynamic developments in science and research
- Create performance-enhancing networks in the research and education system
- Develop and implement new international and European cooperation strategies
- Establish sustainable partnerships between science, industry and society
- Gain the best scientists for Germany
- Create structures and processes that promote equal opportunities and a family-friendly work/life balance

An annual progress report is compiled by the funding agencies to monitor the achievement of these concrete goals. The borrowing restrictions imposed as part of the initiative to consolidate public spending, which take effect in 2016 for the federal government and from 2020 onward for the state governments, are another factor affecting research spending. Moreover, at a European level, the rules of participation in the EU's "Horizon 2020" framework programme for research and innovation, which was launched in 2014, have significantly changed the way funding contributions are calculated. The new flat rate of 25 percent granted in respect of general administrative expenses is insufficient for the majority of Fraunhofer Institutes and has a serious impact on their capacity to finance major infrastructural improvements.

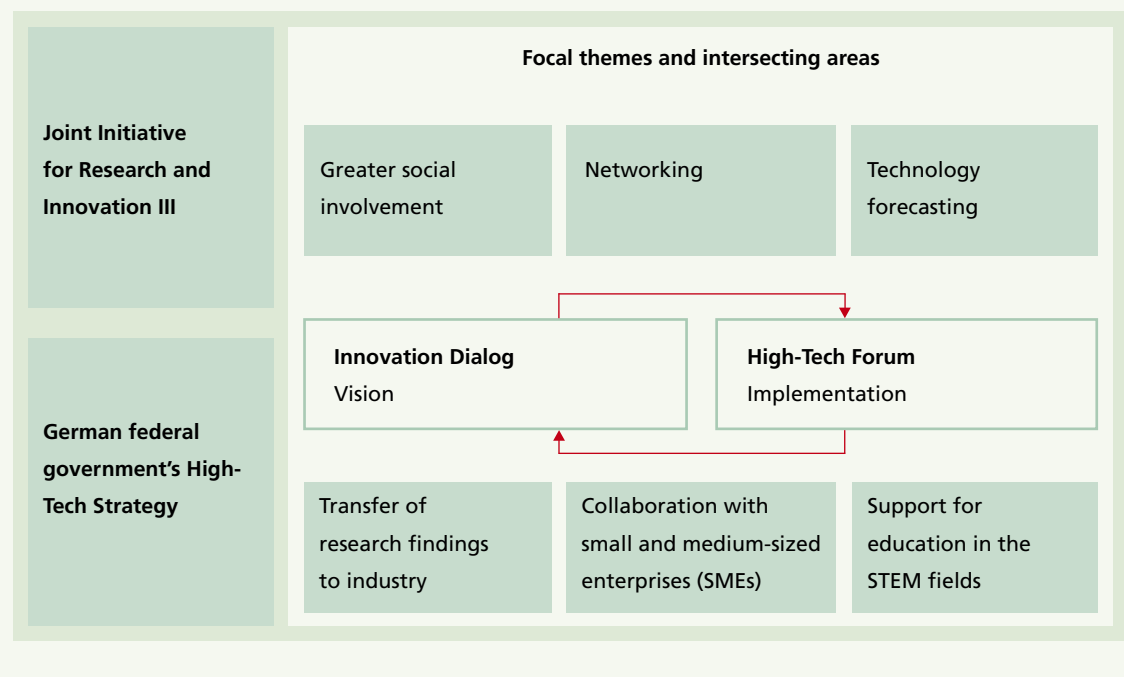
As a result of these changes, the Fraunhofer-Gesellschaft will have to devote far more effort in the future to securing public-sector funding for its research. The obligation to compete with universities and other non-university research organizations for government grants creates a new challenge for Fraunhofer, not only as regards funding but also with respect to other issues such as recruiting staff in specific areas of research or

for government-sponsored projects, the development of business models, and the options available for cooperative ventures between members of the research community and with industrial partners.

As the successor to the "Research Union", the **High-Tech Forum** was founded in early 2015 to advise the federal government on the implementation and development of its new High-Tech Strategy. The forum is co-chaired by the President of the Fraunhofer-Gesellschaft, Prof. Dr. Reimund Neugebauer, representing the research community, and Andreas Barner, Chairman of the Board of Managing Directors of the chemical company Boehringer Ingelheim and President of the Stifterverband, an initiative offering private-sector support for education and science, representing industry. The other 21 members of the forum are drawn from science, industry, public administration and social institutions. The purpose of the High-Tech Forum is to discuss ideas for the implementation and evolution of the High-Tech Strategy. These discussions take place in expert councils led by specialists in the relevant thematic areas. A permanent office to coordinate the High-Tech Forum's activities will be opened in 2015, staffed by members of Fraunhofer and the Stifterverband. As a leading member of the High-Tech Forum, Fraunhofer will have the possibility to formulate recommendations for a concrete action plan, propose topics for discussion by the expert councils and ideas concerning the thematic orientation of the High-Tech Strategy, and place additional thematic content on the agenda. Fraunhofer will also be able to bring its influence to bear on German national research strategy up to the horizon of 2030, and help shape the general outline of Germany's innovation policy.

The **Innovation Dialog** is a twice-yearly event in which the German Chancellor and other representatives of the federal government meet with prominent members of the scientific community and representatives of business associations and social institutions. These meetings are planned to continue through to 2017. The President of the Fraunhofer-Gesellschaft,

Science policy framework within which the Fraunhofer-Gesellschaft operates



Prof. Dr. Reimund Neugebauer, is a member of the steering committee. A frequent item on the agenda is the question of creating the right conditions to sustain research and innovation into the future. In its inaugural session, the partners in this dialog discussed the definition of a benchmark for innovation systems that will serve as the basis for evaluating research topics of future interest and the development of expertise in the STEM fields. The expansion of digital networks and future sources of value creation for German industry were also identified as top-priority topics. Cross-cutting themes of relevance to innovation policy selected for future Innovation Dialog events include new forms of knowledge and know-how transfer, the potential and challenges of European innovation policy in relation to Germany, and the resilience of infrastructures and systems. With the President of the Fraunhofer-Gesellschaft on the steering committee, the organization is in a position to

help shape the thematic focus and content of the Innovation Dialog, benefit from the opportunity for face-to-face meetings with political decision-makers, and establish a monitoring system for innovation policy developments. This will also enable Fraunhofer to manage its own growth on the lines of the main thematic areas of the Innovation Dialog.

The diagram on this page provides an overview of the various financial and thematic aspects of the science policy framework within which the Fraunhofer-Gesellschaft operates, as briefly outlined above. Among the intersecting areas of the two major initiatives, the focal themes of particular interest to Fraunhofer are greater social involvement, improved networking, efficient technology forecasting, support for education in the STEM fields, the transfer of research findings to industry, and collaboration with small and medium-sized enterprises (SMEs).

Economic environment

- German economy in sound health
- R&D expenditure at high level
- Funding for research and innovation remains high priority for federal government

The German economy proved stable in 2014 and, buoyed up by strong domestic demand, held its ground against a difficult global economic environment. The country's **gross domestic product (GDP)** grew by 1.6 percent in real terms, and thus significantly faster than in the previous years (2013: +0.1 percent; 2012: +0.4 percent). Viewed over the longer term, economic growth even exceeded the ten-year average of 1.2 percent per annum. It is noteworthy that growth was the result of increased economic performance not only in almost every area of the service sector but also in the manufacturing and construction sectors.

Companies and public authorities remain aware of the vital importance of research and innovation to future competitiveness. According to the latest statistics published by Stifterverband für die Deutsche Wissenschaft, a private-sector initiative to support science and education, **research and development expenditure** in Germany increased year on year by 1.3 percent to €80.2 billion in 2013. R&D expenditure by universities increased by 3.2 percent, while non-university research institutions boosted their R&D spending by a substantial 6.7 percent. At €53.6 billion, expenditure by private industry on in-house R&D remained at around the previous year's level, whereas expenditure on external contract research rose by 16 percent to a record high of €14.9 billion. Overall, expenditure by private industry on external contract research has thus grown by nearly 75 percent in the period between 2003 and 2013.

Nonetheless, in 2013, Germany didn't quite reach the European Union's targeted goal of raising expenditure on research and innovation to 3 percent of GDP by 2020. The country's **R&D intensity**, i.e. R&D expenditure as a percentage of GDP, came to 2.85 percent, which is actually slightly lower than in 2012. However, this decrease is primarily due to methodological changes arising from the new European system of national and regional accounts (ESA 2010), which was implemented by all EU member states in 2014. One effect of the new ESA is that a different method is now used to calculate GDP. When applied retrospectively to the data for 2013, this results in a marked increase in GDP for that year, and consequently a reduction in R&D intensity in purely arithmetical terms. The methodological change with the most significant quantitative impact on GDP concerns the accounting treatment of research and development expenditure. Whereas under the old system such expenditure was treated as part of the production process and therefore not as a discrete item of value added, from now on it will be capitalized as an investment and thus factored into the calculation of gross value added and hence GDP.

Governments continued to rein in public spending in 2014. Overall, in Germany, the federal, state and local governments, together with the social security funds, generated the second-highest budgetary surplus since reunification. Of these, only the state governments produced a slight deficit. Despite the spending restrictions, expenditure on research and development was once again given high priority in the 2014 **federal budget**. The total amount allocated for this purpose to the various ministries and departments was €14.6 billion. This represents an increase of over 60 percent compared with the level of 2005. Provision has been made for further substantial increases in the federal budget for 2015. Alone the Federal Ministry of Education and Research (BMBF), for example, has been earmarked to receive nearly €15.3 billion to finance its activities. This illustrates the importance accorded to the funding of research and innovation by the German federal government.

Total business volume

- Total business volume rises to €2.06 billion
- Solid growth in the contract research and defense research segments

Fraunhofer remained on its growth trajectory in 2014. Fueled by a consistently high demand for research and development services on the part of industrial and public-sector customers, the organization's **total business volume** showed solid growth, increasing by €50 million compared with the previous year to €2,060 million. This sum includes personnel and non-personnel expenses recognized according to general accounting practice and capital expenditure on fixed assets as measured at the date of acquisition. The amounts recognized do not include depreciation or amortization charges.

The **contract research segment** constitutes the Fraunhofer-Gesellschaft's core business activity, which is financed in accordance with the Fraunhofer model from three complementary sources: research contracts for industry, publicly funded research projects, and base funding for pre-competitive research. Budgeted expenditure for contract research grew by €55 million in 2014, to reach a total of €1,716 million.

The **defense research segment** groups together the research activities of seven Fraunhofer Institutes whose work is of particular relevance to and is funded by the German Federal Ministry of Defence (BMVg). Their budgeted expenditure increased in 2014 by €4 million to a total of €118 million.

Capital expenditure on construction and infrastructure projects, including the initial cost of equipment for new institute buildings, is recognized as a separate accounting item, **major infrastructure capital expenditure**. This item amounted to €226 million in 2014, which is approximately €9 million lower than the exceptionally high level in 2013.

In the following, we report on expenditure and income items for each of these segments. For information on the accounting principles applied by the Fraunhofer-Gesellschaft, please refer to the Notes to the financial statements.

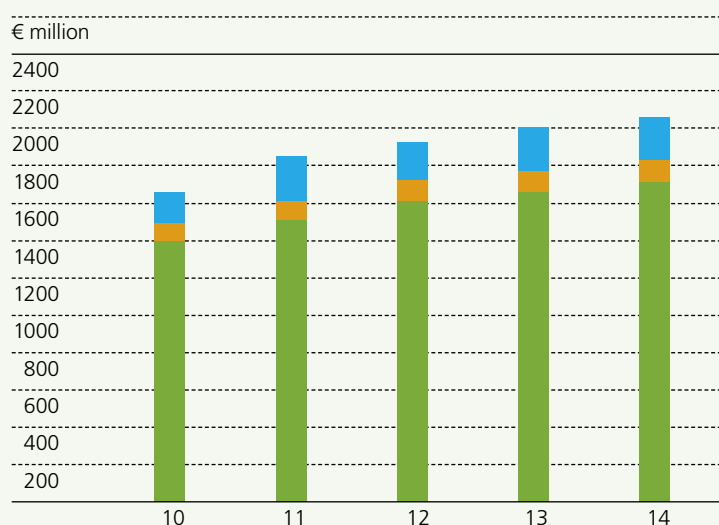
Contract research

- Annual research budget exceeds €1.7 billion
- Industrial revenue increases by 7 percent
- EU revenue grows by 15 percent

Contract research constitutes the Fraunhofer-Gesellschaft's core business activity. By conducting research projects for customers in industry and the service sector, the Fraunhofer Institutes help translate the results of R&D work into practical applications. In doing so, they play a central role in the innovation process that drives the German and European economies. The goal of many of Fraunhofer's publicly funded research projects is to improve existing infrastructures. Areas where such improvements are needed include energy, transportation and healthcare. Above and beyond that, these projects make an important contribution toward networking within the public science and education system, and help to support innovation in the business world.

In 2014, **budgeted expenditure** for the contract research segment **grew by 3 percent** to a total of €1,716 million. Personnel expenses rose by 8 percent to €1,021 million. This rise was mainly due to the general pay increase of 3 percent granted under the public-sector collective wage agreement (TVöD), which came into effect on March 1, 2014, and to significant growth in the number of employees. Non-personnel expenses increased by 1 percent to €556 million. The reversal of reserves amounting to €15 million had the effect of reducing budgeted expenditure. Capital expenditure amounted to €154 million.

The Fraunhofer-Gesellschaft's total business volume 2010–2014



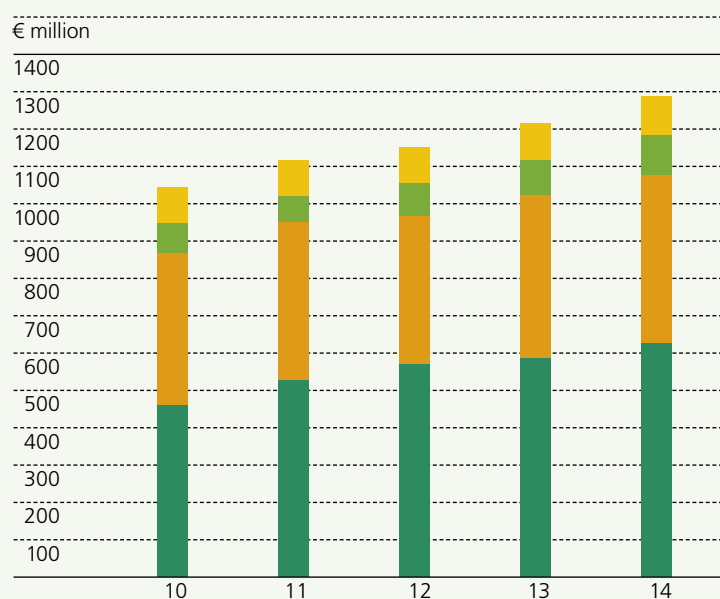
	2010	2011	2012	2013	2014
■ Major infrastructure capital expenditure ¹	162	236	199	235	226
■ Defense research	93	98	113	114	118
■ Contract research	1402	1515	1614	1661	1716
= Total business volume in € million	1657	1849	1926	2010	2060

¹ As of 2011 includes minor building projects (less than €1 million per project) previously recognized under contract research.

Over two-thirds of Fraunhofer's contract research is financed by means of **project revenues**, which in 2014 **increased by 6 percent** to €1,272 million, and thereby grew at a faster rate than expenditure. Project revenues comprise all revenues from external sources, namely revenues from research contracts with industry and research funding provided by

the federal and state governments and the EU Commission. They also include other funds from miscellaneous sources. An amount of €444 million stemming from the base funding granted by the federal and state governments was utilized to make up the difference between revenues and expenditure.

Expenditure and revenue in the contract research segment 2010–2014



	2010	2011	2012	2013	2014
Project revenue	1030	1101	1137	1200	1272
Other revenue	96	94	97	99	103
EU revenue (European Commission)	65	71	88	92	106
Public-sector revenue (German federal and state governments)	406	405	382	431	445
Industrial revenue	463	531	570	578	618
Base funding¹	372	414	477	461	444
= Total revenue in € million	1402	1515	1614	1661	1716
Personnel expenses	745	784	868	945	1021
Non-personnel expenses	443	514	543	549	556
Change in special reserve for license-fee revenue and allocation to foundation capital	56	74	52	0	–15
Capital expenditure	158	143	151	167	154
= Total expenditure in € million	1402	1515	1614	1661	1716

¹ In 2012 and 2013, this item included changes in Fraunhofer-Gesellschaft reserves.

Industrial revenues totaled €618 million and were thus **7 percent higher than in the prior year**. In the public sector, project revenues from the federal and state governments increased in 2014 by 3 percent overall to €445 million, entirely as the result of a sharp increase in funding by the state governments, which grew by 13 percent to €163 million. Another important source of public-sector funding for Fraunhofer projects is the EU Commission. **EU revenues** made particularly gratifying progress in 2014: they **grew by a significant 15 percent** to reach €106 million. Other sources of revenue rose by 4 percent to nearly €103 million.

One notable development is that the contract research departments of the three former FGAN institutes, which were integrated in the Fraunhofer-Gesellschaft in 2009, have performed remarkably well. The BMVg had agreed to continue financing these departments during the five-year transition period up to and including 2014. By 2014, industrial contracts already accounted for over one third of their revenues, justifying their entitlement to funding according to the Fraunhofer model from 2015 onward and confirming the **success of the dual-use approach** practiced by their parent institutes in the defense research segment.

Defense research

- Annual research budget grows to €118 million
- Dual-use research continues to develop successfully

The defense research segment groups together the research activities of seven Fraunhofer Institutes in the field of defense and security, which are financed by the German Federal Ministry of Defence (BMVg). The purpose of this research is to develop solutions that provide the best possible protection against the entire spectrum of potential threats to the security of people, infrastructures and the environment. Alongside their defense-related activities, these institutes also have contract research departments that work together with private industry and public-sector customers on the development of solutions for civilian applications. This dual-use aspect of their work is equally successful.

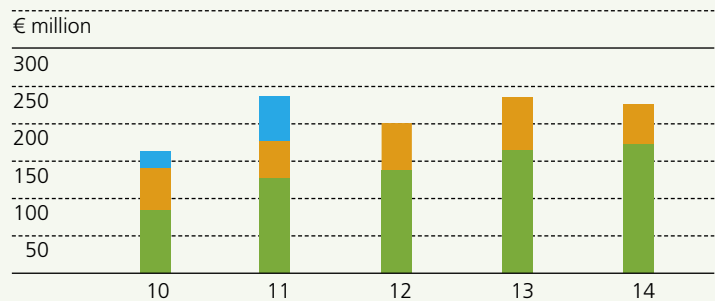
The defense research segment's budgeted expenditure increased in 2014 by 4 percent to €118 million. This amount comprises €72 million in personnel expenses, €30 million in non-personnel expenses, and €16 million in capital expenditure. The totality of this budgeted expenditure was financed by the BMVg, which provided €60 million in the form of base funding and a further €58 million as project funding.

Major infrastructure capital expenditure

- Capital expenditure on major infrastructural works slightly lower than in the prior year
- One-quarter of infrastructure spending funded by the EU

In 2014, the Fraunhofer-Gesellschaft spent a total of €226 million on improving the building infrastructure of its research locations. Capital expenditure on the construction of new buildings, the extension of existing buildings, and the purchase of land amounted to €141 million. Fraunhofer expended a further €47 million on furnishings and scientific instruments to equip new buildings. In addition to the construction of new buildings and extensions, major infrastructure capital expenditure also includes minor building projects to improve the functionality of existing buildings that require a comparatively low outlay (less than €1 million per project). In 2014, a total of €38 million was spent on projects of this type, which corresponds to around one-sixth of Fraunhofer's expenditure on infrastructural improvements.

Major infrastructure capital expenditure and funding sources 2010–2014



	2010	2011	2012	2013	2014
■ Economic stimulus programs I and II	22	59			
■ European Regional Development Fund (ERDF)	57	51	62	71	54
■ German federal and state governments	83	126	137	164	172
= Funding of major infrastructure capital expenditure in € million	162	236	199	235	226

The cost of constructing new buildings and extensions to existing buildings is customarily covered by funds granted by the BMBF and the state in which the facility is located on a 50:50 basis (after taking into account any co-financing agreements). Minor building projects are funded to 90 percent by the federal government, with the states contributing the remaining 10 percent. Overall in 2014, the **federal and state governments** together provided around €172 million in funding for infrastructural projects. The remaining €54 million – or approximately one-fourth of total infrastructure expenditure – benefited from **EU funding** and was co-financed by the European Regional Development Fund (ERDF). Some of the main infrastructure projects are presented below by way of example.

In May 2014, the Fraunhofer Institute for Ceramic Technologies and Systems IKTS inaugurated its second location, situated in Hermsdorf, Thuringia. The costs of the building project, which totaled €18 million, were funded to the tune of €13.5 million by the ERDF, while the remaining €4.5 million were split between the Free State of Thuringia and the German federal government. As a participant in the Thuringian government's GreenTech Campus initiative, the institute helps to develop energy-efficient, environmentally friendly solutions based on technical applications of advanced ceramic materials, and plays a major role in the local industrial network.

Major infrastructure capital expenditure 2014

Institute / Research Institution	Location	Total	ERDF ¹	Federal/state governments
Marine Biotechnology	Lübeck	17.9	9.0	9.0
Reliability and Microintegration	Berlin	15.3	7.6	7.6
Integrated Circuits	Nürnberg	12.1		12.1
Laser Technology/Production Technology Competence Center	Aachen	11.3		11.3
Silicate Research	Bayreuth	9.4	4.7	4.7
Building Physics	Holzkirchen	8.9		8.9
Manufacturing Engineering and Automation	Stuttgart	8.3		8.3
Clinical Research Center	Hannover	8.2		8.2
Cell Therapy and Immunology	Leipzig	8.2	5.3	2.8
Silicon Technology	Itzehoe	8.1	4.1	4.1
Secure Information Technology – CASED ²	Darmstadt	6.9		6.9
Structural Durability and System Reliability	Darmstadt	6.3		6.3
Manufacturing Technology and Advanced Materials	Bremen	6.2		6.2
Physical Measurement Techniques	Kaiserslautern	6.1	3.0	3.0
Wind Energy and Energy System Technology	Bremerhaven	6.1	0.5	5.5
Electron Beam and Plasma Technology – RESET ³	Dresden	5.2	3.1	2.1
Manufacturing Engineering and Automation	Bayreuth	4.4	2.2	2.2
Electronic Nano Systems	Chemnitz	4.1	2.4	1.6
Ceramic Technologies and Systems	Hermisdorf	3.9	2.6	1.3
Silicate Research	Würzburg	3.1	1.2	2.0
Mechanics of Materials	Karlsruhe	2.9		2.9
Interfacial Engineering and Biotechnology	Straubing	2.0		2.0
Integrated Circuits	Fürth	2.0	1.0	1.0
Biomedical Engineering	Saarbrücken	1.8	0.9	0.9
Solar Energy Systems	Freiburg	1.6		1.6
Integrated Circuits	Waischenfeld	1.5	0.7	0.7
Manufacturing Engineering and Automation	Rostock	1.5	1.1	0.4
Center for Silicon Photovoltaics	Halle	1.3	1.0	0.3
Chemical Technology	Pfinztal	1.1		1.1
Institute Center Dresden	Dresden	1.0	0.6	0.4
Other construction work		11.7	2.4	9.3
Main infrastructure projects funded by German federal / state governments and ERDF¹		188.4	53.5	134.9
Minor building projects		37.5		37.5
Total major infrastructure capital expenditure in € million		225.9	53.5	172.4

1 ERDF = European Regional Development Fund.

2 CASED = Center for Advanced Security Research Darmstadt.

3 RESET = Resource-Conserving Energy Technologies (planned extension to the Institute Center Dresden).

Also in May 2014, the new cleanroom facility at the Fraunhofer Institute for Silicon Technology ISIT in Itzehoe was taken into operation. The total cost of the building amounted to €38.3 million, 50 percent of which was funded by the ERDF and 25 percent each by the state of Schleswig-Holstein and the federal government. The facility offers a surface area of 1500 square meters accommodating cleanrooms and laboratories in which Fraunhofer ISIT develops advanced components and fabrication processes based on micro- and nanotechnology for its industrial customers. It provides working space for 44 employees and serves as a beacon highlighting the cutting-edge, technological research carried out in Itzehoe.

The new building housing the Clinical Research Center in Hannover was inaugurated in September 2014. The construction project cost a total of €30 million which was financed in equal halves by the state of Lower Saxony and the federal government. An additional €8 million was contributed by the state of Lower Saxony in the form of funding for the Helmholtz Centre for Infection Research (HZI). With a total of 6000 square meters at their disposal, the Fraunhofer Institute for Toxicology and Experimental Medicine ITEM, Hannover Medical School (MHH) and the HZI can now, for the first time, share their medical expertise in early-phase clinical and epidemiological studies.

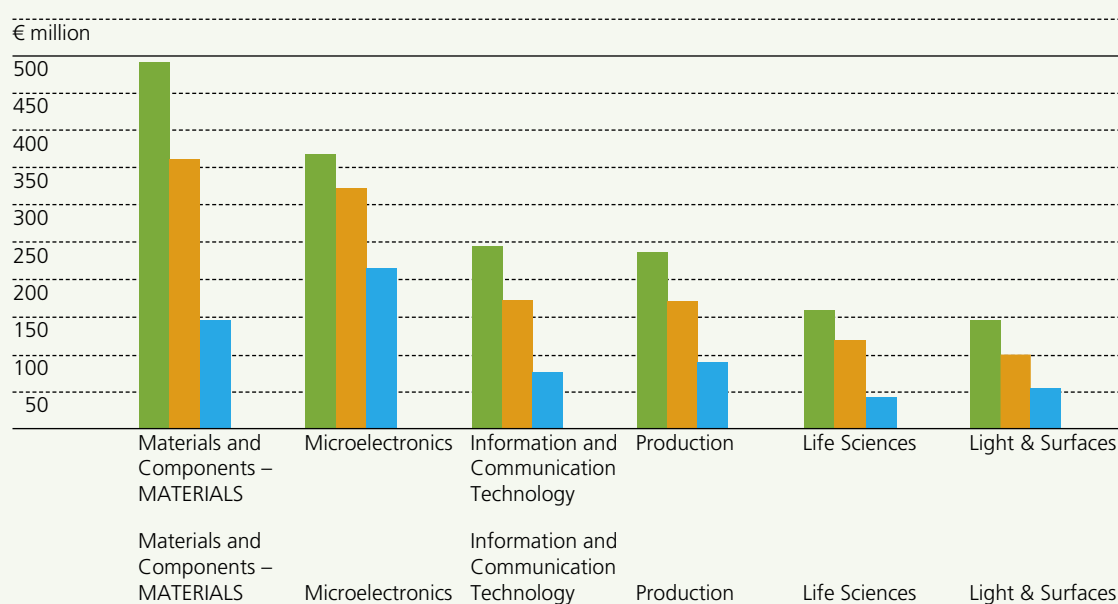
Fraunhofer Groups

Collaboration in groups based on related areas of expertise enables the Fraunhofer Institutes to develop cross-institutional research strategies and to coordinate the procurement and shared use of strategic items of equipment. What is more, the chairs of the groups can bring the influence of the institutes to bear on the overall policy of the Fraunhofer-Gesellschaft. There are six Fraunhofer Groups comprising Fraunhofer Institutes and Research Institutions in the contract research segment, plus the Fraunhofer Group for Defense and Security VVS, in which the institutes funded by the German Federal Ministry of Defence (BMVg) have joined forces.

With budgeted expenditure of €492 million in 2014, the Fraunhofer Group for **Materials and Components – MATERIALS** is the largest group within the Fraunhofer-Gesellschaft in financial terms. It encompasses 14 institutes with a focus on materials science, whose activities include developing new materials, improving the properties of existing materials, materials characterization, evaluating the behavior of materials under different conditions of use, and developing methods of production. The group's expertise covers the entire spectrum of metallic, inorganic non-metallic and polymer materials, including materials derived from renewable resources. The group's budgeted expenditure increased by 6 percent in 2014. Project revenues grew by 7 percent to €361 million, maintaining the proportion of operating expenditure covered by project revenues at the very high level of 83 percent.

The Fraunhofer Group for **Microelectronics** is made up of 11 research units that offer research services and develop application-oriented solutions for the benefit of customers in the fields of semiconductor technology, communication technology, ambient assistance systems, energy-efficient systems and e-mobility, lighting, security and entertainment.

Expenditure and revenue of the Fraunhofer Groups in the contract research segment 2014



Budgeted expenditure						
in € million	492	369	245	237	159	145
Operating expenditure	437	343	232	222	135	130
Capital expenditure	55	26	13	15	24	15
Project revenue in € million						
361	323	173	171	119	101	
Industrial revenue	145	215	76	89	42	54
Public-sector revenue ¹	216	108	97	82	77	47
Growth in %						
Budgeted expenditure	+6	+1	+4	+4	+13	+6
Project revenue	+7	+12	+3	+3	+16	+2
Industrial revenue	+4	+23	+5	+7	+5	0
Public-sector revenue ¹	+9	–5	+2	–1	+22	+5
Project funding ratio in %²						
All projects	83	94	75	77	88	78
Industrial funding	33	63	33	40	31	42
Public-sector funding ¹	50	31	42	37	57	36

1 Public-sector revenue comprises funding granted by the German federal and state governments and the EU Commission, and other revenue (research grants, other R&D, non-R&D).

2 Proportion of operating expenditure covered by project revenue (excluding imputed depreciation of capital assets).

While the group's budgeted expenditure in 2014, at €369 million, remained around the previous year's level, its project revenues increased by a substantial 12 percent to €323 million. This outstanding result was due above all the contribution by the Fraunhofer Institute for Integrated Circuits IIS, which is the largest institute in the group in financial terms. The group as a whole ranked first with regard to the ratio of revenues to operating expenditure, which amounted to 63 percent in the case of industrial revenues and 94 percent in the case of project revenues.

The Fraunhofer **ICT Group** comprises 17 research units that offer tailored IT solutions, professional technology consulting and pre-competitive research for new products and services in the business areas of digital media, e-business and e-government, information and communication technologies, energy and sustainability, medicine, production, security, financial services and automotive manufacturing. Examples of the group's work include the development of imaging techniques for use in medicine and integrated software solutions for applications ranging from the interconnection of different media to the digitization of historic monuments. In 2014, the Fraunhofer ICT Group's budgeted expenditure amounted to €245 million, which represents an increase of 4 percent, while project revenues increased by 3 percent to €173 million. The proportion of operating expenditure covered by project revenues thus amounted to 75 percent.

The Fraunhofer Group for **Production** combines the expertise of 7 Fraunhofer Institutes that specialize in the fields of product development, manufacturing technologies and systems, logistics, production processes and production workflow management. Together they offer a range of services encompassing the entire product lifecycle and every link in the supply chain. Focal areas of the group's research include energy-saving and resource-conserving manufacturing technologies and efficient logistics design. Of particular note within this group

is the E3 Research Factory for resource-efficient production operated by the Fraunhofer Institute for Machine Tools and Forming Technology IWU, which was one of the prizewinners in the Germany-wide competition "Landmarks in the Land of Ideas". In 2014, the group's budgeted expenditure increased by 4 percent to €237 million. Public-sector revenues registered a slight fall to €82 million, but this was compensated for by a significant increase in industrial revenues, which grew by 7 percent to €89 million and thus covered 40 percent of the group's overall expenditure.

