



ANNUAL REPORT 2015

FOCUS ON PEOPLE

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 benefits 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 67 institutes and research units. The majority of the 24,000 staff are qualified scientists and engineers, who work with an annual research budget of more than 2.1 billion euros. Of this sum, 1.8 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 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 processes. 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 and the acceptance of new technologies, and by 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.

www.fraunhofer.de

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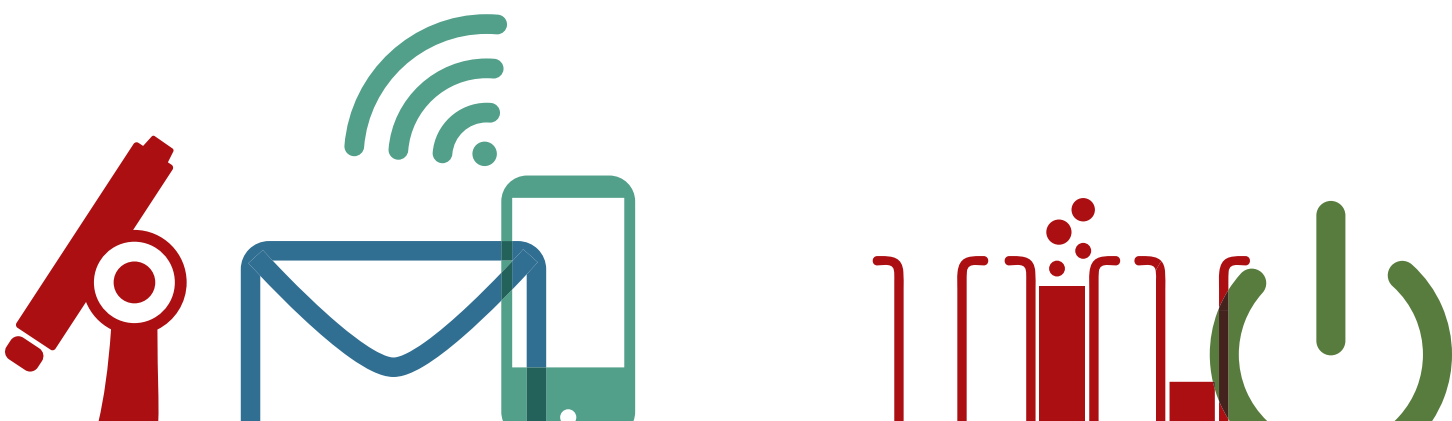


Ladies and gentlemen,

It is people who are the focus of Fraunhofer's work – in two ways. First, applied science is inconceivable in the absence of inquisitive humans. However much we, as specialists in applied technologies, might value automation and intelligent control systems, the essence of our research is in fact creativity and the evaluation of results in terms of how they benefit people. And this will always be the domain of the women and men who conduct and apply scientific research in our laboratories and offices.

The second point is precisely the way we consistently focus our work so that it benefits people. Even though we are active in the most diverse technological fields – we design machinery, invent software, and promote new energy sources and medical technology – our goal is the well-being of humanity: security, healthcare, mobility, communication, environment, housing. This goal is what drives us, and it is what has made Fraunhofer successful over the decades.

In the past year we were able to continue this positive development – with a new record level of industrial revenue, with 24,000 employees, and a research budget of more than 2.1 billion euros. In recent years, several important measures have helped the Fraunhofer-Gesellschaft to adapt its structure



in line with this growth: its base funding is now distributed more efficiently, the Fraunhofer Groups have assumed more responsibility, and a new stability indicator allows us to adjust individual institute portfolios to changing markets quickly and consistently.

In addition, we are strengthening our effectiveness as the most important European player in applied research. Major initiatives with important science and industry partners, such as the Industrial Data Space, help us identify and take advantage of innovation opportunities. We also play a crucial role in such trends as industry 4.0 and the design of 5G transmission standards. We focus on complex areas of research with great future relevance, such as biosensors and the realization of autonomous systems. With such initiatives and objectives, we can trigger spurts of industrial development to the benefit of the entire German and European economy.

Our institution-wide approach is of fundamental importance in the formation of comprehensive collaborations, as it allows us to pool our expertise and put it at the disposal of our external partners and customers. This makes us more attractive in the marketplace for research and development services, which means we can better promote important technologies and strengthen the position of industry in international competition.

We at Fraunhofer want to use our increased importance to industry and science to consciously and consistently drive applied research forward for the benefit of society. In a phrase: Real research for real people.

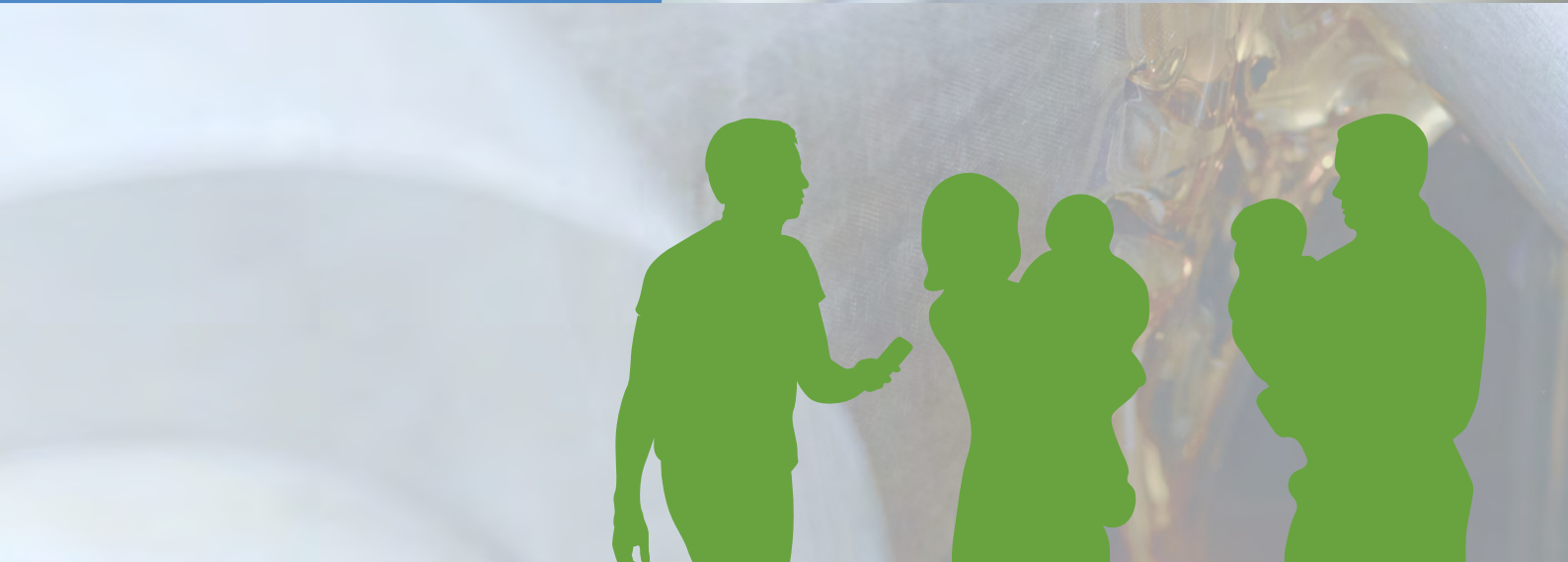
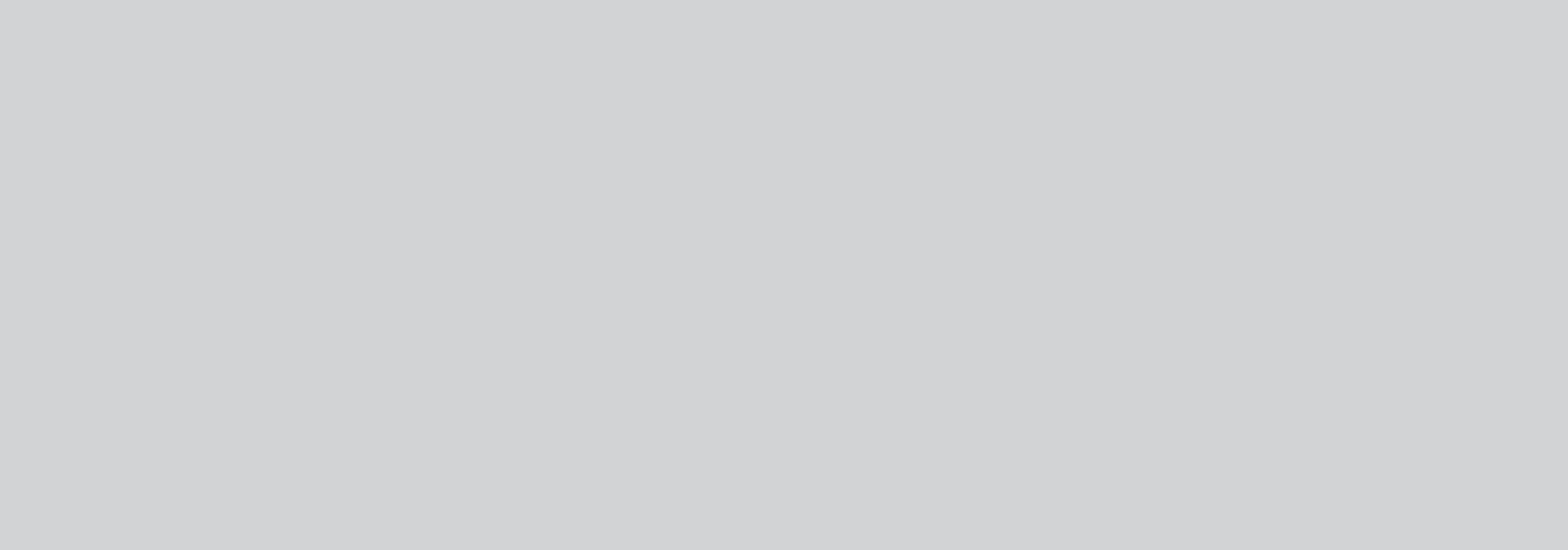
Fraunhofer's success is determined in large part by the outstanding performance of its employees. On behalf of the entire Executive Board, I want to thank you, our customers, and Advisory Board and Senate members, for your continued trust and commitment.

Sincerely,



Reimund Neugebauer
President of the Fraunhofer-Gesellschaft





The background of the entire page is a light gray, semi-transparent image of industrial machinery, likely a lathe or similar manufacturing equipment, showing various metal components and tooling.

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REPORT OF THE EXECUTIVE BOARD





THE EXECUTIVE BOARD

MANAGEMENT REPORT 2015

REPORT OF THE SENATE
ON THE FINANCIAL YEAR 2015

INSIDE THE FRAUNHOFER SENATE



THE EXECUTIVE BOARD

THE DUTIES OF THE EXECUTIVE BOARD INCLUDE MANAGING THE FRAUNHOFER-GESELLSCHAFT AND REPRESENTING ITS INTERESTS INSIDE AND OUTSIDE THE ORGANIZATION. IT ELABORATES THE BASIC FEATURES OF THE FRAUNHOFER-GESELLSCHAFT'S SCIENCE AND RESEARCH POLICY, ALONG WITH EXPANSION AND FINANCIAL PLANNING, IT ACQUIRES ITS BASE FUNDING AND ARRANGES ITS DISTRIBUTION TO THE INSTITUTES, AND IT APPOINTS INSTITUTE DIRECTORS.



Reimund Neugebauer is Professor for Machine Tools and Forming Technology at Technische Universität Chemnitz (TU Chemnitz). After leadership roles in the mechanical engineering industry, he set up the Fraunhofer Institute for Machine Tools and Forming Technology IWU in 1991, which grew to become an international center for manufacturing engineering in his 21 years of service as its director. He has been President of the Fraunhofer-Gesellschaft since October 2012.

Prof. Dr.-Ing. habil. Prof. E. h. Dr.-Ing. E. h. mult. Dr. h. c. mult.

Reimund Neugebauer

President, Corporate Policy and Research



After studying to become a lawyer, Alexander Kurz worked as a manager and board member for major research organizations such as CERN and the Karlsruhe Institute of Technology (KIT). He has been a member of the Executive Board of the Fraunhofer-Gesellschaft since June 2011.

Prof. Dr. rer. publ. ass. iur.

Alexander Kurz

Senior Vice President Human Resources, Legal Affairs and IP Management



Alfred Gossner initially pursued a career with the Allianz Group, including various international postings. Before joining the Fraunhofer-Gesellschaft in 2002, he served as a member of the board of management of Allianz Versicherungs-AG.

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

Alfred Gossner

Senior Vice President Finances, Controlling and Information Systems

MANAGEMENT REPORT 2015

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Summary of the Fraunhofer-Gesellschaft's business development in 2015

| | 2014 | 2015 | Change | |
|--|--------|--------|--------|------|
| Business volume in € million | 2060 | 2115 | +55 | +3% |
| Contract research | 1716 | 1835 | +119 | +7% |
| Defense research | 118 | 127 | +9 | +8% |
| Major infrastructure capital expenditure | 226 | 153 | -73 | -32% |
| Breakdown of expenditure in % | | | | |
| Personnel expense ratio | 53 | 55 | +2 | |
| Non-personnel expense ratio | 28 | 29 | +1 | |
| Capital expenditure ratio | 19 | 16 | -3 | |
| Contract research funding in € million | | | | |
| Project revenue | 1272 | 1305 | +33 | +3% |
| Industrial revenue | 618 | 641 | +23 | +4% |
| Public-sector revenue ¹ | 654 | 664 | +10 | +2% |
| Funding requirements | 444 | 530 | +86 | +19% |
| Sources of contract research funding in %² | | | | |
| Projects | 73 | 73 | 0 | |
| Industry | 37 | 37 | 0 | |
| Public sector ¹ | 36 | 36 | 0 | |
| International revenue in € million³ | 276 | 291 | +15 | +5% |
| Patent applications per year | 563 | 506 | -57 | -10% |
| Active patent families at year end | 6625 | 6573 | -52 | -1% |
| Employees at year end | 23 786 | 24 084 | +298 | +1% |

- 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 Funding sources for the operating budget including imputed depreciation of investments (excluding institutions in start-up phase and change in reserve).
- 3 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 67 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 healthcare, nutrition and the environment.

The majority of the 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 €2.1 billion. Of this sum, more than €1.8 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, enabling pre-competitive research whose solutions will be relevant to industry, state and society in the future.

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
- Materials and Components – MATERIALS
- Microelectronics
- Production
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. 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. 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. If needed 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 enable institutes in a temporarily adverse risk situation to open up new lines of business.

The Executive Board considers certain current issues in business or politics and coordinates them internally. For example, in 2015 Fraunhofer spearheaded the **Industrial Data Space (IDS) initiative**. This initiative aims to apply European standards of law, security and privacy to a digital infrastructure that enables innovative ICT and network-based applications and services, while at the same time preserving the data sovereignty of companies and citizens. Due to the complex nature

of the initiative and the many partners involved, the Executive Board is overseeing the conceptual phase to ensure effective and efficient collaboration with businesses. Another topic Fraunhofer picked up in 2015 is battery cell production for electric cars. The Fraunhofer Institute for Laser Technology ILT, for example, is working on a new laser-based process for producing lightweight battery packs.

Strengthening the transfer of technology is another central element of Fraunhofer strategy. To address promising technology sectors of regional significance and help develop relevant systems solutions that require networks of several institutes, the **Corporate Business Development and Marketing** department has been further expanded and its team of industry experts has grown. These experts determine the R&D needs of the companies, initiate cross-institute projects and ensure their successful implementation by involving the Fraunhofer Groups and Alliances. In addition, for each customer the Corporate Business Development and Marketing department brings together the appropriate opportunities for collaboration with Fraunhofer, thus boosting the development of strategic partnerships. Companies receive tailored support in the form of innovation counselling for brainstorming sessions, feasibility studies, product and process development work in the case of R&D support, and training formats to support the implementation of new technologies and procedures.

Business model development strengthens the expansion of systems solutions and the formation of strategic collaborations with companies. In 2015, additional cross-institute acquisition formats were developed and carried out. One example is the first Fraunhofer Day in Schleswig-Holstein, which was held at the Fraunhofer Research Institution for Marine Biotechnology EMB in Lübeck and organized jointly with the Schleswig-Holstein Chambers of Commerce and Industry and the Schleswig-Holstein Ministry of Economic Affairs. A total of

nine Fraunhofer Institutes from the region presented engaging exhibits to demonstrate the potential of new technologies, especially for small and medium-sized enterprises (SMEs).

2015 also saw further work to establish the central IP commercialization function as the coordinating body for tapping additional potential in licensing Fraunhofer's **Intellectual Property** (IP). This involves actively putting together cross-institute portfolios of patents with a variety of possible applications and offering them to companies. In the case of existing patent portfolios, licensing programs will be defined and implemented and any patent infringements investigated. This increases the chances that Fraunhofer Institutes can exploit their intellectual property while also reducing costs.

The **Fraunhofer Academy** is systematically professionalizing Fraunhofer's continuing education programs as a path for technology transfer. In 2015, the Academy's focus was once again on new professions based on dynamic market needs. A good example of this is the Fraunhofer Big Data Alliance's "data scientist" qualification. Since January 2015, the Fraunhofer Academy has also offered its own certifications for the skills participants acquire through its study courses, certified training courses and seminars. And 2015 was the first time that the Fraunhofer Academy offered the "Fraunhofer research manager" qualification, with a view to professionalizing research management in the strategic field of technology transfer.

As well as intensifying its focus on technology transfer, Fraunhofer is currently developing a structured strategy for **fundraising**. Its aim is to attract additional funds that it can use in the future to finance selected research projects. The first donations and bequests that Fraunhofer has already attracted indicate promising potential here.

Integration and creation of new entities

The Fraunhofer-Gesellschaft owes its progress to the growth of its institutes, the integration of external research institutions and the creation of new departments and project groups. As a general rule, the creation and integration 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. 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. A critical consideration in this evaluation is whether the entity's competency profile is a strategic fit with Fraunhofer's existing R&D portfolio. In addition, the financing through the Fraunhofer funding model must be deemed secure in the medium term, and ongoing institutional support for the new entities must be available.