The Fraunhofer Group for **Life Sciences** pools the Fraunhofer-Gesellschaft's expertise in the biological sciences, biomedicine, pharmacology, toxicology, and food technology. The 7 research units that make up this group offer their customers innovative know-how in the fields of medical translational research, biomedical engineering, regenerative medicine, health-promoting foods, biotechnology, and safety issues pertaining to processes, chemicals and pesticides. The Fraunhofer Institute for Process Engineering and Packaging IVV in Freising had good reason to celebrate in 2014: two of its researchers, Dr. Stephanie Mittermaier and Dr. Peter Eisner, together with Katrin Petersen of the company Prolupin GmbH, received the German Future Prize – the Federal President's Award for Technology and Innovation, for the development of a process that enables proteins derived from lupine seeds to be used to manufacture novel food products. In 2014, the group's budgeted expenditure increased by 13 percent to €159 million, and thus grew at a faster rate than any other Fraunhofer Group. This increased expenditure was matched by an overall rise of 16 percent in project revenues, whereby public-sector revenues grew at the much higher rate of 22 percent, compared with industrial revenues which grew by 5 percent. The group ranked first with regard to the ratio of public-sector revenues to operating expenditure, which amounted to 57 percent, and second in the case of project revenues, which covered 88 percent of the group's budgeted expenditure.

The 6 member institutes of the Fraunhofer Group for **Light & Surfaces** conduct research into the key enabling technologies of photonics and surface engineering. The group's core competencies include coating systems and functionalized surfaces, laser-based manufacturing processes, materials processing, optical measuring techniques, and the development of micro-optical and precision-engineered systems. In this way, the group carries on the tradition of the organization's founder, Joseph von Fraunhofer, who was the first scientist to measure the absorption lines in the solar spectrum, precisely 200 years ago (in 1814). In 2014, the group's budgeted expenditure increased by 6 percent to €145 million. Project revenues grew by a total of 2 percent to €101 million. At 42 percent, the group ranked second in terms of the proportion of operating expenditure covered by industrial revenues.

The Fraunhofer Group for **Defense and Security VVS** brings together the expertise of the 7 defense-related Fraunhofer Institutes and their respective contract research departments. Its research activities focus on the protection of people and property, enhancing the security of critical infrastructures, and monitoring risks to the civilian population and armed forces. In Germany, the group has established a strong reputation as a driver of innovation in all areas of defense and security research. The member institutes are also very active on a European level, and make use of their many networking contacts to carry out joint research activities. In 2014, the group's budgeted expenditure increased by 10 percent to €221 million. This increase was largely due to the growth registered by the civilian-sector contract research departments, whose budgeted expenditure increased by 14 percent to €103 million. The group's project revenues totaled €137 million, which is 14 percent higher than in 2013. The ratio of revenues to operating expenditure amounted to 70 percent.

Financial position

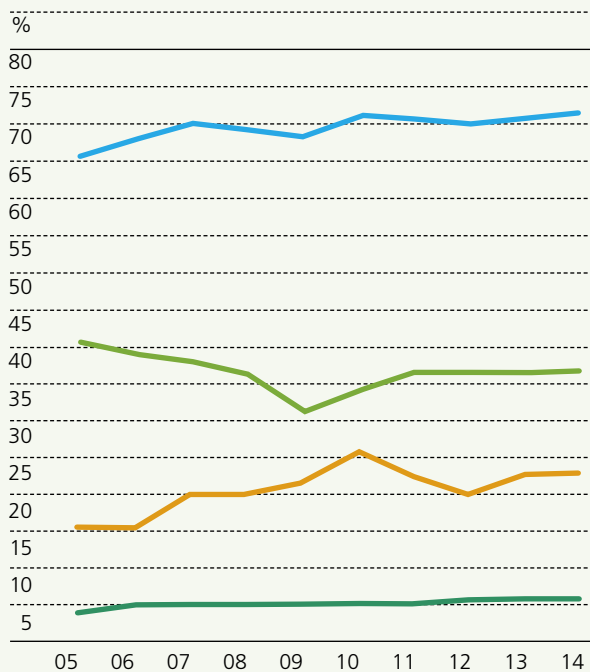
- Proportion of expenditure covered by project revenues reaches all-time high of 73 percent
- Higher funding ratios needed
- Wide variations in project funding by state governments

The Fraunhofer-Gesellschaft's funding rests on three pillars – base funding, revenue from contracts with industry, and revenue from public-sector project funding. According to the principles of the Fraunhofer model, each of these sources should account for roughly one-third of total funding.

In recent years, the Fraunhofer Institutes have consistently realigned the focus of their research activities with market needs and actively capitalized on their opportunities to acquire research contracts. The Fraunhofer-Gesellschaft's continuing growth demonstrates that customers find its R&D services attractive and at the same time is indicative of German industry's demand for innovation. However, increases in base funding have not kept pace with Fraunhofer's excellent growth, with the result that the proportion of expenditure in the contract research segment covered by base funding has steadily fallen in the past few years.

For this reason, the **proportion of project revenues** relative to the operating budget in the contract research segment, including imputed depreciation of investments (excluding research institutions in the startup phase and change in reserve) has continued to rise, and in 2014 reached an **all-time high of 72.9 percent** (2013: 71.8 percent) at the reporting date. The ratio of industrial revenues to operating expenditure amounted to 36.9 percent. Project funding granted by the federal and state governments covered 23.9 percent of operating expenditure, while a further 6.2 percent was covered by funding granted by the EU Commission.

External sources of funding¹ in the contract research segment 2005–2014



■ Project funding (total)²
72.9% (2013: 71.8%)

■ Industrial funding (contract research)
36.9% (2013: 36.5%)

■ Project funding granted by the German federal and state governments
23.9% (2013: 23.1%)

■ Project funding granted by the EU Commission
6.2% (2013: 5.9%)

1 As a percentage of the operating budget including imputed depreciation of capital assets (excluding institutions in start-up phase and changes in reserves).

2 Includes other sources of project funding, which account for 5.9 percent of the total (2013: 6.3 percent).

Public-sector funding of research projects is subject to the Federal Budgetary Regulations and equivalent regulations in the individual states. Additional regulations on the part of the European Union may also apply if EU funds are used for refinancing. The EU regulations make provision for the flat-rate reimbursement of costs in cases where the full-cost model is not applicable. As a publicly funded research organization, Fraunhofer's mandate includes the duty to utilize part of the funds it receives to develop new areas of strategic interest through pre-competitive research. Inadequate funding quotas, funding that only partially covers the costs incurred, and insufficiently high flat-rate reimbursement of personnel costs and overheads make this difficult to achieve, because this ties up resources from base funding that could otherwise be used to finance pre-competitive research. In the case of projects funded by the German Federal Ministry of Education and Research (BMBF), binding rules for calculating funding quotas have been in place for many years. These generally provide for the application of the full-cost model when allocating project funding to Fraunhofer, thus making it unnecessary to deviate a portion of the organization's base funding. In Fraunhofer's opinion, this practice, which also applies to collaborative projects involving industrial partners, has proved to be expedient. In view of the decreasing proportion of expenditure covered by base funding, and in keeping with the underlying principles of the Fraunhofer model, this practice urgently needs to be extended to research programs funded by other federal ministries that meet the relevant criteria.

The allocation of project funding by the state governments is similarly disparate, due to the varying legal and financial conditions that apply in different states. These differences are particularly marked in cases where funding is refinanced by the European Regional Development Fund (ERDF) or the European Social Fund (ESF). As a result, the actual funding quotas diverge substantially. It remains to be seen to what extent the

state guidelines for the ERDF funding period 2014–2020 will have an impact on the use of flat-rate costing. In view of the present public-funding objectives and budgetary constraints, the framework for project funding by the state governments needs to be harmonized across the board to enable wider use of the full-cost model. The rules governing the use of structural funds already permit this approach, even in cases where EU funds are utilized for refinancing. It is imperative that base funding should be reserved exclusively for the financing of in-house pre-competitive research, so as to allow the Fraunhofer-Gesellschaft to continue enhancing its innovative strength and thereby contribute toward securing Germany's growth and prosperity.

As well as intensifying its efforts to acquire new research contracts, Fraunhofer is also currently developing a structured fund-raising strategy with the aim of obtaining additional funds that it can use in the future to finance freely selected research projects. A comparison with other players in the R&D market and initial discussions with possible sponsors reveal that Fraunhofer has not yet fully capitalized on its potential as regards private donations and similar forms of support.

Net asset position

- Total assets exceed €2.8 billion
- Special reserve created to account for the present value of future payments in connection with the sale of patent rights

The Fraunhofer-Gesellschaft's total assets amounted to €2,842 million at the reporting date of December 31, 2014, which is 7 percent or €185 million higher than the previous year's level.

Fixed assets increased by a total of €102 million to around €1,961 million, of which €1,932 million related to property, plant and equipment. At the reporting date, property, plant and equipment represented 68 percent of total assets and was thus the predominant item on the assets side of the Fraunhofer-Gesellschaft's balance sheet. Intangible assets amounted to €12 million and financial assets to €17 million.

Current assets increased by €83 million compared with the previous year. Inventories net of advance payments received amounted to €40 million. The present value of future payments relating to the sale of patent rights, amounting to €80 million, was recognized under other accounts receivable. Overall, accounts receivable and other current assets increased to €600 million, including trade receivables which increased by €9 million.

Marketable securities decreased by €16 million to €199 million. Additions totaling €121 million were offset by disposals amounting to €137 million, resulting from the sale of shares for pre-financing purposes. As in previous years, the Fraunhofer Fund's available assets were invested in a widely diversified portfolio consisting of money market instruments, bonds, multi-asset funds, stock-market shares, commodities, and shares of equity in renewable-energy companies. In view of the uncertain market situation, the Fraunhofer Fund applied a risk-adjusted model in its asset allocation policy, with the Fund

steering and proactively containing its investment risks through dynamic and systematic management of the allocations to the individual segments and through risk overlay with threshold control.

Cash and cash equivalents, including the Fraunhofer-Gesellschaft's current bank accounts, increased by €2 million to €31 million, of which €30 million was set aside for investment as part of the special reserve for license-fee revenue. In 2014, Fraunhofer made use of the provisions of its management statutes to carry forward funds amounting to €0.4 million granted by the Federal Ministry of Defence (BMVg).

Prepaid expenses and deferred charges, which mainly relate to prepaid rent and to maintenance contracts and services, remained largely unchanged at €10 million.

Equity grew by €2 million – an amount representing the net income for the year from the association's accounts – and totaled €16 million at the reporting date. This includes a legacy of €1 million that was donated to the Fraunhofer-Gesellschaft and recognized under restricted reserves. The non-profit organization's capital is that portion of the Fraunhofer-Gesellschaft's assets that has not been acquired out of public funds. In addition to the capital of the non-profit organization and the restricted reserves, equity is also deemed to include the special reserves for license-fee revenue and for grants relating to fixed assets.

The special reserve for license-fee revenue decreased by €15 million in 2014 and amounted to €229 million at the reporting date. An amount of €19 million from this reserve was utilized, while an amount of €4 million was transferred to the reserve, corresponding to the net income for the year arising from the non-profit organization's asset management portfolio.

Funds received for the purpose of acquiring or constructing fixed assets are transferred to a special reserve, which is reduced each year by an amount corresponding to the annual depreciation expense on the assets in question. The special reserve for grants relating to fixed assets increased by €101 million to €1,946 million in 2014, in line with the carrying amount of the assets financed by such external funds.

The special reserve for funds used to finance current assets is used to account for income not yet received less expenses not yet paid at the reporting date. In 2014, this reconciliation item increased to €221 million.

A new special reserve was created in 2014 to account for the present value of future payments in connection with the sale of patent rights, amounting to €80 million.

Provisions for pensions and similar obligations amounted to €10 million. The Fraunhofer-Gesellschaft has a reinsurance policy in place to cover its existing pension obligations, as a means of offloading biometric risks and converting uncertain long-term liabilities into foreseeable, calculable costs. The pension provisions are measured using the capitalized value calculated by the insurance company at the reporting date.

Other provisions increased by €4 million to €142 million. With the exception of provisions for compensated leave, the change in other provisions had no impact on the funding situation due to the simultaneous change in the special reserve for funds used to finance current assets. In the case of pension and compensated leave provisions, corresponding balancing amounts are entered on the assets side of the balance sheet.

In 2014, liabilities decreased by €21 million to €191 million. This item included €69 million in unappropriated grants from the federal and state governments, €96 million in trade payables, and €26 million in other liabilities.

Deferred income amounted to €7 million, and relates primarily to lump-sum license fee payments received for mp3 technology before the reporting date that are not yet recognized as revenue.

No significant events have arisen since the reporting date that are material to assessing the development of the Fraunhofer-Gesellschaft's business in the year under review or which have a substantial impact on its financial position, net assets or operating results.

Subsidiaries, equity investments and spin-offs

- Stakes in a total of 79 companies
- International subsidiaries continue upward trend
- Internal programs provide high level of support for spin-off activities

At the reporting date, the Fraunhofer-Gesellschaft held equity investments in a total of 79 companies operating in a wide range of market sectors. The transfer of technology to industrial applications was the main focus of Fraunhofer's investment in 56 of these companies, while the remaining 23 were of a strategic nature. In 2014, the Fraunhofer-Gesellschaft added 5 companies to its investment portfolio and divested its shares in 4 other companies. The total carrying amount of these **equity investments** at the reporting date was €6.1 million.

With a view to institutionalizing its R&D activities outside Germany, Fraunhofer operates four **international subsidiaries** as well as two foundations and one non-profit association, which in turn run their own research units. Due to the negligible effect of the revenues generated by the subsidiaries on the parent organization's net assets, financial situation and operating results, Fraunhofer does not draw up consolidated financial statements.

Established in 1994, **Fraunhofer USA, Inc.**, is a wholly owned, non-profit subsidiary of the Fraunhofer-Gesellschaft with headquarters in Plymouth, Michigan. Under the auspices of Fraunhofer USA, seven Fraunhofer Centers conduct research on behalf of industrial clients, public-sector organizations and academic institutions. In addition, Fraunhofer USA hosts the American marketing activities of two Fraunhofer Institutes. The budgeted expenditure of Fraunhofer USA in 2014 amounted to the equivalent of €35.1 million in U.S. dollars (provisional figure). Due to litigation expenses resulting from a dispute over intellectual property (IP) rights with a research partner, a provision was set aside to cover the anticipated

costs. Project revenues generated by Fraunhofer USA in respect of contracts with third parties amounted to a total of €19.6 million based on the provisional financial statements. With U.S.-dollar revenues equivalent to €6.2 million, the Center for Molecular Biotechnology CMB was the best-performing institution.

Fraunhofer's Austrian subsidiary, **Fraunhofer Austria Research GmbH**, started operations from its headquarters in Vienna in 2009. The Fraunhofer-Gesellschaft is the sole owner of this non-profit, limited-liability company. The legal entity Fraunhofer Austria Research GmbH covers the Austrian activities of two Fraunhofer Institutes in two separate units: the Production Management and Logistics unit in Vienna and the Visual Computing unit based in Graz. Based on the entity's provisional financial statements for 2014, Fraunhofer Austria's operating budget amounted to €3.3 million, with project revenues totaling €2.5 million.

Together with the Trade Association of South Tyrol, the Fraunhofer-Gesellschaft established the non-profit subsidiary **Fraunhofer Italia Research Konsortial-GmbH** with headquarters in Bolzano in 2009. The Fraunhofer-Gesellschaft holds a 99-percent stake in this subsidiary, which functions as legal representative for the Fraunhofer centers located in Italy. They include the Fraunhofer Innovation Engineering Center IEC in Bolzano, which receives institutional funding from the Independent Province of Bolzano in South Tyrol. The Center will receive around €4.9 million in base funding under the terms of the region's budgeted expenditure for the period 2015 to 2018. Fraunhofer Italia's operating budget for 2014 amounted to €1.4 million, around €0.8 million of which was covered by project revenues (according to the latest projections).

Fraunhofer UK Research Ltd., a wholly owned subsidiary of the Fraunhofer-Gesellschaft with headquarters in Glasgow, Scotland, was established in 2012. Together with the

Fraunhofer Institute for Applied Solid State Physics IAF, it operates the Fraunhofer Centre for Applied Photonics CAP in close cooperation with the University of Strathclyde in Glasgow. Fraunhofer UK's provisional budgeted expenditure amounted to the equivalent of €1.9 million in 2014, with provisional project revenues amounting to around €1.0 million.

Domiciled in Santiago de Chile, the **Fundación Fraunhofer Chile Research** was set up in 2010 with the Fraunhofer-Gesellschaft as its sole owner and operates as a non-profit foundation. In 2014, the Center for Solar Energy Technology CSET was created in collaboration with the Fraunhofer Institute for Solar Energy Systems ISE in Germany. Based on provisional figures, Fraunhofer Chile's budgeted expenditure in 2014 amounted to the equivalent of €3.5 million.

The **Associação Fraunhofer Portugal Research** is based in Porto and was created in 2008 as a non-profit organization under Portuguese law as a collaborative venture between the German and Portuguese chambers of commerce. The Fraunhofer Portugal Research Center for Assistive Information and Communication Solutions AICOS currently operates under the umbrella of this association. According to its provisional financial statements, Fraunhofer Portugal generated project revenues of €1.6 million in 2014, compared with a budgeted expenditure of €2.6 million.

In Sweden, the **Stiftelsen Fraunhofer Chalmers Centrum för Industrimatematik** was founded as a non-profit foundation under Swedish law managed jointly by the Fraunhofer-Gesellschaft and Chalmers University in Gothenburg. Fraunhofer and Chalmers University have equal voting rights on the foundation's board of trustees. The foundation manages the activities of the Fraunhofer-Chalmers Research Centre for Industrial Mathematics FCC, which was established in collaboration with the Fraunhofer Institute for Industrial Mathematics ITWM in Kaiserslautern, Germany. According to provisional data, the FCC generated project revenues of €3.4 million from a research budget of €4.3 million.

In addition to its international activities, the Fraunhofer-Gesellschaft takes an active interest in its spin-offs, taking minority stakes in them for a variety of different reasons.

Spin-offs play a very important role as an avenue through which the Fraunhofer-Gesellschaft can capitalize on its intellectual property rights. The Fraunhofer Venture department typically provides support to the founders of spin-off companies during the early stages of the creation process. In return for the know-how transferred to the spin-off, the Fraunhofer-Gesellschaft receives a minority stake in the equity of the fledgling company. As well as generating returns from the transfer of technology, spin-offs also help promote entrepreneurial thinking and the establishment of cooperative networks with businesses operating in the same sphere as the respective Fraunhofer Institutes. Moreover, spin-offs are of great benefit to the national economy because they lead to the creation of new jobs and give industry a stronger competitive edge through product innovation. In 2014, Fraunhofer Venture provided support to 40 spin-off projects, and 16 new businesses were established as spin-offs from the Fraunhofer-Gesellschaft.

Since Fraunhofer first launched its support program for spin-offs, which goes by the name of “FFE – Fraunhofer Fosters Entrepreneurship”, no less than 115 teams of budding entrepreneurs have chosen this route to set up their own company. In 2014, funds totaling €1.35 million were granted to 11 new projects. A parallel initiative, now entering its fourth year, is the “FFM – Fraunhofer Fosters Management” program. In 2014, it provided support to 6 spin-offs in which the Fraunhofer-Gesellschaft holds an equity interest. The aim of this program is to strengthen the management skills of the new executives and guide them through the highly critical early phase of their business.

Overall, the Fraunhofer-Gesellschaft expects the positive trend in its spin-off activities to continue in the medium term.

International activities

- Significant growth trend in international revenues
- Growing network of international partners
- Fraunhofer USA celebrates its 20th anniversary

Global networks linking members of the scientific community are the order of the day in today's high-tech world. The supply chains of Germany's export-oriented industrial companies have a distinctly international character. To consolidate its role as the driving force behind innovations that enable German industry to maintain its leading edge in the face of global competition, Fraunhofer has consistently expanded its international activities on a sustainable basis. Fraunhofer is a brand name that stands for excellence in applied research and is recognized throughout the world as one of the most successful examples of technology transfer between science and industry. Fraunhofer largely owes its position as a leading research organization to the international profile of its institutes, which also helps to assure the organization's innovative power.

In 2014, **revenues generated from projects with international partners** reached a total of €276 million (excluding license-fee revenues). This sum includes €27 million in revenues resulting from contracts between Fraunhofer subsidiaries outside Germany and external third parties. Overall, Fraunhofer's international revenues grew by 10 percent.

Revenues generated in Europe increased by 10 percent in 2014 to a total of €200 million. The proportion of these revenues originating from **European customers outside Germany** amounted to €94 million, which represents an increase of 4 percent. With revenues of €16 million, Austria was the most important European market for Fraunhofer, followed by France with €11 million and the Netherlands with €10 million. These industrial revenues are complemented by public-sector funding, one of the main sources of which is the

European Commission. In 2014, Fraunhofer received grants totaling €106 million for research projects under the EU Framework Programme – a significant 15-percent increase compared with the previous year. According to the European Research Ranking, which is based on statistics gathered by the European Commission, Fraunhofer has featured among the top German organizations every year since 2007 in the categories “Funding & Projects”, “Networking”, and “Diversity”.

Networking – be it on a national or international basis – is one of the hallmarks of Fraunhofer’s successful business policy. The European Framework Programme for Research and Innovation serves as Fraunhofer’s central networking platform in Europe, and also for cementing ties with other research organizations in Germany. One example is the central office of the European Knowledge and Innovation Community (KIC) for Raw Materials, which is managed jointly by Fraunhofer and the Helmholtz Association of German Research Centers. The aim of this consortium is to enhance the competitiveness and stimulate the growth of the raw materials sector in Europe – and attract investors – by means of radical innovation and the creation of new businesses. The consortium comprises a total of 116 partner organizations from 21 European countries, among them many well-known educational and research institutions and industry associations. Fraunhofer is represented by more than a dozen institutes and the Fraunhofer Academy. Fraunhofer is also represented in the Knowledge and Innovation Community for Healthy Living and Active Ageing, of which the Fraunhofer Institute for Integrated Circuits IIS is a member.

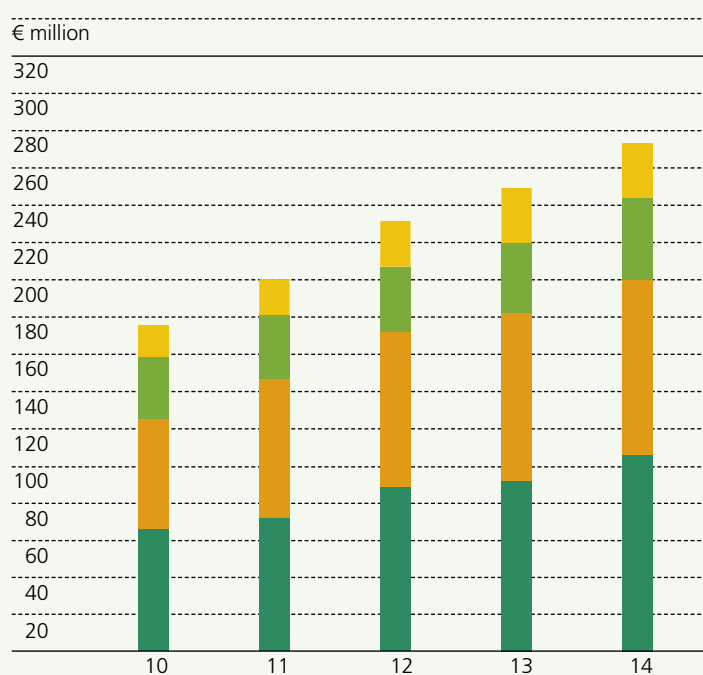
The European Union’s Joint Technology Initiatives (JTI) are another instrument that promotes collaboration between science and industry in Europe, through EU-sponsored, long-term, joint strategic research projects based on public-private partnerships. In the field of aeronautics, for example, a consortium of Fraunhofer Institutes has been participating in the “Clean Sky” Joint Technology Initiative since it was launched under the seventh Framework Programme (FP7), and is continuing

this work under the follow-up initiative “Clean Sky II”, in close collaboration with key partners in the aeronautics industry. Other Joint Technology Initiatives in which Fraunhofer is a participant are “Bio-based Industries” and “Electronic Components and Systems”, both by submitting proposals and by providing expert consultants. The Fraunhofer Institute for Material Flow and Logistics IML is responsible for coordinating partner requests for the new Joint Technology Initiative in the rail transportation sector, “Shift2Rail”.

In 2014, Fraunhofer increased its revenues from projects in **North and South America** by 16 percent to €44 million. The U.S. market accounted for €37 million of these revenues, €20 million of which were generated by the organization’s North American subsidiary Fraunhofer USA, Inc. With revenues of over €3 million, Brazil constitutes Fraunhofer’s most important market in South America.

In 2014, Fraunhofer celebrated the 20th anniversary of its first international subsidiary, Fraunhofer USA, Inc., created on September 14, 1994, in Rhode Island. Today, Fraunhofer USA comprises seven Fraunhofer Centers, each operating as legally independent entities with their own research facilities, and two marketing offices. Like the Fraunhofer Institutes in Europe, they work at the interface between academic research and private industry. In this way, Fraunhofer has been able to build up a closely meshed network of collaborative partnerships in the United States over the years, based on mutual trust and respect. The broad spectrum of research carried out by Fraunhofer USA allows Fraunhofer employees from Germany to gain first-hand experience of the U.S. American research market without contributing to the brain drain – mitigating the often-feared risk that highly qualified scientists might emigrate permanently. The doors of Fraunhofer USA are also open to German students wishing to gather experience in the United States. They are offered the opportunity of participating in projects at the Fraunhofer Centers as part of their study curriculum, in many cases through one-to-one agreements with universities in Germany.

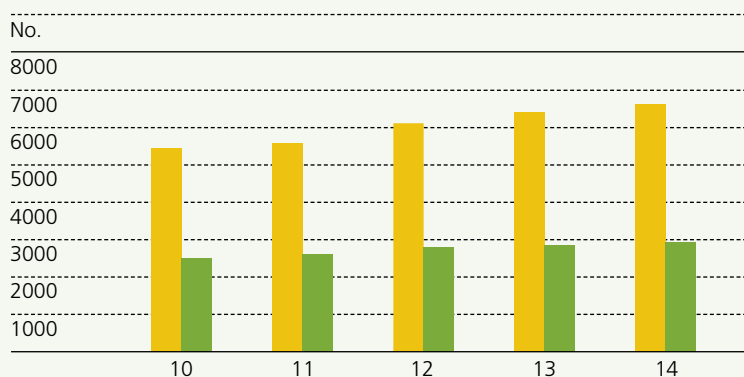
Revenue from work with international customers and partners 2010–2014



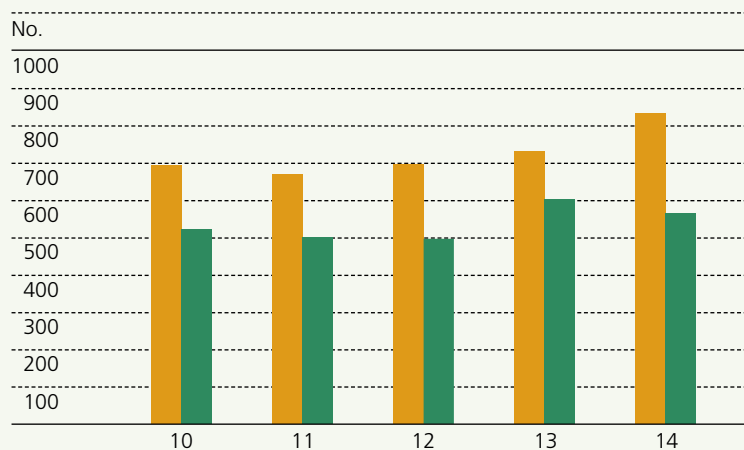
	2010	2011	2012	2013	2014
Asia	17	18	24	29	30
North and South America	33	35	35	38	44
European countries	59	74	84	90	94
EU Commission	65	71	88	92	106
Other countries	1	2	2	1	2
= Total international revenue¹ in € million	175	200	233	250	276

¹ This amount includes income generated by international subsidiaries with third parties, which amounted to €27 million in 2014.

Invention disclosures and patent applications by the Fraunhofer-Gesellschaft 2010–2014



	2010	2011	2012	2013	2014
Active patent families ¹	5457	5657	6103	6407	6618
Of which patents valid in Germany	2505	2605	2794	2847	2932



	2010	2011	2012	2013	2014
Invention disclosure reports per year	694	671	696	733	831
Patent applications per year	520	500	499	603	564

¹ Portfolio of active patents and utility models and pending patent applications at year end.

Fraunhofer's revenues in **Asia** in 2014 amounted to €30 million, an increase of 4 percent on the previous year. Japan was once again by far the strongest Asian market, generating revenues of €12 million, followed by China with €7 million and South Korea with €4 million.

In the fall of 2014, Fraunhofer inaugurated the Fraunhofer Project Center for Electroactive Polymers at the National Institute of Advanced Industrial Science and Technology Kansai (FPC at AIST) in Osaka, Japan. Here, AIST scientists work together with the Fraunhofer Institute for Manufacturing Engineering and Automation IPA on precompetitive research projects, developing sensors and actuators based on electroactive polymers (EAPs) and technologies for energy generation and storage. The Kansai region hosts a large and thriving community of Japanese high-tech companies specializing in robotics, lightweight construction, battery technologies, photovoltaics and nanotechnology.

Intellectual property activities

- More than two patent applications every working day
- Fraunhofer again among the Top 100 Global Innovators

The Fraunhofer-Gesellschaft is one of the most active and important sources of patent applications in Germany. In 2014, our research institutions produced a total of 831 invention disclosure reports – more than ever before. Patent applications were filed for 68 percent of these inventions – or 564 to be exact. This means that, on average, Fraunhofer submits more than two patent applications every working day. Fraunhofer's portfolio of active intellectual property (IP) rights (patents and utility models) and pending patent applications had increased to a total of 6618 by the end of 2014. That includes 2932 patents granted for the German market. The number of exploitation agreements in current use increased to 3526. As a result of this performance, Fraunhofer ranked among the

Top 100 Global Innovators for the second year running – a status accorded to only four German organizations in 2014. This award is presented annually by the Thomson Reuters media group on the basis of the number and quality of patented inventions.

In 2014, the responsibility for managing the Fraunhofer-Gesellschaft's IP rights was transferred to the new Executive Board function Technology Marketing and Business Models, which is tasked with expanding activities related to the commercialization of IP assets. The marketing efforts of the new department created for this purpose will benefit from the business orientation of the new board-level function, which will apply a cross-institute approach to these activities. This widens the scope of the existing patent strategy process, which until now was tailored to the needs of specific Fraunhofer Institutes. In order to compensate better for fluctuations in its traditional sources of income, Fraunhofer has implemented a results-oriented system of IP management. This enables the institutes to improve management of their IP portfolios and tap additional sources of revenue to complement their contract research activities by offering licensing agreements to a wider clientele.