As part of the integration of the former Research Establishment for Applied Sciences (FGAN), Fraunhofer created three new contract research departments at the Fraunhofer Institute for Optronics, 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. After the five-year trial period, which was fully funded by the German Federal Ministry of Defence (BMVg), these contract research departments were evaluated positively in 2015 and became eligible for the 90:10 base funding from the federal and state governments.

Moreover, an additional seven project groups were also positively evaluated in 2015 and became eligible for the 90:10 base funding from the federal and state governments:

- Fraunhofer IML's Center for Maritime Logistics and Services in Hamburg
- Fraunhofer IKTS's branch in Hermsdorf
- Fraunhofer MEVIS's Project Group Image Registration in Lübeck
- Fraunhofer ICT's Project Group Functional Lightweight Design in Augsburg
- Fraunhofer IGB's Project Group Catalytic Processes for a Sustainable Supply of Raw Materials and Energy on the Basis of Renewable Resources in Straubing
- Fraunhofer ICT and Fraunhofer IWM's Project Group New Drive Systems in Karlsruhe
- Fraunhofer IGB's Center for Chemical-Biotechnological Processes in Leuna

Fraunhofer has greatly strengthened its position in the strategic fields of biotechnology, logistics, and production technology with these new core competencies.

In 2015, the Fraunhofer Institute for Production Technology IPT's Project Group Mechatronic Systems Design in Paderborn was evaluated positively. At the beginning of 2016, this group became an autonomous entity, further strengthening Fraunhofer's research portfolio in both microelectronics and production.

Given that the increase in institutional funding from the Joint Initiative for Research and Innovation III is comparatively smaller than in previous funding periods, it is expected that Fraunhofer will be unable to accommodate as many new units in the future.

Sustainability

Fraunhofer is committed to sustainable development. This commitment to sustainability is clearly expressed in the Fraunhofer Sustainability Report, which presents all Fraunhofer's sustainability management strategies, goals and measures. The expectations of Fraunhofer's sustainability management form the basis of active dialog with industry, science, government and society, for instance through 2015's stakeholder dialog with representatives from the worlds of industry, politics, science, government and public interest groups. A commitment to ethical responsibility – beyond legal regulations – when dealing with security-related research is one area of focus. Based on benchmarks and analyses of requirements, Fraunhofer initiated additional measures in 2015: from educating employees on increased consideration of ethics for all internally funded research projects, to the establishment of a strictly confidential central counselling service for questions of an ethical nature. The goal of these measures is to ensure that all employees are aware of their ethical responsibility, and to provide them with a point of contact, support and guidance in the event of a conflict.

Fraunhofer has also adopted a research policy objective "to increase the involvement of the public and the participation of citizens in research and innovation processes". Especially for issues of particular relevance to society, such as automated driving, urban security, fair food production, and big data, Fraunhofer is supporting a **participatory approach to defining technology**. Alongside strategic talks with stakeholders from society, Fraunhofer is initiating a dialog with citizens. The Fraunhofer Institute for Secure Information Technology SIT, for example, carried out an online survey entitled "Big data

and privacy", met with citizens directly to seek their views, and analyzed some 10,000 online articles, comments and Twitter feeds. On the one hand, this enabled knowledge transfer at the citizen level; on the other, it was a chance to gather citizens' opinions on the opportunities and risks of big data.

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 **High-Tech Forum** was founded in early 2015 to advise the federal government on the implementation and development of its new High-Tech Strategy (HTS). The forum is co-chaired by the President of the Fraunhofer-Gesellschaft, Prof. Dr. Reimund Neugebauer, representing science, and Prof. Dr. 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 18 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 eight thematic areas:

- Challenges and success factors for collaboration and transfer
- Innovation system performance and SME innovation capability
- Public participation and transparency
- Internationalization
- Innovative workplace
- Autonomous systems
- Sustainable management
- Digital technologies and health

In addition, the forum develops priorities and strategic guidelines for Germany. In 2015, Fraunhofer and the Stifterverband created a permanent office to coordinate the High-Tech Forum's activities. As a leading member of the High-Tech Forum, Fraunhofer will have the possibility to formulate recommendations for a concrete action plan, and provide an impetus for innovative policies. At the same time, Fraunhofer can offer its knowledge and methodological expertise to implement the High-Tech Strategy.

In the next few years, the financial scope of Fraunhofer's research will be limited by several developments:

At the beginning of 2016, the German Chancellor and the prime ministers of the states entered into a new **Joint Initiative for Research and Innovation III**. In it, they agreed that the base funding granted to non-university organizations would be subject to an annual increase of 3 percent until 2020. Given that the annual rate of increase in the previous periods was 5 percent per year, this means that the base funding received by the Fraunhofer-Gesellschaft will grow more slowly than in the past. This in turn will limit the growth of the Fraunhofer-Gesellschaft: Germany's reputation as an innovative location was achieved through the contributions of the Fraunhofer Institutes, which are made possible through the base funding for pre-competitive research. Because the increase in base funding in recent years was disproportionate to, and lower than, the excellent developments in business revenue and public funding, the relative share of base funding has reduced. A further reduction would threaten Fraunhofer's financing model, and with it, the successful mix of research projects.

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 state governments, are another factor affecting research spending. In the medium term, it is expected that funding levels from the federal and state governments will no longer continue the positive trend of recent years. Already in 2015, Fraunhofer's project volume with the federal and state governments fell slightly.

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 full-cost funding mechanism has been replaced by a flat rate of 25 percent granted in respect of general administrative expenses. For many Fraunhofer Institutes, this means lower coverage of their general administrative expenses, with the result that, in the future, base funding will have to be withdrawn from pre-competitive research and instead used to cover the cost of EU-funded projects. This means future project funding developments will also reduce the scope of Fraunhofer's financial options, which in turn will critically affect Fraunhofer's growth.

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, Fraunhofer formulated six key objectives. The Fraunhofer declaration can be found among the publications on the Joint Science Conference (Gemeinsame Wissenschaftskonferenz – GWK) website (www.gwk-bonn.de). In relation to the objective "Create performance-enhancing networks in the research and education system", for instance, the stated measure is to further expand networking with universities.

To foster increased cooperation with universities and effective regional networking with industry, Fraunhofer has developed a sustainable model for its locations: regionally-based national **High Performance Centers**. Fraunhofer also sees these as fundamental to pursuing Germany's Excellence Initiative. The key criteria here include focusing scientific research in different regions, integrating the regional economy, transfer of knowledge and ideas, excellence in scientific achievements and in transfer and commercialization, and hence also the involvement of businesses in the review and decision-making processes. Since the start of 2015, Fraunhofer has already launched five High Performance Centers together with selected universities. In their pilot phase, they are funded through a partnership between the states, industrial partners and Fraunhofer. A federal funding contribution to enable regular operation is still outstanding.

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 scheduled to continue through 2017. The President of the Fraunhofer-Gesellschaft, 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 2015, the committee investigated digital networking and the future of value creation in the German economy, as well as the innovation potential of human-machine interactions. The transfer of knowledge, technology and know-how will be discussed at the spring 2016 meeting. 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.

BUSINESS REPORT

Economic environment

- Sound German economy growing at a steady rate
- High level of R&D expenditure
- Funding for research and innovation remains high priority for federal government

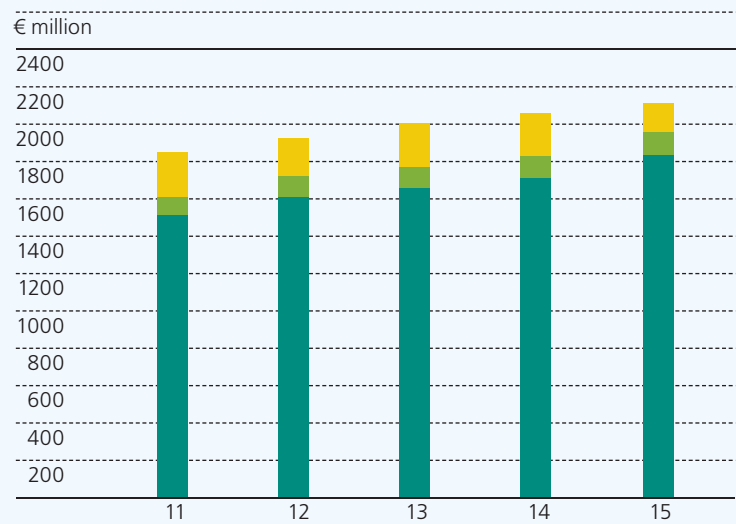
Germany's economic situation in 2015 was marked by solid, continuous growth. The country's gross domestic product (GDP) increased by 1.7 percent in real terms, which indicates that the economy is growing faster than in previous years (GDP up 1.6 percent in 2014, and up 0.3 percent in 2013). Viewed on a longer timescale, economic growth exceeded the ten-year average of 1.3 percent per annum for the second consecutive year. It is noteworthy that not only almost every sector of the service industry but also the manufacturing sector increased their economic performance significantly.

Industry and government alike remain aware of the vital importance of research and innovation to future competitiveness. According to the latest available statistics compiled by Stifterverband für die Deutsche Wissenschaft, a private-sector initiative to support science and education, in-house R&D spending by private industry in Germany amounted to €57 billion in 2014. This represents an increase of around 50 percent since 2004. Within this same ten-year period, expenditure by private industry on external contract research has more than doubled to reach a record level of €16 billion in 2014. This increased capital expenditure has had a corresponding impact on the innovative power of German companies: Germany ranks third in the list of countries that have filed the most patent applications with the European Patent Office (EPO), after the United States and Japan. According to the EU Industrial R&D Investment Scoreboard 2015, five of the ten most innovative companies in Europe are based in Germany.

Germany has not yet reached the European Union's target of raising total 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, amounted to 2.87 percent in 2014, based on the latest available statistics. This is nonetheless slightly higher than in 2013. In total, public and private spending on R&D in Germany in 2014 exceeded €83 billion. This represents an increase of just below 5 percent compared with the previous year. According to a study conducted by the Commission of Experts for Research and Innovation (EFI), this increase is due to higher industrial R&D spending. Overall, 68 percent of the country's total R&D expenditure was funded by private industry.

Governments successfully continued their efforts to rein in public spending in 2015. Altogether, federal, state and local governments and social security funds generated a budgetary surplus for the second year in succession, by reducing actual expenditure by a total of around €19.4 billion. Despite the imposed spending restrictions, R&D expenditure was once again given high priority in the 2015 federal budget. The total amount allocated for this purpose to the various ministries and departments was €14.9 billion. This represents an increase of over 65 percent compared with the level of 2005. Provision has been made for further substantial increases in the federal budget for 2016. The German Federal Ministry of Education and Research (BMBF) alone has been earmarked to receive nearly €16.4 billion in funding in 2016, an amount that is expected to rise to over €17 billion in 2017. This shows how much importance the German federal government accords to promoting research and innovation.

The Fraunhofer-Gesellschaft's total business volume 2011–2015



| | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|-------------|-------------|-------------|-------------|-------------|
| Major infrastructure capital expenditure | 236 | 199 | 235 | 226 | 153 |
| Defense research | 98 | 113 | 114 | 118 | 127 |
| Contract research | 1515 | 1614 | 1661 | 1716 | 1835 |
| = Total business volume in € million | 1849 | 1926 | 2010 | 2060 | 2115 |

Total business volume

- Total business volume rises to €2115 million
- Solid growth in the contract research and defense research segments
- Relatively low capital expenditure on major infrastructure

Fueled by a consistently high demand for research and development services by customers in industry and the public sector, Fraunhofer's total business volume showed solid growth, increasing by €55 million year on year to €2115 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.

Budgeted expenditure on contract research increased in 2015 by €119 million to a total of €1835 million, while budgeted expenditure in the defense sector increased by €9 million to €127 million. Capital expenditure on institute buildings, as well as the initial cost of equipment for newly constructed buildings or extensions, are recognized as a separate accounting item below major infrastructure capital expenditure. This item amounted to €153 million in 2015, which is significantly lower than in 2014. In the following we report on expenditure and income items separately for each of the two segments, contract research and defense research.

Contract research

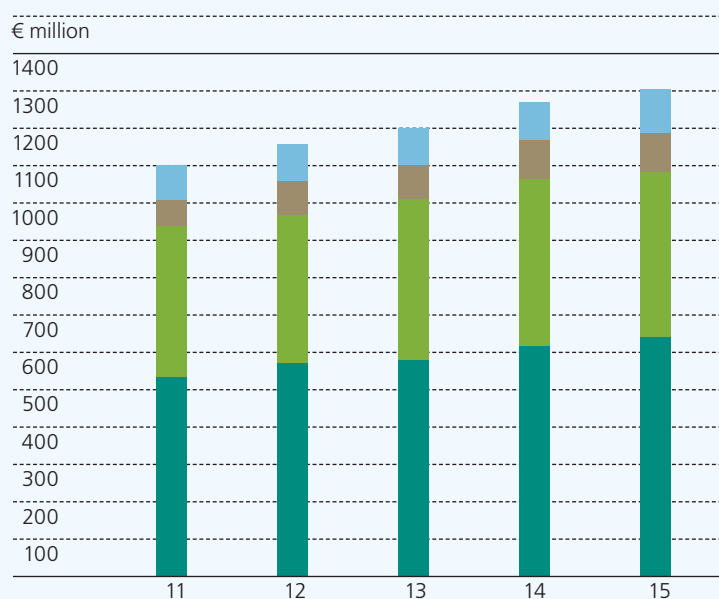
- Annual research budget exceeds €1.8 billion
- Industrial revenue increases by 4 percent
- Public-sector funding by federal and state governments and the EU remains stable

The contract research segment comprises three complementary areas of work: research conducted under contract to customers in industry and the service sector, publicly funded research projects, and pre-competitive research financed by means of the organization's base funding. Through their research for private-sector customers, the Fraunhofer Institutes help translate their research findings into real-life 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 in essential areas such as energy, transportation and healthcare. Moreover, these projects make an important contribution toward the creation of networks linking different elements of the public science and education system, and promote innovation in the business world.

In 2015, budgeted expenditure for the contract research segment increased to a total of €1835 million. Personnel expenses rose by 4 percent to €1066 million. Non-personnel expenses increased at the same rate to €580 million. Capital expenditure amounted to €160 million, which here again represents an increase of 4 percent compared with the previous year. A further factor affecting this segment's budgeted expenditure in 2015 was an allocation of €29 million to the special reserve for license-fee revenue; in 2014, an amount of €15 million had been drawn down from this reserve.

Over two-thirds of Fraunhofer's budgeted expenditure for contract research is financed by means of project revenue, which in 2015 increased by 3 percent to a total of €1305 million.

Revenue and expenditure in the contract research segment 2011–2015



| | 2011 | 2012 | 2013 | 2014 | 2015 |
|--|-------------|-------------|-------------|-------------|-------------|
| Project revenue | 1101 | 1137 | 1200 | 1272 | 1305 |
| Other revenue | 94 | 97 | 99 | 103 | 118 |
| EU-revenue (European Commission) | 71 | 88 | 92 | 106 | 105 |
| Public-sector revenue (German federal and state governments) | 405 | 382 | 431 | 445 | 441 |
| Industrial revenue | 531 | 570 | 578 | 618 | 641 |
| Funding requirements¹ | 414 | 477 | 461 | 444 | 530 |
| = Total revenue in € million | 1515 | 1614 | 1661 | 1716 | 1835 |
| Personnel expenses | 784 | 868 | 945 | 1021 | 1066 |
| Non-personnel expenses | 514 | 543 | 549 | 556 | 580 |
| Change in special reserve for license-fee revenue and allocation to foundation capital | 74 | 52 | 0 | –15 | 29 |
| Capital expenditure | 143 | 151 | 167 | 154 | 160 |
| = Total expenditure in € million | 1515 | 1614 | 1661 | 1716 | 1835 |

¹ In 2012 and 2013, this item included the transfer of funds from Fraunhofer reserves.

Project revenue comprises not only revenue from contracts with industry but also public funding granted by the German federal and state governments and the EU, and miscellaneous other sources. Industrial revenue grew by 4 percent to €641 million. Revenue from project funding granted by the German federal and state governments, at €441 million, remained at the previous year's level. Revenue from project funding granted by the European Commission, at €105 million, also remained stable, deviating only minimally from the previous year. Revenue from other sources increased to €118 million. In 2015, an amount of around €530 million granted to Fraunhofer by the German federal and state governments as base funding was utilized to finance contract research.

Defense research

- Annual research budget increases to €127 million
- Sum comprises equal amounts of base funding and project funding

The defense research segment groups 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 of a military or paramilitary nature so as to assure 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 aspect of their work is equally successful, thus supporting the concept of dual-use research and enabling security issues to be studied from a holistic perspective.

The defense research segment's budgeted expenditure increased in 2015 by 8 percent to €127 million. This amount comprises €76 million in personnel expenses, €32 million in

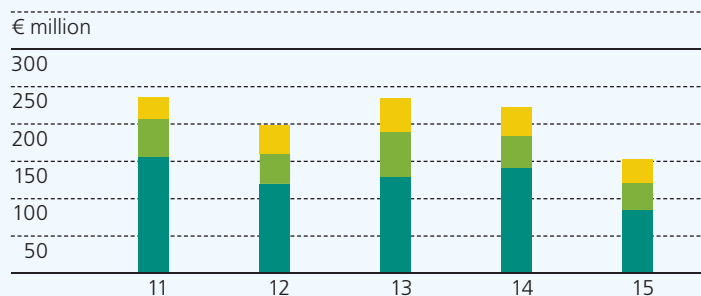
non-personnel expenses and €19 million in capital expenditure. To cover this budgeted expenditure, the BMVg provided €63 million in form of base funding and a further €64 million in form of project funding.