One of the prerequisites for generating a continuous flow of license-fee revenues is a strategy that supports a long-term program of pre-competitive research regardless of changes in the economic environment. This approach enables the Fraunhofer-Gesellschaft to build up comprehensive property right clusters in targeted areas of interest. In order to accelerate the transformation of research findings into commercial applications through licensing agreements with high-tech companies, the Fraunhofer Future Foundation promotes in-house research projects that it has identified as being crucial to future market demand. In this way, the Foundation helps the Fraunhofer-Gesellschaft to assure its role as an innovator and thereby improve the competitiveness of German industry.

EMPLOYEES

Overview

- Workforce up by 2.4 percent to nearly 23,800 employees
- Fraunhofer holds its place as one of the top ten preferred employers

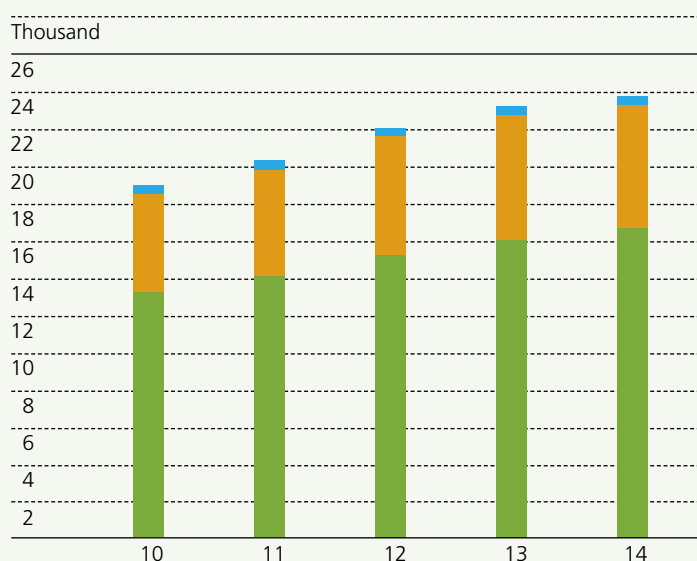
At December 31, 2014, Fraunhofer had 23,786 employees, most of whom hold degrees in the natural sciences or an engineering discipline. This represents an **increase** of 550 or 2.4 percent in the **number of employees** compared with the previous year. Fraunhofer's long-term recruitment policy is based on a wide range of different measures to attract future scientists at every stage of their education, starting at kindergarten level and extending to university graduates. One of the more specific challenges is that of balancing the need for top-class scientists and business managers with that of promoting interest in science on a more general level. A further priority is that of encouraging more women to apply for posts in management, a social issue to which Fraunhofer pays a great deal of attention, in its own interests.

In 2014, as in previous years, Fraunhofer ranked among the **top ten preferred employees**, as illustrated by the results of the latest survey published by the Universum consulting agency. To maintain this position in the long term, Fraunhofer carries out its own regular opinion surveys in which potential job applicants and current employees are asked to define the reasons why they chose Fraunhofer as an employer. Their responses provide a basis for the continuous improvement of the factors that determine Fraunhofer's status as an attractive employer. Alongside the application-oriented approach that is a basic feature of Fraunhofer research, the plus points mentioned include extremely well-equipped workplaces, laboratories and workshops, personalized career development, opportunities for continuing education, a health management system attuned to genuine needs, and a compensation system that recognizes outstanding performance.

In recent years, Fraunhofer has developed a holistic concept for **supporting future specialists in the STEM fields** (science, technology, engineering and mathematics), which takes in all stages of education. As well as developing age-adapted educational formats for children and helping school-leavers with their choice of university education in the STEM fields, this program also offers temporary work opportunities at Fraunhofer to enable future scientists, technologists, engineers and mathematicians to add to their qualifications. Each year, Fraunhofer employs some 7000 student assistants, undergraduate and postgraduate students, and student interns. An online survey carried out in 2014 specifically addressing this group of people revealed that they were knowingly using the opportunity to work for Fraunhofer as a stepping stone to a future career in science. The positive outcome of this survey has prompted Fraunhofer to launch a new in-house initiative to introduce information on career options at Fraunhofer, and the associated opportunities to obtain additional qualifications, at an early stage of the support program for this target group.

Another important target group for Fraunhofer is the vocational training sector. The **vocational training** provided by Fraunhofer is mainly intended to cover the organization's own needs for qualified specialists. At present, no less than 480 trainees are preparing to work for Fraunhofer in 38 different professional disciplines, including dual courses in which periods of academic study alternate with practical experience. To enhance their professional skills and scientific knowledge, Fraunhofer offers accompanying seminars focusing especially on practical applications, including social skills and methodologies. In 2014, the number of Fraunhofer's training contracts decreased by 2.8 percent. On a national level however, the number of new training contracts decreased by 3.7 percent in 2014. The looming shortage of specialized workers calls for new forms of recruiting. That is why Fraunhofer has integrated social media and job fairs in its recruiting policy, in order to market its vacancies to specific target groups, including talented

Growth in the Fraunhofer-Gesellschaft's workforce 2010–2014



	2010	2011	2012	2013	2014
■ Trainees	487	488	470	494	480
■ Graduate, undergraduate and school students	5 313	5 765	6 403	6 694	6 619
■ Scientific, technical and administrative personnel	13 202	14 073	15 220	16 048	16 687
= Total number of employees	19 002	20 326	22 093	23 236	23 786

students who feel uncomfortable in an academic environment but might be better suited to more practice-oriented courses of study or traditional apprenticeships.

Significant progress was made in 2014 concerning **performance-related compensation** for the majority of Fraunhofer employees. After implementing the relevant provisions of the German Academic Freedom Act in an agreement with the Central Works Council, Fraunhofer was for the first time able to offer a large number of its employees the equivalent of a profit-sharing bonus, linked to the financial results of the

respective institutes. In keeping with Fraunhofer's status as a non-profit organization, these bonus payments are based (solely) on industrial revenues. Fraunhofer welcomes this opportunity to utilize part of its financial resources that do not stem directly or indirectly from public sources to reward outstanding performance. However, because the Act restricts the group of beneficiaries entitled to such payments, namely research scientists and science-related personnel, it is not possible to include all employees who contributed to the achieved results. This has been widely criticized by the staff concerned.

Career opportunities at Fraunhofer

- Personal career development through a variety of support programs
- Wide range of support and career opportunities for doctorate students at Fraunhofer

The Fraunhofer career system is based on the assumption that a large majority of the scientists employed will stay with the organization for only a limited number of years. This is the logical consequence of Fraunhofer's social mission, which is to enable young people to develop their full innovative potential, provide them with training, and prepare them for a variety of career paths in science and industry or as independent entrepreneurs. The alternative is for them to continue in a career with Fraunhofer, in which case they benefit from personal career planning support once they have completed their initial period of familiarization.

At Fraunhofer, personal career development and planning is discussed with all employees as part of their annual assessment interviews. In addition to this, ad-hoc meetings are arranged whenever this is deemed appropriate, for instance after the award of a PhD, at the beginning or end of a specific project, or to take account of changes in the employee's personal situation. The important point is that the employee's personal career objectives should be viewed from the perspective of their existing skills and future potential, bearing in mind their current lifestyle obligations and the need to balance them with Fraunhofer's requirements and the opportunities it can offer. In 2014, Fraunhofer introduced a new model for career planning and professional development based on nine essential skills that Fraunhofer employees are expected to provide. On a general level it serves as a common basis for determining the core competencies that contribute most to Fraunhofer's success, and at the same time it can be used as a yardstick for specific areas of work. Through this model, Fraunhofer has laid the

foundations for a new, sustainable approach to HR and career management that applies to all employees, while at the same time providing managers with a useful tool for decisions concerning the recruitment of new employees and the professional development of existing employees.

For scientists planning to pursue a career in research, the award of a doctorate (PhD) is the chief requirement, which for many Fraunhofer employees represents the first step in their career path. In addition to the possibility of obtaining a doctorate by participating in Fraunhofer research projects, Fraunhofer offers many other opportunities for scientists to develop their careers and obtain further qualifications. These include the participation in seminars, conferences and specialized forums, and invitations to participate in a wide range of national and international R&D projects, either as collaborating scientists, or as project managers, or by helping to prepare bids for proposals. Moreover, Fraunhofer's close ties with the academic community permit doctoral candidates to benefit from the support of the universities at which the directors of Fraunhofer Institutes hold a parallel appointment as a department chair. The Fraunhofer Institutes are also frequently partners to graduate schools.

Fraunhofer has implemented a number of programs to support its career development activities, based on the usual development paths at its own institutes. The most recent among them is a common development program for managers based on the guidelines for management training published in 2014.

The Fraunhofer Vintage Class is an established fast-track program for furthering the career development of scientists with management potential. Since the program was launched nine years ago, six of its graduates have acceded to posts as members of the executive board of Fraunhofer Institutes. The most recent appointments were that of Prof. Dr. Ina Schieferdecker, who was appointed to the executive board of

the Fraunhofer Institute for Open Communication Systems FOKUS as of January 1, 2015, and Prof. Dr. Stefan Hiermaier, who is now the director of the Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut, EMI.

Equal opportunities

- TALENTA program to support women in research has desired effect
- Significant increase in the proportion of women scientists

It is Fraunhofer's declared objective to significantly increase the **proportion of women scientists** by 2017, both among its staff in general and in management positions. Concrete targets are defined for each level of the hierarchy in an independent cascade model. The implementation of activities is monitored and summarized in a once-yearly report. In total, the aim is to raise the proportion of women in research and management positions to over 21 percent by 2017. In the case of posts without management responsibility, Fraunhofer plans to increase the proportion of women to over 23 percent. Based on the findings of an in-house survey addressing its female members of staff, Fraunhofer has developed a general concept for promoting equal opportunities for men and women, published in 2014, which it presented for objective appraisal by representatives of the scientific, business and political decision-making communities.

The concept is centered on the **TALENTA** program of measures to support the career development of women in research and management. This three-part program is designed to promote the professional development of women scientists at different stages of their careers, dubbed "start", "speed up" and "excellence" respectively. In the two modules "career time" and "qualification" the program provides women with sparring partners for the next career move, time out to obtain

further qualifications, e.g. by studying for a master's degree or doctorate, and assistance with obtaining support for building up other specialized skills, such as human resources management. TALENTA already produced the desired results in 2014. The intake of new scientific personnel in the five areas of research of most relevance to Fraunhofer included a higher proportion of women in relation to the number of graduates in the relevant disciplines. As a result, the number of non-management positions occupied by women increased to 21.8 percent, thus marginally exceeding the target set for 2014. Fraunhofer intends to devote all of its efforts to the continuation of this program, which promises to prepare more and more women for senior roles in research and management. As a result of this sustainable approach to increasing the representation of women in research, the number of women acceding to management positions is gradually rising, but it will be some time before this has a significant effect.

External experts have praised the Fraunhofer-Gesellschaft's commitment to equal opportunities. Fraunhofer beat numerous well-known DAX companies to second place in the competition for the **Human Resources Excellence Award 2014**, in the category "equal professional opportunities" for its TALENTA program. Fraunhofer is convinced that this structured program, with its focus on the individual, will enable the organization to promote the careers of up-and-coming women scientists and recruit new scientists at all stages of their professional development.

RISK SITUATION AND OUTLOOK

Risk management and identified risks

- Continuous monitoring of Fraunhofer's risk exposure
- No anomalies in the overall risk situation

In carrying out its applied research, the Fraunhofer-Gesellschaft takes calculated risks in order to create innovations that will benefit both the economy and society at large. The **risk management** system is designed to identify existing and potential risks at an early stage and to manage them by means of appropriate measures in such a way that they either do not materialize at all or have no consequences that could jeopardize Fraunhofer's ability to fulfill its mission as defined in its statutes or prevent it from meeting its business objectives. The risk management process is set down in the Fraunhofer-Gesellschaft's risk management manual. The central departments inform the Executive Board of identified risks – both routinely and on an ad-hoc basis – via the established reporting channels. Fraunhofer supplements these activities by preparing a separate, annual risk report, which summarizes and prioritizes these risks on the basis of the collective opinion of a team of risk assessment experts. Fraunhofer understands "risk" to mean all internal and external events and developments that might jeopardize the fulfillment of its business objectives. These include both risks that can be given a monetary value and those of a qualitative nature.

Risks arising from changes in the political, legal and economic framework of applied research are categorized as **business risks**.

Political decisions concerning a reduction in planned funding contributions or restrictions placed on transferring unused portions of the previous year's funding can affect Fraunhofer financially. The renewal of the Joint Initiative for Research and Innovation for a third period (2016–2020) has given Fraunhofer a measure of security in its medium-term financial planning, but this time the yearly increase in base funding is

only 3 percent as opposed to 5 percent in the period up to 2015. This partly reflects the impact of the borrowing restrictions that have prompted certain state governments to look for cost savings in the area of research funding. Meanwhile, Fraunhofer continues to lobby the federal and state governments to maintain its institutional funding at a level in keeping with its mission, and in proportion to its performance.

Fraunhofer's access to public-sector funding for research projects is subject to changing regulations and conditions. This is particularly true in the case of projects funded through the European Framework Programme for Research and projects funded by the state governments – the latter being often refinanced by the ERDF. Support for the institutes is optimized to counteract the risk that changes to funding instruments and thematic areas of research do not have a sustainable negative impact on their ability to acquire and finance research projects. Reduced revenues may also result from changes to funding regulations concerning the reimbursements of costs or from an unfavorable interpretation of these costing models. The Fraunhofer-Gesellschaft regularly audits project expenditure and implements continuous improvements in consultation with the funding agencies to ensure that the cost calculation system meets the necessary requirements, and negotiates with the relevant European and national bodies to obtain their approval of the calculation methods applied by Fraunhofer.

As a non-profit organization and beneficiary of public funds, Fraunhofer keeps a close eye on changes in legislation that might affect its access to financial support and continuously evaluates these changes with respect to their possible impact on the financing of its activities. By adapting to these changes and taking appropriate countermeasures, Fraunhofer ensures that its funding model remains in conformity with current research funding legislation.

Fraunhofer counters the risk of strategic errors in its development plans by continuously enhancing its diversified research portfolio. Improved monitoring and controlling systems enable the early detection of critical entities in Germany and abroad, and support a proactive approach to growth management. Established strategy planning processes permit constant feedback from relevant market players in Germany, Europe and worldwide.

Risks arising from the organization's financing activities are categorized as **financial risks**.

The Fraunhofer-Gesellschaft is exposed to capital market risk insofar as it invests part of its capital and reserves with a view to earning a return. These investments are concentrated in open-end funds within the meaning of the German Investment Act and in closed-end funds. The organization pursues a widely diversified investment policy and, in view of the uncertainty prevailing in the money and capital markets, keeps a constant watch on the risk situation. All risks are measured and controlled in real time, making it possible to respond rapidly to any changes in the market situation.

Credit risk, which essentially relates to project prefinancing and unrecoverable payments, is minimized by near-real-time monitoring of payment schedules, coupled with effective dunning procedures and contractually agreed terms of payment.

Fraunhofer channels the results of its research – such as patents – into existing companies or its own start-ups. This generates returns for the original parent organization in the form of additional research contracts or the proceeds of the subsequent disposal of shares in these businesses. Financial risks for the Fraunhofer-Gesellschaft may arise from the liability and performance of its international subsidiaries, to the extent that the organization has long-term contractual obligations toward the subsidiary in question. The development of equity investments is monitored in real time by the investment controlling department.

Potential losses due to the inadequacy or failure of internal processes and systems, human error, or external events are categorized as **operational risks**.

The Fraunhofer-Gesellschaft preserves and expands its research expertise by recruiting highly qualified scientists and encouraging them to stay with Fraunhofer. The organization's close ties with universities enable the up-and-coming generation of researchers to get to know Fraunhofer at an early stage. Fraunhofer's already very favorable reputation in the relevant employment markets is reinforced by a human resources policy that is sustainable and geared to the long term.

The provision of research services calls for a reliable and secure IT infrastructure. Fraunhofer takes targeted measures to mitigate potential IT risks, including those arising from the growing trend toward centralized IT services. These measures are defined in a binding IT security manual.

By continuously improving its standard procedures and guidelines, Fraunhofer ensures that its business processes are designed and implemented in compliance with the increasingly stringent legal and regulatory requirements. A compliance management system is in place to ensure that all matters concerning rules and regulations are dealt with in a systematic manner.

Through its contract research projects for industry, Fraunhofer is exposed to liability and performance risks such as product liability and warranty commitments. It manages these risks through suitably formulated liability restriction clauses in its standard contracts and general business terms and conditions, as well as through a multitier approval process based on the advice of competent lawyers.

The current **overall assessment** of the Fraunhofer-Gesellschaft's risk situation reveals nothing that could endanger its existence in the long term.

Outlook

On a financial level, the growth of the Fraunhofer-Gesellschaft is driven by a steadily increasing demand for applied research and development services on the part of industry and in the public sector. While continuing to grow in its established areas of expertise, Fraunhofer has expanded into several new areas in recent years, notably by setting up project groups to build up expertise in additional fields of research. Given that many of these project groups became eligible for a share in the base funding granted by the federal and state governments in 2014, it is all the more gratifying to see that the proportion of contract research expenses covered by external sources of revenue has nonetheless reached an all-time high. This demonstrates the capacity of the Fraunhofer Institutes to respond to the rapidly changing requirements of the market environment.

The increase in funding from external sources in 2014 was mainly attributable to industrial revenues, which grew faster than revenues from other sources. On the basis of the current volume of contracts, and on condition that general economic trends remain stable, Fraunhofer anticipates a further moderate increase in its industrial revenues in 2015. On the other hand, revenue from projects funded by the federal and state governments is not expected to grow significantly, given the continuing tendency to consolidate public spending budgets. Despite this minor shift in the relative proportions of private and public funding for contract research, the underlying basis of the Fraunhofer model remains solid and intact.

In the future, Fraunhofer's research policy will be based to an even greater extent on combining the strengths of individual Fraunhofer Institutes in joint, interdisciplinary research projects. One overarching topic, which the German federal government has already incorporated in its High-Tech Strategy, and which opens up a wealth of opportunities for technology transfer from the Fraunhofer Institutes, is the paradigm shift that could justifiably be called the fourth industrial revolution. The main features of industry 4.0 are connected manufacturing systems, components and control units that communicate with one another via a data infrastructure such as the Internet, automatically control their own functions, and are capable of adapting to individual customer requests: The product selects its own production line. The new technology platforms will have to cover a wide range of requirements, necessitating the resolution of data security issues and the development of appropriate official and de facto industrial standards. Fraunhofer intends to play a role in this process as a neutral protagonist and moderator between industrial partners, and actively help to shape industry 4.0. One specific area in which Fraunhofer aims to become the technological leader is barrier-free interaction between humans and robots.

In addition to this, Fraunhofer continues to support the new energy economy, not only by developing new solutions for generating and storing energy but also and more importantly by integrating systems at grid level, in other words, using information and communication technologies and simulation platforms for the reliable planning and balancing of energy supplies and demand. As a further contribution to sustainable social development, Fraunhofer implements projects at selected locations in newly developing countries, for instance a project to recycle plastic waste and use it to manufacture wood-polymer composite materials.

Through its work, Fraunhofer helps to reinforce Germany's innovative strength, and intends to continue doing so in the future as partner in innovation and pacemaker for science and industry.

The Executive Board would like to thank the Fraunhofer-Gesellschaft's members, patrons, friends and, most of all, its employees for their support and dedicated work throughout 2014.

Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V.

The Executive Board

Prof. Dr.-Ing. Reimund Neugebauer

Prof. (Univ. Stellenbosch) Dr. rer. pol. Alfred Gossner

Prof. Dr. rer. publ. ass. iur. Alexander Kurz

Prof. Dr.-Ing. Dr. h. c. mult. Alexander Verl

REPORT OF THE SENATE ON THE FINANCIAL YEAR 2014

The Fraunhofer-Gesellschaft continued on a growth trajectory in 2014, seamlessly following on from its successful performance in previous years. This growth was driven by steadily increasing demand for applied research and development services on the part of industry and in the public sector. The German economy remained stable throughout the year, buoyed up by strong domestic demand in an otherwise difficult global economic environment. Moreover, the German federal government maintained its positive stance on support for research and innovation.

The Fraunhofer-Gesellschaft's positive financial statements for 2014 again received an unqualified audit certificate from the independent auditors.

In 2014, the Senate fulfilled the tasks it is charged with under the Statute of the Fraunhofer-Gesellschaft. It convened twice in the course of the financial year: at the Fraunhofer Institute for High-Speed Dynamics, Ernst Mach-Institut, EMI in Freiburg on May 21, and at the Fraunhofer Forum in Berlin on October 9.

The main decisions taken in accordance with the Statute concerned the Fraunhofer-Gesellschaft's structure:

- The Senate resolved to integrate the Fraunhofer Center for Organics, Materials and Electronic Devices Dresden COMEDD into the Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP in Dresden under the direction of Prof. Dr. Volker Kirchhoff with effect from July 1, 2014. By merging these two entities, Fraunhofer aims to strengthen their respective existing areas of expertise in the medium term and boost Dresden's role in organic electronics research.



- The Senate approved the Fraunhofer-Gesellschaft's plans to establish a subsidiary in Singapore (Fraunhofer Singapore Research Ltd.) by acquiring the assets of the Fraunhofer Project Center for Interactive Digital Media at NTU. The new legal entity, Fraunhofer Singapore Research Ltd., will be responsible for the planned activities in Singapore of the Fraunhofer Institutes for Computer Graphics Research IGD and Ceramic Technologies and Systems IKTS and for any research groups established in Singapore by these and other Fraunhofer Institutes in the future.

The Senate wishes to thank the Executive Board and all employees of the Fraunhofer-Gesellschaft for their commitment and their successful work in the financial year 2014.

Prof. Dr.-Ing. Ekkehard D. Schulz
Chairman of the Senate of the Fraunhofer-Gesellschaft

Prof. Dr.-Ing. Alexander Verl took up the post of senior vice president with responsibility for Technology Marketing and Business Models on April 1, 2014. In this role, he has been tasked with developing new formats for cross-institute co-operation with a view to acquiring contracts for large-scale projects. The aim is to make it easier for customers to find suitable partners in the complex Fraunhofer system by grouping together the institutes that best fit their requirements. Another aim is to generate additional revenue through the targeted marketing of intellectual property right clusters.

REVIEW OF FRAUNHOFER RESEARCH



THE CREATIVE POWER OF LIGHT

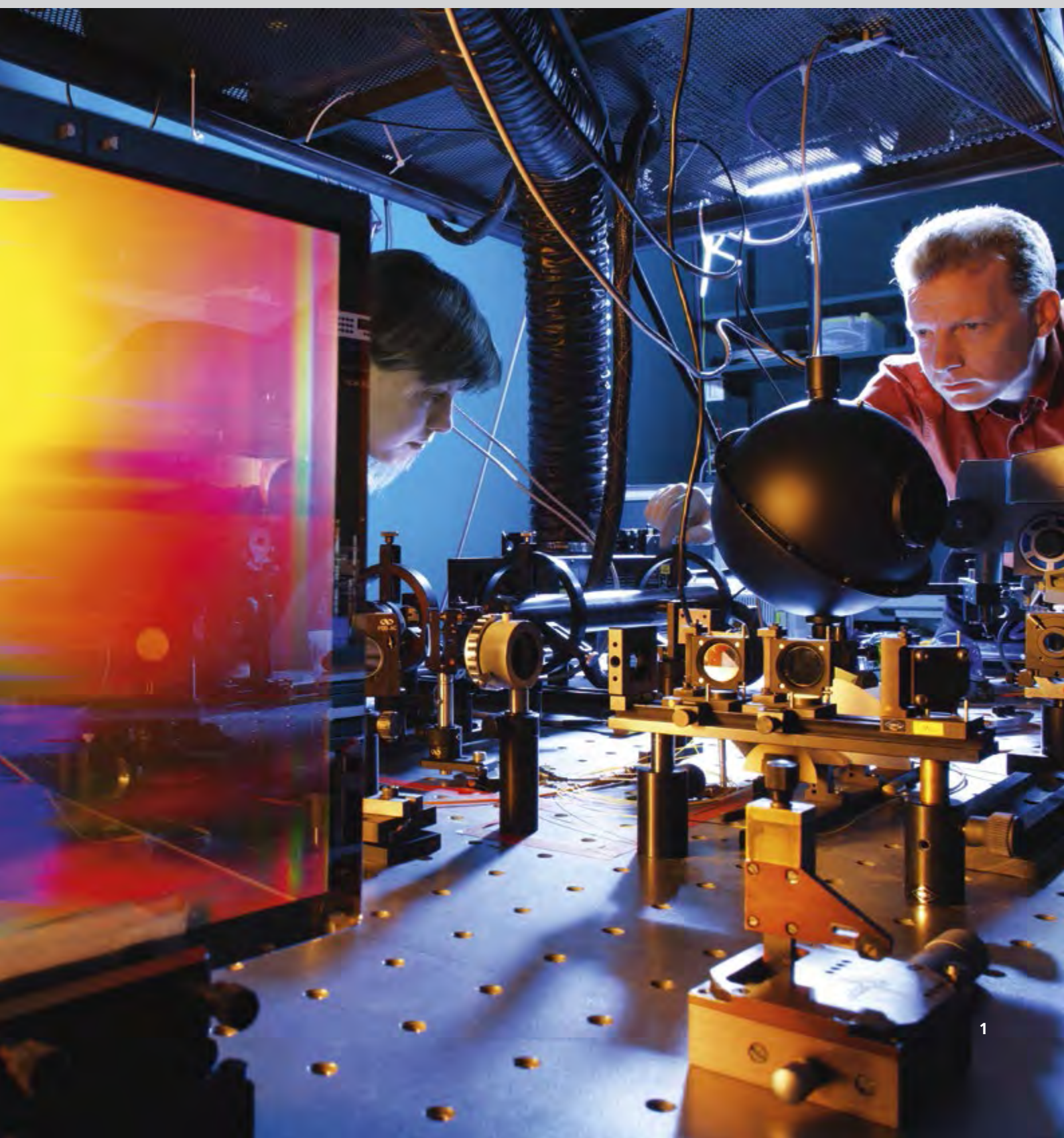
PROJECTS AND RESULTS 2014

AWARDS 2014

PEOPLE IN RESEARCH

FRAUNHOFER INSTITUTE SPIN-OFFS





THE CREATIVE POWER OF LIGHT

Prof. Dr. Andreas Tünnermann

Light and life

Decision makers in science and industry are dubbing the 21st century the “century of light” – prompting UNESCO to declare 2015 the International Year of Light. The Fraunhofer-Gesellschaft is acting as a partner and ambassador for this initiative, thus honoring the memory of its patron, Joseph von Fraunhofer, who himself developed the most high-resolution telescope and spectrometer of his time. In 1814, the Munich researcher first reported observing dark features in the solar spectrum, named after him as the Fraunhofer lines. Fraunhofer’s work on the spectral composition of light made him one of the founders of modern spectral analysis. The optical instruments he developed opened up a whole new perspective in our understanding of the world.

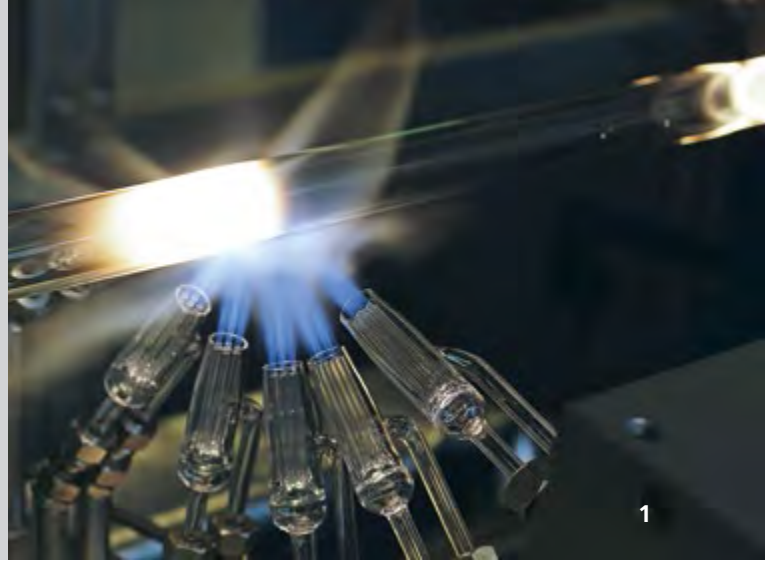
Light is the very beginning of life on Earth, and has shaped the course of the human race ever since we learned to make use of fire. Optical instruments have been part of our daily lives for thousands of years – just look at the mirror, which we know to have been used well before the time of Christ. Microscopes and telescopes were vital to developing our understanding of the world. Some 400 years ago, for instance, Galileo Galilei used a refracting telescope to observe mountains on the moon, solar spots, the rings of Saturn and some of Jupiter’s moons. Then in 1880, Robert Koch was able to use a high-resolution microscope to identify the pathogens responsible for anthrax and tuberculosis. Today, modern light microscopy allows us to look inside individual cells at resolutions of less than 10 nanometers. Telescopes such as the Very Large Telescope in Chile or the Hubble telescope in space provide us with information about the origin of our universe. Light also found its way into art, and its use plays a particularly prominent role in painting, as we see in the works of the great impressionists.

Energy and information

People interact with their environment using their senses. Sight is particularly important, allowing us to find our way in unfamiliar places, react to unexpected events, absorb all sorts of information and initiate complex decision processes. Human communication also relies significantly on visual aspects via the conscious or unconscious interpretation of body language. And light is an information medium, a vital part of our modern information society; who could imagine the Internet without fiber optic cables to transmit information in ultrafast pulses of light? Via spectral analysis, light also allows for the differentiation of materials on the atomic and molecular level. Today’s finest watches rely on identifying the precise light frequency at which the quantum mechanical state of an atom, ion or molecule is altered.

¹ Measuring the optical parameters of a diffraction grating, used for instance for spectral analysis in materials testing.

The creative power of light



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Moreover, light is a source of energy that can be converted into other forms. Methods of harnessing sunlight using photovoltaics, photothermy and even artificial photosynthesis will undoubtedly play a key role in meeting our energy demands in the future. Making use of light as a wear-free tool paves the way for new energy- and resource-efficient processes in industrial manufacturing, as well as for the optimization of technical products and the production of low-friction bearings or flow-optimized injectors.

Green Photonics – that is, the sustainable use of light – will revolutionize our century just as electronics revolutionized developments in the 20th century. Light is a trailblazer and catalyst for science and technology, which will be especially stimulated by developments in laser and plasma technology. These days, almost every branch of science and technology makes use of light applications. Employing optical and opto-electronic systems in technology leads to new products, techniques and processes that stand out for their improved productivity, quality and eco-friendliness. In medicine, light-based diagnostics and treatments are unlocking new ways to detect the most widespread diseases early on and treat them effectively.

Through its research, the Fraunhofer-Gesellschaft helps to advance the development to light sources and their application in the fields of information technology, energy, the environmental protection, health, safety and mobility. A particular emphasis is placed on energy- and resource-efficient production.

Light in industrial production

Although the solid-state laser has been around for more than 50 years, we are still finding innovative new permutations of this concept. It was only a few years ago that the introduction of novel solid state laser geometries featuring optimized cooling that made it possible to overcome the barriers to scaling up laser output without compromising on beam quality. The most successful geometries are the disk laser, the fiber laser and the slab laser. Consistently applying these designs to develop high-performance lasers is the fundament of the German laser industry's current market leadership in laser material processing. Developing fiber and slab laser technology in particular is high on the list of the Fraunhofer-Gesellschaft's current priorities.

Currently, these sorts of systems are used primarily for joining (welding) and splitting (cutting) materials. These lasers have been well established in industrial manufacturing for many years now due to their technological advantages over conventional techniques. Current focal points of research in laser cutting include technique and system developments for high-speed cutting applications. The machines enable laser cutting of flat woven fabric as well as one-piece woven material with the help of camera-based geometry recognition, e.g. in the laser cutting of airbag material.

High-performance laser beam sources could play a particularly important role in the manufacture of lightweight automotive components from fiber-reinforced plastics. Using fiber lasers, the contact-free cutting of consolidated – or compacted – composite fiber materials is possible, with a heat-affected zone that doesn't surpass 100 micrometers in width.



To meet industry's increasingly demanding requirements, special beam shaping systems are used that are based on conventional galvanometer scanners but tailored to these users' specific needs. In contrast to conventional laser cutting, this allows for cycle times approaching those of punching. But unlike punching, highly dynamic laser cutting offers the manufacturer more freedom in the design of their components. Another advantage of the laser as a wear-free tool is that it avoids high tool costs and unplanned production downtime when tools break.

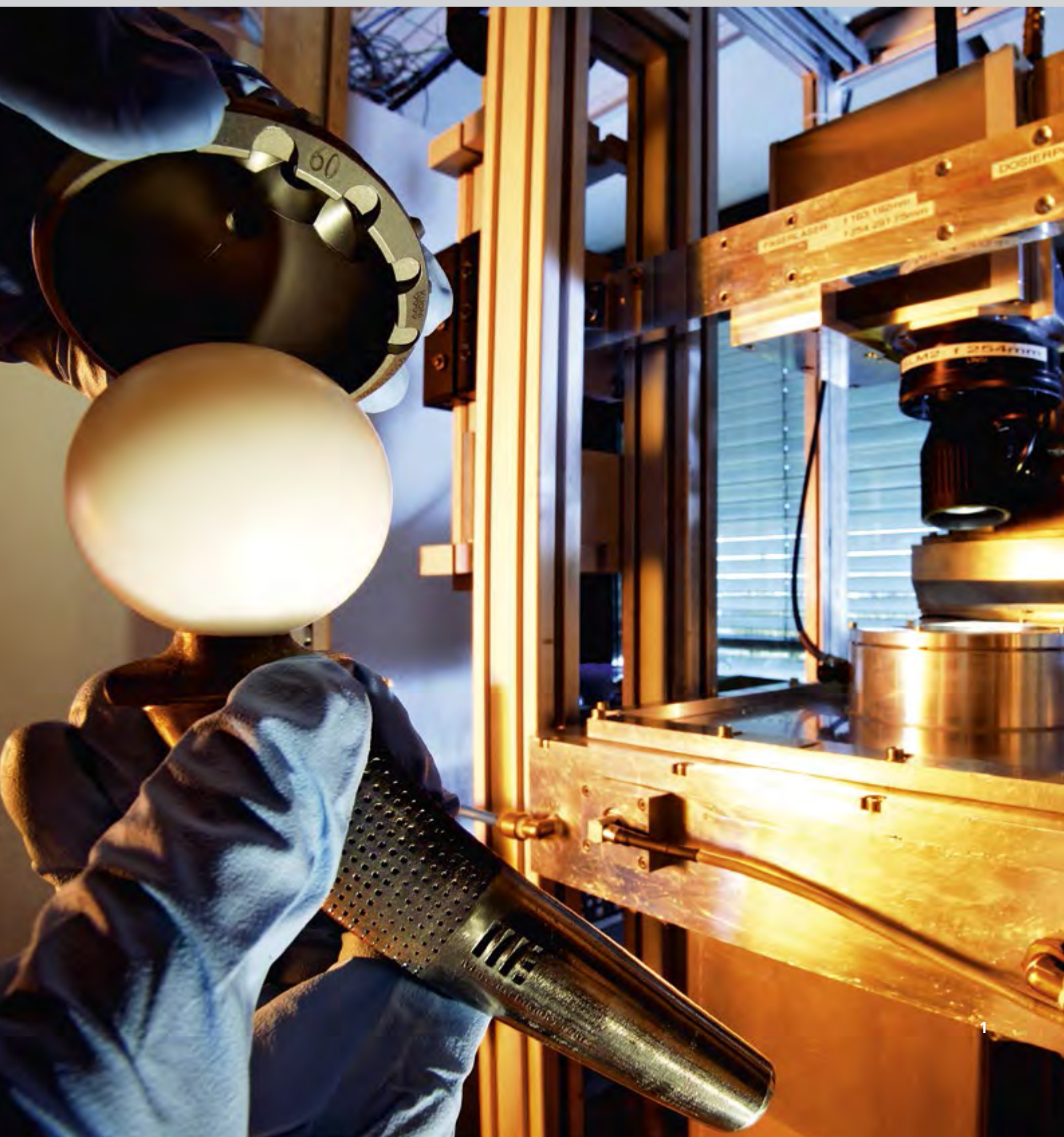
Laser welding is a modern joining technology used in a wide range of industrial applications, especially in mass production. Processes featuring integrated short-term heat treatment, adapted filler materials and high-frequency beam manipulation unlock a new approach to achieving seamless welds in a variety of materials: hardened and high strength steels; cast iron; aluminum and special alloys; alloys susceptible to heat cracking; and highly rigid components used for a durable, crash-safe and cost-effective chassis structure made from high-strength multi-phase steel. Using multi-pass narrow gap laser welding, the institutes participating in the Fraunhofer Group for Light & Surfaces successfully and seamlessly joined 30 millimeter sheets of aluminum alloy susceptible to heat cracking with the help of a 4 kilowatt laser. This is an application that had previously been out of the reach of even electron beam technology.

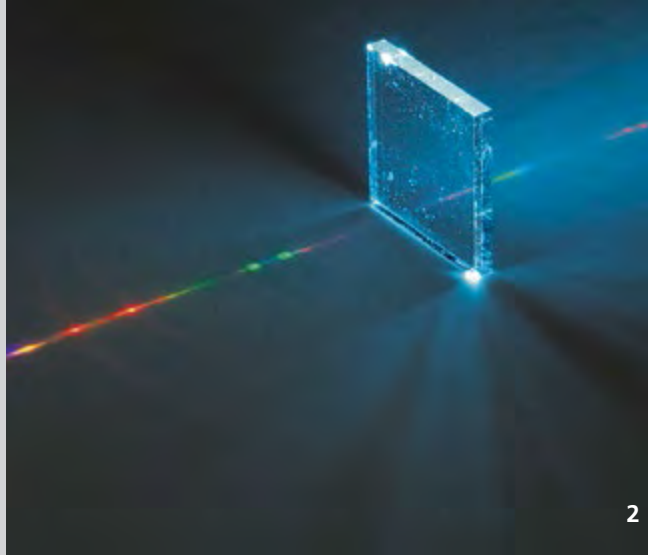
Another challenge for joining technology is the manufacture of lithium-ion batteries for the automotive industry. Here, laser welding is an effective and reliable technique ideal for joining stacks of aluminum or copper foils with one another and with the current collector. The cell stacks need to be hermetically sealed by enclosing the current arresters in a plastic housing. A more durable and cost-effective result is achieved by means of selective laser pretreatment before sealing.

Ultrafast lasers are a new type of high-performance industrial laser. Radiation emission is outstanding, drawing on the vital basic principles of physics with regard to light-matter interaction and bypassing conventional energy deposition processes. With laser pulses measured in picoseconds and femtoseconds, the energy absorbed into the material is concentrated on just a few nanometers, avoiding heat damage. Furthermore, the high photon density renders the laws of conventional absorption null and void, allowing pretty much any material to be processed, irrespective of the wavelength employed. Finally, ultrafast lasers allow for non-linear modifications to materials, paving the way for new material functionalities. These properties will be instrumental to the precision processing of solar cells, batteries, tools and electronics components and open up a sizeable market for ultrafast laser technology – and not just in the domain of micro processing.

1 Preparation of preforms for manufacturing fiber optic cables to transmit data.

2 Cutting edge of carbon-fiber-reinforced plastic (CFRP).





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Thanks to current developments in upscaling the performance of ultrafast lasers to the kilowatt range, there are also significant potential applications emerging in the area of macro processing. High-performance ultrafast lasers can thus be used to cut fiber-reinforced composites without interference and equip large surfaces with microstructures that reduce friction to a minimum. However, this technology solution relies on a fundamentally new system technology able to apply extremely high frequencies of several megahertz to the workpiece at speeds of over 100 m/s. New system approaches are drawing on diffractive optical elements that split the laser beam into hundreds of partial beams. This boosts productivity significantly.

As well as enabling high-precision microstructuring of a range of materials, ultrafast lasers also offer the chance to create three-dimensional structures within transparent solids. When laser pulses are focused on the material, the high intensity leads to non-linear absorption at the point of focus and thus to localized material modification. Depending on the processing parameters, this makes it possible to modify an array of properties, especially optical properties such as the refractive index. Applications include waveguide and grating inscription and the separation of tempered glass. Structured areas can also be selectively etched to generate complex three-dimensional cavities, for instance for microfluidic applications. If the pulses are directed at high repetition rates, it is even possible to join transparent materials free of intermediate layers.

Additive manufacturing techniques are also on the cusp of industrial implementation. They are used in processes that call for complex component geometries, fast reaction times and resource-efficient production. One multi-award-winning innovation is selective laser melting (SLM). This works similarly to a laser printer, which takes the saved data and puts it on paper in 2D form. In SLM, the data are CAD data and the material is applied in layers of just a few tens of micrometers.

High-power lasers melt the metal powder and build up the workpiece layer by layer, allowing for highly complex, customized components. Products are manufactured 1:1 from the design data. In industrial applications, the data are supplied from CAD drawings, while in medical applications they come from computer tomographs and other imaging techniques. With regard to plastics, comparable rapid manufacturing techniques have been employed in industry for many years now.

1 Hip socket implants can be manufactured with extreme precision using the selective laser melting technique.

2 Volume-Bragg grating inscribed into quartz glass using ultrafast laser pulses.

3 Waveguides generated within quartz glass using ultrafast laser pulses.

The creative power of light



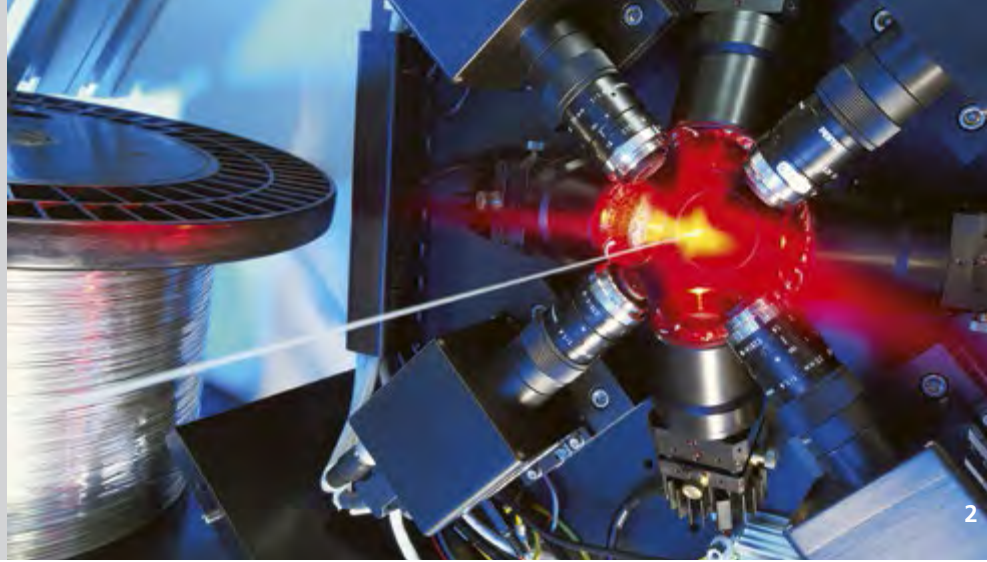
Another technology belonging to the family of additive manufacturing techniques is laser material deposition, which is primarily used in the maintenance of aircraft turbines, and employs a wide variety of new materials such as TiAl-based and nickel-based super alloys. The error-free processing of these materials is a great challenge. With the help of modified regulated temperature procedures and supplementary sources, it is now possible to construct crack-free components in inert atmospheric conditions. This expertise is employed mainly in the areas of engine construction, energy technology, tool manufacture and medical technology.

Nevertheless, the laser is not always the best energy source to fulfill manufacturing needs. With its combination of light and particles, plasma has become more popular in the functionalization of technical surfaces. Its productive use in industrial processes calls for high-performance plasmas and accompanying plasma that enable even large surfaces to be treated. One example is the coating of plastic foils for food packaging. These foils are a way of protecting food from spoiling without requiring much material. However, since they let through large quantities of water vapor and oxygen, the plastic foil has to be treated with a thin barrier coating. This coating is applied in high-output systems, and the use of plasma significantly increases the effectiveness of the barrier.

Aside from surface treatment, foils can also undergo structured plasma printing, which allows for structure widths and distances of 25 micrometers. This plasma printing technique can be used to set surface wettability in a targeted manner. The structures can then be metalized using wet chemical techniques – this provides a cost-effective technique for manufacturing biosensors, circuit boards and RFID antennas, for instance. Together with their partners, the institutes of the Fraunhofer Group for Light & Surfaces built a first industrial roll-to-roll plasma printing facility capable of continuously functionalizing foils with a width of up to 450 millimeters at a speed of 10 meters per minute.

1 Selective laser melting (SLM) is ideal for manufacturing highly complex components.

2 The Wire AOI in-line inspection system enables comprehensive quality control for wire surfaces in real time.



Light measurement

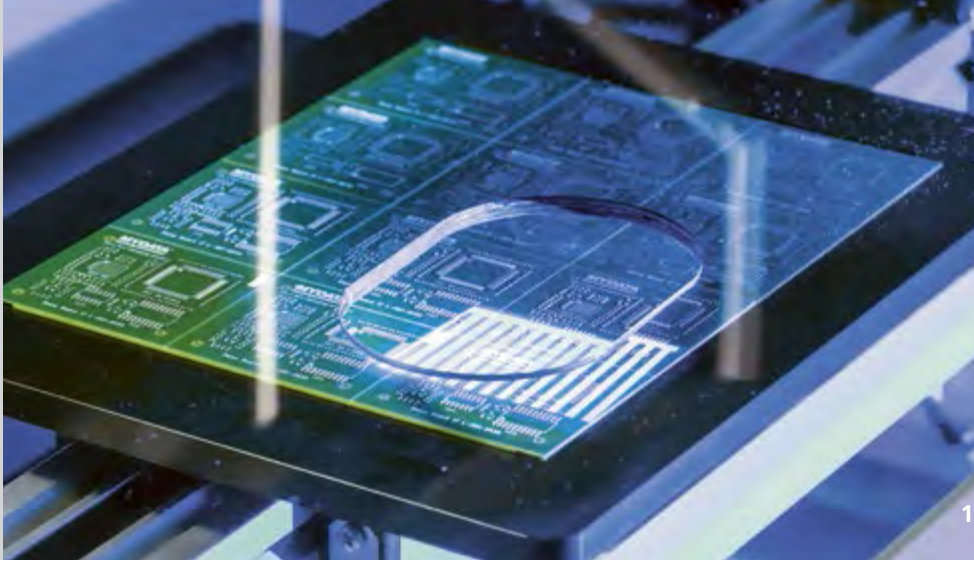
As well as being used as a wear-free tool in industrial manufacturing, light also finds application as a non-contact measuring instrument to keep up with the increasingly rigorous dimensional accuracy demanded of metal pre-products and workpieces, for instance in the aerospace and automotive industries.

In response, the Fraunhofer Group for Light & Surfaces has developed a new generation of displacement sensors that provide absolute values, such as in the measurement of rolled sheets. These sensors operate on a single beam path and achieve an accuracy of significantly less than a micrometer. The principle is based on utilizing phase information. Applications for the new sensors include in-line measurement of the thickness of both gloss and matt rolled sheets with a strip thickness of 500 micrometers – accurate to 250 nanometers. The bd 2 thickness measuring system processes up to 70,000 thickness measurements a second and can measure rolled sheets at speeds of 210 km/h.

As well as the considerable demands in terms of dimensional accuracy, the manufacturing processes for belt products can often be susceptible to error due to wear of draw plates and other tools used in the cold forming of wire blanks. As a result, it is common to see faults on the wire surface in later stages of production. An in line inspection system developed by the Fraunhofer Group for Light & Surfaces detects

these errors while production is still ongoing, allowing for comprehensive quality monitoring of the wire surface for micro defects in real time. The system employs pixel-parallel processing based on cellular neural networks (CNN). Now, for the first time, it is possible for four cameras to capture and evaluate 40,000 pictures a second – up to five times as much as ordinary cameras.

Another example application is the high-speed, high-resolution sensor for inspecting circuit boards to ensure quality. This sensor's job is to determine the height and volume of the soldering paste before components are placed on the circuit board in order to avoid any faulty contact among the various parts. This involved developing a high-speed 3D sensor system. The sensor comprises a stripe projection unit and a high-resolution camera that moves to reach a variety of measuring positions. To gather the 3D data, a series of stripe patterns are projected onto the surface to be measured. This image capturing process happens at 180 hertz, allowing for a pure 3D image capture time of just 33 milliseconds. By running the calculation and evaluation processes side by side, the entire circuit board surface can be checked at a speed of up to 90 cm² per second with a lateral resolution of less than 20 micrometers and a vertical resolution of less than 5 micrometers.



Future of light technologies

In this overview we have looked at just a few of the light technologies used in industry today. Utilizing light paves the way for a great variety of innovations in diverse sectors. Whether it is information technology, quality monitoring, projection technology, lighting, display technology or safety – the potential applications of light are almost innumerable, and the potential of its technologies are a long way from being exhausted. As science turns its gaze towards the phenomenon of light, which for us will always remain linked with the historical figure of Joseph von Fraunhofer, we stand at the beginning of an illuminating journey. We watch with bated breath to see where it will take us – and, here at Fraunhofer, we are delighted to lend a hand along the way.

Prof. Dr. Andreas Tünnermann

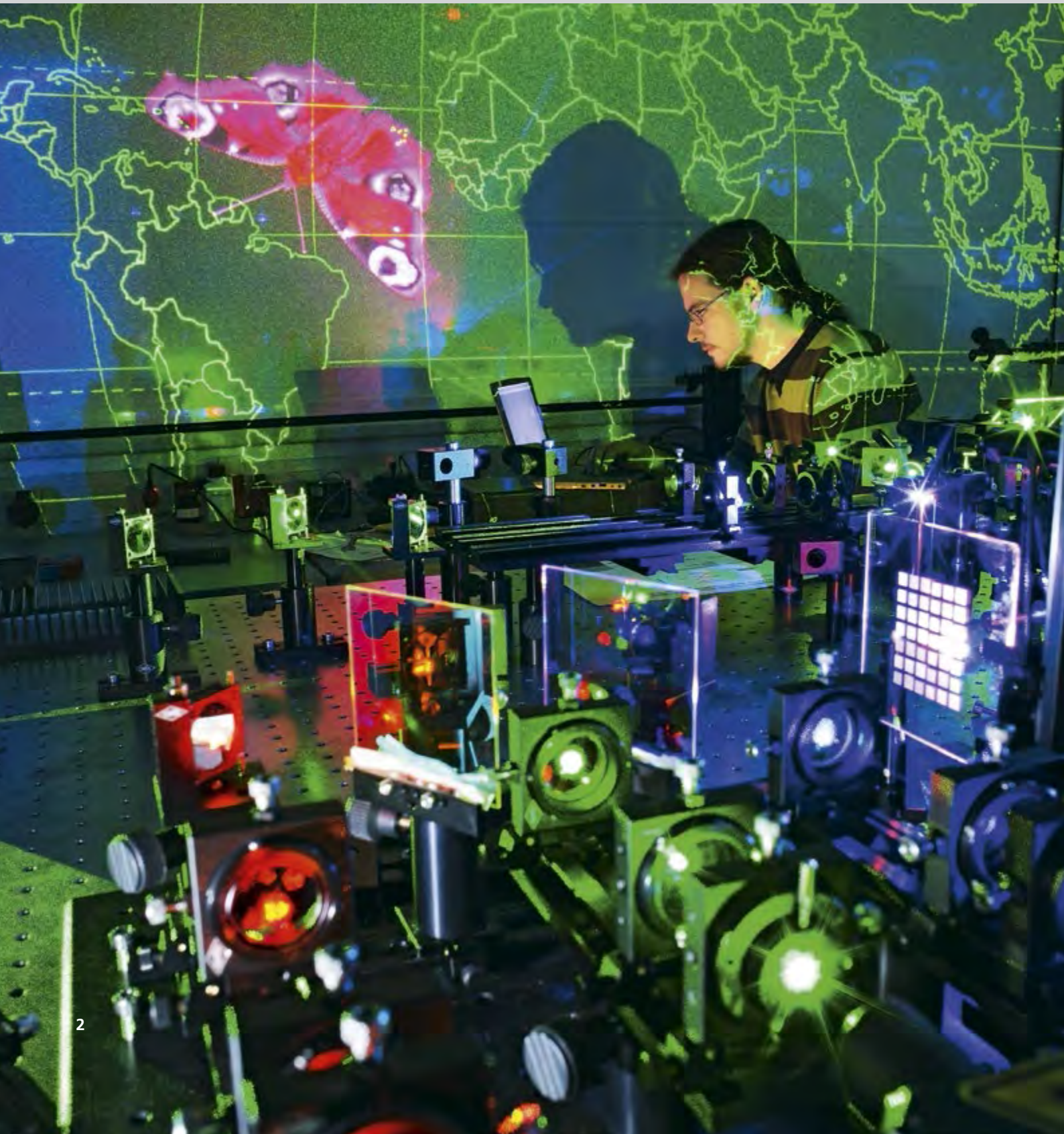
Director of the Fraunhofer Institute for Applied Optics
and Precision Engineering IOF in Jena

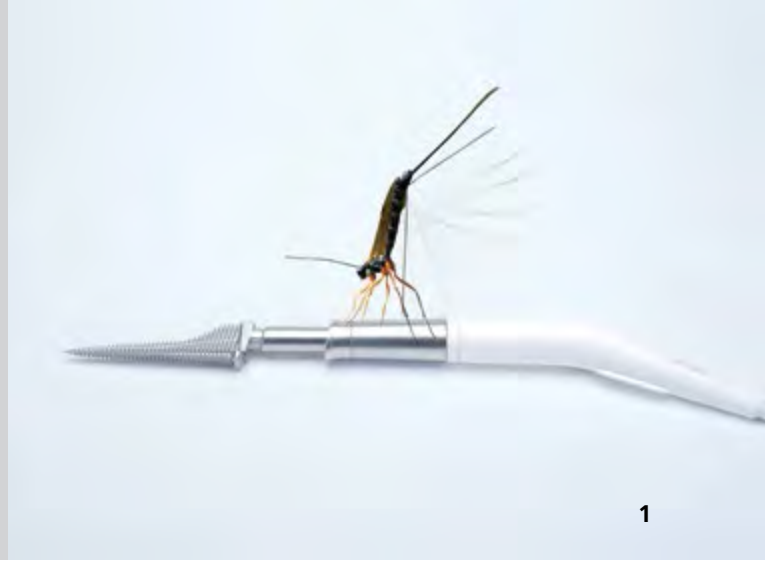
Chairman of the Fraunhofer Group for Light & Surfaces

1 Optical quality control: The 3D soldering paste sensor checks soldering points in just fractions of a second.

2 Projecting color images via laser using holograms allows for a much greater depth of field than other projection techniques.

The creative power of light





1

PROJECTS AND RESULTS 2014

HEALTH AND ENVIRONMENT

Prize-winning bionic drills 1

In a process of evolution extending over billions of years, nature has come up with quite a few astonishing things, which have inspired some extremely interesting technological developments. Now biotechnologist Oliver Schwarz and his team from the Fraunhofer Institute for Manufacturing Engineering and Automation IPA have added a new highlight to the list: the bionic drill. This is a surgical instrument that makes it possible to mill bone material with significantly greater ease and precision than ever before, for instance to fit prosthetic hip joints. The idea for the non-rotating drill, which operates on a pendulum stroke principle, comes from horn-tail insects, which use a similar technique to drill deep holes in wood within which to deposit their eggs. The drill was honored with the International Bionic Award, presented by the VDI (Association of German Engineers) and the Schauenburg-Stiftung for technological developments modelled on natural phenomena.



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Lighthouse project: Cell-free bioproduction

Protein to order 2

Proteins with special properties play an important role in many areas of the medical, pharmaceutical and food industries. Until now, these proteins have mostly been produced with the help of microorganisms or cell cultures in bioreactors: the biomolecules generated are then separated from the nutrient solution in a laborious process. A much better way of doing it are in vitro methods, in which the proteins are produced outside of living cells using cellular extracts. This allows even for the expression of toxic proteins that couldn't be produced in cells. In the lighthouse project "Cell-free bioproduction", researchers from various Fraunhofer Institutes have teamed up to develop scalable techniques based on novel and optimized extracts as well as new reactor concepts. This should make it quicker and cheaper to produce proteins with alternative properties than ever before.

Speedy identification of cancerous cells

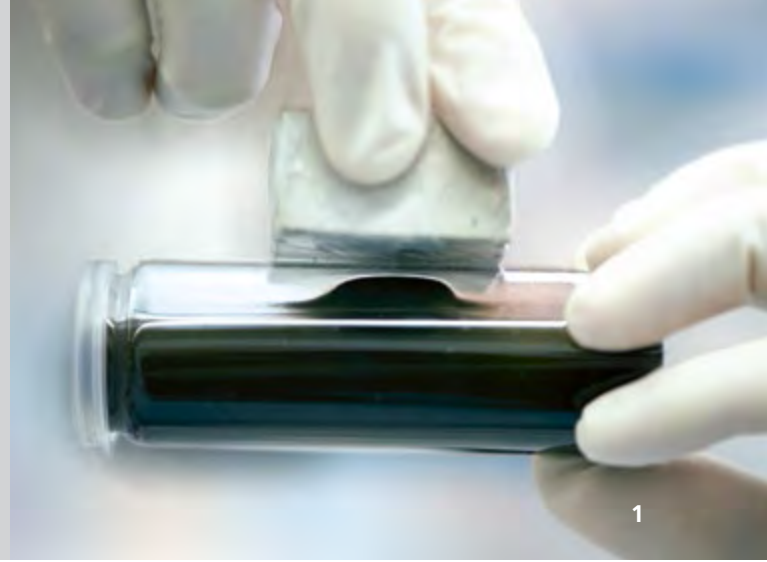
The sooner a firm diagnosis of cancer can be made, the sooner treatment can be started – and the greater the chances of survival. That's why automated techniques that can quickly and accurately diagnose cells are so valuable in oncology, not least because it isn't easy to visually differentiate healthy and cancerous cells. Researchers at the Fraunhofer Institute for Ceramic Technologies and Systems IKTS have developed a device for diagnosing prostate cancer that can tell within a minute and a half whether a test sample contains cancerous cells. Analysis is based on autofluorescence following a laser pulse, which is characteristically different depending on whether the tissue is healthy or diseased.

Degradable implants 3

"Implant and forget" would be every surgeon's dream. Should it be necessary to insert implants – for instance in the case of a torn tendon in the shoulder, requiring stabilization at the point of the tear while healing takes place – it has often been necessary to remove these shoulder anchors in a second surgery. Now, the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM has developed supporting implants that no longer have to be removed at a later stage. Once they have served their purpose as a stable support during the healing process, they degrade naturally and are reabsorbed by the body. Furthermore, the material – a metal-ceramic composite – is adjusted in advance so that the rate of reabsorption matches that of the new bone tissue growing to replace it. In the case of shoulder anchors, the aim is for this process to take place over one to two years.

Research to combat infection

Infectious diseases are the second most common cause of death. The increasing resistance of pathogens to antibiotics is reason enough to demonstrate the importance of research in this field, and that we must not hold back in our efforts. In response, health care company Sanofi and the Fraunhofer Institute for Molecular Biology and Applied Ecology IME have joined together to found a Center of Excellence for Natural Products Research in Gießen. The goal of the collaboration is to research and optimize naturally occurring chemical and biological compounds, primarily with a view to treating infectious diseases. However, diabetes, pain research and rare diseases are also areas in which compounds derived from naturally occurring substances can play an important role both in prevention and treatment.



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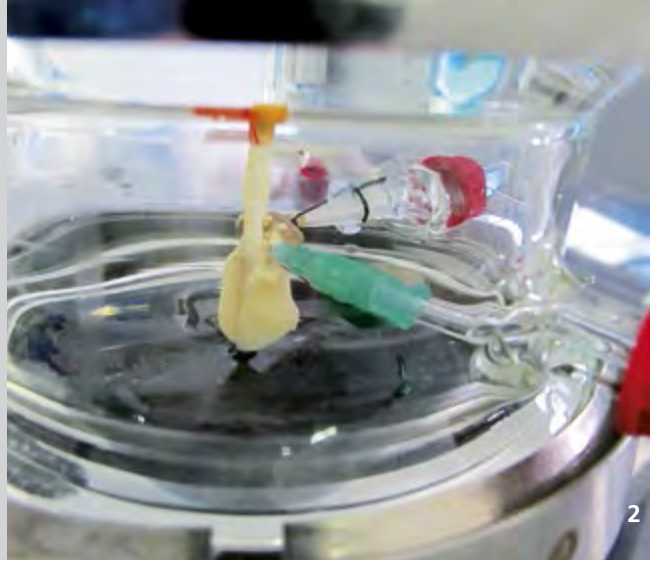
Environmental threat from embankments?

The banks of Germany's federal waterways are put under mechanical strain from the vessels using them, and for that reason rock fill has been used to stabilize the embankments. In northern Germany, artificial iron-silicate stone taken from the melt generated in copper production has been used for this for many years now in addition to natural stones. This artificial material is particularly dense and abundant in large quantities; however, it also contains residues of metals, especially copper. In a joint project with the German Federal Institute of Hydrology, industry partners and the universities of Koblenz-Landau and HafenCity Hamburg, researchers looked into the issue in the laboratory at the Fraunhofer Institute for Molecular Biology and Applied Ecology IME, in mesocosms belonging to Mesocosm GmbH and outdoors. The researchers were on the lookout for the quantity of metal released and its impact on aquatic organisms. Results were incorporated into a concept for the risk analysis of materials for marine construction.