Major infrastructure capital expenditure

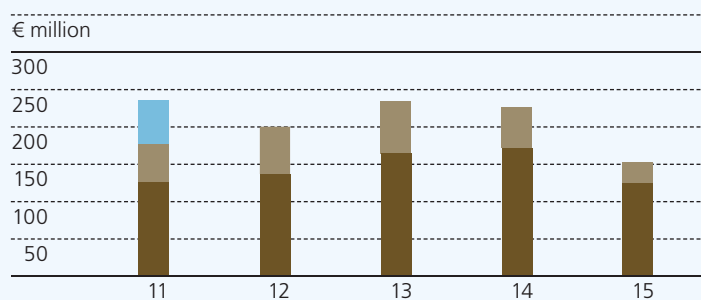
- One-fourth of the cost of major infrastructure projects is financed by the EU
- Significant reduction in major infrastructure capital expenditure due to transition to new ERDF funding period

In 2015, the Fraunhofer-Gesellschaft spent a total of €153 million on its research buildings. Capital expenditure on the construction of new buildings, the extension of existing buildings, and the purchase of land – collectively referred to as major construction projects – amounted to €86 million. Fraunhofer expended a further €35 million on furnishings and scientific instruments to equip these newly constructed buildings and extensions. Compared with previous years, expenditure on major construction projects decreased significantly. This decrease is due to the transition between ERDF (European Regional Development Fund) funding periods. Whereas the majority of construction projects co-financed by the ERDF in the 2007–2013 funding period had been completed by 2015, many of the projects eligible for co-financing in the current (2014–2020) funding period are still at the planning stage. Major construction projects are financed on a 50:50 basis by the BMBF and the state where the facility is located (after taking into account any co-financing agreements). Overall in 2015, the German federal and state governments together provided around €93 million in funding for such projects. Approximately one-fourth of the total expenditure on major construction projects benefited from EU funding and was co-financed by the European Regional Development Fund (ERDF) to the tune of €28 million.

Major infrastructure capital expenditure and funding sources 2011–2015



| | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|------------|------------|------------|------------|------------|
| Minor building projects ¹ | 30 | 38 | 45 | 38 | 32 |
| Equipment of new facilities with scientific instruments and furniture | 50 | 41 | 61 | 47 | 35 |
| Purchase of land, construction of new buildings and extensions | 156 | 120 | 129 | 141 | 86 |
| = Total major infrastructure capital expenditure in € million | 236 | 199 | 235 | 226 | 153 |



| | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|------------|------------|------------|------------|------------|
| Economic stimulus program II | 59 | | | | |
| European Regional Development Fund (ERDF) | 51 | 62 | 71 | 54 | 28 |
| German federal and state governments ² | 126 | 137 | 164 | 172 | 125 |
| = Funding of major infrastructure capital expenditure in € million | 236 | 199 | 235 | 226 | 153 |

¹ Small-scale construction, extension and renovation projects costing less than €1 million.

² Includes other government grants, which in 2015 amounted to €1 million.

Major infrastructure capital expenditure 2015

| Institute / Research Institution | Location | Total | ERDF ¹ | Federal / state governments |
|--|--------------|--------------|-------------------|-----------------------------|
| Manufacturing Engineering and Automation | Stuttgart | 13.1 | | 13.1 |
| Integrated Circuits | Nürnberg | 9.7 | | 9.7 |
| Cell Therapy and Immunology | Leipzig | 9.7 | 6.3 | 3.4 |
| Material and Beam Technology | Dresden | 8.2 | 6.1 | 2.1 |
| Silicate Research – HTL ² | Bayreuth | 7.0 | 3.5 | 3.5 |
| Wind Energy and Energy System Technology | Bremerhaven | 5.6 | 0.5 | 5.2 |
| Building Physics | Holzkirchen | 5.2 | | 5.2 |
| Marine Biotechnology | Lübeck | 4.7 | 2.4 | 2.4 |
| Silicon Technology | Itzehoe | 4.0 | 2.0 | 2.0 |
| Manufacturing Technology and Advanced Materials | Bremen | 4.0 | | 4.0 |
| Mechanics of Materials | Karlsruhe | 3.9 | | 3.9 |
| Structural Durability and System Reliability | Darmstadt | 3.8 | | 3.8 |
| Silicate Research – IWKS ³ | Alzenau | 3.7 | 1.8 | 1.8 |
| Chemical Technology | Augsburg | 3.0 | 1.4 | 1.6 |
| Chemical Technology | Pfinztal | 2.9 | | 2.9 |
| Manufacturing Engineering and Automation | Bayreuth | 2.4 | 1.2 | 1.2 |
| Interfacial Engineering and Biotechnology | Straubing | 2.2 | | 2.2 |
| Laser Technology/Production Technology Competence Center | Aachen | 2.1 | | 2.1 |
| Clinical Research Center | Hannover | 2.0 | | 2.0 |
| Silicate Research – IWKS ³ | Alzenau | 1.9 | 1.0 | 1.0 |
| Secure Information Technology – CASED ⁴ | Darmstadt | 1.9 | | 1.9 |
| Silicate Research | Würzburg | 1.7 | 0.6 | 1.1 |
| Ceramic Technologies and Systems | Hermisdorf | 1.7 | | 1.7 |
| Applied Polymer Research | Potsdam-Golm | 1.7 | | 1.7 |
| Wind Energy and Energy System Technology | Bremerhaven | 1.5 | | 1.5 |
| Silicate Research – IWKS ³ | Hanau | 1.5 | | 1.5 |
| Chemical Technology – GAR ⁵ | Garching | 1.3 | | 1.3 |
| Telecommunications | Berlin | 1.3 | | 1.3 |
| Optronics, System Technologies and Image Exploitation – AST ⁶ | Ilmenau | 1.1 | 0.4 | 0.7 |
| High-Speed Dynamics | Freiburg | 1.0 | | 1.0 |
| Other construction work | | 7.6 | 1.0 | 6.6 |
| Main infrastructure projects funded by | | | | |
| German federal / state governments and ERDF¹ | | 121.4 | 28.3 | 93.1 |
| Minor building projects | | 31.9 | | 31.9 |
| Total major infrastructure capital expenditure in € million | | 153.3 | 28.3 | 125.0 |

1 ERDF = European Regional Development Fund.

2 HTL = Center for High Temperature Materials and Design.

3 IWKS = Project Group Materials Recycling and Resource Strategies.

4 CASED = Center for Advanced Security Research Darmstadt.

5 GAR = Project Group Electrochemical Storage.

6 AST = Advanced System Technology branch.

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 2015, a total of €32 million was spent on projects of this type, which corresponds to around one-fifth of Fraunhofer's capital expenditure on infrastructural improvements. Minor building projects are 90-percent funded by the federal government, with the states contributing the remaining 10 percent.

Two of the largest major construction projects are presented below by way of example.

The new research building for the Fraunhofer Center for High Temperature Materials and Design (HTL) in Bayreuth was inaugurated in July 2015. Half of the construction costs, which totaled over €20 million, were covered by the ERDF, while the other half was financed by the Free State of Bavaria and the German federal government, each of which contributed 25 percent of the total costs. The new research building has a surface area of 2600 square meters and provides working space for around 80 employees. The Fraunhofer Center for High Temperature Materials and Design develops materials and components for high-temperature applications along with the corresponding measurement techniques and simulation processes.

In April 2015, the Fraunhofer Research Institution for Marine Biotechnology EMB moved into its new building in Lübeck. The construction costs totaling €30 million were split three ways, with 50 percent funded by the ERDF and 25 percent each by the state of Schleswig-Holstein and the federal government. The facility has a surface area of 5000 square meters and contains high-tech laboratories, aquaculture installations, a food technology center, manufacturing halls and cryobank storage. Fraunhofer EMB was founded in Lübeck more than seven years ago, and has since then been developing innovations for industrial use in the field of life sciences.

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 €491 million in 2015, the Fraunhofer Group for **Materials and Components – MATERIALS** is the largest group within the Fraunhofer-Gesellschaft in financial terms. It encompasses 14 institutes whose areas of expertise extend from developing new materials, improving the properties of existing materials, materials characterization and evaluating the behavior of materials under different conditions of use, to the development of production processes. An outstanding example is the Fraunhofer Institute for Wood Research, Wilhelm-Klauditz-Institut, WKI. In 2015, this institute was distinguished with the GreenTec Award, Europe's largest environmental and business prize, for developing an environmentally friendly foam material based on wood fibers that possesses exceptional mechanical and acoustic properties. The 14 institutes that make up this group generated project revenues of €362 million in 2015. Both budgeted expenditure and project revenues thus remained stable, enabling the group to maintain the proportion of operating expenditure covered by project revenues at the very high level of 83 percent.

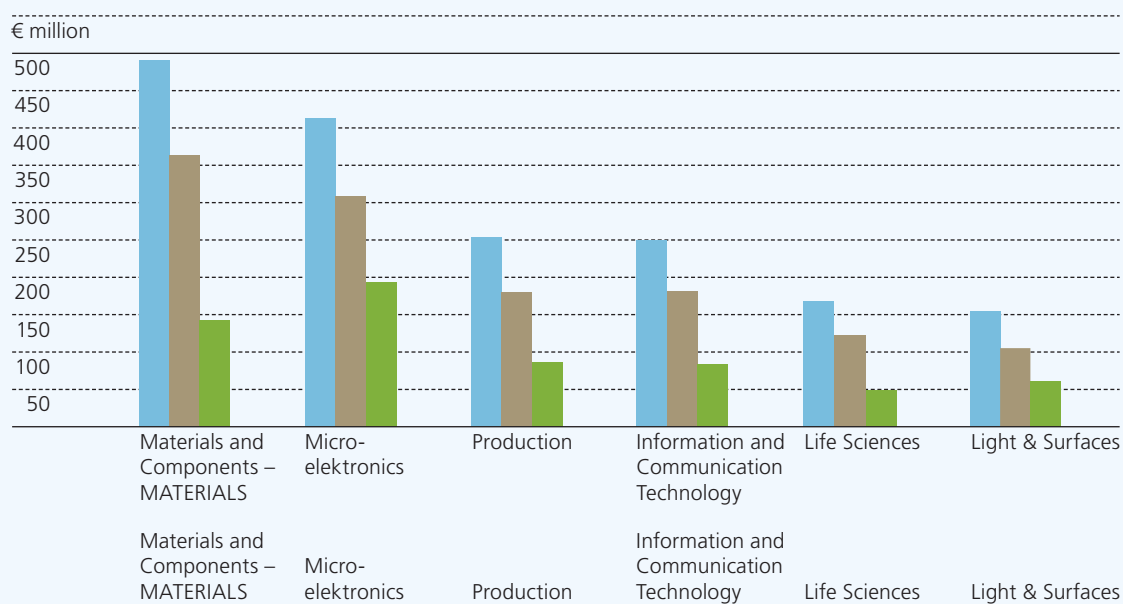
The Fraunhofer Group for **Microelectronics** consists of 11 member institutes that conduct cutting-edge research and develop application-oriented solutions in the fields of semiconductor technology, communications technology, ambient assisted living, energy-efficient systems and e-mobility, lighting systems, safety and security, and entertainment electronics. A noteworthy example of pioneering development work is that of Prof. Dr. Oliver Ambacher, who received the Karl Heinz Beckurts Prize in 2015. In cooperation with industrial partners, the director of the Fraunhofer Institute for Applied Solid State Physics IAF and his team have developed highly efficient electronic components based on the novel semiconductor material gallium nitride (GaN) for use in mobile communication systems. The new GaN technology is an important step toward implementing the 5G mobile communication standard that the European Union plans to introduce in 2020. In 2015, this Fraunhofer Group's budgeted expenditure increased by 12 percent to €413 million, thus growing at a higher rate than any of the other groups. As in 2014, industrial revenue covered a major part, namely 51 percent, of the group's operating expenditure.

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. In 2015, the group's budgeted expenditure increased by 7 percent to €254 million. This growth was supported by a rise of 13 percent in public-sector revenue, which increased to €93 million and thus covered 40 percent of the group's funding requirements.

The Fraunhofer **ICT Group** combines the expertise of 17 Fraunhofer Institutes and Research Institutions 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-commerce 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 digitalization of historic monuments. In 2015, the group's budgeted expenditure amounted to €250 million, or slightly more than in the previous year. On the income side, industrial revenue increased substantially by 10 percent to €84 million, which represents 35 percent of the group's spending requirements.

The Fraunhofer Group for **Life Sciences** pools the Fraunhofer-Gesellschaft's expertise in the biological sciences, biomedicine, pharmacology, toxicology, and food technology. The 7 member institutes of this group give their customers access to 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. In 2015, the group's budgeted expenditure increased by 6 percent to €168 million. Its industrial revenue grew by 18 percent, which is a higher rate than that achieved by any other Fraunhofer Group. Altogether, project revenue from all sources covered 83 percent of the group's operating expenditure, which is an exceptionally high funding ratio.

Expenditure and revenue of the Fraunhofer Groups in the contract research segment 2015



| | | | | | | |
|---|------------|------------|------------|------------|------------|------------|
| Budgeted expenditure | | | | | | |
| in € million | 491 | 413 | 254 | 250 | 168 | 155 |
| Operating expenditure | 439 | 381 | 234 | 239 | 147 | 137 |
| Capital expenditure | 52 | 32 | 20 | 11 | 21 | 18 |
| Project revenue in € million | | | | | | |
| 362 | 309 | 180 | 182 | 122 | 107 | |
| Industrial revenue | 143 | 193 | 87 | 84 | 49 | 61 |
| Public-sector revenue ¹ | 219 | 116 | 93 | 98 | 73 | 46 |
| Growth in % | | | | | | |
| Budgeted expenditure | 0 | +12 | +7 | +2 | +6 | +6 |
| Project revenue | 0 | –5 | +6 | +5 | +2 | +5 |
| Industrial revenue | –2 | –10 | –1 | +10 | +18 | +12 |
| Public-sector revenue ¹ | +2 | +7 | +13 | +1 | –6 | –2 |
| Project funding ratio in %² | | | | | | |
| All projects | 83 | 81 | 77 | 76 | 83 | 78 |
| Industrial funding | 33 | 51 | 37 | 35 | 34 | 44 |
| Public-sector funding ¹ | 50 | 30 | 40 | 41 | 49 | 34 |

1 Public-sector revenue comprises funding granted by the German federal and state governments and the European 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).

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. Through this work, the group follows in the footsteps of the organization's eponym, Joseph von Fraunhofer, who was the first scientist to measure the absorption lines in the solar spectrum, over 200 years ago. In 2015, the group's budgeted expenditure increased by 6 percent to €155 million. Industrial revenue grew by 12 percent to €61 million, resulting in a project funding ratio of 44 percent and placing the group in second place among the Fraunhofer Groups in this respect.

The Fraunhofer Group for **Defense and Security VVS** brings together the expertise of the 7 defense-related Fraunhofer Institutes and their respective civilian-sector contract research departments. The main focus of its research activities is concentrated on the protection of people, enhancing the security of critical infrastructures, pro-active crisis management, 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 at the European level, and make use of their many networking contacts to carry out joint research activities. In 2015, the group's budgeted expenditure increased by 7 percent to €238 million. This growth is due in equal measure to an increase in the volume of defense research contracts and of contract research for civilian applications.

Financial position

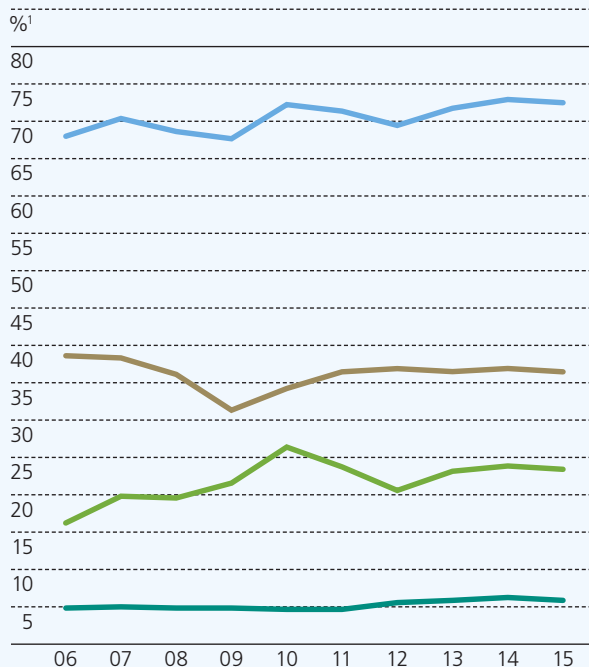
- Relative proportions of funding sources remain stable
- Higher funding ratios needed
- Wide variation in project funding by state governments

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. The proportions of budgeted expenditure covered by industrial revenue and public-sector project funding respectively have grown steadily year on year, confirming that the Fraunhofer Institutes continue to play an important role in Germany's success as a driver of innovation.

The proportion of project revenue from all sources relative to operating expenditure in the contract research segment, including imputed depreciation of capital assets (excluding research institutions in the start-up phase and change in reserve) amounted to 72.5 percent at the reporting date for the fiscal year 2015. Industrial revenue accounted for 36.5 percent of the funding required to cover Fraunhofer's operating expenditure. A further 23.4 percent was covered by project funding granted by the German federal and state governments. Project funding provided by the European Commission contributed an additional 5.9 percent, while the remaining 6.7 percent originated from diverse other sources.

However, these ratios also reflect a downward trend in the proportion of research financed by means of the organization's base funding, which, despite the increases of recent years, has not grown at the same rate as project revenue. Base funding is essential for the Fraunhofer Institutes to pursue independent, pre-competitive research. A solution must be found to prevent

External sources of funding¹ in the contract research segment 2006–2015



■ Project funding (total)²

72.5% (2014: 72.9%)

■ Industrial funding (contract research)

36.5% (2014: 36.9%)

■ Project funding granted by the German federal and state governments

23.4% (2014: 23.9%)

■ Project funding granted by the European Commission

5.9% (2014: 6.2%)

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

2 Includes other sources which account for 6.7 percent of total funding (2014: 5.9 percent).

the share it represents in Fraunhofer's mix of funding sources from declining any further, because otherwise in the long run it will lead to a corresponding reduction in project revenue, which presents the risk of inhibiting Fraunhofer's future growth. This trend could be reversed by introducing a system that ties base funding to business performance, thus providing Fraunhofer with the necessary financial scope to invest in its future growth and create greater capacity for innovation.