Hugo Geiger Prize

Magnets extract recyclable materials from water 1

Cleaning industrial and urban waste water is an environmental challenge, and one that is growing in importance as raw materials become more and more expensive. The fact remains that many contaminating substances, for instance metals or phosphates, are valuable and worth recycling. As part of his dissertation prepared at the Fraunhofer Institute for Silicate Research ISC, Dr. Karl Mandel was successful in developing magnetic particles for a technique that enables these sort of water contaminants to be reclaimed as recyclable materials. It works by modifying the surface of magnetically switchable particles so that they enter into a reversible bond with certain dissolved substances. Following magnetic separation from the liquid, the substances obtained are removed so that the magnetic particles can be used once again. The technique offers a technology platform and is in essence suited to a wide range of purification and recycling processes. In recognition of his research, Karl Mandel was awarded the Hugo Geiger Prize 2014.



Hugo Geiger Prize

Unfettered plant growth

Increasing the biomass in crop plants is one of biological research's primary aims – especially in the light of a growing world populace. As part of her doctoral thesis at the Fraunhofer Institute for Molecular Biology and Applied Ecology IME and at the Institute of Plant Biology and Biotechnology of the University of Münster, Dr. Lena Grundmann analyzed the molecular basis of flower development in tobacco plants. This led her to discover a previously unknown function of the florigen FT as a flower repressor and at the same time demonstrate its effect in enormously increasing plant biomass. This genetically induced, almost unlimited growth would be of particular interest in the case of food crops such as potatoes. The research provided a technology platform that is currently undergoing patenting and has met with significant demand from industry. For her development, Lena Grundmann was awarded the Hugo Geiger Prize 2014.

Lung model replaces animal testing 2

For those diagnosed with lung cancer, chemotherapy is essential. Still, patients respond differently to the various treatments. If it were possible to come up with a clear forecast of effectiveness, this would be a critical advantage in terms of successful treatment, avoiding wasting valuable time and energy on unsuitable medicines. To help make the right choice, researchers at the Würzburg branch of the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB have created a three-dimensional lung model made of human tissue. This makes it possible to test cancer treatments for effectiveness and side effects as well as investigate other phenomena such as metastasis. This is better achieved using the lung model than any animal testing, since the model is made of human tissue.



COMMUNICATION AND KNOWLEDGE

Joseph von Fraunhofer Prize

Digital cinema for everybody 1

There's no denying the quality of digital film screenings, but the way there has been long and expensive. It has taken extensive innovation and setting of standards to reach the point we are today, when digital films can be played in every cinema. To ensure compatibility among the various systems for creating and playing digital cinema packages (DCPs), new software tools were needed. Dipl.-Inf. Heiko Sparenberg and Dr.-Ing. Siegfried Föbel from the Fraunhofer Institute for Integrated Circuits IIS developed easyDCP, a piece of software that generates and validates playable digital cinema packages on the basis of international standards. An innovative decoding technique allows for real-time processing of film data on a standard PC. Its simple and user-friendly design helps not just big film studios but also small and medium-sized production companies to bring digital films to the screen worldwide. EasyDCP software functionality is now a feature of the post-production tools of many renowned producers in the film and TV sector. For their development, the two researchers were awarded the Joseph von Fraunhofer Prize 2014.



Cinema quality at home 2

More resolution equals better image quality – as simple as the equation is, it accurately highlights the main quality factor when showing films. If you want more quality, you need more data. This equation is also true – but only in principle, since data can be compressed, and it is here that researchers at the Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institut, HHI have once again presented an outstanding solution in collaboration with leading electronics manufacturers. The HEVC video compression standard needs only half as much data transfer capacity for the same image quality as its predecessor H.264. This makes it possible to transmit live streams over TV channels in 4K cinema quality, with resolutions four times higher than previous HD transmissions.

Transparent electronics

Organic electrodes can combine a range of very interesting characteristics, as they are high-performance, flexible, cost-effective to manufacture, and can even be made in transparent designs. The manufacturing methods for such transparent electronic components were developed by project partners Carnot MIB from Bordeaux and the former Fraunhofer COMEDD, now integrated into the Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP, in a project that lasted for three years. Called "Image", the project was supported by the German Federal Ministry of Education and Research (BMBF) and the French National Research Agency (ANR). Fluorescent OLED films, organic solar cells, or flexible sensor systems on films can now be custom-manufactured using the methods developed.

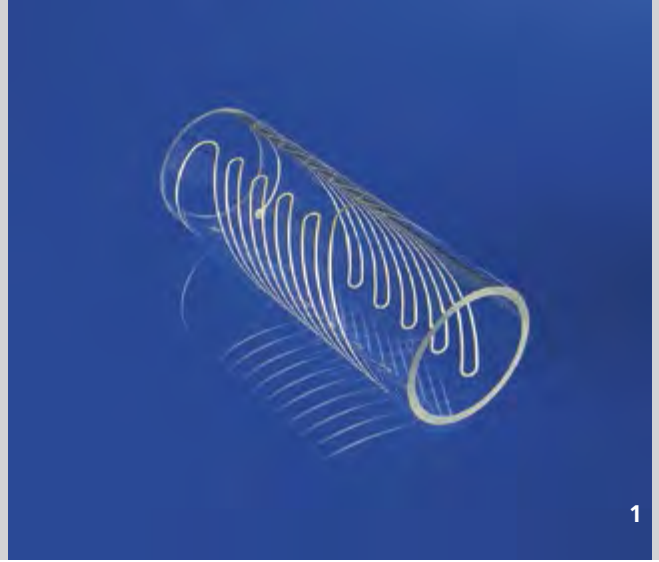


Concrete sounds 3

Concrete is a building material that is always good for a surprise or two. Depending on the formula, it can be used to make components with astonishing characteristics and for a wide variety of applications. Its vibration resistance also makes the material very interesting for acoustic purposes. A cooperative project between the company Concrete Audio and the acoustics specialists at the Fraunhofer Institute for Digital Media Technology IDMT gave birth to a new concept for flat loudspeakers made of concrete. The development work resulted in high-quality, very unusual looking loudspeakers with outstanding technical and acoustic characteristics.

App recognizes feelings

Recognizing the emotions of the person you are talking to is the most normal thing in the world for most people. However, some people – for instance, autistic people – do not know whether the person opposite them is in a good mood or sad, relaxed or angry. If they wear Google Glass, they can use software developed by the Fraunhofer Institute for Integrated Circuits IIS as a helpful tool. The software shows them what the other person is feeling – for example, by displaying the information in real time in the wearer's field of view – which makes communication easier. Market research applications are also conceivable for the technology. The app is a further development of the Fraunhofer SHORE™ software library for facial analysis and is aimed at developers who want to use this technology in their applications.



Projection without limits

If you want to project pictures or films on uneven surfaces – for example, walls with curves or projections – you quickly run into difficulty with depth of field. Similar to a camera, you have to set the optics to a narrow range of focus. If you increase the depth of field by closing the aperture, the image becomes significantly darker. A projection system from the Fraunhofer Institute for Applied Optics and Precision Engineering IOF research labs compensates for this drawback by means of numerous micro-projectors that are placed side by side and connected in parallel. This ensures that the image remains bright and allows projection surfaces of all different shapes to be used.

Printed sensors 1

Printing technology for manufacturing components and electronics still has lots of potential. Researchers at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM have now developed methods for printing sensors on various surfaces. Resistors, transistors, conductor paths, and capacitors are designed on a computer screen and then applied directly to two- and three-dimensional surfaces using “functional ink” such as electronic materials in liquid or paste form. The range of applications for such printed electronics is virtually unlimited and includes digital thermometers, electronic circuits, solar cells, and intelligent packaging with built-in sensors.

Technologies for immersive media enjoyment

In cinema, 3D special effects are in demand. Investigating how more creativity could be introduced into such productions and what paths will become possible for film and media productions in the future was the remit of the Fraunhofer Digital Media Alliance in the SpatialAV project, which was launched three years ago by the Fraunhofer Institutes for Integrated Circuits IIS, for Telecommunications, Heinrich-Hertz-Institut, HHI, for Digital Media Technology IDMT, and for Open Communication Systems FOKUS. In various production scenarios, the experts showed what can be integrated into the production process today and in the future. To this end, they developed software algorithms for the automatic calibration of stereo systems, panorama camera systems with interactive navigation capability, a new type of light-field capturing system, and object-oriented audio techniques.



2

Microchips for hot jobs

Classic microelectronics works only within a certain temperature range. This is why cooling systems are often needed for computers. However, in some fields of application, higher temperatures prevail, such as in oil extraction or when sensors are required to monitor operating statuses near hot engines. Researchers at the Fraunhofer Institute for Microelectronic Circuits and Systems IMS have now developed a method for manufacturing microchips that work problem-free even at temperatures of 300 °C. The method allows much finer patterning than can be found in the high-temperature microchips available on the market until now, resulting in significantly enhanced functionality. This is necessary to open up new markets and applications.

The Service Manufactory: Where customers can get creative 2

In May, JOSEPHS® – The Service Manufactory was opened in Nuremberg city center. It is a venue where visitors can help to design a product or service themselves. JOSEPHS® is a place where the world of innovation can be experienced while also serving as an open laboratory for developing services. Companies can come there together with users to develop and test their service innovations on a sound scientific basis. A workshop, a think tank, a gadget shop, and a coffee shop are united in one place across an area of over 400 square meters. The workshop features research islands that change every three months, where visitors can test current concepts from participating companies free of charge and on site in a real environment during regular retail opening hours and further develop them with their own ideas. In the adjacent think tank, workshops and presentations take place in alternation. JOSEPHS® is a project by the Fraunhofer Working Group on Supply Chain Services SCS, which is being carried out in cooperation with the Friedrich-Alexander University of Erlangen-Nürnberg and is sponsored by the Bavarian Ministry of Economic Affairs and Media, Energy and Technology.



1

SECURITY AND PREVENTION

Hugo Geiger Prize

Laser light in many colors 1

Progress in laser technology over the past few decades has led to many interesting applications in research, measurement technology and industry. As most laser sources are limited to narrow, sharply delineated wavelength ranges, researchers want to develop laser generators that can operate across a broad range of wavelengths. A decisive step on the road to making this a reality was achieved by Dr. Jens Kießling in the course of his doctoral thesis, which he wrote at the Department of Microsystems Engineering at the University of Freiburg and at the Fraunhofer Institute for Physical Measurement Techniques IPM. Dr. Kießling designed and built an optical parametric oscillator – a frequency converter, in other words – that can convert the light from a monochromatic pump laser in principle into laser light of any wavelength one might want. By using orientation-patterned gallium arsenide, it was possible to make such an oscillator for the particularly hard to reach far-infrared terahertz range. The findings flowed into the “C-WAVE” device, which provides laser light across the visible spectral range. Jens Kießling received the 2014 Hugo Geiger Prize for his work.



Laser finds leaks

Methane is an important energy source. It is generated in biogas plants by means of fermentation, for instance. However, the gas is also very flammable and harmful to the climate, so it is very important that leaks in biogas plants are detected as soon as possible. In a project sponsored by the German Federal Ministry of Food and Agriculture (BMEL), the Fraunhofer Institutes for Physical Measurement Techniques IPM and for Environmental, Safety and Energy Technology UMSICHT cooperated with Schütz GmbH Messtechnik to develop a laser-based measurement system that selectively responds to methane and can therefore be used to monitor such plants.

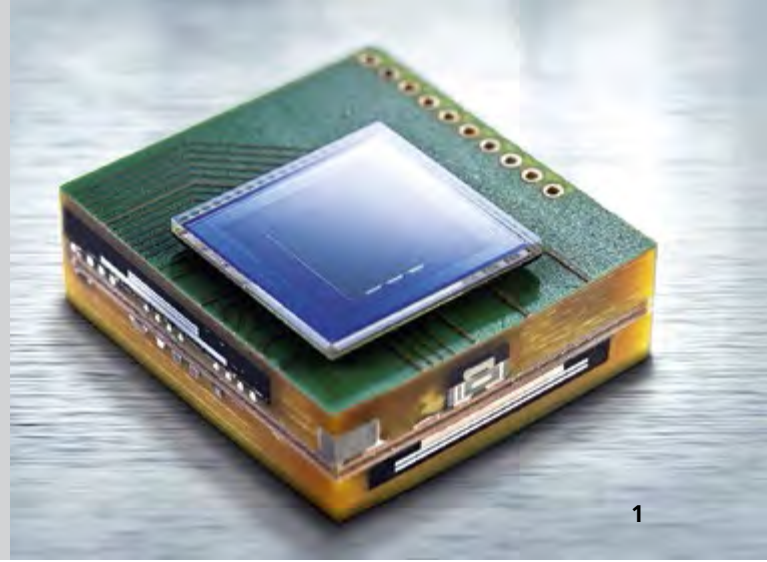
Mini-radar checks sewage pipes

Sewage pipes often leak. When it happens, the pipe must be repaired to prevent sewage from seeping out and eventually polluting the ground water. Until now, the optical inspection methods generally used have only been able to check superficially for cracks and leaks. A new radar-based testing method that also makes visible the space behind the wall of the pipe – the so-called pipe zone or embedment – is currently being developed at the Fraunhofer Institute for Nondestructive Testing IZFP in cooperation with three partners and with the support of the German Federal Ministry of Education and Research (BMBF).

Joseph von Fraunhofer Prize

Screening risky post 2

Security technologies are in ever greater demand. Complex infrastructures and the growing mobility of people and goods make reliable but swift controls at critical spots imperative. Controlling mail is an important concern for security experts. Working together closely, Prof. Dr. René Beigang from the Fraunhofer Institute for Physical Measurement Techniques IPM and Dipl.-Ing. Thorsten Sprenger from Hübner GmbH & Co. KG successfully managed to utilize terahertz technology for a mail scanner. This required a few decisive innovations, such as completely fiber-based laser beam guidance, emitter and detector units manufactured to high precision, and an automated spectroscopic analysis adapted to terahertz spectra. An important advantage of terahertz technology is that equipment operators do not need to be shielded for health reasons as is the case with X-ray units. The device can safely screen the contents of items of mail in C4 format and identify individual substances such as drugs and explosives. It is already available on the market under the name "T-COGNITION"; adaptations are already in development to make it suitable for other applications. For their work, the two researchers received the 2014 Joseph von Fraunhofer Prize.



1

Greater security at train stations

At Europe's major train stations, many different aspects of security are the responsibility of various transport and security organizations. They use a broad range of IT systems, including geographic information systems, video cameras and gas sensors, which are supposed to help them respond quickly and appropriately in critical situations. In the EU-sponsored demonstration project SECUR-ED, the Fraunhofer Institute for Industrial Engineering IAO has been working together with 40 partners to devise and test solutions to improve organizational and IT cooperation when unexpected events occur inside major European cities. The solutions cover different kinds of threats and factor in different legal and cultural parameters.

An eye for cars 1

Cars can now do some of the thinking – driver assistance systems help to prevent accidents or at least to make them less serious. To do this, they need fast and reliable information, much of which is image data. Researchers at the Fraunhofer Institute for Reliability and Microintegration IZM have developed a very compact camera specifically for use in cars: a total of 72 passive and 13 active components such as LEDs, a DC voltage converter, a memory chip, an image sensor, and an image processor had to be arranged in the module to save as much space as possible. All electronic parts are integrated directly in the PCB made of glass fiber and epoxy resin, and image processing also takes place in the camera. This gives the overall system a particularly high degree of functional reliability.

Sensor network safeguards rail transport

To prevent accidents and excessive wear, the wheels of rail vehicles have to be inspected regularly. As periodic checks do not pick up damage that arises between inspections, however, continuous monitoring would be better. Together with industrial partners, the Fraunhofer Institute for Reliability and Microintegration IZM has now developed a sensor-based inspection that continuously collects data while the train car is in use and saves them in the cloud via radio. Because the sensors notice even the tiniest damage, it is often possible to avoid the need for larger-scale repairs by taking action early.



2

Flying robots on inspection duty

Helicopter drones are exceptionally agile and can reach virtually every last corner of a site. In view of this agility, researchers at the Fraunhofer Institute for Nondestructive Testing IZFP have dreamed up a new task for them: building inspection. Automatically stabilized in flight, the miniature aircraft can guide a camera along a defined section of a building's shell and capture detailed images of the façade. Particularly in the case of bridges, industrial facilities, and complex buildings, the flying robots can carry out the risky jobs that would otherwise require rope access, cranes, scaffolding or bucket trucks.

Warning by cellphone 2

Sirens have been phased out as warning signals in many towns and cities. In times of danger, such as when a major fire breaks out, the population is informed by other means. As almost everyone carries a cellphone or smartphone around with them these days, issuing warnings via mobile communications is an important addition. For this reason, the Fraunhofer Institute for Open Communication Systems FOKUS has developed the KATWARN warning system on behalf of Germany's public insurance providers. The system enables public authorities to issue targeted warning messages to the population, which can also be limited to certain neighborhoods – for example, the instruction to keep windows closed if there is a chemical plant fire. Cellphone users who download the KATWARN app to their smartphone free of charge receive the warning message in both text and graphical form. Since 2011, more and more German administrative districts, cities, and states have connected up to the system.



MOBILITY AND TRANSPORTATION

Portals with potential

When planning a journey, you can let a travel agency arrange the means of transport and the accommodation for you – or else you can try to organize it all yourself online. Numerous travel portals offer users information and the option of booking directly. However, searches can be time-consuming and do not always lead to the desired result, as some portals are in need of serious improvement. This was the conclusion of a study carried out by the Fraunhofer Institute for Applied Information Technology FIT, which puts forward concrete improvement suggestions for the most popular providers of such portals.

Adhesive technology for lightweight components

Adhesion is an art in itself – and one that is increasingly in demand in production engineering. After all, the best way of joining the lightweight components used in the auto industry to reduce fuel consumption is by gluing them together. Researchers at the Fraunhofer Institute for Structural Durability and System Reliability LBF have created a new joining technique that offers particular advantages: graded adhesion. The technique involves using two different hardening methods at the same time to produce a joint with a stiffness gradient. This results in better resistance to vibration stresses and therefore to joints with higher long-term stability.

Electric vehicles that refuel all by themselves 1

Autonomous driving is currently one of the automotive industry's main development goals. At the Fraunhofer Institute for Manufacturing Engineering and Automation IPA, researchers are working on a further step in this direction. The objective of the research is for drivers to be able to drop their electric car off at a parking garage and collect it again later, fully charged. In the meantime, the vehicle seeks out a charging station by itself, connects itself up, refuels, and then frees up the space for the next vehicle. The researchers are helped in their work by the institute's extensive experience in industrial robotics technology.

Autonomous sea transport

Self-controlling vehicles have long ceased to be the stuff of fantasy. Aircraft autopilots take over the controls for periods, cars park themselves, and autonomous transport systems are increasingly the focus of research in the area of maritime transport too. In the EU-sponsored MUNIN project, researchers at the Fraunhofer Center for Maritime Logistics and Services CML, together with eight partners from five countries, are developing the concept for a freighter that will travel the world's oceans without a crew. Innovative new systems in the engine room and on the bridge continuously measure and evaluate the current status of the ship and its environment. Whenever action is needed – for example, to avoid a collision – it is carried out independently. As a supplementary measure, the voyage on the high seas is also monitored from control stations on dry land.



2



3

Lighthouse project: Electromobility II

Progress for electric cars 2

Most experts agree that the future belongs to electromobility. On the road to get there, however, many technical developments are still required, especially for increasing the performance of electric cars. In the “Electromobility II” lighthouse project, 16 Fraunhofer institutes are combining their research capacities. The focus of their research efforts is on improving performance and reducing weight in the domains of chassis, powertrain, battery, range extender, body construction, and last but not least, the infrastructure to supply the cars with energy when they are out and about. Coordination of the institutes has been entrusted to the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM.

Humans and machines in interactive driving simulator

How do people and vehicles or construction machinery influence each other? How do changes to one component affect the others? Researchers at the Fraunhofer Institute for Industrial Mathematics ITWM have developed a special, elaborately constructed driving simulator whose movements are particularly well coordinated with the visual stimuli and appear very realistic. The purpose of RODOS® (RObot-based Driving and Operation Simulator) is to realistically analyze the interplay between human, vehicle, and the environment – for example, by studying people’s behavior in stressful situations or accident scenarios under safe, reproducible laboratory conditions. Results of the research are flowing into the development of improved safety and assistance systems for construction and agricultural machinery as well as automobiles.

Onward into the future: The nano-supercapacitor 3

Capacitors are interesting for electromobility as an additional energy storage device. In the EU ElectroGraph project, ten partners from research and industry – coordinated by the Fraunhofer Institute for Manufacturing Engineering and Automation IPA – are developing new kinds of supercapacitors with significantly increased storage capacity. A particularly interesting aspect is the use of the nano-material graphene. Possessing an internal surface area of up to 2,600 square meters per gram, it offers greater storage capacity than all other materials previously available. With their very fast charging and discharging capability, such supercapacitors have the ability to significantly improve the performance of energy storage devices for electromobility.

Electric bus without overhead catenaries

Electric vehicles are still held back by batteries’ limited energy content. For certain applications, however, a viable solution is already possible. Together with industrial partners, the Fraunhofer Institute for Transportation and Infrastructure Systems IVI has developed a fast-charging electric bus that can charge within seven minutes to complete a 20-kilometer route. All this requires is a lithium polymer battery with a capacity of 85 kilowatt-hours, which is fitted to the roof of the bus and is recharged at the charging station via a pantograph. Having passed a field test in Dresden’s municipal bus network, a challenging uphill route was selected for further testing of the system.



PRODUCTION AND SERVICES

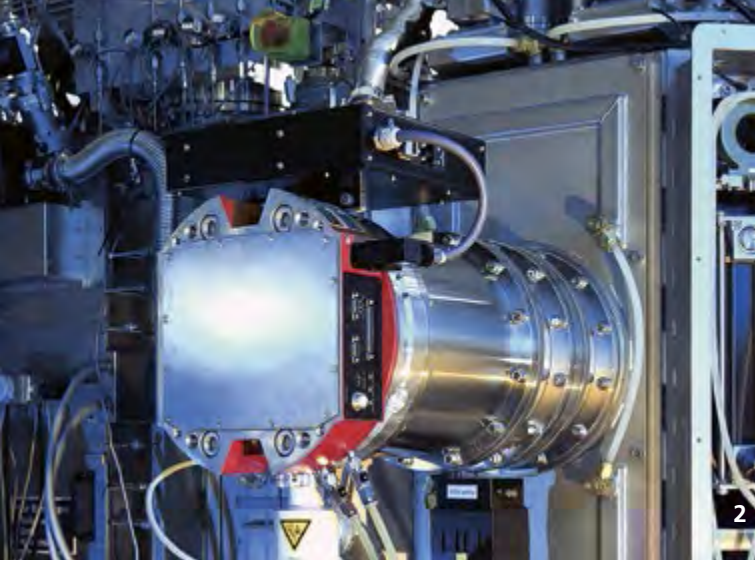
Lighthouse project E³ Production

People-friendly manufacturing 1

Over the past few years, it has become evident that a competitive manufacturing sector is a decisive factor in a country's wealth creation process, especially in times of economic crisis. Developing future-proof production technologies is therefore of vital significance for Germany and Europe. In the "E³ Production" lighthouse project – whose goal is to create resource-efficient, low-emissions manufacturing environments that factor in human needs – Fraunhofer wants to develop production technologies and plants whose eco- and people-friendly characteristics pave the way for a problem-free return of factories into residential areas. This will allow us to continue to experience the benefits of having value-creating production plants working for us, even in the densely populated center of Europe.

Laser welds even thick sheets

Laser welding plays an important role as a joining technology in the construction of sheet metal and steel structures. Researchers at the Fraunhofer Institute for Material and Beam Technology IWS have now created a new method for welding metal sheets with a thickness of up to 50 millimeters. Thanks to the outstanding quality of the laser used, it can be operated in very deep and narrow cracks. The method delivers significant improvements in terms of energy consumption and material and the quality of the finished weld. One consequence is that alloys at risk of cold cracking become amenable to welding applications. The relatively low laser power used also makes mobile applications possible, such as for repair jobs in power plant engineering.



Megatron® opens up new coating possibilities 2

Coatings can seriously alter the properties of components and products. Even minor modifications to applied layers are significant. Scientists at the Fraunhofer Institute for Surface Engineering and Thin Films IST have developed the Megatron® sputtering device, which can be used to compose such layers in any or very precisely defined combination. It also makes material combinations possible that were formerly unrealizable. This opens up previously unknown possibilities in coating technology and gives rise to new product characteristics for different fields of application.

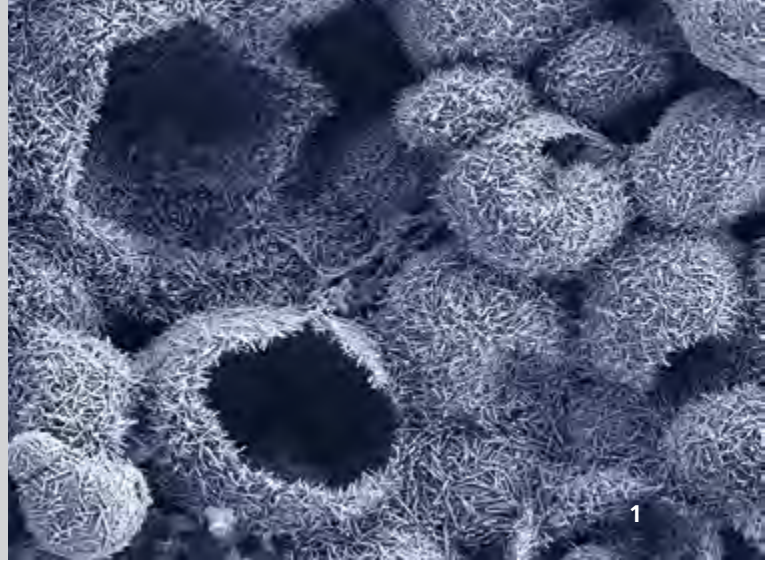
Virtual sensors for real production

An ideal production machine would, to a large extent, run autonomously and monitor itself. So that ordinary wear cannot unexpectedly bring the entire production process to a standstill as a result of the failure of individual components, the machine would also know when important parts have to be replaced preventively. A new smart concept for the status monitoring of metal-forming machines from the Fraunhofer Institute for Machine Tools and Forming Technology IWU comes close to this ideal. It combines some real sensors with comprehensive simulation technology, which allows it to provide predictive maintenance in a form that has never been seen before. In the researchers' opinion, this concept of "virtual sensors" is the best approach for depicting integrated stress scenarios in a cost-effective manner and thereby minimizing the downtime of production systems.



Tape placement system facilitates lightweight construction 3

Lightweight construction technologies are gaining in importance – particularly in automotive manufacturing, where they lead to an increase in vehicle performance and to a reduction in fuel consumption. Materials such as fiber-reinforced plastics play an important role in these technologies, but processing them is more time-consuming than conventional materials. Researchers at the Fraunhofer Institute for Production Technology IPT have developed a special tape placement system that allows the automated depositing and arranging of various continuous fiber-reinforced semi-finished products. Known as a Multi-Material-Head, the modular system can be adapted to different fiber and matrix materials and to different robot systems. It improves resource and energy efficiency when manufacturing components from fiber-reinforced plastics. The development received the 2014 JEC Europe Innovation Award.



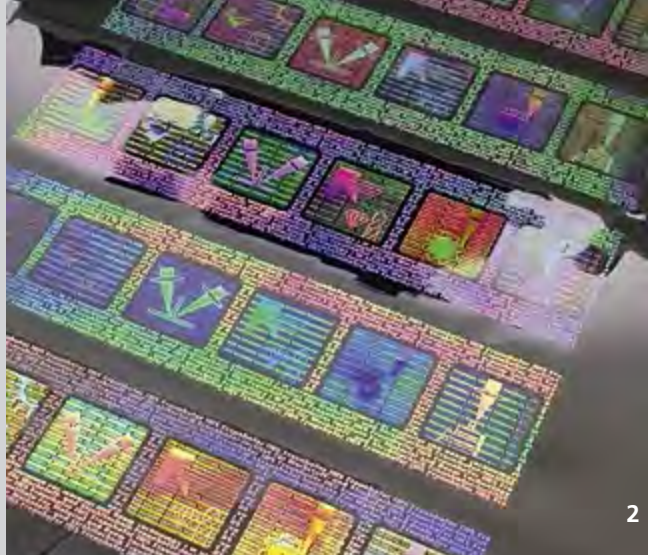
Joseph von Fraunhofer Prize

Rapid adhesion for manufacturing

Adhesive technology has significant advantages for industrial manufacturing, allowing the creation of large-area joints that are very secure, vibration-resistant, and stable over the long term. Before now, however, it has been necessary to join components together immediately after applying the adhesive, as adhesive-coated parts can be neither warehoused nor transported. Three Fraunhofer researchers have discovered the route to a new kind of industrial adhesion: Prof. Dr. Andreas Hartwig, Dipl.-Ing. (FH) Andreas Lühning, and Dr. Matthias Popp from the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM have jointly developed new kinds of structural adhesive that permit components to be pre-coated and stored, with a very fast subsequent joining process. The core element of the technology is the stable heterogeneous mixture of adhesive and nano-scale hardener, which only becomes active when heated up and then triggers immediate hardening. Separating the application of adhesive and the joining of materials in terms of both when and where they occur opens up attractive options for manufacturing. The newly developed materials and methods are already proving themselves in industrial use. For their research achievement, the three scientists received the 2014 Joseph von Fraunhofer Prize.

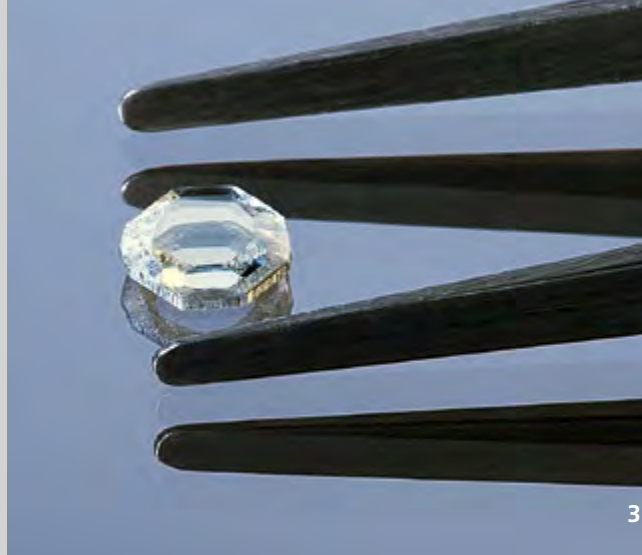
Thermal barrier coating and protection against oxidation 1

Thermal barrier coatings play an important role wherever metallic materials need to be protected against high temperatures. Researchers at the Fraunhofer Institute for Chemical Technology ICT have developed a slurry-based, multi-purpose, high-temperature coating system that consists of a top layer of connected hollow aluminum oxide balls above a metallic diffusion layer. The covering layer is heat-insulating, while the diffusion layer provides protection against oxidation and corrosion. This new type of coating can be used for many applications, such as in the turbine sector, for incinerators and reactors in the chemical and petrochemical industries, and for steel girders in the building industry.



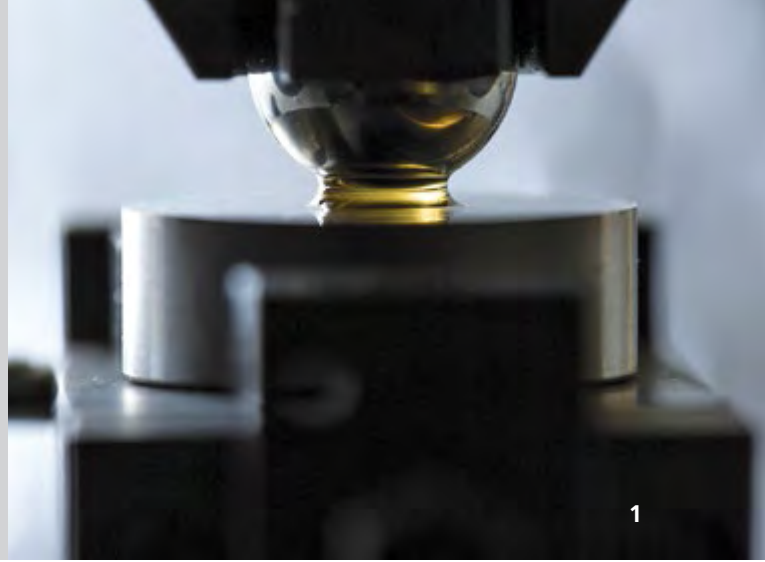
Microstructures over large areas 2

Micropatterned surfaces can fulfill a variety of functions: not only do they create non-reflective surfaces and guide, scatter, and polarize light, but they also change the adhesion, wetting, and friction coefficient of surfaces. Potential applications include the automotive industry, medical technology, and solar engineering. Researchers at the Fraunhofer Institute for Material and Beam Technology IWS have developed a new laser-assisted method based on direct laser interference patterning (DLIP) that accomplishes rapid 3D surface patterning with resolutions in the sub-micrometer range – and achieves this over areas of up to 50×50 centimeters. The particularly efficient and cost-effective method can be used on many surfaces including those made of metal, polymers or ceramics.



Growing diamonds from plasma 3

Humble carbon becomes one of the most coveted substances in the world if it can only be brought into the right crystal form – as a diamond. The properties of diamonds are what make them so highly valuable and irreplaceable for certain technical applications: extreme hardness, thermal conductivity, and transparency. However, diamonds are rare, and so scientists have been working on methods to artificially manufacture the crystals for a long time. Researchers at the Fraunhofer Institute for Applied Solid State Physics IAF have been growing diamonds using a plasma-assisted CVD method. Polycrystalline, monocrystalline, as an ultrathin layer, or in the form of a perfect sphere – the Fraunhofer-developed method supplies diamonds for a huge variety of purposes.



ENERGY AND MATERIALS

Stifterverband Science Prize

Reducing friction and saving on costs 1

Since friction and wear are a primary cause of energy loss in many motors and machines, developing systems with more efficient, lower-friction technology is one of the main tasks for applied research. Lubricants play a special role. Liquid crystal systems offer a new, promising approach to lubricant development because their molecules align themselves in the direction of movement, significantly minimizing friction. In an effort to achieve a better understanding of this phenomenon – one that nature has already successfully demonstrated in lubricating the joints of mammals – and to make the phenomenon technically useful, two companies have joined forces with the Fraunhofer Institute for Mechanics of Materials IWM. Dr. Andreas Kailer and Dr. Tobias Amann from Fraunhofer IWM, Dr. Holger Kretzschmann from Nematel GmbH & Co. KG as well as Werner Stehr and Susanne Beyer-Faiß from Dr. Tillwisch GmbH Werner Stehr have spent the last two years developing concepts for new, highly efficient lubricants that could mean a quantum leap in the field of tribology. The properties of the liquid crystal-based lubricants offer the prospect of significant savings through equipment that runs more efficiently, as well as enabling new design concepts, for instance in the area of high-precision sliding bearings. Large companies are already interested or involved in the further refinement of the new technology. The team received the Stifterverband Science Prize 2014 for its work.



Riblets for more wind power 2

Sharks have shown us how it's done: their rough skin has been proven to reduce drag as they glide through the water in search of prey. Researchers at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM used that knowledge to develop a micro-structured paint that can reduce air drag, a technology that could be put to good use in aircraft. Studies also suggest that wind turbines coated with the paint could generate as much as 5 to 6 percent more energy, and reduce rotor blade noise emissions significantly – a consequence that is likely to increase people's acceptance of the turbines.

More efficiency in commercial laundries

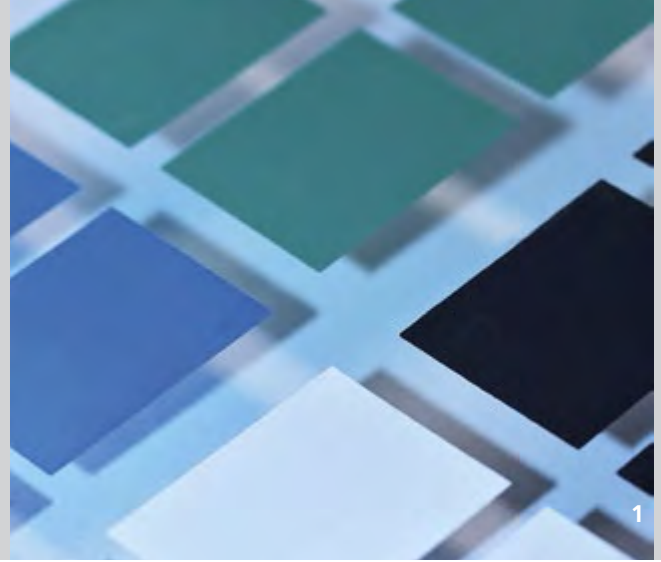
Commercial laundries handle as much as fifty tons of laundry every day. This also means that they need lots of energy and other resources – and that they could cut consumption significantly if their operations and systems were optimized. In collaboration with the German Textile Cleaning Association (DTV – Deutscher Textil-Reinigungs-Verband), the Fraunhofer Institute for Factory Operation and Automation IFF is using automated systems for laundry sorting or picking, for instance, to arrive at better solutions. One approach entails integrating RFID technology, thus making it possible to identify every laundry item reliably throughout the entire laundering process by means of a sewn-on chip.



Lighthouse project: Critical rare earths

Precious and necessary: High-tech metals 3

Rare earth metals, such as neodymium, dysprosium, europium or cerium, are referred to as materials of strategic economic importance. Without them, manufacturing many high-tech products – such as mobile telephones or electric motors – would become impossible. Since as much as 85 percent of the world's rare earth metals are produced in China, their availability also takes on an economic dimension. Now, seven Fraunhofer Institutes are engaged in finding a substitution for and a means of recycling and reusing neodymium and dysprosium used in high-performance magnets in a lighthouse project. A further focus is more efficient processes and optimized design for magnet production in order to produce new high-performance magnets that require less of the precious metals, establish optimized production and manufacturing processes and explore procedures for the recovery and recycling of neodymium and dysprosium.



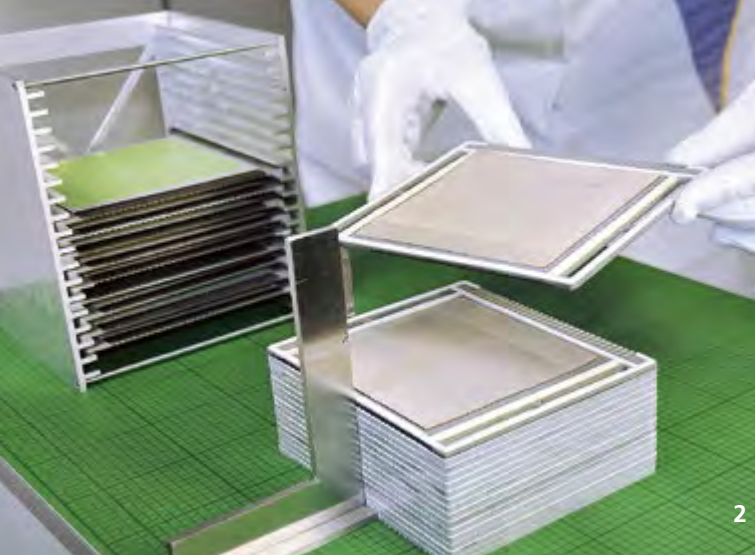
Grid energy storage

Unfortunately, renewable energy cannot be generated on command: sometimes, the wind doesn't blow or cloud cover blocks the sun. That's why Germany's transition to a new energy economy is dependent on storage technologies. In the "Roadmap storage" research project, sponsored by the German Federal Ministry of Economy and Energy (BMWi), the Fraunhofer Institute for Wind Energy and Energy System Technology IWES, RWTH Aachen University and the "Stiftung Umweltenergierecht" are working together to determine future storage needs for the grid. Fraunhofer IWES is coordinating the project. The project participants believe that, in addition to putting storage capacity in place – which assumes the utmost importance when the percentage of renewables exceeds 60 percent – the supply system's necessary flexibility can largely be achieved through network expansion and load management, as well as flexible biogas, cogeneration and power-to-heat plants.

The Fraunhofer Institute for Factory Operation and Automation IFF is pursuing research on large energy storage systems in collaboration with SK Innovation, a manufacturer of battery systems. The two will primarily be working together on battery management and the development of storage system sub-components that will facilitate accurate communication between advanced large energy storage systems and electrical grids.

Decorating glass without lead 1

Whether perfume bottles, beer mugs or other drinking glasses, ornamentation on glass containers is aesthetically pleasing. But such decoration is technically challenging because the glass colors must melt at temperatures at which the vessels themselves remain completely stable. The leaded glass used for this purpose will soon be banned by a new EU directive because the lead poses a danger to human health. As a response, researchers at the Fraunhofer Institute for Silicate Research ISC have developed paint for decorating glass that is easy to process, provides the same brilliance and durability as the leaded colors and contains no toxic substances.



Mini power stations for all 2

When it comes to efficiency, fuel cells are hard to beat – they can convert natural gas into electrical energy far more efficiently than combustion engines can. In collaboration with the heating specialist Vaillant, the Fraunhofer Institute for Ceramic Technologies and Systems IKTS has designed fuel cells that have taken a big step towards marketability. Fraunhofer IKTS offered substantially more testing support for this in 2014. The Vaillant devices are currently undergoing testing in comprehensive practical tests in everyday household conditions. The aim is to develop marketable mini power plants for everyone using the accumulated experience.

Fraunhofer Future Foundation project

Harvesting energy

Efficient energy use is the order of the day. Yet a move away from nuclear power and fossil fuels is possible only when we learn to handle energy in a highly rational and effective way. As part of the HARVEST project (highly efficient adsorbing materials and network systems for energy technology), Fraunhofer researchers are searching for ways to develop new methods for energy use. The aim of the project is to develop materials and components for highly efficient adsorption and thermal transference in order to facilitate a new generation of gas heat pumps. With them, household appliances could be optimized and cooling and climate control could be realized by means of waste heat. Financed by the Fraunhofer-Zukunftsstiftung (Fraunhofer Future Foundation), HARVEST is being carried out by the Fraunhofer Institutes for Manufacturing Technology and Advanced Materials IFAM and for Solar Energy Systems ISE.



Wood foam for thermal insulation 3

Wood is known for being both a CO₂-neutral fuel and an insulating material. But it turns out there is room for improvement when it comes to insulation: scientists at the Fraunhofer Institute for Wood Research, Wilhelm-Klauditz-Institut, WKI have now developed a wood foam that prevents heat loss more efficiently. Made from finely ground up wood, the substance is expanded and foamed using a gas, and then left to harden. The resulting foam sheet or foam shape can be used in ways similar to familiar hard foam products – that is, not just for thermal insulation, but also for packaging material. This means CO₂-neutral wood foam could replace petroleum-based expanded polystyrene in many fields of application.

AWARDS 2014

IN ADDITION TO MANY PRIZES FOR FIRST-CLASS SCIENTIFIC ACHIEVEMENT, RESEARCHERS OF THE FRAUNHOFER-GESELLSCHAFT REGULARLY WIN MAJOR NATIONAL AND INTERNATIONAL AWARDS FOR THEIR ACHIEVEMENTS IN THE FIELD OF APPLIED RESEARCH. WE WISH TO HONOR THEM HERE.

GreenTec Award

From dandelions to car tires

Car tires made from dandelions? Initially, that sounds like a strange idea. However, given that this plant exudes milky latex similar to the latex found in the rubber tree, the relationship is no longer implausible. Ten years of research has yielded an extremely attractive technological and environmental result: Russian dandelions can be grown in temperate latitudes in soils of low quality, so that tropical forests can be preserved along with fields for food crops. Continental AG has already started testing tires made with dandelion rubber for their road-worthiness. In 2014, the tire manufacturer's joint research project with the Institute for Plant Biology and Biotechnology at Münster University (WWU) and the Fraunhofer Institute for Molecular Biology and Applied Ecology IME was distinguished with the GreenTec Award, Europe's largest environmental and business prize.

German Cancer Prize

Personalized tumor therapy

The Cancer Prize, donated by the German Cancer Society and the German Cancer Foundation, is one of the most renowned awards in German oncology. Along with two other researchers, the 2014 award was given to Prof. Dr. Christoph Klein, who holds the chair of Experimental Medicine and Therapy Research at the University Hospital Regensburg, and is also head of the Project Group on Personalized Tumor Therapy of the Fraunhofer Institute for Toxicology and Experimental Medicine ITEM. His work has effected a paradigm shift in experimental cancer research because it has recognized the metastasis of a tumor and its spread as early events of progressive malignancy. His concept of tumor progression shows the causal link between the molecular differences that have arisen in the course of evolution and the diagnostic and therapeutic heterogeneity of tumor diseases, forming an important basis for personalized diagnosis and treatment.



German Future Prize

Sumptuous lupines 1

Lupine seeds are suitable as a high quality food. However, they contain a bitter compound and bothersome aromas that have to be extracted before they can be used. Dr. Stephanie Mittermaier and Dr.-Ing. Peter Eisner at the Fraunhofer Institute for Process Engineering and Packaging IVV and Katrin Petersen from Prolupin GmbH joined forces to develop a process that removes these elements without influencing the special properties of the lupine proteins. Lupine proteins can be used in place of milk proteins. These high-purity proteins can be used to make far more than just ice cream, cheese and pudding; they are also an ideal base for cakes and sausage products. Now, the refining technique has reached industrial maturity. For their work, the three researchers were awarded the German Future Prize 2014 by German Federal President Joachim Gauck. The prize is endowed with 250,000 euros.

1 Dr. Stephanie Mittermaier, Dr. Peter Eisner and Katrin Petersen (from left) were awarded the 2014 German Future Prize for a process that recovers lupine proteins for food.



Heinz Maier-Leibnitz Prize

Outstanding research for secure software 1

Software security is an issue of increasing importance because more and more operations in engineering, supply and communication are directly dependent on functioning software. That is why it is all the more important to put more focus on research in the field of software security. The Heinz Maier-Leibnitz Prize is viewed as the most important distinction for up and coming researchers in Germany. Awarding the prize to Prof. Dr. Eric Bodden from the Fraunhofer Institute for Secure Information Technology SIT is not just a great honor for him and the institute; it is also an indicator of the importance of his work in the area of secure software development.

EARTO Innovation Prize

Data requires security

Regular reports about data theft and misuse have made it clearer than ever that data security is very important. In the IND²UCE project, the Fraunhofer Institute for Experimental Software Engineering IESE and its research partners are addressing people's chronic loss of confidence in data storage with a new concept. All data will be armed with small packets of information that specify what can be done with it and what cannot. For example, access could be limited to company premises, or only during a predefined time period. An industrial partner plans to integrate the tool into its operating software and bring it to market. In the opinion of the EARTO Innovation Prize jurors, this development has potential to initiate an economic or social shift, and awarded the research partners the 2014 prize. Located in Brussels, EARTO is a European umbrella organization that represents some 350 research and technology organizations.



Zayed Future Energy Prize

Energy research worth the money 2

Germany's decision to transition to a new energy economy is a recent, politically motivated change of course. The development of alternative energy concepts has been a topic of research for somewhat longer. For more than thirty years, the Fraunhofer Institute for Solar Energy Systems ISE has been among the leaders in the search for the optimal use of renewables. Today, it is known for its research worldwide – as evidenced by its most recent honor, the Zayed Future Energy Prize 2014, which is endowed with US\$1.5 million. The key reasons for selecting the institution is its part in a tangible industrial, societal and ecological change, its leadership role and exemplary function as well as its future-readiness and potential for innovation. As proposed by institute director Prof. Dr. Eicke Weber, the Fraunhofer-Gesellschaft's Executive Board has agreed to use the prize money – US\$1.5 million, or 1.089 million euros – for a funding program that finances Fraunhofer projects in the area of sustainable energy supply in countries outside of Germany.



National Academy of Television Arts and Sciences

Emmy Award

More quality for data streams 3

The National Academy of Television Arts and Sciences Emmy is one of the most important television awards in the United States. In 2014, the winner in the Technology and Engineering category was the Moving Picture Experts Group MPEG, of which the Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institut, HHI, is a member. The reason for the award is the highly successful MPEG-2 standard. Worldwide, nearly all digital receivers – including those in TVs, Blu-ray players, smart-phones and tablet computers – are equipped with the MPEG-2 Transport Stream Standard for receiving videos. Fraunhofer HHI integrated Multiview Video Coding (MVC), Scalable Video Coding (SVC) as well as the most recent High Efficiency Video Coding Standard (HEVC). This contribution to development makes it possible for MPEG-2 to keep up with the rapidly growing digital device market.

PEOPLE IN RESEARCH



PRACTICAL UTILITY LIES AT THE HEART OF ALL RESEARCH ACTIVITIES CONDUCTED BY THE FRAUNHOFER-GESELLSCHAFT: REAL RESEARCH BY REAL PEOPLE.

OUR SUCCESS IS FOUNDED ON THE ENTHUSIASM AND EXCEPTIONAL SKILLS OF PEOPLE AT ALL LEVELS OF THE ORGANIZATION. HERE WE PRESENT PORTRAITS OF SIX PEOPLE WHO ARE REPRESENTATIVE OF THE EXCELLENT STANDARD OF WORK AND FIRST-CLASS RESULTS REPEATEDLY OBTAINED BY OUR RESEARCHERS – BUT WE COULD HAVE CHOSEN MANY MORE.



DR. RER. NAT. LENA GRUNDMANN

Biotechnologist M. A. | Group manager at the branch lab for plant-based biopolymers at the Fraunhofer Institute for Molecular Biology and Applied Ecology IME in Münster

People who know what they want and say what they think are considered to be open minded. Such qualities lead to more confidence, because open-minded people are respected for being exactly what they are. They can also pursue their goals more consistently. Lena Grundmann knew from the very beginning what she wanted to achieve in her career. She has done a great deal to reach her goals, and has achieved something noteworthy for her efforts.

After completing a bachelor's degree in life sciences at Münster University (WWU) in Westphalia, Lena Grundmann began a master's program in the field of biotechnology. She received financial support for several years from the German National Academic Foundation, which assists particularly talented young scientists and bases its selection criteria on performance, initiative and responsibility. The tobacco plant was already the focus of her master's thesis. Tobacco is a much studied object in applied biology research in part because of its natural ability to act as bioreactor for the natural production of pharmaceutically valuable proteins, such as antibodies or vaccines. The results of her research were so promising that Lena Grundmann built her doctoral work around it – with outstanding results. For her dissertation, she received the Hugo Geiger Prize 2014.

In her research, the scientist carefully examined the plant proteins believed to cause flowering and discovered something unexpected. One tobacco protein believed to initiate the flowering process in fact caused the exact opposite: Genetically modified plants, which produced large quantities of this protein, did not flower at all but grew unabated. This new finding got Lena Grundmann's imagination racing, because normally, tobacco plants stop growing and die once they flower and

produce seeds. However, if this natural process could be delayed or even prevented – especially in regard to related food plants such as potatoes and tomatoes – it would open up very interesting perspectives for agriculture and achieving food security for people. Lena Grundmann found this application-oriented approach an especially motivating result of her research.

As Lena Grundmann knows, part of any success in applied research comes down to a working cooperation, not just with industrial partners but also within the research group itself. "Collaboration within the mixed WWU-Fraunhofer IME working group is excellent – both in terms of support for the research as well as among the employees and students."

Bit by bit, the research group in Münster is revealing the genetic pathways governing the flowering of the tobacco plant. The potential for highly interesting applications for cultivated plants has of course caught the eye of industrial partners, such that scientific success will soon be joined by economic success. Lena Grundmann and her team have already come out on top as two-time winners in the internal competition "Best New Customer", The researcher's linear openness has also proven to be an important success factor in negotiations. So far, one Japanese and one American company have agreed to contracts with the Fraunhofer research group worth millions.

PROF. DR.-ING. WELF-GUNTRAM DROSSEL

Engineer | Co-director of the Institute and director of the scientific areas Mechatronics and Lightweight Structures at the Fraunhofer Institute for Machine Tools and Forming Technology IWU in Chemnitz

An engineer is above all an engineer – and not just a mechatronics specialist, electrical engineer, production specialist or lightweight structures specialist. A definition of the engineer's occupation could be the special skill needed to see and tackle technical problems – because something can always be improved, combined, refined or invented from scratch. And that ultimately brings all available technologies with it.

In this sense, Welf-Guntram Drossel has built his career out of not one but many technical disciplines. During his information technology studies at Dresden University of Technology, he specialized in measuring technology and technical acoustics. He completed his doctorate in the area of forming technology, writing his dissertation on finite element simulation in cold forging. His work received the *Land* of Saxony Prize for Forming Technology – and recommended him to the Fraunhofer Institute of Machine Tools and Forming Technology IWU and to Professor Neugebauer – a preliminary decision that shaped his future career. At Fraunhofer IWU, Welf-Guntram Drossel first specialized in control technology and parallel kinematics; later, he built up the Adaptronics department in Dresden. From 2005, he headed up the central Mechatronics department, and in 2011 he became the managing senior engineer for Production Systems. He has been Institute director for the scientific areas Mechatronics and Lightweight Structures since 2012.

Especially in multifunctional lightweight structures, it becomes clear just how important it is to look beyond the limitations of one's own area of expertise. Here, materials science is just as important as knowledge about sensors and adaptronics. When everything is combined properly, it is possible to create lightweight components that, for example, actively dampen vibrations as required and also provide digital information on their temperature and the load condition. These and other exciting projects are addressed in the Collaborative Research Center's "High-volume production-compatible production technologies for light metal- and fiber-composite-based components with integrated piezo sensors and actuators (PT-PIESA)". Welf-Guntram Drossel is the center's coordinator. In this area, he wants to make a mark with new production technologies and products.

For the distinguished research engineer, cross discipline work has always held an important place in his heart. "When it comes to further refining production technology, we've always had the best experiences in collaborations bringing together various areas of expertise, for example designers and technicians." That's why he also supports the newly opened "maker-space" 3D lab at Dresden University of Technology. Since February 2015, anyone can experience what interdisciplinary work means on a tangible level here, in that anyone can manufacture their own creative ideas using the 3D printer and then test them in real life. Even amateurs can use the cutting-edge technology – from which Welf-Guntram Drossel, as a proven research manager, expects to see valuable creative stimulus for the professional researchers.





PROF. DR. RER. BIOL. HUM. JESSICA FREIHERR

Nutritionist | Professor for functional imaging of the chemosensory system
at RWTH Aachen University, head of the “Multisense” Attract group at the Fraunhofer Institute
for Process Engineering and Packaging IVV in Freising

Food is part of everyday life, yet also assumes an existential significance. We need food to survive, and we must be very careful about our food choices because otherwise we might eat something unsuitable or even poisonous. For this reason, people tend to fall back on nearly all their sensory and mental abilities when it comes to selecting the right foods: sight, smell, taste, feel, memory and trust. The nutritionist Jessica Freiherr is especially interested in the decision-making process in the choice of food. To thoroughly investigate the influencing factors at work, she initiated the “Multisense” Attract project.

To a significant degree, a food's quality is distinguished by smell. Accordingly, the olfactory process has taken on an important role in Jessica Freiherr's career: After her studies and degree in nutritional sciences at Friedrich Schiller University in Jena, she explored the neuronal processing of olfactory information during her doctoral studies at Ludwig-Maximilians-Universität in Munich. Her other scientific work also focused on the senses as they related to smell and taste. Upon completing her PhD, she accepted a two year post-doctoral position at the University of Pennsylvania in the US. Afterwards, Jessica Freiherr took on a position as professor of functional imaging of the chemosensory system at RWTH Aachen University.

Jessica Freiherr's Attract group now pursues a comprehensive approach: The Multisense project is aimed at considering the holistic sensory perception evoked by food and optimizing products in their presentation. “We want to develop stimulation scenarios that allow for a holistic perception and measure physiological and psychological parameters”, says Jessica Freiherr of the project's goals. “That way, we can analyze acceptance, preference or aversion and better understand purchasing decisions.” These are research objectives that the food industry is also keen to learn more about, because in addition to the price, being able to create a multisensory impression of a food in a commercial setting could be a decision factor at the point of sale.

Any person strongly engaged in science knows that interest in a research topic is not just limited to working hours. If you spend your day examining food and how it is perceived, you cannot visit a supermarket like an ordinary customer. And if you study olfactory perception, you might find yourself observing your own reaction to relevant environmental stimuli with greater awareness. For Jessica Freiherr, a new and highly interesting field of personal perception opened up in 2014 after her child was born. How this “natural” area of multisensory perception plays out on her research is bound to be exciting.

DR. RER. NAT. MATTHIAS POPP

Chemist | Group manager for adhesives and polymer chemistry at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM in Bremen

Companies often turn to a Fraunhofer Institute when they want to overcome a technical problem. We're a first stop in such cases because, nearly every time, our researchers find a solution. This holds true because we have people like Matthias Popp: For him, problems are simply challenges that call upon his skills, and finding a suitable solution gives him great pleasure.

Achieving the high level of competence required to deal with difficult tasks quite often requires a trip through university on the road to success. Matthias Popp studied chemistry at the University of Bremen. After completing his doctorate, he joined a medium-sized company in the plastics sector as product developer and testing supervisor and gained his first research experience with adhesives. His career at Fraunhofer began with a chance meeting: on the way to a trade fair, he met Professor Andreas Hartwig from Bremen's Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM on a train. The conversation led to his applying for a job at the institute – with success. After several years of research at Fraunhofer, the pragmatic problem solver wanted to gain more industrial experience. While working as a development specialist at 3M in Neuss – a company with high expectations when it comes to innovation – he developed adhesives for the aviation industry among other things. That was an interesting and formative time, but after four years, Matthias Popp decided to return to his old employer: "The independent and extremely varied research I conducted at Fraunhofer IFAM had stayed fresh in my memory, and the collaboration with industrial partners to solve problems was very satisfying. So I went back to Fraunhofer, this time as group leader for adhesives and polymer chemistry."

The ability to repeatedly find pragmatic solutions is something much appreciated in applied research and in the manufacturing industry in particular. And Matthias Popp has received corresponding recognition for work: One of his innovative adhesive developments from his 3M days won awards. For his contribution to the "Adhesive bonding with pre-applied adhesives" project at Fraunhofer, he and his colleagues Andreas Lühring and Professor Andreas Hartwig received the Joseph von Fraunhofer Prize 2014.

This research work exemplifies Fraunhofer know-how and how it is always transferred to a practical result. A storable adhesive that can be pre-applied to components, and which then hardens extremely quickly when required, was previously unknown – although it would benefit production significantly. The approach developed by the Fraunhofer team was the first to deliver the desired result: a pre-applied adhesive with an integrated but inactive curing agent that can be activated thermally and which establishes a strong bond within a few seconds.

In this way, the team created component properties that no one had considered possible until then. After such successes, it's clear that Matthias Popp belongs to the kind of researcher who looks forward to those times when someone asks the impossible of him.





PROF. DR. RER. NAT. PETRA KLUGER

Biologist (technical orientation) | Professor at the Faculty for Applied Chemistry at Reutlingen University, Head of the Cell and Tissue Engineering Department at the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB in Stuttgart

“We grow with the tasks we face”, replies Petra Kluger when asked how she approached her own professional development. “I was always keen to assume responsibility at an early stage, and then simply focused on making sure I delivered the necessary results.” This propensity for tackling challenges head on has certainly brought her remarkable success.

After studying Technical Biology at the University of Stuttgart, Petra Kluger was awarded a scholarship by the Peter and Traudl Engelhorn Foundation and began working on her doctoral thesis at the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB and the University of Stuttgart. In her work, she was able to show how skin cells adapt their shape and physiology to different structures and chemically modified substrates. This detailed knowledge about specific cell-material interactions is hugely significant for the development of optimized implants and prostheses. In 2012, Petra Kluger received the Ring of Honor from the Association of German Engineers (VDI) for her top-rated dissertation, further research work and her commitment to education and the development of young talent.

Professor Kluger's career development has kept pace with her research success without the need for any change in employer or department. She joined the Cell and Tissue Engineering Department at Fraunhofer IGB as a student assistant while still studying for her first degree. She stayed on to complete her PhD, becoming group manager and eventually deputy head of department. She received a lot of support from the institute along the way, including the chance to participate in training courses for young managers, and always had the backing of

her colleagues and supervisors. In 2012, a new responsibility came along – one that, while also related to the field of biology, posed a very special challenge for the young scientist: she became a mother.

Did this mark the end of a promising career? Not in the slightest. Petra Kluger took maternity leave, but stayed in touch with the research group and returned a year later to take up a new role as head of department. And that's not all: in 2013 she was invited to take up a professorship at Reutlingen University – a welcome step forward in her career, since Petra Kluger had always been an enthusiastic advocate of teaching and developing young talent. So it's fair to say that her career took a turn following her maternity leave – albeit upwards.

Naturally, this raises the question of how to cope with the dual responsibility. But Petra Kluger has the support of her family and knows how to organize her time. She teaches in Reutlingen two days a week as part of her shared professorship, and otherwise works either at the Fraunhofer Institute or from home. Her husband, who works for a company that provides engineering and consulting services to the mobility industry, manages to leave work early on occasion. And then there's the daycare center sponsored by Fraunhofer IGB right next door.

Petra Kluger has a full work schedule and carries a lot of responsibility. But because her working environment, particularly the team and colleagues around her, and her personal motivation are in harmony, she can rise to meet new challenges with joy and increasing success, both on a professional and personal level.



PROF. DR.-ING. PETER LIGGESMEYER

Engineer | Executive director of the Fraunhofer Institute for Experimental Software Engineering IESE in Kaiserslautern

Keeping a close eye on the details without losing sight of the bigger picture is a skill not everyone has, but one required for somebody who wants to take on a high level of responsibility in research. That person should also be able to master detailed scientific work while at the same time making the most of the challenging threshold areas between disciplines. Peter Liggesmeyer, who studied electrical engineering and is now head of a software institute, has got what it takes.