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), there are binding rules for determining funding quotas. These generally provide for the application of the full-cost model when allocating project funding to Fraunhofer, thus making it unnecessary to appropriate 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 limited availability of 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 such 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. In the future, given that the state guidelines for the ERDF funding period 2014–2020 place greater emphasis on flat-rate costing, with the result that significant items previously recognized under the full-cost model are no longer reimbursed, it is probable that funding quotas will decrease. 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 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 economic growth and prosperity.

Net asset position

- Total assets approaching €2.9 billion
- Structure of assets dominated by property, plant and equipment (nearly 70 percent)

The Fraunhofer-Gesellschaft's total assets at the reporting date of December 31, 2015, amounted to €2856 million, or slightly above the previous year's level. Fixed assets increased by a total of €33 million to €1994 million, of which €1961 million related to property, plant and equipment. At the reporting date, property, plant and equipment represented almost 70 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 €21 million.

Current assets decreased by €23 million compared with the previous year to €847 million. Inventories net of advance payments received amounted to €21 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, the total amount of receivables and other assets decreased to €542 million. Trade receivables increased to €14 million.

Marketable securities increased by €32 million to €231 million. In 2015 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 balance available on the Fraunhofer-Gesellschaft's checking accounts, increased by €22 million to €53 million, of which €27 million was set aside for investment as part of the special reserve for license-fee revenue.

Prepaid expenses and deferred charges, which mainly relate to prepaid rent and to maintenance contracts services, increased by €4 million to €14 million.

Total equity rose slightly compared with the previous year and amounted to €16 million at the reporting date. In addition to an amount of €15 million carried forward, the capital of the non-profit organization also includes €1 million recognized as a restricted reserve. The non-profit organization's capital is that portion of the Fraunhofer-Gesellschaft's assets that has not been acquired out of public funds. For the purposes of asset management, equity is also deemed to include the special reserves for license-fee revenue and for grants relating to fixed assets in addition to the capital of the non-profit organization and the restricted reserve.

The special reserve for license-fee revenue increased by €29 million in 2015 and amounted to €258 million at the reporting date. This net increase represents the difference between the amount of €11 million that was utilized and the amount of nearly €40 million that was transferred to this reserve.

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 €33 million to €1979 million in 2015, 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 2015, this reconciliation item decreased to €194 million.

The special reserve created to account for the present value of future payments in connection with the sale of patent rights amounted to €80 million.

Provisions for pensions and similar obligations amounted to €10 million. The pension provisions are measured using the capitalized value of the pension obligations at the reporting date as calculated by the reinsurer.

Other provisions decreased by €5 million to €137 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 grants 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 2015, total current liabilities decreased by €14 million to €177 million. This item included €94 million in unappropriated grants from the German federal and state governments, €73 million in trade payables, and €10 million in other current liabilities.

Deferred income amounted to €5 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 after the reporting date that are material to the assessment of the Fraunhofer-Gesellschaft's business performance in the year under review or that have a significant impact on its financial position, net assets or operating result.

Subsidiaries, equity investments and spin-offs

- Shareholdings in a total of 85 companies
- Greater investment in technology-sharing ventures
- Creation of Fraunhofer's first German subsidiary, PIA gGmbH

At the reporting date, the Fraunhofer-Gesellschaft held **equity investments** in a total of 85 companies operating in a wide range of market sectors. The transfer of technology to industrial applications was the main reason for Fraunhofer's investment in 62 of these companies, while the remaining 23 were of a strategic nature. In 2015, Fraunhofer added seven companies to its investment portfolio and divested its shares in one company. The total carrying amount of these equity investments at the reporting date was €9.8 million, or €3.7 million more than in the previous year. A large part of this increase was due to a further injection of capital by Fraunhofer into Prolupin GmbH. This company's outstanding research had been honored in 2014 with the award of the German Future Prize – the Federal President's Award for Technology and Innovation.

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.

Another important event in 2015 was the creation of Fraunhofer's first-ever German subsidiary, **PIA gGmbH**. The not-for-profit limited-liability company with the registered name "Produktinformationsstelle Altersvorsorge gemeinnützige GmbH" is based in Kaiserslautern and is a wholly owned subsidiary of the Fraunhofer-Gesellschaft. Its purpose is to serve as an independent evaluator of pension insurance products, working under contract to the German Federal Ministry of Finance (BMF).

Established in 1994, **Fraunhofer USA, Inc.**, is a wholly owned, not-for-profit subsidiary of the Fraunhofer-Gesellschaft headquartered 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. Based on provisional data, the budgeted expenditure of Fraunhofer USA in 2015 amounted to the equivalent of around €37.7 million, while its project revenues generated by contracts with third parties, translated into euros, totaled €19.4 million. With U.S.-dollar revenues equivalent to €7.2 million, the Center for Molecular Biotechnology CMB was once again the best-performing Fraunhofer Center in the United States.

Fraunhofer's Austrian subsidiary, **Fraunhofer Austria Research GmbH**, started operating from its headquarters in Vienna in 2009. The Fraunhofer-Gesellschaft is the sole owner of this not-for-profit, limited-liability company. The legal entity Fraunhofer Austria covers the activities of two Fraunhofer Institutes at two locations in Austria: the Production Management and Logistics unit in Vienna and the Visual Computing unit in Graz. Based on the available provisional data, Fraunhofer Austria's operating budget in 2015 amounted to €3.3 million and its project revenue totaled €2.4 million.

Together with the Trade Association of South Tyrol, Fraunhofer established the not-for-profit subsidiary **Fraunhofer Italia Research Konsortial-GmbH** with headquarters in Bolzano in 2009. The Fraunhofer-Gesellschaft holds 99 percent of the shares in this entity that represents the legal interests of present and future Fraunhofer Centers operating in Italy, such as the Fraunhofer Innovation Engineering Center IEC in Bolzano, which receives base funding from the Autonomous Province of Bolzano – South Tyrol. Under the terms of the province's current research funding program for the period from 2015 to 2018, the center can expect to receive a total of around €4.9 million in base funding from this source. In 2015, Fraunhofer Italia had an operating budget of €1.4 million, of which approximately €0.5 million was covered by project revenue 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. It jointly manages the Fraunhofer Centre for Applied Photonics CAP in a collaborative venture between the Fraunhofer Institute for Applied Solid State Physics IAF in Freiburg, Germany, and the University of Strathclyde in Glasgow. According to the preliminary data for 2015, Fraunhofer UK's operating budget translated into euros amounted to €2.9 million, of which the equivalent of €2.0 million was covered by project revenue.

Domiciled in Santiago de Chile, the **Fundación Fraunhofer Chile Research** was set up in 2010 with the legal status of a not-for-profit foundation, solely owned by the Fraunhofer-Gesellschaft. Initially created to manage the Fraunhofer Center for Systems Biotechnology CSB, the Center for Solar Energy Technologies CSET was added in 2014 and has since been expanded. Based on provisional data and translated into euros, Fraunhofer Chile's operating expenditure in 2015 amounted to €4.7 million and revenue from its projects with third parties was just short of €1.0 million.

The **Associação Fraunhofer Portugal Research** is based in Porto and was created in 2008 as a not-for-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 2015 and its budgeted expenditure amounted to €2.7 million.

In Sweden, the **Stiftelsen Fraunhofer Chalmers Centrum för Industrimatematik** was founded in 2001 as a not-for-profit foundation under Swedish law. The Fraunhofer-Gesellschaft and Chalmers University in Gothenburg 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 the provisional financial data for 2015, the FCC generated project revenues of €3.5 million from a research budget of €4.7 million.

In addition to its subsidiaries, the Fraunhofer-Gesellschaft's equity interests also include spin-offs created by former Fraunhofer employees, in which it frequently acquires a minority shareholding for numerous different reasons.

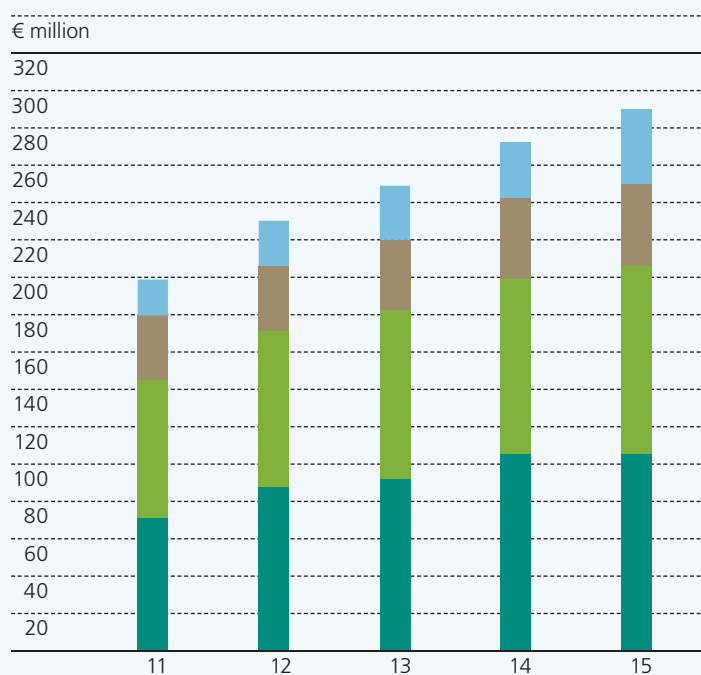
Spin-offs play a very important role as an avenue through which Fraunhofer can capitalize on its intellectual property rights. The Fraunhofer Venture department typically provides support to the founders of spin-off companies during the early stages of the creation process; in certain cases, Fraunhofer enters into a technology transfer agreement with the new company in return for a consideration in the form of a minority share in the company's equity. 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 spheres as the Fraunhofer-Gesellschaft. 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 2015, Fraunhofer Venture provided support to 27 new spin-off projects, and 24 new businesses were established as spin-offs from the Fraunhofer-Gesellschaft.

Under the framework of the "FFE – Fraunhofer Fosters Entrepreneurship" program, Fraunhofer granted funds totaling €1.3 million to a further eleven spin-off projects in 2015. Under a parallel initiative, the "FFM – Fraunhofer Fosters Management" program, seven start-ups in which the Fraunhofer-Gesellschaft holds an equity interest received financial support totaling €0.4 million in 2015. The aim of this program is to enable the executives of these companies to improve their management skills.

Overall, the Fraunhofer-Gesellschaft expects the positive trend in its spin-off activities to continue in the medium term. A new proactive approach is offered by the latest program: "FDays". With its focus on business design and reducing critical uncertainties, this program aims to empower selected groups of Fraunhofer intrapreneurs by systematically breaking down preconceived ideas in order to accelerate start-up activities. In 2015, an additional, financial, incentive was introduced in the form of a spin-off award for institutes that take the bold step of choosing this technology transfer route despite the uncertainties with which it is often associated.

Revenue from work with international customers and partners 2011–2015



| | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|------------|------------|------------|------------|------------|
| Asia | 18 | 24 | 29 | 30 | 40 |
| North and South America | 35 | 35 | 38 | 44 | 44 |
| European countries | 74 | 84 | 90 | 94 | 101 |
| EU revenue (European Commission) | 71 | 88 | 92 | 106 | 105 |
| Other countries | 2 | 2 | 1 | 2 | 1 |
| = Total international revenue¹ in € million | 200 | 233 | 250 | 276 | 291 |

¹ This includes income generated by international subsidiaries with third parties, which amounted to €27 million in 2015.

International activities

- International revenue continues to grow
- Highest growth rate of 33 percent registered in Asia
- Added value through scientific cooperation

International cooperation with high-caliber research partners and innovative companies around the world enables Fraunhofer to secure its future by strengthening its capacity for innovation. By working in collaboration with the best in every field, Fraunhofer is able to meet future global challenges with innovative and durable solutions.

Fraunhofer's internationalization strategy focuses on managing its research activities in a competitive international environment and builds on the principle that the essential aspects of any strategic international collaboration are that it creates scientific added value for Fraunhofer while generating positive effects both for Germany and for the partner country concerned.

Before engaging in international activities, Fraunhofer evaluates their impact on a scientific, economic and regional level based on a thorough analysis of specific research markets and scientific partners by knowledgeable experts in the Fraunhofer Institutes and Groups. The findings of these experts are complemented by a more general analysis covering aspects such as the innovative strength of the country in question and the strength of its ties with German industry.

Fraunhofer has developed a number of instruments and internal guidelines governing its long-term engagement in activities outside Germany. All international activities are monitored by Fraunhofer's quality management teams and their results are subject to continuous assessment.

In 2015, **revenue generated from projects with international partners** increased by 5 percent to a total of €291 million (excluding license-fee revenue). This sum includes €27 million in income that Fraunhofer's international subsidiaries generated with third parties.

International revenue generated in Europe increased in 2015 by 3 percent to a total of €206 million. The proportion of this revenue originating from **European customers** outside Germany amounted to €101 million, which represents an increase of 8 percent. Switzerland and Austria are the most important European markets, each contributing €18 million to Fraunhofer's revenues, followed by the Netherlands and the United Kingdom with €10 million each and France with €9 million. These industrial revenues are complemented by public-sector project funding, one of the major sources of which is the **European Commission**. In 2015, revenue from EU project funding amounted to €105 million, which is on a par with the previous year's level. This is particularly remarkable given that many projects sponsored during the previous ERDF funding period were completed and thus no longer eligible for support in 2015. 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".

A recent example of European cooperation is the participation of the Fraunhofer Institute for Medical Image Computing MEVIS in an ICON (intercultural online health network) project. The institute's research partner in this project is the Diagnostic Image Analysis Group (DIAG) based at the Radboud University Medical Center in Nijmegen, the Netherlands, one of the world's leading research groups in the field of medical identification and diagnostics. The role of Fraunhofer MEVIS in this project focuses on imaging and visualization techniques, workflow design and numerical modeling, while the DIAG contributes its expertise in computer-assisted diagnosis and

automated pathological image analysis and classification. Because the DIAG is embedded in a university clinic, research findings can be rapidly translated into clinical applications, thus gradually optimizing routine clinical procedures for the end user.

In 2015, Fraunhofer's revenues from projects in **North and South America** amounted to €44 million, which is the same as in the previous year. The United States accounted for €39 million of this total, €19 million of which was generated by the organization's North American subsidiary Fraunhofer USA, Inc. With revenues of €2 million in 2015, Brazil once again constituted Fraunhofer's most important market in South America.

Early 2015 saw the official inauguration of the Fraunhofer Project Centre for Biomedical Engineering and Advanced Manufacturing at McMaster University – BEAM, which is jointly run by the Fraunhofer Institute for Cell Therapy and Immunology IZI and McMaster University in Hamilton, Canada. The Project Centre conducts research into challenging areas of the life sciences and healthcare, and aims to develop cell-based therapeutics, diagnostic methods and devices, novel biomaterials, and innovative manufacturing processes and automated systems. Among the projects currently in progress, one relates to novel biosensor technologies that will enable manufacturing processes for cell-based therapeutics to be monitored in real time, while another focuses on the development of diagnostic tools and the corresponding industrial-scale manufacturing processes for point-of-care diagnostics.

In terms of global economic development, research and development expenditure has been growing at a very high rate in recent years, especially in **Asia**. Fraunhofer's revenues in Asia grew substantially in 2015, increasing by 33 percent to a total of €40 million. Japan and China were by far the strongest Asian markets, generating revenues of €14 million and €12 million respectively, followed by South Korea with €4 million. Revenue from the countries of the Middle East has also been rising steadily over the past few years to reach a total of €6 million in 2015.

In 2015, the Fraunhofer Institutes for Building Physics IBP and for Structural Durability and System Reliability LBF started working on an ICON project in collaboration with the Institute of Acoustics at the Chinese Academy of Sciences, one of the world's leading centers of expertise in metamaterials, a new discipline in the field of acoustics. Low-frequency sound waves are a particularly troublesome source of noise pollution. An increasing number of studies indicate that exposure to this type of noise represents a serious danger to health. It is therefore likely that stricter government regulations will be introduced in the not-too-distant future. Acoustic metamaterials offer a means of channeling such disturbing sound waves so as to reduce their environmental impact. Their unique properties have already attracted the interest of manufacturers in major industrial sectors such as aerospace, rail technology, building construction and production machinery, but a considerable amount of development work remains to be done before metamaterials reach commercial maturity.

Various events held in 2015 to celebrate the 50th anniversary of the establishment of diplomatic relations between Germany and Israel shone a spotlight on the excellent scientific and business ties that meanwhile exist between the two countries. For Fraunhofer, Israel is a highly valued research partner. In 2015, Fraunhofer intensified its collaboration with centers of excellence in Israel, mainly in the fields of medical research, cybersecurity and nanotechnology.

Intellectual property activities

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

Compared with other German research organizations, Fraunhofer comes out top with the highest number of inventions, new patent applications and total number of patents held.

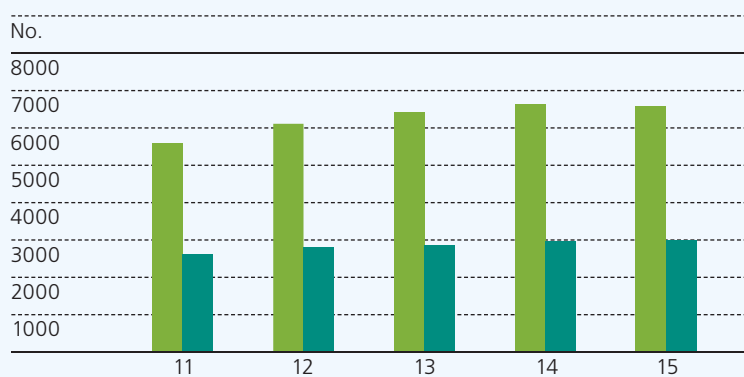
Even when compared with industrial companies Fraunhofer's output is outstanding. For ten years in succession, Fraunhofer has ranked among the German Patent and Trade Mark Office's 15 most prolific patent applicants, and is one of the top ten in the register of trade marks. Similar statistics compiled by the European Patent Office (EPO) have placed Fraunhofer among the 50 most active patent applicants for many successive years.

As a result of applying a more professional IP management strategy, in which inventions undergo a selection procedure that involves evaluating them according to precise criteria, the number of patent applications has decreased slightly in recent years. Nonetheless, with 506 applications based on the newly defined priorities, Fraunhofer is still filing more than two patent applications per working day. Fraunhofer's portfolio of active patents and utility models and pending patent applications has expanded steadily over the years. The number of patent families has nonetheless decreased to 6573, due to the consolidation of certain patent portfolios held by individual institutes. The total number of newly registered German patents owned by Fraunhofer exceeded 3000 for the first time in 2015. Exploitation agreements were signed for a total of 3015 active contracts in 2015. As a result of this performance, Fraunhofer ranked among the **Top 100 Global Innovators** for the third year in succession – a status it shared with three other German industrial companies in 2015. This award is presented annually by the Thomson Reuters media group on the basis of the number and quality of patented inventions.

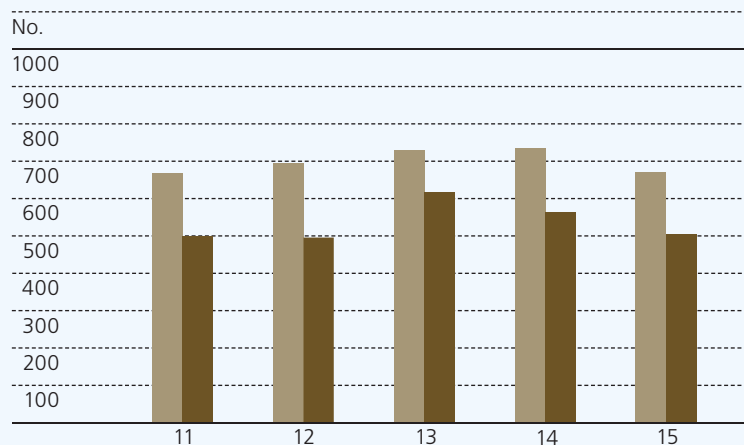
Since 2014, the responsibility for managing the Fraunhofer-Gesellschaft's IP rights has been integrated into the Executive Board function Technology Marketing and Business Models, which is tasked with expanding activities related to the commercialization of IP assets. The marketing efforts of the new department created for this purpose benefit from the business orientation of the new board-level function, which applies a cross-institute approach to these activities. This widens the scope of the previous patent strategy process, which 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 an earnings-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 revenue 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-Zukunftsstiftung (Fraunhofer Future Foundation) promotes in-house research projects that it has identified as being crucial to future market demand. The German Council of Science and Humanities (Wissenschaftsrat) has spoken out in favor of continuing this aspect of the Foundation's work, on the grounds that it provides Fraunhofer with the independent financial resources it needs to engage in innovative, long-term, pre-competitive research projects. Fraunhofer's traditional business model as it stands would not be able to do this.

Invention disclosures and patent applications by the Fraunhofer-Gesellschaft 2011–2015



| | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|------|------|------|------|------|
| Active invention disclosures ¹ | 5657 | 6103 | 6407 | 6625 | 6573 |
| of which patents valid in Germany | 2605 | 2794 | 2847 | 2955 | 3001 |



| | 2011 | 2012 | 2013 | 2014 | 2015 |
|---------------------------------------|------|------|------|------|------|
| Invention disclosure reports per year | 671 | 696 | 733 | 736 | 670 |
| Patent applications per year | 500 | 499 | 616 | 563 | 506 |

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

EMPLOYEES

Overview

- Workforce up to more than 24,000 employees
- Equal opportunities at work remain the top priority in terms of diversity management
- Support for future specialists in the STEM fields at all stages of education

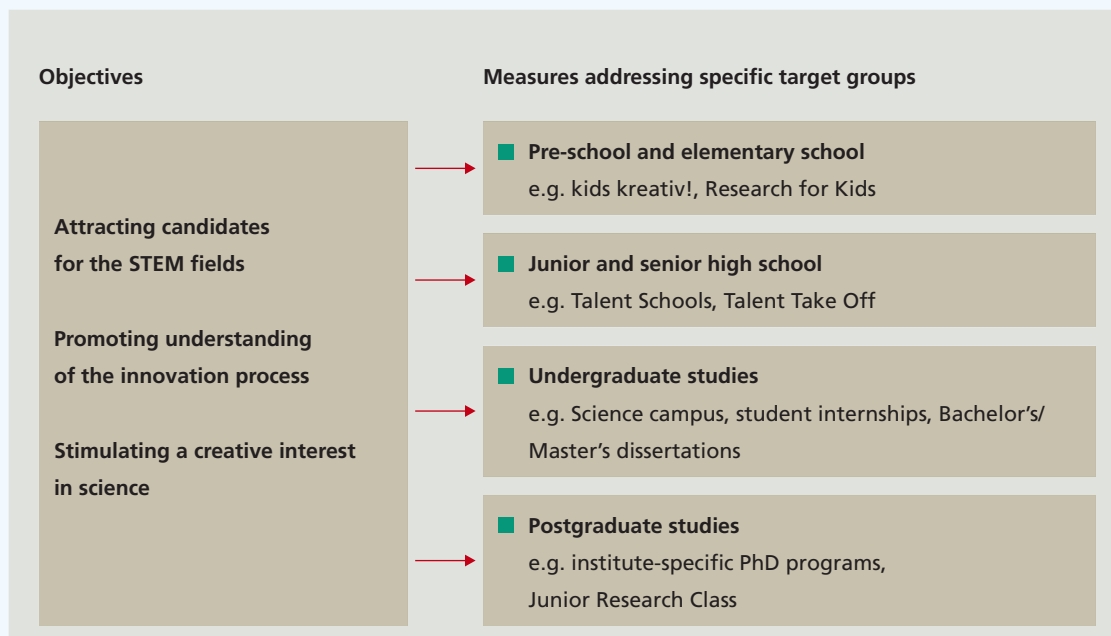
At December 31, 2015, Fraunhofer had 24,084 employees, most of whom hold degrees in the natural sciences or an engineering discipline. This represents an increase of nearly 300 or 1.3 percent in the number of employees. While the number of permanent employees increased by 2.3 percent, the number of PhD candidates and other postgraduate and undergraduate students was slightly lower than in the previous year.

Providing **equal professional opportunities** is and will remain one of the top priorities in Fraunhofer's diversity management strategy, which has been continuously improved and systematically driven forward in the past ten years. It incorporates scientific findings derived from studies of the national and international context as well as employees' opinions based on in-house surveys. In a parallel initiative, the Executive Board decided to allocate a total of €22 million over the period from 2014 to 2019 to programs to promote personal career development and to improve the working environment accordingly. Following the principle that providing equal professional opportunities is a management responsibility, and in consultation with the institute management, the Executive Board has decided to include the diversity targets agreed with the BMBF in the variable compensation for members of institute management from 2017 onward.

Fraunhofer's mission as an employer is to train qualified specialists for future roles in society, be they in industry, science or entrepreneurship. In doing so, Fraunhofer does not focus solely on trainees with purely scientific ambitions. The key issue lies more in generating a **broad interest in the STEM fields** (science, technology, engineering and mathematics) and providing support to future specialists in these fields throughout all stages of their education. To do so, Fraunhofer has developed and implemented a holistic concept that specifically addresses this target group. Through its presence on the web and in the social media, including a career fan page on Facebook, Fraunhofer reaches the attention of some 70,000 children, adolescents and students every year.

An important instrument Fraunhofer utilizes to assure the future supply of adequately trained non-scientific personnel is its **vocational training** program, which has been continuously enhanced in recent years. This program is mainly intended to cover Fraunhofer's own needs for qualified specialists. In October 2015, a total of 452 trainees were enrolled on courses at various Fraunhofer locations, leading to qualifications in 40 different professional disciplines, including 19 dual courses in which periods of classroom study alternate with practical experience. In 2014, Fraunhofer had 480 trainees. The decrease is due to numerous contributing factors including changes in the qualifications needed for certain jobs and hence changes in the content of training courses or altered recruitment requirements. Fraunhofer is attentively observing these developments and intends to adapt its vocational training program accordingly.

Fraunhofer's role in the education system



In addition to the usual content of such training courses, Fraunhofer organizes special seminars designed to enhance the trainees' social and methodological skills. Trainees are also offered the possibility of getting to know other Fraunhofer locations by participating in an exchange scheme that allows them to swap places with another trainee at a different Fraunhofer Institute for a two-week period, giving both of them the chance to expand their knowledge of other working practices and areas of research.

Diversity is the lifeblood of innovation. Fraunhofer's internationalization strategy aims to leverage the potential inherent in diversity – and this in turn implies further challenges for the HR management at Fraunhofer. An **international HR project** was launched in 2015 with the aim of identifying requirements and developing suitable instruments and tools. The main topics of interest include recruitment in other countries, provision of HR support to an international workforce, and mobility programs.

In 2015, as in previous years, Fraunhofer ranked among the top ten preferred employers, as illustrated by the latest independent surveys conducted by recognized agencies such as Universum. To maintain this status in the long term, Fraunhofer carries out its own **organization-wide employee surveys** at four-year intervals. On the basis of the results of the 2011 in-house survey, Fraunhofer defined six action areas: management, career, innovation, compensation, networking and project work. Progress has been made throughout the organization in each of these areas in the past four years. Results include the guidelines for management training, a new model for career planning and professional development based on essential skills, and a new agreement with the Central Works Council concerning the distribution of profit-sharing bonuses. The response rate for the employee survey held at the end of 2015 was 81.4 percent, and thus higher than in 2011. The results of the 2015 survey will be presented to the institutes in the first quarter of 2016 and subsequently analyzed in a structured follow-up process.

Personal career development

- Short-term contracts are an integral part of Fraunhofer's human resources policy
- Focus on personal career planning and development during the qualification stage

Fraunhofer welcomes the reform of the Academic Fixed-term Contract Act (WissZeitVG). The corresponding guidelines introduced by Fraunhofer in 2013 acknowledge the fact that short-term contracts are an integral part of Fraunhofer's HR policy, through which it meets its obligations as a source of intellectual resources for industry and science. The duration of these limited-term contracts with Fraunhofer depends on the personal career plans of each individual employee. In critical cases, where an employee has cumulated several short-term contracts, these guidelines allow such situations to be evaluated and processed. On the whole, since the introduction of the new guidelines in 2013, the proportion of scientific, technical and administrative personnel employed under short-term contracts has decreased by 2.7 percentage points to 48.6 percent.

Each year, around 1000 employees leave Fraunhofer after a few years in order to pursue their **individual career paths** in industry, other research posts or by setting up their own companies. This is perfectly in tune with Fraunhofer's mission of providing highly qualified workers for tasks of social importance. During their time at Fraunhofer, these people have acquired skills consistent with their future career ambitions. Starting in 2016, Fraunhofer will carry out an online exit survey of all employees who decide to leave in order to assess the extent to which Fraunhofer has contributed to their professional skills, the reasons why they have decided to quit Fraunhofer, and the direction in which they wish to move on after their time with Fraunhofer.

For employees who wish to continue their career with Fraunhofer, as of 2015 they now have the option of choosing between a path that leads to a management post and one that allows them to obtain an equivalent status as a senior researcher or research assistant at a Fraunhofer Institute. Both options are open to scientific and non-scientific personnel.

Fraunhofer has developed a model for career planning and professional development that describes the essential skills required for specific job profiles. In the case of managers, it explicitly defines the skills needed to carry out this type of work in accordance with the guidelines for management training. These form the basis of all career development activities for managers, and cover management skills, leadership skills and personal skills.

As part of the employee onboarding process, a joint introductory event is held for new Fraunhofer employees to complement similar activities in the individual institutes. The two-day event at the Fraunhofer House in Munich enables the new recruits to experience Fraunhofer “live” and familiarize themselves with the world of research at Fraunhofer. This event serves an essential purpose in that it helps new employees to identify with Fraunhofer almost immediately.

The **Junior Research Class** is a new career development program introduced by Fraunhofer in 2015 that challenges young Fraunhofer researchers to resolve scientific challenges by proposing original ideas, stimulating new inventions, and applying cross-disciplinary solutions. It focuses on scientific excellence and application-oriented pre-competitive research. The one-year program addresses researchers who have been working at Fraunhofer for three or four years and have either already obtained a PhD or are in the final phase of their doctorate studies.

The **“Step forward”** mentoring program provides support to Fraunhofer employees in both scientific and non-scientific posts who wish to prepare for their next career move. It specifically addresses highly motivated employees who have been working at Fraunhofer for at least four years. The program provides one-to-one mentoring by an experienced specialist or manager and includes workshops dealing with topics such as “choosing the right location”, “career advancement checklist”, and “self-marketing, or how to be my own PR officer”.

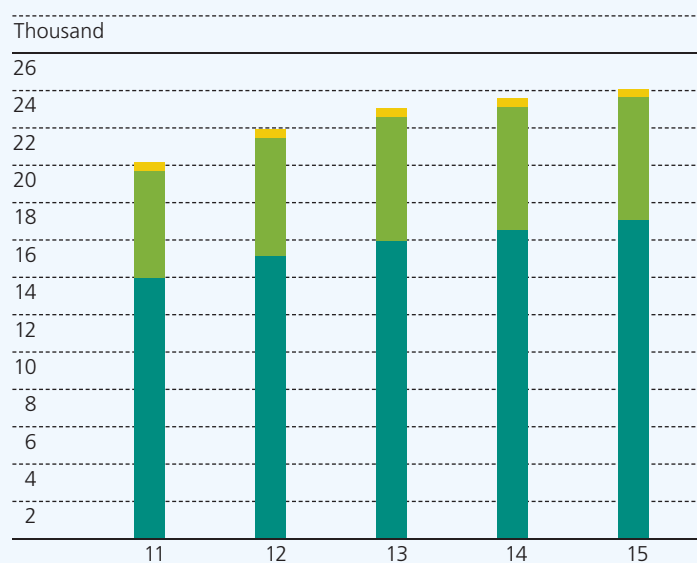
The **TALENTA** program was added to the range of career development programs for specific target groups in 2013. It offers support to women who wish to establish a career as scientists or managers at Fraunhofer. The program consists of three streams: “speed up” and “excellence” are designed for management candidates or established managers, whereas “start” is for women just starting their careers and provides support and orientation during their first steps as professional scientists.

“Attract” is another Fraunhofer management support program, in this case for postdocs. Its aim is to recruit and promote outstanding researchers from outside the organization. As the head of an Attract group at one of the Fraunhofer Institutes, they have an opportunity to develop their innovative ideas into real-life applications.

The **Fraunhofer Vintage Class** is an established fast-track program for furthering the career development of scientists with management potential. Over the past ten years, it has helped many participants accede to management-level posts in a Fraunhofer Institute. The program is essentially based on personalized training in areas such as scientific excellence, strategic management, leadership, self-management skills, and international or intercultural competence.

The portfolio of programs and support is complemented by personalized instruments such as coaching, mentoring and conflict mediation training.

Growth in the Fraunhofer-Gesellschaft's workforce 2011–2015



| | 2011 | 2012 | 2013 | 2014 | 2015 |
|--|---------------|---------------|---------------|---------------|---------------|
| Trainees | 488 | 470 | 494 | 480 | 452 |
| Graduate, undergraduate and school students | 5765 | 6403 | 6694 | 6619 | 6554 |
| Scientific, technical and administrative personnel | 14 073 | 15 220 | 16 048 | 16 687 | 17 078 |
| = Total number of employees | 20 326 | 22 093 | 23 236 | 23 786 | 24 084 |

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. 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. The **risk management** system is designed to identify existing and potential risks at an early stage and to manage them 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.

Risks arising from changes in the political, legal or economic framework governing the applied research market are classified as **business risks**.

As a not-for-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. Fraunhofer main-

tains an ongoing dialog with the funding agencies at federal, state and EU level and, if necessary, makes the appropriate amendments to its funding model to ensure that it remains in conformity with current funding legislation.

Political decisions concerning a reduction in planned funding contributions or restrictions placed on carrying forward 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) gives Fraunhofer a measure of security in its medium-term financial planning, but the yearly increase in base funding is now only 3 percent as opposed to 5 percent in the second period, which expired at the end of 2015. Fraunhofer applies a strategy of forward-looking growth management to contain the risk of any further reduction in the proportion of its spending requirements covered by institutional resources, and continues to lobby the German 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 project funding is affected by changes in the supported thematic areas of research and the available funding instruments. This is particularly true in the case of projects funded through the European Framework Programme and to an increasing extent in the case of projects funded by the state governments, many of which are refinanced by the ERDF. A loss of income can also result from changes in funding regulations or a disadvantageous interpretation of such regulations. By carrying out frequent audits and continuously improving its cost management processes, the Fraunhofer-Gesellschaft ensures that it meets the requirements for the reimbursement of incurred expenses, and negotiates with the relevant European and national bodies to obtain their approval of the costing models applied by Fraunhofer.

Fraunhofer counters the risk of a possible decline in its project revenue from industrial research contracts by continuously enhancing its diversified research portfolio and through the development of new acquisition and customer loyalty strategies. Established strategy planning processes permit constant feedback from relevant market players in Germany, Europe and worldwide.

The Fraunhofer-Gesellschaft preserves and expands its research expertise by recruiting highly qualified scientists and encouraging them to stay with Fraunhofer. To ward off the potential risk of being unable to recruit a sufficient number of qualified specialists, Fraunhofer maintains close ties with universities, which are one of its main sources of new employees, and operates a sustainable HR policy geared to its long-term staffing requirements.

Risks arising from the organization's financing activities are classified 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 pre-financing 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 Fraunhofer in the form of additional research contracts or the proceeds of the subsequent disposal of shares in these businesses. The development of equity investments is monitored in close to real time by the financial controlling department.