After completing his studies, Peter Liggesmeyer achieved his doctorate and qualified as professor in 2000 at the University of Bochum. Today he is chair of Software Engineering: Dependability at the Technical University of Kaiserslautern and is executive director of the Fraunhofer Institute for Experimental Software Engineering IESE. While all his formal qualifications are to do with electrical engineering, his professorship concerns computer science, with strong links to traditional engineering disciplines, such as electrical and mechanical engineering. In addition, Peter Liggesmeyer is president of the German Informatics Society.

Having an interdisciplinary mindset is extremely important for applied research. Software and computer technologies in particular serve as true interface technologies, playing a decisive role in shaping product characteristics in all other technical areas. In the fields of mobility, medical technology and power supply, for example, it is always the interplay between electrical or mechanical engineering components and computers and software that determines whether or not the entire system runs smoothly and can cooperate reliably with its environment. Peter Liggesmeyer summarizes the unique difficulties posed by such smart ecosystems as follows: "Many challenges

that we have no problem mastering in individual disciplines are difficult to tackle when applied to the system as an integrated whole. And that's exactly what we're working on. We want to develop methodologies for the targeted, quality-assured development of complex systems."

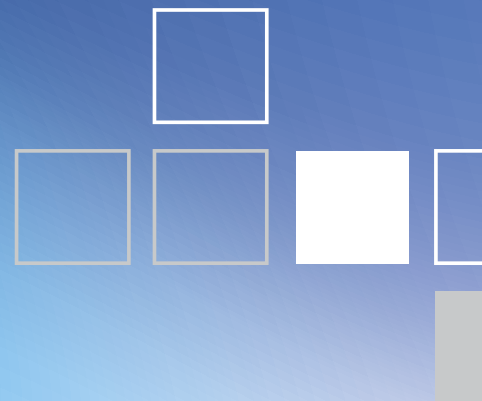
Operational safety has been an established issue within the engineering sciences for twenty years – but not in the software field. Realizing that safety would become a key challenge for integrated systems, Peter Liggesmeyer began steering research in this direction. Today, his chair and Fraunhofer IESE are considered the port of call for expert advice on the subject, with worldwide demand for the knowledge accumulated in this pool of talent.

Peter Liggesmeyer's ability to see things from a cross-disciplinary perspective has established his success in the research field – also because it is a deep-seated part of his personality, and not just something he affects. His wide-ranging personal interests allow him to find the necessary balance in his private life to the sizeable professional challenges he faces. After his involvement with his family – which of course takes top priority – his hobbies include paleontology, fly fishing and, last but not least, collecting art. Over many years, his creative interest led him to organize the "Art and Technology" exhibition series together with the Cultural Department of the City of Kaiserslautern. Here, too, Peter Liggesmeyer successfully managed to unite two very different topic areas into one perfectly functioning integrated system.

FRAUNHOFER INSTITUTE SPIN-OFFS

THE FRAUNHOFER INSTITUTES ARE PRIZED BY BUSINESS AND GOVERNMENT ALIKE BECAUSE THEY DRAW EXISTING COMPANIES INTO THEIR ORBIT AND PROVIDE THE SEED FROM WHICH NEW COMPANIES ARE BORN.

EVERY YEAR, MORE THAN 50 FRAUNHOFER INSTITUTE EMPLOYEES USE THE EXPERTISE THEY HAVE COLLECTED THERE TO START UP THEIR OWN BUSINESSES. HERE ARE JUST SOME OF THE COMPANIES FOUNDED BY FRAUNHOFER EMPLOYEES.



FuelCell Energy Solutions GmbH
Generating clean energy at the point of use

Energy is the engine that drives every modern society, but rising costs and increasing environmental pressures demand new solutions for generating electricity as cleanly and efficiently as possible.

FuelCell Energy Solutions GmbH (FCES) is a joint venture between the Fraunhofer Institute for Ceramic Technologies and Systems IKTS and the US company FuelCell Energy, Inc. (FCE). Its comprehensive service portfolio for fuel cell power plants includes research and development, production, sales, installation and commissioning as well as service and maintenance. Fuel cells are considered to be an extremely efficient and clean form of energy: MCFC power plants use an electrochemical process to convert energy derived from natural gas or biogas directly into electricity and heat, with virtually no harmful emissions.

The Dresden-based company with a production facility in Munich combines Fraunhofer's technological innovation potential with the commercial strengths and production expertise of the parent company, FCE. The aim is to more quickly transfer the latest developments in fuel cell technology into practice and reduce costs. FCES's service portfolio is primarily aimed at facilities with high energy requirements, such as industrial companies, large data centers, hospitals, and even utility companies themselves. Founded in 2012, FCES has already developed a customer base of several clients at home and abroad. The first fuel cell power plant produced in Germany has been supplying the new Federal Ministry of Education and Research building with electricity since December 2014.



FuelCell Energy Solutions
Saubere, effiziente, zuverlässige Energie

UBERBLIK GmbH
Digital pin board for connected work processes

Team-based project work is most effective if the parties involved can keep track of their ideas and work processes on a shared platform. Bulletin boards are a particularly popular solution, as they allow each employee to quickly gain an overview of the current project status and see what their colleagues are working on. Nowadays, however, organization-wide collaboration is not uncommon, and project partners are often spread across multiple locations. To help such "virtual teams" swap ideas and information effectively, the company UBERBLIK GmbH developed a digital platform with the same name. Founded in June 2014 as part of a BMBF project run through Fraunhofer headquarters, UBERBLIK GmbH was created to work up the concepts developed there into a marketable product.

UBERBLIK's user interface is easy to use and suitable for PCs, tablets and smartphones. Users can create "boards" for various topics that each resemble a kind of digital bulletin board. All group members can access these boards and use them to store, manage and edit documents, pictures and videos. In addition, UBERBLIK guarantees its users a very high security standard: stored data is not only encrypted, but also signed.

UBERBLIK is already being used in pilot applications such as the Discover Markets project run by the Fraunhofer-Gesellschaft and several smaller companies in the creative or consulting field. In addition, police teams in one of Germany's federal states are using the platform to coordinate their work more effectively. CEO Dr. Sebastian Denef now aims to attract investors in order to refine UBERBLIK and implement it in new applications.



UBERBLIK

wettransform GmbH Harmonizing spatial data

Maps of Europe featuring uncharted territory have long been a thing of the past. These days, every river and undulation is mapped with the highest degree of precision. However, the way such spatial data sets are presented and the quality of the information they contain can vary a very great deal, even from municipality to municipality. In order to harmonize the data, the EU created the INSPIRE directive as a basis for an interoperable European spatial information infrastructure.

wettransform GmbH, a spin-off from the Fraunhofer Institute for Computer Graphics Research IGD, helps authorities at the federal state and municipal level to adjust their spatial data to fit the INSPIRE formats. It is based on free open source software resulting from an earlier research project. The tool enables existing data to be uploaded and converted into INSPIRE formats and geometry models. Users are guided step by step through this conversion process.

In 2014, the software was named best open source software for INSPIRE in the SmeSpire Challenge that took place as part of the INSPIRE conference. Currently, CEO Simon Templer and his team are working on an online platform that will allow partners collaborating across countries or working on interregional projects to cooperate even better with one another. Stakeholders can use this platform to combine their data in standardized formats and develop joint models such as flood protection concepts. Over the next few years, the company will continue to accompany the INSPIRE process and assist government and service providers to implement it. Furthermore, wettransform GmbH plans to expand its service portfolio to include other areas of application beyond geo-spatial data.

WiTech GmbH Wireless workplace

No modern-day workplace is complete without a PC, printer and desk lamp, not to mention the panoply of other electronic devices. The power cables needed to connect them are a necessary evil – a tangled mess of cables on and under the desk that not only looks untidy but can also cause accidents.

If it were up to WiTech GmbH, our workstations could soon be powered by a single cable. The spin-off from the Fraunhofer Institute for Electronic Nano Systems ENAS has devised a wireless power and data transmission solution that goes by the name of SUPA. The acronym stands for “Smart Universal Power Antenna”. This inductive power system consists of an array of antennas implemented on a PCB attached to the underside of a flat surface such as a desk and connected to a power source. Each signal sent to an authorized receiving device induces an electromagnetic field in the transmitting coil which generates power in the device. Connecting a data cable to the board allows data to be transferred in the same way. To minimize electromagnetic radiation, only those antennae directly below the transmitting device are activated, and the range of the electromagnetic field is limited to five centimeters.

Managing director Maik-Julian Bükér is in talks with well-known manufacturers in the hope of establishing SUPA as future standard for electrical appliances. A table lamp incorporating SUPA technology was recently launched on the market. WiTech GmbH is also working on retrofit solutions for existing applications. Its market potential is not limited to stationary workstations: SUPA could one day facilitate the use of electronic devices in public spaces and public transportation.

Susteen Technologies GmbH
Converting biomass residues into fuel

Waste is a big problem for the manufacturing industry and municipal biogas or sewage treatment plants, with tons of sewage sludge, fermentation residues, wood waste and paper slurry being generated every day. But one man's waste is another man's valuable raw material: Susteen Technologies GmbH, a spin-off from the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT based in Sulzbach-Rosenberg, intends to launch a TCR-technology based method for converting and recycling all manner of solid biomass residues.

As part of the thermochemical process, the biomass is dried in several steps and split into four components: synthesis gas, bio-oil, biochar and water. After a final cleaning process, the gas can be directly fed into cogeneration units and used to generate power. Bio-oil is suitable for use in blended fuels, or can be turned into a clean fuel after further processing in a refinery. Biochar is useful in agricultural contexts as a soil conditioner, but also makes an ideal fuel for biomass power plants and can significantly increase the efficiency of biogas plants.

CEO Thorsten Hornung sees the sustainable and efficient use of biomass residues as an important contribution to the planned transition to a new energy economy. What's more, this technology also offers significant potential for emerging and developing countries, in that it enables decentralized and independent power supplies to be built even in areas with poor infrastructure. When used in agriculture, for example, biochar has been

proven to help significantly reduce the demand for water in arid regions.

Together with Fraunhofer UMSICHT, the company is currently operating a pilot plant for the process. Initial customer projects are already underway for 2015.

The background of the cover features a green-to-yellow gradient. Two dashed grey lines intersect diagonally in the upper half. In the lower half, there are two dashed lines: a dark green one and a white one, both sloping upwards from left to right.

FINANCIAL REPORT



**BALANCE SHEET
AT DECEMBER 31, 2014**

**INCOME STATEMENT FOR THE
FINANCIAL YEAR 2014**

**RECONCILIATION BETWEEN INCOME
STATEMENT AND PERFORMANCE
STATEMENT (CASH-BASIS ACCOUNTING)**

**PERFORMANCE STATEMENT FOR
INDIVIDUAL FRAUNHOFER ENTITIES**

**EXCERPTS FROM THE NOTES
TO THE FINANCIAL STATEMENTS**

INDEPENDENT AUDITOR'S REPORT

BALANCE SHEET AT DECEMBER 31, 2014

FRAUNHOFER-GESELLSCHAFT ZUR FÖRDERUNG DER ANGEWANDTEN FORSCHUNG E.V., MÜNCHEN

ASSETS	€	€	2014 €	2013 €(1000)
Current assets				
Cash and cash equivalents		31,177,821.90		29,557
Marketable securities		198,821,304.42		214,835
Accounts receivable and other current assets				
Trade receivables	197,135,203.77			188,376
Receivables from the federal and state governments relating to base funding	28,967,762.98			30,391
relating to project billing				
including contract research	189,760,916.59			153,268
relating to pension				
and compensated absence provisions	62,846,097.00			60,123
	281,574,776.57			243,782
Accounts receivable from associated companies	1,009,985.14			934
Other current assets	120,444,995.78			41,031
		600,164,961.26		474,123
Inventories		39,884,453.89		68,599
Prepaid expenses and deferred charges		10,456,229.96		10,976
Total current assets			880,504,771.43	798,090
Intangible assets			12,269,728.28	11,830
Property, plant and equipment			1,932,239,046.06	1,832,304
Financial assets			16,838,058.42	15,051
Total assets			2,841,851,604.19	2,657,275
Trust assets			44,817,847.77	67,068

LIABILITIES AND EQUITY		2014	2013
	€	€	€(1000)
Current liabilities			
Trade payables	95,651,106.08		84,958
Unappropriated grants from the federal and state governments			
relating to base funding	29,923,196.52		30,596
relating to project billing	<u>39,224,831.25</u>		<u>74,089</u>
	69,148,027.77		104,685
Accounts payable to associated companies	73,399.75		33
Other current liabilities	<u>26,018,342.60</u>		<u>22,344</u>
Total current liabilities		190,890,876.20	212,020
Deferred income		6,883,251.15	10,356
Provisions for pensions and similar obligations		10,026,097.00	10,423
Other provisions		141,617,850.00	137,643
Special reserves			
License-fee revenue reserve	229,008,285.76		244,142
Grants relating to fixed assets	1,946,286,974.34		1,844,915
Grants used to finance current assets	221,355,414.36		183,480
Present value of deferred income from patent deal	<u>79,934,233.00</u>		<u>—</u>
		2,476,584,907.46	2,272,537
Equity			
Capital of the non-profit organization			
Carried forward	14,281,048.64		13,836
Retained earnings	<u>411,734.62</u>		<u>445</u>
	14,692,783.26		14,281
Restricted reserve	<u>1,155,839.12</u>		<u>15</u>
Total equity		<u>15,848,622.38</u>	<u>14,296</u>
Total liabilities and equity		<u>2,841,851,604.19</u>	<u>2,657,275</u>
Trust liabilities		44,817,847.77	67,068

INCOME STATEMENT FOR THE FINANCIAL YEAR 2014

FRAUNHOFER-GESELLSCHAFT
ZUR FÖRDERUNG DER ANGEWANDTEN FORSCHUNG E. V., MÜNCHEN

	€	€	2014 €	2013 €(1000)
Revenue from base funding				
Federal government		587,362,559.02		554,475
State governments		125,970,570.15		121,481
			713,333,129.17	675,956
Revenue from own activities				
Revenue from research and development activities				
Federal government: Project funding	328,247,060.56			326,231
Contracts	11,701,235.96			9,928
State governments: Project funding	250,693,669.96			202,090
Contracts	4,128,819.93			2,838
Business, industry and trade associations	623,693,551.94			567,263
Research funding organizations and other sources	134,229,292.24			140,551
		1,352,693,630.59		1,248,901
Decrease in work in progress (prior year: increase)		-12,957,347.69		31,363
Other internally constructed and capitalized assets		4,387,497.07		5,906
Other operating income		42,118,843.37		38,870
Other interest and similar income		28,031.31		32
			1,386,270,654.65	1,325,072
Total base funding and revenue from own activities			2,099,603,783.82	2,001,028
Changes in special reserves				
License-fee revenue reserve		15.133.924		-
Grants relating to fixed assets		-99.454.199,10		-134.779
Grants used to finance current assets		-37.436.228,17		9,473
			-121,756,503.65	-125,306
Total income available to cover expenditure			1,977,847,280.17	1,875,722

	€	€	2014 €	2013 €(1000)
Cost of materials	298,270,911.79			302,201
Personnel expenses	1,081,919,516.51			1,001,089
Amortization of intangible assets and depreciation of property, plant and equipment	295,424,746.76			283,041
Other operating expenses	298,940,227.55			286,288
Amortization of financial assets and current marketable securities	<u>1,739,178.82</u>			<u>2,659</u>
Total expenditure		1,976,294,581.43		<u>1,875,278</u>
Net income for the year		1,552,698.74		444
Transfer from reserves		–		5
Transfer to reserves		<u>–1,140,964.12</u>		<u>–4</u>
Retained earnings		411,734.62		445
Allocation to capital of the non-profit organization		<u>–411,734.62</u>		<u>–445</u>
		<u>–</u>		<u>–</u>

RECONCILIATION BETWEEN INCOME STATEMENT AND PERFORMANCE STATEMENT (CASH-BASIS ACCOUNTING)

Income/receipts	Performance statement €	Non-profit organization capital €	Reconciling items €	Income statement €
Income/receipts				
from base funding	710,609,864.17		2,723,265.00	713,333,129.17
from research and development activities	1,339,745,883.83		12,947,746.76	1,352,693,630.59
Decrease in work in progress			-12,957,347.69	-12,957,347.69
Other internally constructed and capitalized assets	4,387,497.07			4,387,497.07
Other income	40,289,356.68	1,847,917.07	9,600.93	42,146,874.68
Total income/receipts	2,095,032,601.75			
Changes in special reserves				
License-fee revenue reserve			15,133,923.62	15,133,923.62
Grants relating to fixed assets				
Allocations to special reserves (capital expenditure)			-395,833,839.12	-395,833,839.12
Reversal of special reserves (depreciation)		43,762.92	296,335,877.10	296,379,640.02
Grants used to finance current assets	-37,436,228.17			-37,436,228.17
Change in grants receivable relating to pension and compensated absence provisions	2,723,265.00		-2,723,265.00	
Total business volume (cash basis)	2,060,319,638.58	<u>1,891,679.99</u>	<u>-84,364,038.40</u>	<u>1,977,847,280.17</u>

Expenditure/disbursements	Performance statement €	Non-profit organization capital €	Reconciling items €	Income statement €
Expenditure/disbursements				
Cost of materials	301,420,766.50	35,234.38	–3,185,089.09	298,270,911.79
Personnel expenses	1,093,484,474.16	640.00	–11,565,597.65	1,081,919,516.51
Amortization of intangible assets and depreciation of property, plant and equipment		194,313.66	295,230,433.10	295,424,746.76
Other operating expenses	284,657,543.21	108,793.21	15,913,069.95	300,679,406.37
Expenditure as per the income statement				1,976,294,581.43
Changes in special license-fee revenue reserve	–15,133,923.62		15,133,923.62	
Capital expenditure (current and major infrastructure)	395,890,778.33		–395,890,778.33	
Net income for the year		1,552,698.74		1,552,698.74
Total business volume (cash basis)	2,060,319,638.58			
		1,891,679.99	–84,364,038.40	1,977,847,280.17

The Fraunhofer-Gesellschaft prepares its annual financial statements in accordance with the German Commercial Code (HGB) as applicable to large corporate entities.

The annual financial statements for the year ending December 31, 2014, have been audited and fully certified by the auditing firm Rödl & Partner GmbH, Nuremberg.

The income statement is reconciled to the format required by the relevant public funding authorities.

PERFORMANCE STATEMENT FOR INDIVIDUAL FRAUNHOFER ENTITIES

Fraunhofer Institute/ Research Institution for			Expenses		Capital expenditure		Income		Base funding	
			Operating expenses				From external sources			
			2013 €(1000)	2014 €(1000)	2013 €(1000)	2014 €(1000)	2013 €(1000)	2014 €(1000)	2013 €(1000)	2014 €(1000)
Fraunhofer ICT Group										
Algorithms and Scientific Computing SCAI	Sankt Augustin		9,148.6	9,758.3	172.0	911.5	6,614.8	7,404.5	2,705.8	3,265.3
Applied and Integrated Security AISEC	Garching		5,471.0	6,432.8	312.8	198.0	6,095.3	4,968.0	-311.5	1,662.7
Applied Information Technology FIT	Sankt Augustin		11,227.8	11,179.2	415.4	257.5	8,909.8	9,094.9	2,733.5	2,341.7
Communication, Information Processing and Ergonomics FKIE	Wachtberg		5,971.2	6,914.2	440.4	168.2	5,269.7	5,775.5	1,141.9	1,306.9
Computer Graphics Research IGD	Darmstadt		14,397.2	15,806.6	891.3	939.1	11,151.6	11,498.7	4,136.9	5,247.0
Digital Media Technology IDMT	Ilmenau		13,358.1	12,666.3	209.6	162.6	9,753.0	9,305.5	3,814.7	3,523.4
Embedded Systems and Communication Technologies ESK	München		6,403.5	7,004.6	433.2	315.7	5,085.2	5,007.9	1,751.6	2,312.4
Experimental Software Engineering IESE	Kaiserslautern		11,792.0	11,431.5	685.9	473.2	9,431.4	8,739.3	3,046.5	3,165.4
Industrial Engineering IAO	Stuttgart		24,671.0	27,248.6	876.5	1,428.3	19,926.1	22,513.7	5,621.4	6,163.1
Industrial Mathematics ITWM	Kaiserslautern		21,979.2	21,696.8	3,733.6	3,334.9	15,970.8	15,894.6	9,742.0	9,137.1
Intelligent Analysis and Information Systems IAIS	Sankt Augustin		14,705.4	13,013.2	644.0	121.9	8,303.7	8,710.0	7,045.7	4,425.1
Medical Image Computing MEVIS	Bremen		8,357.3	9,404.4	776.2	413.6	7,859.5	7,143.3	1,274.0	2,674.8
Open Communication Systems FOKUS	Berlin		32,315.6	30,316.5	1,873.5	927.7	23,235.7	22,941.3	10,953.4	8,303.0
Optronics, System Technologies and Image Exploitation IOSB	Ettlingen, Karlsruhe		24,523.0	26,910.9	2,912.2	2,350.7	19,259.4	20,001.7	8,175.8	9,259.9
Secure Information Technology SIT	Darmstadt		9,180.1	9,664.8	242.7	124.1	7,703.1	6,321.8	1,719.7	3,467.0
Software and Systems Engineering ISST	Dortmund		4,642.8	4,282.6	369.1	84.3	1,634.8	742.6	3,377.1	3,624.2
Transportation and Infrastructure Systems IVI	Dresden		6,955.8	7,759.3	1,207.8	1,078.2	6,816.3	7,141.6	1,347.3	1,696.0

Fraunhofer Institute/
Research Institution for

Expenses

Operating expenses

Capital expenditure

Income

From external sources

Base funding

2013
€(1000)

2014
€(1000)

2013
€(1000)

2014
€(1000)

2013
€(1000)

2014
€(1000)

2013
€(1000)

2014
€(1000)

**Fraunhofer Group for
Life Sciences**

Biomedical Engineering IBMT	St. Ingbert	22,938.4	15,091.9	4,837.7	1,151.9	18,837.1	11,136.6	8,939.0	5,107.3
Cell Therapy and Immunology IZI	Leipzig	12,619.5	23,361.0	2,210.2	7,953.6	12,527.6	23,253.3	2,302.2	8,061.2
Interfacial Engineering and Biotechnology IGB	Stuttgart	22,206.0	23,883.1	2,291.9	1,563.2	18,334.1	19,470.8	6,163.8	5,975.5
Marine Biotechnology EMB	Lübeck	2,968.3	3,095.3	269.1	24.9	1,886.3	2,314.6	1,351.1	805.7
Molecular Biology and Applied Ecology IME	Aachen, Schmallenberg	24,119.5	29,050.1	3,840.7	6,420.9	22,804.5	27,890.0	5,155.8	7,581.0
Process Engineering and Packaging IVV	Freising	16,405.5	16,699.2	1,659.0	809.4	11,057.5	10,032.9	7,007.0	7,475.6
Toxicology and Experimental Medicine ITEM	Hannover	22,962.1	23,924.4	1,809.3	5,875.6	17,404.8	24,793.7	7,366.7	5,006.3

**Fraunhofer Group for
Light & Surfaces**

Applied Optics and Precision Engineering IOF	Jena	23,911.8	24,953.1	6,310.2	4,254.4	23,449.5	22,629.5	6,772.5	6,577.9
Electron Beam and Plasma Technology FEP	Dresden	24,081.1	23,386.9	2,018.4	2,422.9	17,833.8	17,354.2	8,265.7	8,455.6
Laser Technology ILT	Aachen	29,166.2	31,074.0	5,067.4	3,370.6	25,007.3	24,141.2	9,226.4	10,303.4
Material and Beam Technology IWS	Dresden	23,246.5	24,072.3	3,280.1	2,830.9	18,170.5	18,818.6	8,356.1	8,084.6
Physical Measurement Techniques IPM	Freiburg	15,328.8	14,666.4	725.6	1,177.1	11,185.3	10,246.0	4,869.1	5,597.4
Surface Engineering and Thin Films IST	Braunschweig	11,614.3	12,218.3	714.9	899.2	8,371.6	8,141.1	3,957.5	4,976.4

Performance statement for
individual Fraunhofer entities

Fraunhofer Institute/ Research Institution for		Expenses		Income					
		Operating expenses		Capital expenditure		From external sources	Base funding		
		2013 €(1000)	2014 €(1000)	2013 €(1000)	2014 €(1000)	2013 €(1000)	2014 €(1000)	2013 €(1000)	2014 €(1000)
Fraunhofer Group for Materials and Components – MATERIALS									
Applied Polymer Research IAP	Potsdam-Golm	15,618.4	16,785.0	1,295.3	2,106.4	10,382.9	12,635.4	6,530.8	6,256.0
Building Physics IBP	Holzkirchen, Stuttgart	27,653.8	29,375.1	1,630.2	2,618.1	20,882.1	22,402.9	8,401.8	9,590.3
Ceramic Technologies and Systems IKTS	Dresden, Hermisdorf	36,084.2	50,162.3	3,485.8	4,074.6	28,002.6	37,027.2	11,567.4	17,209.7
Chemical Technology ICT, Polymer Engineering Department	Pfinztal	28,373.8	42,506.8	5,820.6	4,391.6	27,347.7	38,748.1	6,846.7	8,150.4
High-Speed Dynamics, Ernst-Mach-Institut, EMI	Freiburg	7,983.4	8,395.9	1,341.9	1,089.8	6,658.4	7,357.0	2,666.9	2,128.7
Manufacturing Technology and Advanced Materials IFAM	Bremen	37,178.8	39,769.9	8,922.5	5,176.2	33,373.3	33,229.8	12,728.1	11,716.3
Mechanics of Materials IWM	Freiburg, Halle	35,461.9	37,720.5	4,395.2	3,643.8	25,647.1	26,157.3	14,210.0	15,207.1
Nondestructive Testing IZFP	Saarbrücken	27,317.8	14,875.4	1,851.4	659.1	15,383.5	9,960.1	13,785.7	5,574.4
Silicate Research ISC	Würzburg	23,749.9	27,571.8	3,787.1	2,844.6	17,312.6	21,504.1	10,224.4	8,912.2
Solar Energy Systems ISE	Freiburg	73,192.6	74,313.9	13,521.5	11,880.8	67,138.6	62,858.2	19,575.6	23,336.4
Structural Durability and System Reliability LBF	Darmstadt	28,027.4	29,203.9	3,416.5	1,738.8	23,776.6	23,394.8	7,667.3	7,547.9
Systems and Innovation Research ISI	Karlsruhe	23,712.9	22,948.7	676.5	335.9	17,820.6	17,048.9	6,568.9	6,235.7
Wind Energy and Energy System Technology IWES	Bremerhaven, Kassel	30,458.9	32,122.0	8,719.9	12,463.8	34,222.8	38,360.2	4,956.0	6,225.5
Wood Research, Wilhelm- Klauditz-Institut, WKI	Braunschweig	10,476.0	11,297.0	1,027.1	1,636.3	8,771.8	10,204.9	2,731.3	2,728.4

Fraunhofer Institute/
Research Institution for

Expenses

Operating expenses

Capital expenditure

Income

From external sources

Base funding

2013	2014	2013	2014	2013	2014	2013	2014
€(1000)	€(1000)	€(1000)	€(1000)	€(1000)	€(1000)	€(1000)	€(1000)

Fraunhofer Group for Microelectronics

Applied Solid State Physics IAF	Freiburg	11,036.4	10,368.2	1,851.6	1,948.9	9,015.8	7,982.7	3,872.2	4,334.4
Electronic Nano Systems ENAS	Chemnitz	10,588.4	12,399.3	1,780.1	1,801.8	9,838.9	10,718.6	2,529.6	3,482.5
High Frequency Physics and Radar Techniques FHR	Wachtberg	3,796.1	4,633.9	567.0	262.3	3,375.9	4,141.9	987.2	754.2
Integrated Circuits IIS	Erlangen	127,870.4	131,945.0	9,913.6	6,937.9	119,098.1	150,669.6	18,685.9	-11,786.7
Integrated Systems and Device Technology IISB	Erlangen	17,228.0	20,318.9	2,427.6	2,579.2	16,311.0	20,723.6	3,344.6	2,174.5
Microelectronic Circuits and Systems IMS	Duisburg	23,152.1	24,346.9	1,281.8	2,020.6	16,587.6	16,545.8	7,846.2	9,821.7
Modular Solid State Technologies EMFT	München	10,675.4	10,553.5	1,030.7	295.3	5,449.5	7,390.3	6,256.6	3,458.4
Photonic Microsystems IPMS	Dresden	28,939.1	31,894.5	2,646.7	2,534.2	23,634.1	25,650.0	7,951.6	8,778.8
Reliability and Microintegration IZM	Berlin	29,345.2	27,729.8	2,369.1	742.6	22,945.7	22,757.4	8,768.6	5,715.0
Silicon Technology ISIT	Itzehoe	22,487.4	25,244.1	1,180.9	2,575.7	17,968.6	17,662.4	5,699.6	10,157.4
Telecommunications, Heinrich-Hertz-Institut, HHI	Berlin	45,305.6	43,227.4	3,941.3	4,138.3	40,374.7	39,134.4	8,872.1	8,231.3

Performance statement for
individual Fraunhofer entities

Fraunhofer Institute/ Research Institution for		Expenses		Capital expenditure		Income		Base funding	
		Operating expenses				From external sources			
		2013 €(1000)	2014 €(1000)	2013 €(1000)	2014 €(1000)	2013 €(1000)	2014 €(1000)	2013 €(1000)	2014 €(1000)
Fraunhofer Group for Production									
Environmental, Safety and Energy Technology UMSICHT	Oberhausen	31,761.0	36,360.2	2,772.1	1,760.4	25,350.6	25,999.2	9,182.5	12,121.4
Factory Operation and Automation IFF	Magdeburg	17,508.3	17,745.5	2,237.9	778.6	14,693.1	12,550.6	5,053.1	5,973.5
Machine Tools and Forming Technology IWU	Chemnitz	33,313.4	37,188.5	5,375.7	2,927.6	28,356.2	30,437.6	10,332.9	9,678.5
Manufacturing Engineering and Automation IPA	Stuttgart	56,191.7	57,817.2	3,461.1	3,578.5	43,967.2	42,965.1	15,685.6	18,430.6
Material Flow and Logistics IML	Dortmund	23,585.0	24,414.0	1,386.1	973.2	17,016.9	19,461.2	7,954.2	5,926.0
Production Systems and Design Technology IPK	Berlin	17,050.0	17,372.4	1,471.1	1,354.1	12,883.7	13,198.6	5,637.3	5,527.9
Production Technology IPT	Aachen	27,927.6	31,637.4	4,233.1	3,484.4	23,004.7	25,860.0	9,156.0	9,261.8
Fraunhofer Group for Defense and Security VVS									
Applied Solid State Physics IAF	Freiburg	13,638.7	14,369.9	5,067.6	6,273.9	10,718.9	12,272.6	7,987.5	8,371.3
Chemical Technology ICT, Department of Energetic Materials	Pfinztal	11,439.4	12,627.5	2,069.5	1,167.4	4,532.5	4,180.5	8,976.4	9,614.4
Communication, Information Processing and Ergonomics FKIE	Wachtberg	19,489.1	20,989.5	2,412.7	2,551.5	10,889.5	11,499.3	11,012.4	12,041.7
High Frequency Physics and Radar Techniques FHR	Wachtberg	14,445.9	15,267.8	5,164.2	1,736.9	7,557.9	6,929.5	12,052.3	10,075.3
High-Speed Dynamics, Ernst-Mach-Institut, EMI	Freiburg	12,515.3	13,786.2	1,611.6	1,879.5	4,670.8	5,995.2	9,456.1	9,670.5
Optronics, System Technologies and Image Exploitation IOSB, Ettlingen branch	Ettlingen	16,363.8	19,309.5	1,650.4	2,033.3	12,893.9	15,653.6	5,120.2	5,689.1
Technological Trend Analysis INT	Euskirchen	5,594.7	5,686.6	296.3	332.1	1,426.4	1,383.7	4,464.7	4,635.0

Fraunhofer Institute/ Research Institution for		Expenses				Income			
		Operating expenses		Capital expenditure		From external sources		Base funding	
		2013 €(1000)	2014 €(1000)	2013 €(1000)	2014 €(1000)	2013 €(1000)	2014 €(1000)	2013 €(1000)	2014 €(1000)
Other entities, not included in the Fraunhofer Groups									
Center for Central and Eastern Europe MOEZ	Leipzig	4,382.3	5,196.8	106.2	338.0	2,064.6	2,851.5	2,423.9	2,683.2
Information Center for Planning and Building IRB	Stuttgart	7,118.6	7,051.2	144.0	76.6	2,536.3	2,731.5	4,726.3	4,396.4
Polymeric Materials and Composites PYCO	Teltow	3,966.5	4,154.7	445.6	811.9	3,402.8	3,471.3	1,009.3	1,495.3
Technological Trend Analysis INT	Euskirchen	2,013.2	2,341.0	20.2	40.3	1,732.5	1,752.3	300.9	629.0
Centrally managed entities									
Fraunhofer headquarters	München	102,251.6	113,920.7	3,315.2	4,577.4	4,183.9	5,441.9	101,382.8	113,056.2
Institute Center Birlinghoven	Sankt Augustin	908.3	886.6	28.7	35.0	94.4	104.2	842.6	817.4
Institute Center Stuttgart	Stuttgart	70.1	-10.8	1,217.4	42.0	96.1	34.0	1,191.4	-2.8
General overhead costs		-44,030.9	-70,359.5	361.0	734.2	19,254.4	7,520.6	-62,924.3	-77,145.9
Major infrastructure capital expenditure									
				234,950.3	225,863.7	71,829.7	54,436.0	163,120.5	171,427.7
Performance statement		1,589,885.1	1,664,428.9	419,910.5	395,890.8	1,324,367.2	1,384,422.7	685,428.3	675,896.9

EXCERPTS FROM THE NOTES TO THE FINANCIAL STATEMENTS

I. Accounting principles

The annual financial statements for the year ending December 31, 2014 were prepared in accordance with the German Commercial Code (HGB) as applicable to large corporate entities.