Financial risks for the Fraunhofer-Gesellschaft may arise from contingent liabilities and operational risks in connection with its international subsidiaries, to the extent that the parent organization has long-term contractual obligations toward the subsidiary in question. The financial controlling department monitors the performance and liquidity of Fraunhofer entities outside Germany in close to real time. The controlling system for Fraunhofer's international activities is updated whenever necessary to take account of changes in the national and international operating environment.

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

By continuously optimizing 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. Continuous improvements to the relevant management and controlling systems are implemented to support the early detection of critical processes and workflows, enabling suitable countermeasures to be developed and applied. The organization's internal auditors carry out regular and ad-hoc audits to verify compliance with internal regulations and control mechanisms.

Through its contract research projects for German and international customers, Fraunhofer is exposed to contingent liabilities 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 multilayer approval process based on the advice of competent lawyers.

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 and those resulting from external threats. These measures are defined in a binding IT security manual.

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

Outlook

On a financial level, the growth of the Fraunhofer-Gesellschaft is driven by 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 German federal and state governments in the past two years, it is all the more gratifying to see that the proportion of contract research expenses covered by external sources of revenue has kept pace with this development, and amounted to 73 percent in 2015. The proportion of expenditure covered by industrial revenues also remained stable in 2015, and amounted to almost 37 percent. This demonstrates the ability of the Fraunhofer Institutes to respond to the rapidly changing demands of the research market while at the same time securing the financial resources needed to set up new project groups.

On the basis of the present volume of contracts, and on condition that general economic trends remain stable, Fraunhofer expects to see further moderate growth in both its industrial revenue and public-sector project revenue in 2016. In the longer term, Fraunhofer's future growth planning will be based on increases in base funding and public-sector support for research projects.

The global race for innovation has greatly intensified in the past decade. Fraunhofer helps its partners in science and industry to accelerate their innovation processes by offering efficient application-oriented research services. 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 that promises to open up a wealth of opportunities for technology transfer from the Fraunhofer Institutes is the Industrial Data Space (IDS) initiative, mentioned earlier in this report under the heading “Strategic development”.

Fraunhofer is also aligning its portfolio with the United Nations’ 17 Sustainable Development Goals, which came into force at the beginning of 2016. Goal 7, for example, is “affordable and clean energy”, while Goal 2 (zero hunger) aims to end hunger, achieve food security and improved nutrition and promote sustainable agriculture. Fraunhofer supports this goal in particular through new business units such as Precision Agriculture and Aquaculture. As a further contribution to sustainable social development, Fraunhofer implements projects in selected emerging economies and developing countries, usually in collaboration with international partners and local aid organizations.

Prof. Dr. Alexander Verl relinquished his post as senior vice president with responsibility for Technology Marketing and Business Models as of September 1, 2015. He is succeeded by Prof. Dr. Georg Rosenfeld, who took up his new duties on April 1, 2016.

Fraunhofer has defined specific objectives that it aims to achieve during the third period of the Joint Initiative for Research and Innovation. One of these is to maintain the present Fraunhofer model in which funding is divided three ways between three complementary sources of revenue: contract research for private industry, public-sector project funding, and base funding. To do so, Fraunhofer intends to appeal to the funding agencies to obtain a higher level of base funding that covers a higher proportion of its budgeted expenditure. Focal areas of Fraunhofer’s HR policy include closer ties with universities, through joint appointments not only for institute directors but also for managers in general, and the develop-

ment of a wider range of options in the interests of diversity management. Other major aspects of Fraunhofer’s future development plans include sustainability management, the identification of thematic areas of research, and portfolio management.

In terms of its organizational structure and research portfolio, Fraunhofer is ideally equipped to meet future technological and social challenges, and thus in an excellent position to serve as a partner in innovation and pacemaker for science and industry today as in the past. 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 2015.

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

REPORT OF THE SENATE ON THE FINANCIAL YEAR 2015

The Fraunhofer-Gesellschaft continued to make successful progress in 2015. In an otherwise difficult global economic environment, the German economy once again proved to be remarkably stable. The demand for applied research and development services continued to rise, especially on the part of industry, resulting in the organization's highest-ever level of industrial research contracts. Moreover, the German federal government maintained its positive stance on support for research and innovation.

The Fraunhofer-Gesellschaft's positive financial statements for 2015 again received an unqualified audit certificate from the independent auditors.

In 2015, 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: on June 9 at the Wiesbaden Kurhaus and on October 7 at the Fraunhofer Forum in Berlin.

The main decisions taken in accordance with the Statute concerned the Fraunhofer-Gesellschaft's structure and the composition of the Executive Board:

- As of January 1, 2016, the Fraunhofer Research Institution for Polymeric Materials and Composites PYCO was integrated into the Fraunhofer Institute for Applied Polymer Research IAP in Potsdam-Golm, thus concentrating the organization's polymer research activities in the state of Brandenburg. The aim of this move is to enable Fraunhofer PYCO to expand its present area of expertise by generating synergies with the research areas until now dealt with solely by Fraunhofer IAP. Prof. Dr. Alexander Böker has been the director of Fraunhofer IAP since February 1, 2015.
- The Halle branch of the Fraunhofer Institute for Mechanics of Materials IWM, headquartered in Freiburg, became an independent Fraunhofer Institute on January 1, 2016, operating under the name of Fraunhofer Institute for Microstructure of Materials and Systems IMWS and led by Prof. Dr. Ralf B. Wehrspohn. The two branches of Fraunhofer IWM have been very successful in their respective fields in the past few years. By separating them into two independent organizational units, each will be able to concentrate on a specific area of expertise. The Freiburg branch will continue to operate as the Fraunhofer Institute for Mechanics of Materials IWM.



- As of January 1, 2016, the former “Mechatronics Design” project group at the Fraunhofer Institute for Production Technology IPT became the independent Fraunhofer Research Institution for Mechatronic Systems Design IEM in Paderborn, directed by Prof. Dr.-Ing. Ansgar Trächtler. The project group has developed its own strong identity in the fields of interdisciplinary mechatronics design technology and advanced system engineering, both in terms of research focus and market ties.
- Prof. Dr. rer. publ. ass. iur. Alexander Kurz was elected by the Senate for a second term of office as Senior Vice President Human Resources, Legal Affairs and IP Management from June 1, 2016 to May 31, 2021.

Prof. Dr.-Ing. Dr. h. c. mult. Alexander Verl relinquished his post as Senior Vice President Technology Marketing and Business Models as of September 1, 2015, at his own request. His decision, barely two years after his appointment, was motivated by personal reasons. The Senate thanks him for his successful and dedicated work as a member of the Executive Board.

The Senate elected a new chairman at its meeting on October 7, 2015. With effect of January 1, 2016, this office is held by Prof. Dr.-Ing. Heinz Jörg Fuhrmann, CEO of Salzgitter AG. His long-serving predecessor, Prof. Dr.-Ing. Ekkehard D. Schulz, was awarded the Fraunhofer-Gesellschaft’s highest distinction, the Fraunhofer Medal, on this same occasion. The Senate wishes to thank the Executive Board and all employees of the Fraunhofer-Gesellschaft for their commitment and successful work in the financial year 2015.

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

INSIDE THE FRAUNHOFER SENATE

AT THEIR ANNUAL ASSEMBLY, THE MEMBERS OF THE FRAUNHOFER-GESELLSCHAFT ELECT LEADING FIGURES FROM THE WORLDS OF SCIENCE, INDUSTRY, BUSINESS AND PUBLIC LIFE TO SERVE ON THE FRAUNHOFER SENATE FOR A THREE-YEAR TERM OF OFFICE. HERE WE PRESENT PROFILES OF TWO NEWLY ELECTED SENATORS AND THE NEW CHAIRMAN.



PROF. DR.-ING. HEINZ JÖRG FUHRMANN

Prof. Dr.-Ing. Heinz Jörg Fuhrmann took office as the chairman of the Fraunhofer Senate at the beginning of 2016.

Heinz Jörg Fuhrmann studied metallurgy and economics. He started his career in the steel industry at Klöckner-Werke AG before moving on to Preussag Stahl AG (the forerunner of today's Salzgitter AG), where he was appointed to the group's executive board in 1996. Heinz Jörg Fuhrmann has been the CEO of Salzgitter AG since 2011. He has also held a post as visiting lecturer at RWTH Aachen University since 2003, and became a member of the Senate of the Fraunhofer-Gesellschaft on January 1, 2014.

"In my role as chairman of the Senate, I intend to devote my efforts to ensuring that Fraunhofer is able to fulfill its eminently important function as a bridge between top-class basic research and the application of the results of this research as efficiently and productively as it has done in the past."

Heinz Jörg Fuhrmann's predecessor as chairman of the Fraunhofer Senate was Prof. Dr.-Ing. Ekkehard D. Schulz, who held this post from 2008 to the end of 2015. Fraunhofer President Reimund Neugebauer presented the departing chairman with the Fraunhofer-Gesellschaft's highest distinction, the Fraunhofer Medal, in honor of his outstanding and lasting services to the research organization. Ekkehard Schulz was also thanked on behalf of the German government by Thomas Rachel, parliamentary secretary to the German Federal Ministry of Education and Research (BMBF), for his extraordinary commitment. During his term of office, Ekkehard Schulz nurtured and supported numerous strategic developments, including internationalization, the integration of research institutions, and the creation of the Fraunhofer-Zukunftsstiftung (Fraunhofer Future Foundation).



DR. SABINE HERLITSCHKA

Dr. Sabine Herlitschka became a member of the Fraunhofer Senate on January 1, 2016.

Sabine Herlitschka holds a PhD in food science and biotechnology, worked as a postdoc researcher in the biotech industry, and also holds an MBA in general management. The diverse stages of her professional career also include coordinating and raising funds for joint international research and technology projects and internships with renowned institutions in the United States such as the U.S. National Science Foundation. She also held a Fulbright scholarship, and was the first vice-rector for research management and international cooperation at the Medical University of Graz.

Until 2011, Sabine Herlitschka was director of the Division of European and International Programs at the Austrian Research Promotion Agency (FFG), with responsibility for the operational management of European research and technology programs in Austria and for the coordination of pioneering European projects. In 2011, she joined Infineon Technologies AG Austria, shortly thereafter becoming its Chief Technology Officer and, in April 2014, its Chief Executive Officer. She is also a member of numerous national and European expert groups.

“The Fraunhofer-Gesellschaft is one of the leading application-oriented research organizations in the European research area, and I am looking forward to having the privilege of contributing to its success story. Fraunhofer and Infineon have a point in common in that they both focus on major social challenges. At Infineon we make people’s lives easier, safer and greener – with technology that can do more while consuming less, and is accessible to everyone. Digitalization is an issue that poses many particularly difficult and varied questions. Research and technology deliver the answers we need in order to benefit fully from the opportunities digitalization has to offer. I intend to play an active role in this process.”



PROF. DR. WILTRUD TREFFENFELDT

Prof. Wiltrud Treffenfeldt became a member of the Fraunhofer Senate on January 1, 2016.


Wiltrud Treffenfeldt is Chief Technology Officer Europe, Middle East, Africa and India for Dow Europe GmbH, based in Horgen, Switzerland. As such, she is responsible for the company's innovation strategy, which among other things includes setting up an innovation center at King Abdullah University of Science and Technology (KAUST) in Saudi Arabia.

Wiltrud Treffenfeldt has more than 25 years' management experience in industrial, agricultural and pharmaceutical biotechnology and in the chemical industry in Germany and abroad. She worked for Degussa/Evonik as a senior researcher and then as director of corporate biochemical process technology. For over 16 years she taught bioprocess and biomedical engineering at the University of Hannover as a visiting lecturer in the Faculty of Mechanical Engineering. Wiltrud Treffenfeldt holds seats on the supervisory boards of Dow Central Germany and ProBioGen AG, and is a member of the Presidential Council of the German Chemical Industry Association (VCI) and of the German federal government's Bioeconomy Council.

"I have always considered it important for the results of research to be efficiently transformed into marketable products and solutions. These days, innovations are often only possible by applying an interdisciplinary approach involving cross-company collaboration. Fraunhofer has long been a highly valued partner in this respect, and I am looking forward to the tasks that await me as a Senator of the Fraunhofer-Gesellschaft."



REVIEW OF FRAUNHOFER RESEARCH



REAL RESEARCH FOR REAL PEOPLE

PROJECTS AND RESULTS 2015

INITIATIVES AND
HIGH PERFORMANCE CENTERS

AWARDS 2015

PEOPLE IN RESEARCH

FRAUNHOFER INSTITUTE SPIN-OFFS



REAL RESEARCH FOR REAL PEOPLE

Rainer Fischer, Marion Weissenberger-Eibl

From personalized medicine to global health issues, from your very own home to this planet we share, from the lowly dandelion to our carbon footprint: Fraunhofer researchers are considering people's day-to-day lives from every angle. No matter how large or small the issue, it will be looked at from many different perspectives, because we are focusing on people and the world they live in. Every project we undertake, every question we ask, has a practical aspect to it. And whatever the solutions, they will have a direct impact on us as individuals: they could take the form of a new medical therapy or diagnostic tool; they could address our mobility and solve future problems of transportation; they could address people's housing needs, work, and even life itself. Our research considers how to protect the environment and the security of our data. What sources of energy can we use more sustainably and efficiently in the future? What is the future of communications and production? Fraunhofer is addressing society's most pressing issues and how these issues affect us as individuals in major aspects of our lives.

Fraunhofer researchers take a systems-oriented approach to find answers to these important questions. We think outside the box and work hand in hand to achieve results more efficiently and quickly – in cross-institute projects, Fraunhofer Alliances and Fraunhofer Groups. We engage in projects and solutions that pay no heed to national borders.

1 Biomarkers indicate specific molecules in the body and provide valuable information for diagnosis and therapy.

It all starts with health

Good health is essential for people's quality of life and our zest for life. Medical advances have enabled us to cure, mitigate and prevent ever more diseases, but still we face immense challenges. In the West, for example, we are living longer, but not necessarily healthier, lives: more and more people are suffering from neurodegenerative diseases, cancer, or cardiovascular problems. Global health also presents us with major hurdles; these include multi-resistant bacteria, which are a threat to people in both industrialized societies and developing countries. In addition, the so-called diseases of poverty and neglect – like tuberculosis, malaria and Ebola – are of global concern.

How is Fraunhofer addressing these challenges?

Individual diagnostic tools and therapies

Our goals are to help detect diseases as early as possible, to better predict the course of an illness, and to find better, or new drugs to treat them in the future. With medicine becoming more personalized, the ability to classify diseases precisely and select the ideal treatments is more important than ever. For example, we are researching new biomarkers for different types of cancers and multiple sclerosis. Biomarkers are molecules that can be measured to provide valuable information for diagnoses, prognoses and treatment of diseases. We are also researching new drugs, including developing a vaccine for rheumatoid arthritis, a chronic disease with no known cure to date.



A further example is possible new anticancer compounds: active ingredients were discovered in marine fungi and have been tested successfully in preclinical studies. Here, the hypothesis was that marine organisms manufacture substances to help them survive in harsh environments, making them a treasure trove of molecules with the potential for use as active ingredients.

Another important medical topic is the treatment of chronic wounds. Here, we are also focusing on the affordability of diagnosis and treatment. Five Fraunhofer Institutes put together a whole package of treatment protocols, for which they received an EARTO Innovation Award in 2015: the Fraunhofer Institutes for Silicate Research ISC, for Interfacial Engineering and Biotechnology IGB, for Medical Image Computing MEVIS, for Microsystems and Solid State Technologies EMFT and for Molecular Biology and Applied Ecology IME. The relatively new field of insect biotechnology is providing promising options for treating wounds, a subject that is being intensively pursued at Fraunhofer IME. Medicinal maggots are the best natural system to treat open wounds because they clear the wound of both dead tissue and bacteria. The active ingredients from maggots could conceivably be applied in the form of pharmaceutical creams. In the future, why not help patients by using all these approaches together?

1 Some of the substances insects produce have the potential to be used in medications.

2 Multi-resistant bacteria are one of the biggest challenges in pharmaceutical research.

Marine fungi and medicinal maggots are just two examples of many demonstrating that nature often provides the best molecules already. This opens up a huge opportunity for researchers. At Fraunhofer, we are searching for active substances from insects to help fight diseases like malaria, cancer or AIDS. Potentially, the first new active ingredients could be derived from natural sources this way. Those findings can then be pitted against a whole library of compounds that contain hundreds of thousands of substances. For example, we are testing small molecules – chemical building blocks – for specific characteristics, so that we can combine the best of both worlds.

The next generation of new drug discovery is already here: by using certain kinds of stem cells in modern drug screening, such as myocardial cells that pump on their own, we can predict the effects of those drugs on the body much more accurately and reliably. This in turn could accelerate drug development and reduce costly failure rates.

When it comes to interactions between human health and the environment, risk assessment is key. Here, the Fraunhofer Group for Life Sciences offers analytical skills and environmental monitoring. These involve assessing substances such as pesticides, chemicals, biocides, pharmaceuticals, and veterinary products for their risks to human health and the environment. Researchers at Fraunhofer IME are developing solutions as well as supporting the creation of appropriate studies and the filing of documents for approval. One example from agriculture is how to tackle the problem of veterinary antibiotics getting into the environment and ultimately into the stomachs of consumers through the food chain. Such antibiotics must be degraded or modified so that they become inactive and harmless.

Focus on global health

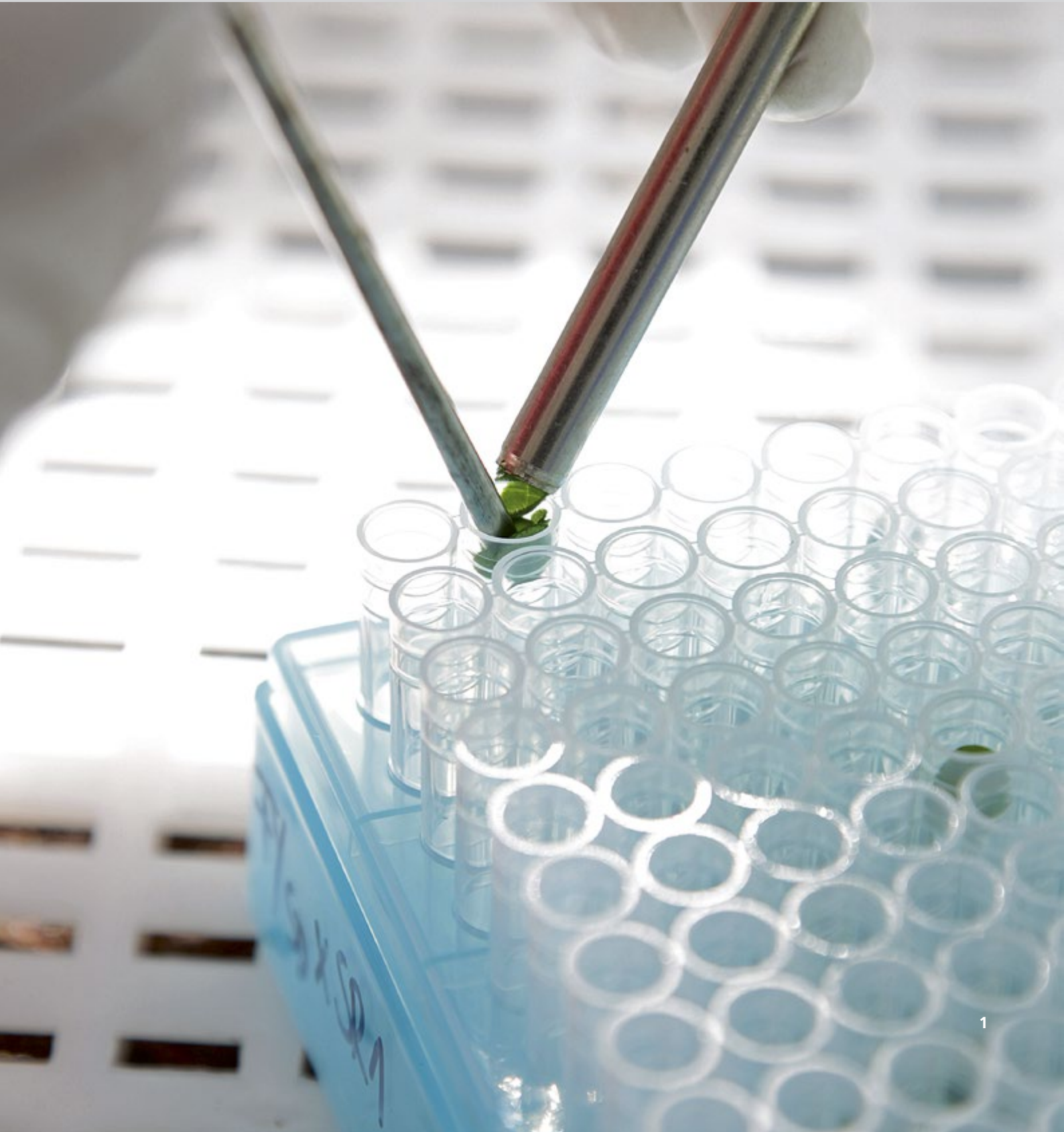
We must also tackle global health issues because pathogens know no boundaries. In 2014, the international group Sanofi and the Fraunhofer-Gesellschaft founded a Natural Product Center of Excellence to develop new therapies against infectious diseases. Prior to the 2015 G7 summit, Chancellor Angela Merkel met with senior researchers from Sanofi and Fraunhofer IME in Frankfurt to exchange views about the joint research on antibiotics. The fight against multi-resistant bacteria is high on the political agenda; Germany's Federal Chancellor herself had put the issue on the agenda for the G7 summit that took place in June 2015. In this area, too, Fraunhofer researchers advise at the highest political levels, for instance as part of the German federal government's Health Forum and its think tank "Pharmadialog", striving to find answers to the challenges the German pharmaceutical industry faces. The next logical step to follow on from this advisory work at the national level is to advise at the international level. The way to achieve the best results is to share knowledge internationally and pool experiences in research and development.

Poverty-related diseases, such as tuberculosis, malaria and Ebola, were also a G7 topic. Fraunhofer researchers are working to develop treatments, including a multi-stage vaccine for malaria that is effective through all the pathogen's different development stages.

The Ebola epidemic of 2014/15 has shown us how critical it is to act swiftly to prevent a global epidemic in the event of an acute outbreak of disease. In the future, antibodies against pathogens such as Ebola could be produced inside plants. For example, ZMapp is an experimental biomedicine that can be produced in tobacco plants. Genetic information is added to the plant and the active compound subsequently isolated. At this time, Fraunhofer IME in Aachen is the only research facility in all of Europe that is able to do this.

These plant-made pharmaceuticals are easier to manufacture than clinical materials made using animal cells, which is why plants are the ideal medium for health crises where time is of the essence. Molecular farming in plants is quite literally reaching new heights. In what is known as vertical farming, fully automated plant breeding is controlled and monitored over several floors.

This concept could work for agriculture, too. If certified, disease-free, non-contaminated seeds are used, and the plants can then be strictly controlled and grow without harmful outside influences, this offers consumers more safety. What's more, these conditions make the substances contained in plants accurately reproducible, which is an advantage for specialty products such as herbs or organically grown vegetables. Such a vertical-farm facility is currently going up in Aachen.





Habitat Earth: How resource efficiency helps people

When we consider the Earth as our habitat, we face challenges of many different kinds. Global health is one of them. Another is the question of sustainability: how do we best deal with our resources, especially in the face of population growth, resource erosion, and climate change?

At the Climate Change Conference held in Paris in December 2015, “energy efficiency” and “emissions neutrality” were two important key words. Researchers from the Fraunhofer Institute for Systems and Innovation Research ISI attended to lecture on ways to achieve the internationally agreed goal of limiting global warming to 2 degrees Celsius – at the lowest possible cost. They introduced country-specific plans to reduce greenhouse gas emissions. It turns out that it is the largest and fastest-growing economies that can not only help to limit global warming but also achieve huge savings if they do.

Applying the new efficiency measures and programs worldwide between 2015 and 2030 could lead to a savings of 2.8 trillion US dollars. The biggest savings would result from the reduced need for investment in new energy supply infrastructure and from lower direct energy costs. Fraunhofer research shows that energy efficiency is the key to controlling the costs associated with the 2-degree target. It’s worth the effort: each country studied stands to benefit from government policies to promote energy efficiency, as long as efficiency policy measures adopted are appropriate to the conditions in the region.

Protecting our habitat depends on achieving a successful transition to a new energy economy. Fraunhofer ISI develops long-term scenarios for the German Federal Ministry for

Economic Affairs and Energy (BMWi) to develop renewable energy. These form the basis for refinements to the energy transition as well as to the federal government’s future energy policy objectives and measures. Through its contribution to the “Leitstudie Strommarkt” study of the electricity market for the BMWi, Fraunhofer provides an important tool for modeling renewable energy’s role in the energy transition. The results of the study form the basis for further research as well as defining energy policy objectives and measures.

From theory to reality – small steps yield great results

Sustainable use of raw materials is important because these are the economic basis of modern societies. But decades of economic growth have driven continuous growth in consumption of commodities worldwide. If we want to protect our environment, we need to research new ways to conserve resources: How can we use them more efficiently? How can we substitute raw materials? And how can we incorporate recycling? Fraunhofer conducts research in all these areas so that our habitat Earth is protected and preserved for future generations.

1 Medicines can be produced using plants.

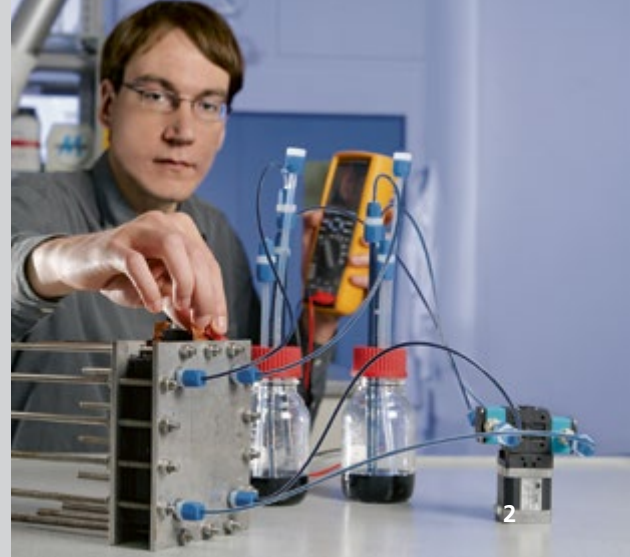
2 Climate protection affects us all: virtually every region of the world is affected either directly or indirectly by its consequences.



Very often, the greatest effects are found in the smallest things. For example, dandelions are being considered as a sustainable alternative source of latex for the rubber-processing industry. This is the goal of a joint project with tire manufacturer Continental. Growing dandelion crops in temperate latitudes near production facilities could be a way to avoid further deforestation of tropical rainforests to make way for rubber trees. It would also shorten transport routes – and both aspects would greatly reduce this resource’s carbon footprint. In 2015, the Joseph von Fraunhofer Prize was awarded to the researchers involved in the development of car tire prototypes made using rubber harvested from the Russian dandelion.

Likewise, recycling industrial waste gas holds much promise: the Fraunhofer Institutes for Environmental, Safety and Energy Technology UMSICHT, for Chemical Technology ICT and for Molecular Biology and Applied Ecology IME have developed a way to convert carbon monoxide-rich gases (syngas) into kerosene and other specialized chemicals. This method could also be used for industrial fumes or the gasification of landfill waste.

Within the Graphene Flagship project – the largest funding initiative in the history of the European Union – 142 organizations from 23 countries are also bridging the gap between theory and reality. With a total of one billion euros, the initiative funds universities, research institutions and companies so they can tap into the miracle material graphene for use in the European market. Graphene is the thinnest material in the world: it is 200 times stronger than steel and six times lighter, it is tear-resistant yet flexible, and it is environmentally friendly. Even though it is just atoms thick, it remains extremely conductive. The Fraunhofer Institutes for Chemical Technology ICT, for Applied Solid State Physics IAF and for Systems and



Innovation Research ISI are partners in this pioneering research project. We are working on another large-scale, inexpensive production method for graphene (graphene flakes) as well as on an efficient technology for graphene deposition and graphene transfer onto aluminum nitride. Fraunhofer is playing an important part in the complex coordination and control of this project.

Fraunhofer ISI is designing strategic technology and application roadmaps for all the partners in the consortium and in the graphene community to help them more effectively assess the drivers for further development of graphene and its future applications. In addition, the institute provides a member of the Executive Board, which is responsible for making the strategic decisions for the funding initiative.

1 Russian dandelion is a source of natural high-quality rubber and can help meet the increasing demand for this raw material in an environmentally friendly way.

2 Graphene is a material with enormous application potential. Fraunhofer is researching its application in redox-flow battery cells.

Society as habitat: Housing, work, life

To open our minds to new ideas and live more aware lives in our environment, we must rethink all areas of life: How do we want to live? What is important? Do we need to own things, or is it enough to just use them? We face these kinds of questions everywhere: How do we want to live, work, and research in the future? At Fraunhofer ISI, we analyze how technological trends are changing society so we can identify future requirements at an early stage and use technology perspectives to connect them with innovative solutions for tomorrow.

In the second cycle of the Foresight Process of the German Federal Ministry of Education and Research (BMBF) together with the VDI Technology Center (VDI TZ), Fraunhofer once again provided methods and content to help identify the societal challenges and technology perspectives for research and innovation in Germany through 2030. The “lessons from the future” that were developed describe how societal and technological changes might impact everyday life in 2030 and point out where there is potential for innovation. The results do not just flow into the BMBF’s research and innovation policies, but are available on the ministry’s website for use by companies and research organizations in their own strategic planning.

These complex rethinking processes are already underway, and they affect our experience of mobility as well. In the future, mobility concepts and services will extend far beyond vehicles as a technology platform. This was the final result of Fraunhofer’s Regional Eco Mobility 2030 (REM 2030) Innovation Cluster, which concluded its work in 2015. Coordinated by Fraunhofer ISI, the Fraunhofer System Research for Electromobility project team spent four years researching different aspects of this field of technology. While technical aspects were a major focus,

they were not the only objective. Solving the mobility challenges of the future requires a systemic, transdisciplinary approach. This innovation cluster of Fraunhofer Institutes worked together to consider mobility in the overall context of vehicles, the technical infrastructure, organizational concepts, intermodal transportation approaches, and operator models. Project participants include the Fraunhofer Institutes for Systems and Innovation Research ISI, for Optonics, System Technologies and Image Exploitation IOSB and for Mechanics of Materials IWM, the Project Group for New Drive Systems at the Fraunhofer Institute for Chemical Technology ICT, and institutes at the Karlsruhe Institute of Technology (KIT), as well as industrial partners.





Dialog: People and research

When it comes to all these issues – mobility, resource efficiency, or health – it is essential for society to embrace them and employ participative processes. This explains why new communication concepts are becoming ever more important. Major societal issues must be discussed broadly. Increasing digitalization and the possibilities of networking are providing individual citizens, social and commercial organizations, and other entities with the foundations for new forms of governance. Networking will enable all stakeholders to become more involved in the political process. New forms of direct democracy and citizen participation will become more relevant in the future – and this will have an impact on Germany's political and administrative culture.

This is why Fraunhofer promotes dialog between research and people. For example, Fraunhofer ISI is engaging in projects and workshops aimed at helping society accept innovative technological developments in an effort to develop and expand on strategies for citizen information and participation.

In this as in other key issues, Fraunhofer supports stakeholders by transforming good ideas into innovative products and services, keeping Germany internationally competitive. Our research has far-reaching effects on the German federal government's High-Tech Strategy. This is why Professor Reimund Neugebauer, the President of the Fraunhofer-Gesellschaft, and Professor Andreas Barner, Chairman of the Board of Managing Directors of Boehringer Ingelheim, are co-chairing the High-Tech Forum. The advisory body for the implementation of the High-Tech Strategy was also created in 2015 to initiate a dialog with the public and with existing stakeholders and different platforms in the fields of research and innovation.

Through its research, Fraunhofer is shaping Germany's development, seeking solutions to today's challenges that build on both technical and non-technical innovations, as well as addressing the demands on society as a whole and on the individuals that comprise it. In 2015, the 24,000 employees of the Fraunhofer-Gesellschaft spent the year focusing on people. People working tirelessly for the benefit of people and turning original ideas and many small steps into lead to great achievements. And all the while we switch our perspective to make sure we always consider all aspects of life – from the smallest to the grandest.

Univ.-Prof. Dr. Rainer Fischer

Director of the Fraunhofer Institute for Molecular Biology and Applied Ecology IME in Aachen,

Chairman of the Fraunhofer Group for Life Sciences

Univ.-Prof. Dr. Marion Weissenberger-Eibl

Director of the Fraunhofer Institute for Systems and Innovation Research ISI

1, 2 Renewable energy sources and electromobility are two cornerstones in plans for sustainable, resource-efficient cities of the future.

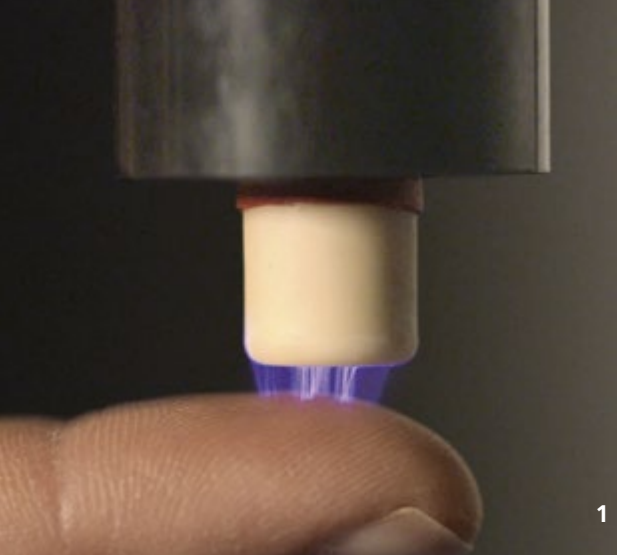
PROJECTS AND RESULTS 2015

HEALTH AND ENVIRONMENT

Fraunhofer Human-Centered Technology Prize

Plasma for the skin 1

Because diseases of the skin are so prevalent and tend to become chronic, they not only pose serious health concerns, but economic ones as well and are considered a public health issue. Prof. Dr. Wolfgang Viöl and Dr. Andreas Helmke of the Fraunhofer Institute for Surface Engineering and Thin Films IST, together with Prof. Dr. Steffen Emmert of the University Medical Center Göttingen and Dr. Dirk Wandke from the company CINOGY GmbH, have established a new method for treating skin diseases: their PlasmaDerm device provides a means for applying a physical non-thermal plasma directly on the skin. The first clinical trials have already shown that PlasmaDerm is antibacterial and increases circulation, and, in terms of potentially negative side effects, it is classified as safe for patients to use. The innovative device is already being widely used in university clinics, hospitals, by private practitioners, wound managers and nursing services. For this development, the four scientists received the 2015 Fraunhofer Human-Centered Technology Prize.



Joseph von Fraunhofer Prize 2015

Rubber from the meadow

Natural rubber is a fundamental ingredient of high-quality rubber products, such as the kind used for making car tires. Until now, the steadily growing demand has been met by tropical rubber tree plantations, resulting in ever-greater ecological problems. In collaboration with Dr. Carla Recker from Continental Reifen Deutschland GmbH, Prof. Dr. Dirk Prüfer and Dr. Christian Schulze Gronover of the Fraunhofer Institute for Molecular Biology and Applied Ecology IME at the WWU Münster (Westfälische Wilhelms-Universität Münster) have conducted extensive research into this delicate monoculture situation and offered up the dandelion as an alternative, sustainable source of rubber for the rubber-processing industry. Using DNA markers, they cultivated highly-productive varieties from the Russian dandelion, which grows wild in soil too barren for food production. They also established an inexpensive, efficient method of extraction for producing natural rubber of equally high quality. The great economic benefits to industry, not to mention the political and environmental benefits, make the establishment of production facilities in temperate climates a good investment. The three researchers were awarded the Joseph von Fraunhofer Prize 2015 for this work.