The basis of the Fraunhofer-Gesellschaft's accounting is the performance statement, from which the annual financial statements are derived.

The performance statement is adapted to the requirements of the public funding authorities in terms of format and reconciliation. It provides a breakdown of operating expenses and capital expenditure at three different levels: individual institutes, headquarters, and the organization as a whole.

The components of the operating budget are presented as income or expenses in accordance with standard accounting practice.

Capital expenditure on property, plant and equipment and on financial assets, on the other hand, is immediately recognized at the full cost of acquisition. Therefore, the operating budget does not include any depreciation/amortization expenses on these items.

In order to provide full accountability for grants received from funding agencies, the performance statement for the organization as a whole is reconciled to the income statement format required by public authorities by eliminating the effect of non-cash income and expense items.

Presentation of annual accounts of the Fraunhofer-Gesellschaft

		Reconciliation with income statement format required by public funding authorities	
Annual financial statements of the Fraunhofer-Gesellschaft			
Balance sheet	Income statement		
Management report	Reconciliation between income statement and performance statement		
Notes to the financial statements	Performance statement		
	Budgeted operating expenses and capital expenditure at Fraunhofer-Gesellschaft level "total business volume"		
	Individual financial statements of the institutes/headquarters		
	Operating expenses	Capital expenditure	
	Costs (excluding depreciation/amortization)	Expenses	
	Income	Income	

The amounts presented in the income statement include items showing the changes in payables and receivables and in depreciation/amortization charges compared with the previous year.

These reconciliation items are presented in the balance sheet as special reserves for grants relating to fixed assets and for grants used to finance current assets.

II. Recognition and measurement methods

Intangible assets and property, plant and equipment are measured at amortized cost, i.e. the cost of acquisition or construction less depreciation/amortization calculated on a straight-line basis.

Since in most cases fixed assets are financed by government grants, a corresponding amount is allocated to the special reserve for grants relating to fixed assets. These adjustments therefore have no impact on equity.

Financial assets and current marketable securities are measured at the lower of cost of acquisition or fair value.

Work in progress is measured at the lower of cost of construction or fair value. Construction costs include applicable personnel expenses, cost of materials, general administrative expenses, and depreciation/amortization charges. Prepaid expenses (including VAT) are disclosed in a separate line item.

Trade receivables are recognized net of related valuation allowances, if any. Cash and cash equivalents, and other current assets, are recognized at their nominal value. Foreign currency holdings are recognized at the exchange rate prevailing on the reporting date.

Payments made in the current year for which the associated benefits will be received in a future period are recognized in the balance sheet as prepaid expenses.

The retained earnings presented in the Fraunhofer-Gesellschaft's annual financial statements, i.e. remaining net income for the year after transfers to/from reserves, are allocated in full to the capital of the non-profit organization, in accordance with the Executive Board resolution concerning the appropriation of net income.

Excerpts from the notes to the financial statements

Funding used to finance non-current assets is allocated to the special reserve for grants relating to fixed assets.

A similar special reserve exists for funding used to finance current assets.

The Fraunhofer-Gesellschaft made use of the instrument provided for in its financial statutes to recognize a balance sheet reserve that will enable the organization to use revenues from the licensing of audio-encoding technologies as a means of financing its own pre-competitive research in areas of importance to its medium-term strategy. The special license-fee revenue reserve decreased in 2014 by €15.1 million. An amount of €19.2 million from this reserve was utilized, while an amount of €4.1 million was transferred to the reserve, corresponding to the net income for the year arising from the non-profit organization's asset management portfolio.

Provisions for pensions and similar obligations for which the Fraunhofer-Gesellschaft has a reinsurance policy in place are measured on the basis of the capitalized value calculated by the insurance company at the reporting date. In all other cases, pension provisions are accounted for at the service cost as measured by actuarial methods. Other provisions consist of amounts set aside to cover all identifiable risks and contingent liabilities. These provisions are measured in accordance with Section 253 para. 1 of the German Commercial Code (HGB) on the basis of a reasonable estimate of the probable outcome, including future cost increases. Other provisions for liabilities due in more than one year are discounted at the average market interest rate for loans of a similar residual maturity as calculated by the Deutsche Bundesbank in December 2014, pursuant to Section 253 para. 2 of the German Commercial Code (HGB). Provisions for part-time early retirement working arrangements are measured on the basis of existing contracts and a forecast of expected future contracts.

Liabilities are measured at the settlement amount.

Payments received in the current year for benefits to be delivered in a future period are recognized in the balance sheet as deferred income. Transactions in foreign currencies are recognized at the applicable hedging rate for the currency in question. Open items are translated at the exchange rate prevailing on the reporting date.

Items in transit are noted in a separate line at the foot of the balance sheet for the Fraunhofer-Gesellschaft as trust assets and trust liabilities.

INDEPENDENT AUDITOR'S REPORT

We have audited the annual financial statements, comprising the balance sheet, the income statement and the notes to the financial statements together with the bookkeeping system, and the management report of the Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V., Munich, for the business year from January 1 to December 31, 2014. The maintenance of the books and records and the preparation of the annual financial statements and management report in accordance with German commercial law and supplementary provisions of the articles of incorporation are the responsibility of the Company's management. Our responsibility is to express an opinion on the annual financial statements, together with the bookkeeping system and the management report based on our audit.

We conducted our audit of the annual financial statements in accordance with § 317 HGB (German Commercial Code) and German generally accepted standards for the audit of financial statements promulgated by the Institute of Public Auditors in Germany (Institut der Wirtschaftsprüfer, IDW). Those standards require that we plan and perform the audit such that misstatements materially affecting the presentation of the net assets, financial position and results of operations in the annual financial statements in accordance with principles of proper accounting and in the management report are detected with reasonable assurance. Knowledge of the business activities and the economic and legal environment of the Company and expectations as to possible misstatements are taken into account in the determination of audit procedures. The effectiveness of the accounting-related internal control system and the evidence supporting the disclosures in the books and records, the annual financial statements and the management report are examined primarily on a test basis within the framework of the audit. The audit includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall presentation of the annual financial statements and management report. We believe that our audit provides a reasonable basis for our opinion.

Our audit has not led to any reservations.

In our opinion, based on the findings of our audit, the annual financial statements comply with the legal requirements and supplementary provisions of the articles of incorporation and give a true and fair view of the net assets, financial position and results of operations of the Company in accordance with principles of proper accounting. The management report is consistent with the annual financial statements and as a whole provides a suitable view of the Company's position and suitably presents the opportunities and risks of future development.

Nuremberg, March 19, 2015

Rödl & Partner GmbH

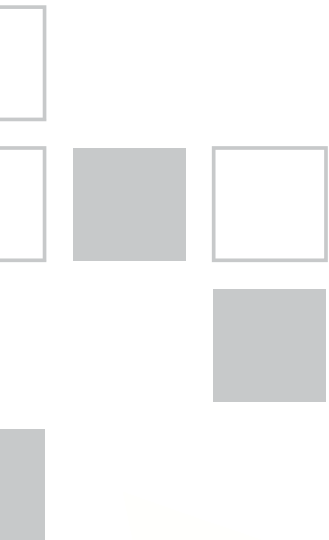
Wirtschaftsprüfungsgesellschaft, Steuerberatungsgesellschaft
(Auditors, Tax Consultants)

Vogel

Wirtschaftsprüfer (Auditor)

Hahn

Wirtschaftsprüfer (Auditor)



SERVICE



**STRUCTURE OF THE
FRAUNHOFER-GESELLSCHAFT**

**MEMBERS, CONSTITUENT BODIES,
COMMITTEES**

FRAUNHOFER GROUPS

FRAUNHOFER ALLIANCES

ADDRESSES IN GERMANY

INTERNATIONAL ADDRESSES

EDITORIAL NOTES



STRUCTURE OF THE FRAUNHOFER-GESELLSCHAFT

Constituent bodies and their tasks

The **Executive Board** consists of the President and several other full-time members. Its duties include managing the Fraunhofer-Gesellschaft and representing its interests both inside and outside the organization. It formulates the basic principles of the Fraunhofer-Gesellschaft's scientific and research policy, plans its growth and its finances, ensures its base funding, organizes the distribution of funds among the individual institutes, and appoints the institute directors.

A total of 66 **institutes and research entities** at locations across Germany operate under the umbrella of the Fraunhofer-Gesellschaft. Each cultivates its own market presence and manages its own budget. They are organized in seven **Fraunhofer Groups**, each devoted to a specific area of technology. The purpose of the groups is to coordinate thematically related areas within the Fraunhofer-Gesellschaft and harmonize the market presence of the respective group members. The spokespersons, together with the Executive Board, make up the **Presidential Council** of the Fraunhofer-Gesellschaft. The Presidential Council participates in Executive Board decision-making processes and, as such, is entitled to make proposals and recommendations and has the right to be heard.

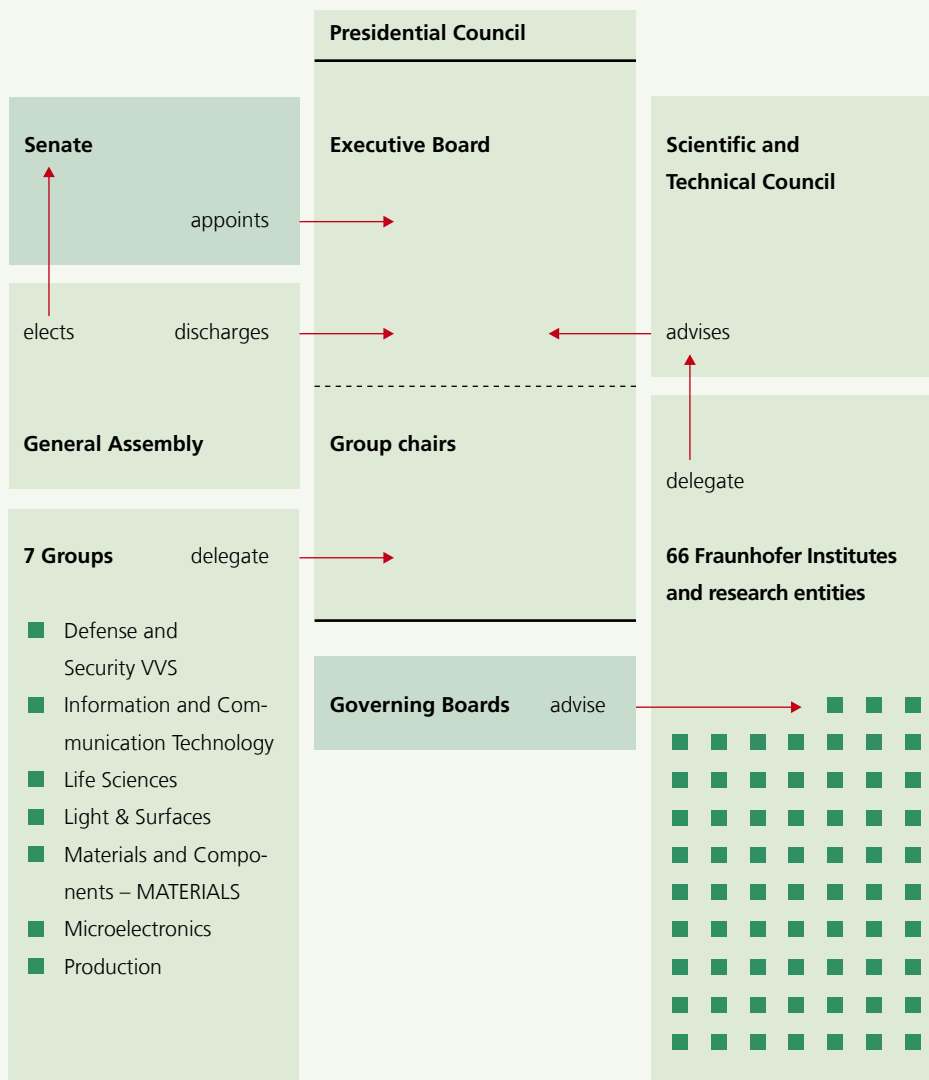
The **Senate** has around 30 members, who are eminent figures from the worlds of science, business and public life, plus representatives of the German federal and state governments, and members of the Scientific and Technical Council. The Senate is responsible for decisions concerning basic science and research policy. It also formulates decisions concerning the establishment, incorporation, devolution, merger or dissolution of research entities belonging to the Fraunhofer-Gesellschaft.

The **General Assembly** is made up of the members of the Fraunhofer-Gesellschaft. Official membership is open to members of the Senate, the Executive Board, institute directors and senior management, and the governing boards. Ordinary membership is open to individuals and legal entities who wish to support the work of the Fraunhofer-Gesellschaft. Honorary members may be elected from among the research staff and patrons of the Fraunhofer-Gesellschaft in recognition of outstanding services to the organization. The General Assembly elects the members of the Senate, discharges the Executive Board of its responsibilities and formulates decisions concerning amendments to the Statute.

The **Scientific and Technical Council** is the organization's internal advisory body. It consists of the directors and senior management of the institutes and an elected representative of the scientific and technical staff of each institute. The Scientific and Technical Council provides advice to the Executive Board and other constituent bodies in matters of fundamental importance. It makes recommendations concerning research policy and personnel policy, issues statements on the creation of new institutes or the closure of existing ones, and participates in the appointment of the directors of the institutes.

The **Governing Boards** are external advisory bodies of the institutes. They consist of representatives of science, business and public life. For each institute, approximately twelve members are appointed to the Governing Board by the Executive Board with the approval of the director(s) of the institute. The Governing Boards act as advisors to the directors of the institutes and the Executive Board on matters concerning the research orientation and any structural changes to the institute.

Structure of the Fraunhofer-Gesellschaft



Although the Fraunhofer-Gesellschaft is basically a decentralized organization, its structure also allows for a centrally agreed strategy and effective centralized management. Various bodies and committees are responsible for coordination, consultation and leadership across the organization as a whole.

MEMBERS, CONSTITUENT BODIES, COMMITTEES

Members

The Fraunhofer-Gesellschaft has 1,145 members, composed of 299 ordinary members, 887 official members, one honorary senator and 10 honorary members. (Some members have multiple functions.)

Honorary members

- Dr.-Ing. Peter Draheim
- Dr. h. c. mult. Dipl.-Ing. Hermann Franz
- Dr. Alfred Hauff
- Dr. Axel Homburg
- Dr.-Ing. Horst Nasko
- Dr. Dirk-Meints Polter
- Prof. Dr. rer. nat. Erwin Sommer
- Prof. Klaus-Dieter Vöhringer
- Prof. em. Dr.-Ing. Prof. h. c. mult. Dr. h. c. mult. Dr.-Ing. E. h. Hans-Jürgen Warnecke
- Dr. rer. pol. Hans-Ulrich Wiese

Senate

Members from the science and business communities, and from public life

- Prof. Dr.-Ing. Dr.-Ing. E. h. Dr. h. c. Ekkehard D. Schulz
Chairman of the Senate of the Fraunhofer-Gesellschaft
- Prof. Dr. phil. nat. Dipl.-Phys. Hermann Requardt
Former Member of the Managing Board, Siemens AG, Deputy Chairman of the Senate of the Fraunhofer-Gesellschaft
- Dr. Lutz Bertling
President, Bombardier Transportation GmbH
- Michael von Bronk
Member of the Managing Board, Vattenfall Europe Mining & Generation
- Prof. Dr.-Ing. habil. Prof. E. h. mult. Dr. h. c. mult. Hans-Jörg Bullinger
Professor of Industrial Science and Technology Management, University of Stuttgart
- Prof. Dr.-Ing. Heinz Jörg Fuhrmann
Chairman of the Executive Board, Salzgitter AG
- Dr. Nicola Leibinger-Kammüller
President and Chairwoman of the Managing Board, TRUMPF GmbH + Co. KG.
- Friedhelm Loh
Owner and Chairman of the Board of Management, Friedhelm Loh Group
- Hildegard Müller
Chairwoman of the General Executive Management Board, German Association of Energy and Water Industries
- Prof. Dr.-Ing. E. h. Hans J. Naumann
Chairman and CEO, NILES-SIMMONS Industrieanlagen GmbH
- Dipl.-Ing. Eckhardt Rehberg
Member of the German Bundestag, CDU/CSU parliamentary group
- Carsten Schneider
Member of the German Bundestag, SPD parliamentary group
- Prof. Dr. phil. habil. Dr.-Ing. Birgit Spanner-Ulmer
Director of Production and Technology, Bayerischer Rundfunk
- Prof. Dr. rer. nat. Christiane Vaeßen
Prorector, FH Aachen, University of Applied Sciences
- Prof. Dr. Fritz Vahrenholt
Management Board, German Wildlife Foundation
- Michael Vassiliadis
National chairman of the industrial trade union IG Bergbau, Chemie, Energie

- Dr.-Ing. Hubert Walzl
Member of the Production Board, Audi AG
- Prof. Dr. Dr. h. c. mult. Martin Winterkorn
Chairman of the Board of Directors, Volkswagen AG

Members representing government institutions

- Markus Hoppe
State secretary, Thuringian Ministry of Economics, Science and Digital Society
- Dr. Ole Janssen
Director, German Federal Ministry of Economics and Technology (BMW)
- Thomas Rachel
Parliamentary secretary, German Federal Ministry of Education and Research (BMBF)
- Dr. Susanne Reichrath
Director, Special Representative for Universities, Science and Technology in the Prime Minister's Office, State Chancellery, Saarland
- Rolf Schumacher
Director, Ministry of Finance and Economics, Baden-Württemberg
- Harald Stein
President, German Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support

Members delegated by the Scientific and Technical Council

- Prof. Dr. Dieter Prätzel-Wolters
Director of the Fraunhofer Institute for Industrial Mathematics ITWM
Chairman of the Scientific and Technical Council
- Dipl.-Ing. Stefan Schmidt
Fraunhofer Institute for Material Flow and Logistics IML
Deputy Chairman of the Scientific and Technical Council
- Prof. Dr. rer. nat. habil. Andreas Tünnermann
Director of the Fraunhofer Institute for Applied Optics and Precision Engineering IOF

Honorary senator

- Prof. em. Dr.-Ing. Prof. h. c. mult. Dr. h. c. mult. Dr.-Ing. E. h. Hans-Jürgen Warnecke

Permanent guests

- Dr. Walter Dörhage
Head of the Universities and Research department, Office of the Senator for Education and Science, Bremen

- Andrea Hoops
State secretary, Ministry of Science and Culture, Lower Saxony
- Dipl.-Ing. Wolfgang Lux
Deputy Chairman, Fraunhofer-Gesellschaft general works council
- Prof. Dr. Manfred Prenzel
Chairman, German Council of Science and Humanities
- Manfred Scheifele
Chairman, Fraunhofer-Gesellschaft general works council
- Prof. Dr. Martin Stratmann
President of the Max Planck Society for the Advancement of Science
- Prof. Dr.-Ing. Johann-Dietrich Wörner
Chairman of the Executive Board, German Aerospace Center (DLR)

Governing Boards

A total of 776 members of Governing Boards work for the institutes of the Fraunhofer-Gesellschaft; some belong to more than one Governing Board.

Scientific and Technical Council

The Scientific and Technical Council has 145 members, 80 of whom are delegated institute managers, while 65 are elected representatives of the scientific and technical staff of each institute.

Chair of the Scientific and Technical Council

- Prof. Dr. Dieter Prätzel-Wolters
Fraunhofer Institute for Industrial Mathematics ITWM

Presidential Council

The Presidential Council of the Fraunhofer-Gesellschaft consists of the four Executive Board members and the seven chairs of the Fraunhofer Groups listed below:

- Prof. Dr.-Ing. Jürgen Beyerer (Guest member)
Fraunhofer Institute for Optics, System Technologies and Image Exploitation IOSB
- Prof. Dr.-Ing. Peter Elsner
Fraunhofer Institute for Chemical Technology ICT
- Prof. Dr. rer. nat. Thomas Hirth
Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB

- Prof. Dr. Matthias Jarke
Fraunhofer Institute for Applied Information Technology FIT
- Prof. Dr.-Ing. Dipl.-Phys. Hubert Lakner
Fraunhofer Institute for Photonic Microsystems IPMS
- Prof. Dr.-Ing. Michael Schenk
Fraunhofer Institute for Factory Operation and Automation IFF
- Prof. Dr. rer. nat. habil. Andreas Tünnermann
Fraunhofer Institute for Applied Optics and Precision Engineering IOF

Executive Board

- Prof. Dr.-Ing. habil. Prof. E. h. Dr.-Ing. E. h. mult. Dr. h. c. Dr. h. c. Reimund Neugebauer (President)
- Prof. (Univ. Stellenbosch) Dr. rer. pol. Alfred Gossner
- Prof. Dr. rer. publ. ass. iur. Alexander Kurz
- Prof. Dr.-Ing. Dr. h. c. mult. Alexander Verl

As of March 1, 2015

FRAUNHOFER GROUPS

The Fraunhofer Groups are organizational units of the Fraunhofer-Gesellschaft in which institutes and research institutions specializing in related areas of technology have joined together to coordinate their research and development activities and present a single face to the market. They also help to formulate the organization's business policy and implement its working methods and funding model.

- Fraunhofer Group for Defense and Security VVS
www.vvs.fraunhofer.de
- Fraunhofer ICT Group
www.iuk.fraunhofer.de
- Fraunhofer Group for Life Sciences
www.lifesciences.fraunhofer.de
- Fraunhofer Group for Light & Surfaces
www.light-and-surfaces.fraunhofer.de
- Fraunhofer Group for Materials and Components
– MATERIALS
www.materials.fraunhofer.de
- Fraunhofer Group for Microelectronics
www.mikroelektronik.fraunhofer.de
- Fraunhofer Group for Production
www.produktion.fraunhofer.de

For further information on the Fraunhofer Groups, please consult our website:

www.fraunhofer.de

FRAUNHOFER ALLIANCES

Interdisciplinary alliances have been established between Fraunhofer Institutes or individual research departments to enable them to jointly develop and market solutions for specific business sectors.

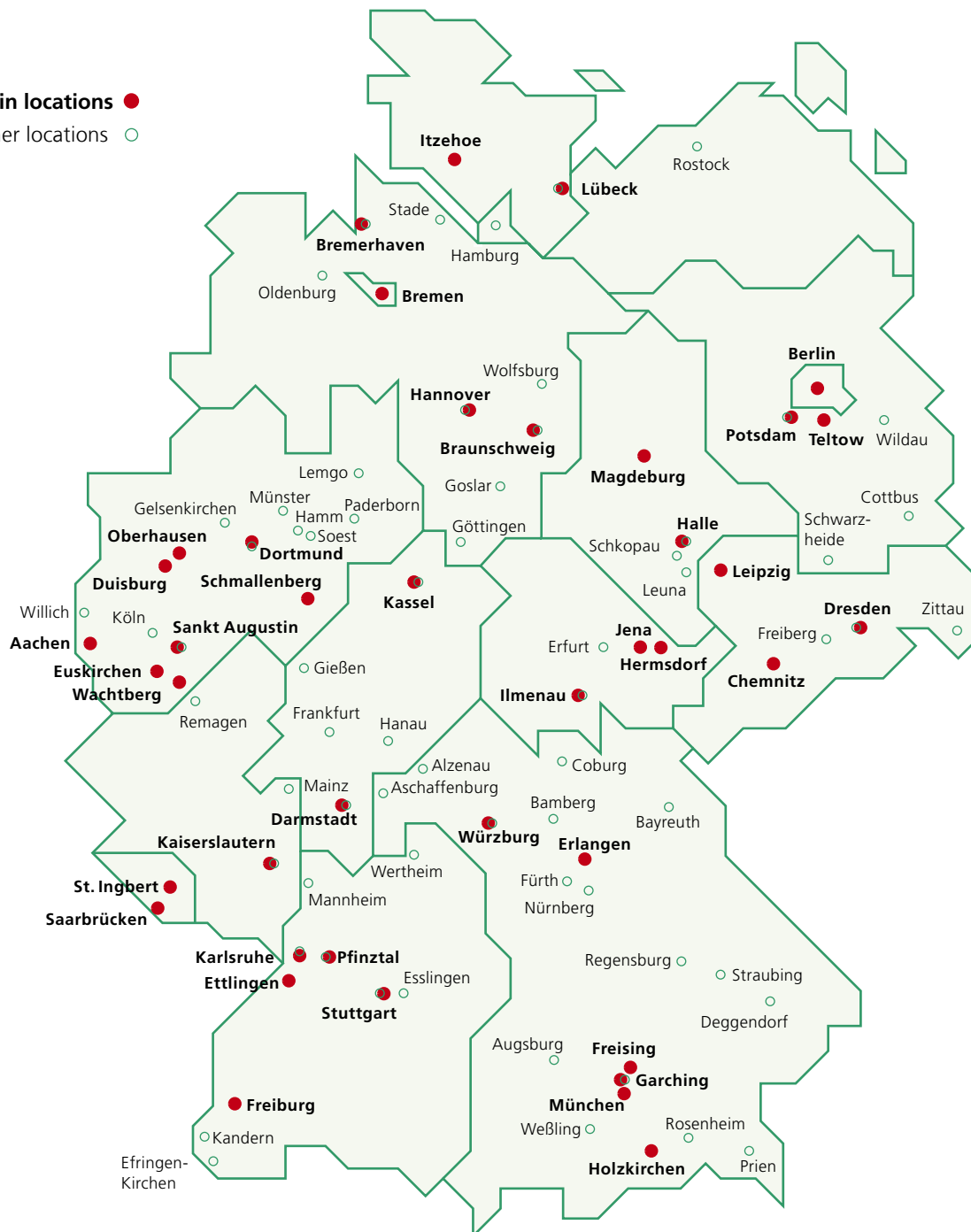
Fraunhofer Adaptronics Alliance
Fraunhofer Additive Manufacturing Alliance
Fraunhofer AdvanCer Alliance
Fraunhofer Ambient Assisted Living Alliance AAL
Fraunhofer Automobile Production Alliance
Fraunhofer Battery Alliance
Fraunhofer Big Data Alliance
Fraunhofer Building Innovation Alliance
Fraunhofer Cleaning Technology Alliance
Fraunhofer Cloud Computing Alliance
Fraunhofer Digital Media Alliance
Fraunhofer Embedded Systems Alliance
Fraunhofer Energy Alliance
Fraunhofer Food Chain Management Alliance
Fraunhofer Lightweight Design Alliance
Fraunhofer Nanotechnology Alliance
Fraunhofer Photocatalysis Alliance
Fraunhofer Polymer Surfaces Alliance POLO®
Fraunhofer Simulation Alliance
Fraunhofer Space Alliance
Fraunhofer Traffic and Transportation Alliance
Fraunhofer Vision Alliance
Fraunhofer Water Systems Alliance (SysWasser)

For further information on the Fraunhofer Alliances, please consult our website:

www.fraunhofer.de

Main locations ●

Other locations ○



ADDRESSES IN GERMANY

The Fraunhofer-Gesellschaft

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Fax +49 89 1205-7531
info@fraunhofer.de
www.fraunhofer.de

Executive Board:

Prof. Dr.-Ing. habil. Prof. E. h. Dr.-Ing. E. h. mult.
Dr. h. c. Dr. h. c. Reimund Neugebauer
(President, Corporate Policy and Research)
Prof. (Univ. Stellenbosch) Dr. rer. pol. Alfred Gossner
(Senior Vice President, Finance, Controlling and
Information Systems)
Prof. Dr. rer. publ. ass. iur. Alexander Kurz
(Senior Vice President Human Resources, Legal Affairs
and IP Management)
Prof. Dr.-Ing. Dr. h. c. mult. Alexander Verl
(Senior Vice President Technology Marketing and
Business Models)

Contact for businesses:

Dr. Kai Kohler
Phone +49 89 1205-4400
kundenanfragen@zv.fraunhofer.de

Historic Fraunhofer Glassworks

Fraunhoferstraße 1
83671 Benediktbeuern

Addresses, focal fields of research, and contacts
for all Fraunhofer Institutes and Groups are
available in English and German on the Internet:

www.fraunhofer.de



INTERNATIONAL ADDRESSES

Fraunhofer International

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International Business Development
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Fax +49 89 1205-77-4700
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