Chip-based diagnostics for blood poisoning 2

Sepsis, commonly known as blood poisoning, is the third leading cause of death in Germany. This condition arises when a bacterial infection in the blood causes the body's defense mechanism to go out of control. Broad-spectrum antibiotics can delay the spread of bacterial pathogens in the blood, but due to widespread resistance to antibiotics, they cannot be relied upon for successful treatment. The blood test used to determine the presence of specific compounds, and hence, the potential cure, takes a long time – too long for the 40 per-

cent of patients who succumb to sepsis within days. Now, the Fraunhofer Institute for Laser Technology ILT offers a new chip-based diagnostic tool that detects infection-causing bacteria in the blood and can be conducted in just a fraction of the time. The test includes an automated resistance analysis developed by the Fraunhofer Institute for Applied Information Technology FIT that also measures the sensitivity to specific antibiotics. This in turn leads to a timely administration of an effective medicine, thus greatly increasing the survival rate of affected patients. Based on the miniaturization and automation of complicated laboratory methods and coupled with laser-based analytics and customized analysis algorithms, this recipe for success works to identify an appropriate antibiotic much faster and more effectively than before.

German Students Award 2015

A heart valve for life

Implanting artificial heart valves has already become a routine operation. However, the replacement valves have a limited lifespan. And because they cannot grow, the operation must be repeated in children after a certain amount of time. Svenja Hinderer, a chemist at the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB, has developed an artificial heart valve from a hybrid electrospun material that contains proteins onto which the body's own cells can bind. The potential for this development is enormous – once implanted, the artificial valve could stay there for a lifetime. In children's hearts, they could even grow with them. For her development work, the researcher received the German Students Award (Deutscher Studienpreis) and award money worth 25,000 euros.



Strap-on power

Just as for many professions, being able to lift heavy loads is part of the job; it is also the cause of many back problems and injuries. Even knowing this, caregivers and workers from a wide array of professions still end up lifting something on the job that is too heavy for them or lifting incorrectly. In collaboration with industry partners, researchers from the Fraunhofer Institutes for Production Systems and Design Technology IPK and for Reliability and Microintegration IZM have developed a supportive vest to monitor movement and help people avoid work-related injuries. Unobtrusive, the CareJack vest is light, soft and comfortable to wear. It supports the back without restricting freedom of movement.

Fraunhofer Lighthouse Project Medical assistants in the body

Implants are increasingly taking on more tasks inside the body: they can repair fractured bones, control heart rate and collect data. To further develop the diagnostic and therapeutic potential of these implanted medical devices, twelve Fraunhofer Institutes, under the leadership of the Fraunhofer Institute for Biomedical Engineering IBMT, have joined forces to work on the Fraunhofer Theranostic Implants Lighthouse Project. In one subproject, an intelligent hip prosthesis equipped with electronic sensors continuously monitors its position, allowing the physician to readjust its fit as needed – without surgery. In another project, an implanted sensor continuously sends circulation data to an external receiver so that a tailored medical treatment can be administered promptly. In a third project, a myoelectric prosthetic hand controller, capable of providing sensory feedback, is being developed and tested. The movement of the individual fingers of the artificial hand is controlled via muscle contractions and the detectable bioelectric potential. Even complex movements are possible. As the sensors measure the gripping force

of the prosthesis, they form the basis for electrical stimulation of the peripheral nerves, thus inducing adequate feeling for the wearer.

Robots assist surgeons 1

A helping hand is very useful on the operating table, especially if its precision is unsurpassable. Therefore, robotic technology is often employed in the surgical field. The Project Group for Automation in Medicine and Biotechnology, part of the Fraunhofer Institute for Manufacturing Engineering and Automation IPA, developed two interesting solutions: the “helping hand” for example, assists the surgeon by holding instruments steady and can respond to spoken instructions without being touched to position instruments accordingly. This permits very precise and safe handling of this device while also retaining sterility. The surgical robot NiLiBoRo in turn, provides extremely gentle access to tumors in the inner ear. The robot is able to adjust its path while drilling through bone to avoid nerves or blood vessels, thereby minimizing the risks of surgery.

No molecule will go undetected

In modern bio-science laboratories, supersensitive detection systems are becoming increasingly important. Scientists want the most reliable way to measure the presence of biomolecules quantitatively but also minimize the sample consumption. The Fraunhofer Institute for Applied Information Technology FIT has developed a single molecule detection machine (SMDM) for measuring tiny quantities of nucleic acid. The system is used to identify biomarkers, which are early indicators of a disease or predictors of a course of therapy. In this way, diseases can be detected earlier; newer, more precise drugs can be found more quickly; environmental pollutants can be evaluated and the quality of biological processes can



be better controlled. The SMDM is currently being used in RIBOLUTION, the Fraunhofer Foundation project for quality control in nucleic acid analytics, where a highly-sensitive detection of nucleic acids in mass concentrations is required.

Silver socks vs. pond critters

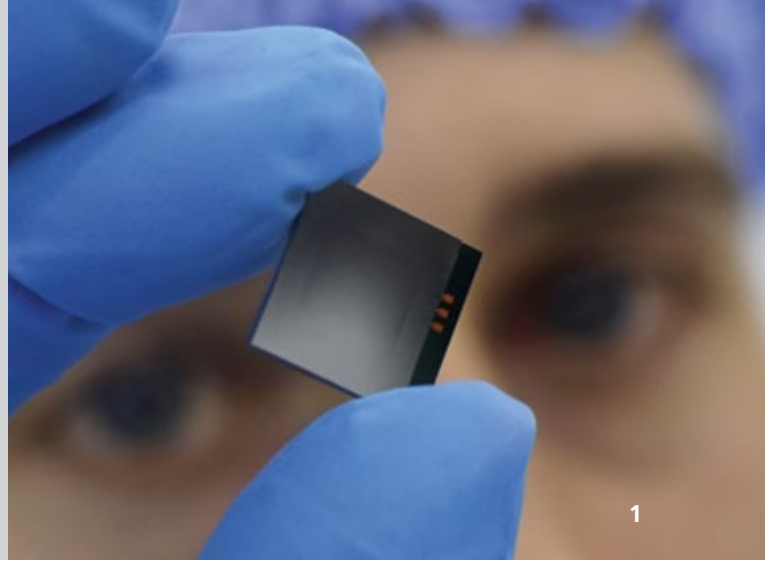
Silver ions kill bacteria. The textile industry uses this to its advantage by treating sportswear and undergarments with silver nanoparticles: they release silver ions that fight off the bacteria caused by sweat. However, with laundering, the particles pass through wastewater treatment plants into the environment and pollute aquatic ecosystems. If and how they affect the complex interactions in the ecosystem has up to now only been assessed by simple laboratory tests, which possess a great degree of uncertainty. The Fraunhofer Institute for Molecular Biology and Applied Ecology IME conducted realistic studies using cubic meter tanks (microcosms) to measure the impact of equal amounts of silver, either in a soluble salt or as nanoparticles, on aquatic communities. The aim is to study the release kinetics and determine the thresholds for problematic concentrations. The first results show that significant effects occur with the highest concentrations. In the experiments with silver nitrate, algae and small crustaceans were directly affected. In the experiments with nanoparticles, silver was released more slowly, and algal bloom developed because only the algae-eating crustaceans were reduced.

Maximizing microalgae 2

Algae may very well be our ideal bio-producer. From algae, you can make dietary supplements as well as cosmetics, biodiesel fuel and other important substances. Therefore, one must ensure the conditions are optimum for it to thrive. To this end, researchers at the Fraunhofer Center for Chemical-Biotechnological Processes CBP in Leuna collaborated with the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB and Subitec GmbH to build a pilot plant. An important innovation is the flat-plate reactors, which ensure a better supply of light and allow them to yield a five-fold increase in algae concentration. Further research with this reactor and different algae should result in bioproduction on an industrial scale.

VascuBone can grow bones

Until now, surgeons treating patients with bone defects used metal implants or autologous tissue from the pelvic bone. Metal remains a foreign body onto which no bone can attach while only a limited amount of autologous tissue is available. The VascuBone project, developed by 19 partners from four countries, was coordinated by Prof. Dr. Heike Walles from the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB in Würzburg. Together, the team created a toolbox to custom-make vascularized bone implants that can be used to treat minor defects as well as serious injuries. The novel result is a diamond-coated ceramic granulate with large pores. It is implanted with two additional components – proteins from the patient's blood to promote the growth of bone tissue and blood cells from the spinal cord to ensure that the implant is not rejected. The project was funded by the EU.

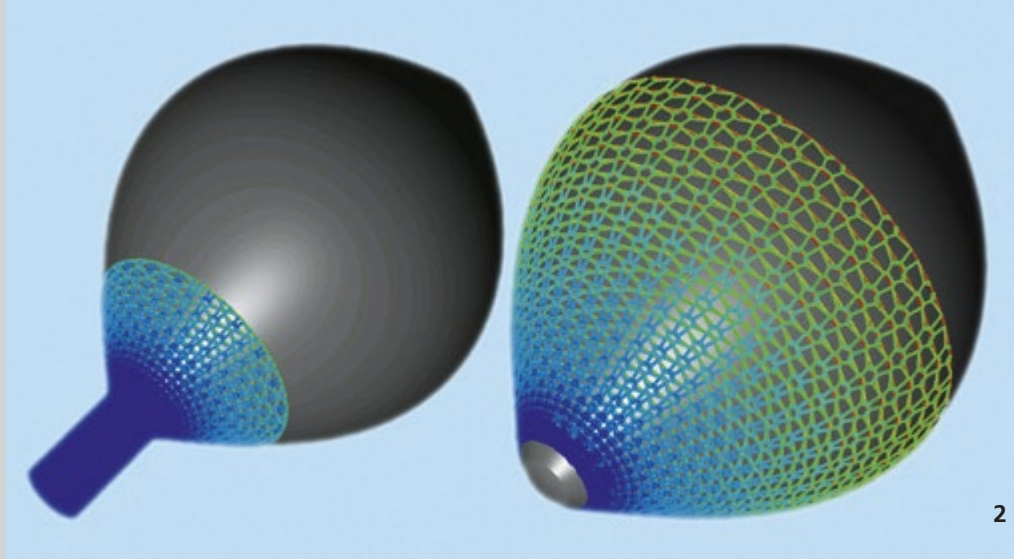


COMMUNICATION AND KNOWLEDGE

Joseph von Fraunhofer Prize 2015

A concert hall for on the move

Enjoying music is heavily dependent on the acoustics of the venue and the technical capacities of the instruments or equipment used. But today's listeners wish to experience music under very different conditions, including on smartphones and tablets, with or without headphones, or using their car's sound system. Oliver Hellmuth, Jan Plogsties M.Sc. and Dipl.-Ing. Harald Popp from the Fraunhofer Institute for Integrated Circuits IIS took on in the technical challenge of developing optimized audio system for these devices. Relying on the institute's vast expertise in audio coding, they created special algorithms that process the music to improve reception of the sound experience on the respective device. Cingo technology optimizes audio content for playback on mobile devices, while Symphoria refines the sound in vehicles. Google, Samsung and Audi are among the first customers of these innovative solutions. For their work, the researchers were honored with the 2015 Joseph von Fraunhofer Prize.



Microtechnology makes music 1

With the rapid spread of mobile electronics, the demand for miniaturized speakers has also increased. Present in all mobile devices such as smartphones, tablets and laptops, this market requires about one billion micro speakers per year – and the number keeps rising. A new approach to their construction uses metallic glasses, which differ from normal metals by their amorphous structure. A collaboration between the Fraunhofer Institute for Electronic Nano Systems ENAS, the Center for Microtechnologies (ZfM) at Chemnitz University of Technology and Tohoku University Sendai created prototypes of micro speakers with metallic glass membranes. They combine outstanding functional properties with the advantages of standard microtechnology processes to promise first-class performance that can be manufactured inexpensively.

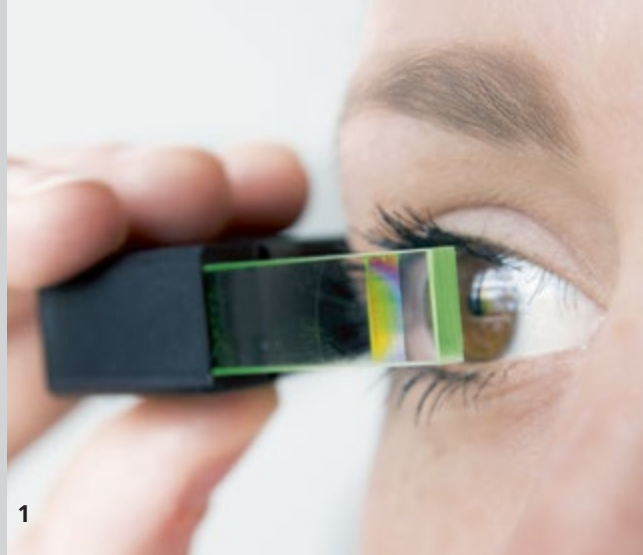
Simulating technical textiles 2

Technical fabrics, in contrast to most textiles used for apparel, must fulfill very specific parameters and requirements. Examples include compression bandages and covers for car seats and airbags. Materials for protective vests need a certain bending stiffness to fulfill their functions while textiles for car seats must be durable, especially at the edges. Many factors are testable, but knowing which yarn and which weave will meet a certain requirement is a very complex question with many variables. These can now be answered quite efficiently using calculated simulations, a method developed at the Fraunhofer Institute for Industrial Mathematics ITWM. With these, researchers can accurately predict which properties the textiles will have depending on the yarn and the structure.

Hugo Geiger Prize 2015

A new material for efficient storage

With the proliferation of highly-complex mobile devices, the demand for high-performance and energy-efficient semiconductor storage increases. Existing materials and technologies are hardly able to keep pace with developments. In his doctoral thesis, Dr.-Ing. Johannes Müller, from the Fraunhofer Institute for Photonic Microsystems IPMS, successfully made a decisive contribution to the study and understanding of the ferroelectric properties of silicon-doped hafnium dioxide and its application in semiconductor storage. He also demonstrated through a generalization of the phenomenon that hafnium-based ferroelectrics are a completely new class of materials, earning him international recognition. This extremely energy-efficient, ultra-small and CMOS-compatible storage technology puts applications which were previously not possible with ferroelectrics within reach: implementing piezoelectric actuators, energy harvesters and sensors in chips are now conceivable. For this research, the Fraunhofer scientist was awarded the 2015 Hugo Geiger Prize.



Internet for all

Do you have to live in a city to keep up with current events and experience culture? This idea will soon be a thing of the past. Policies and research are helping people in rural areas connect to the Internet just as effectively as people in urban areas. The Internet is not just for a source of instant entertainment, but also a means for medical monitoring and innovative agricultural concepts, such as Smart Farming. With the Smart Rural Areas initiative, the Fraunhofer Institute for Experimental Software Engineering IESE, together with politicians and organizations, has launched a strategic research program, which was awarded the Landmark in the Land of Ideas prize in January 2015. In the next few years, the program will be expanded to become part of the Digital Village project. The most important topics are digital solutions through the use of intelligent information and communication technologies. With these, new housing and living concepts will get a chance again.

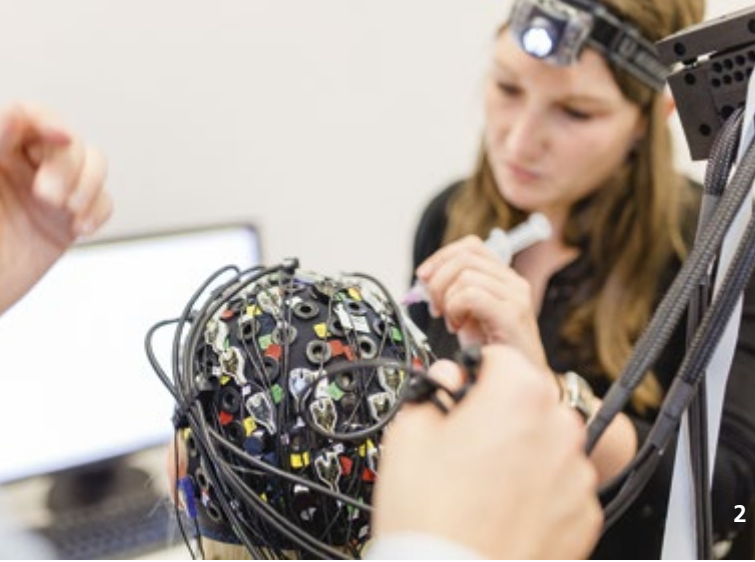
Data glasses – small and light 1

Data glasses offer up fascinating possibilities. Just as normal eyeglasses do, they correct poor eyesight, but they also offer up additional information via the display to the wearer. Until now, this option had one serious disadvantage: a relatively bulky construction that made them rather conspicuous. Now, experts at the Fraunhofer Institute for Applied Optics and Precision Engineering IOF have applied their experience in the design and manufacture of micro-optical systems and have successfully reduced the size of the data glasses to one-fifth the original. This will enable the production of far more discrete and lighter data glasses. A further innovation: the invisible lattice structure applied to the glass for the display of information now covers the entire field of view. These kinds of data glasses will yield new applications in private as well as professional use.

Hugo Geiger Prize 2015

Substances for brilliant displays

Quantum dots are semiconductor-based nanoparticles with specific properties. They have a narrow emission spectrum, and their color can be adjusted with the particle size. Among other things, they are used in displays to improve brilliance and efficiency. However, the cadmium compounds that have been used up to now create problems for both health and the environment. As part of his doctoral thesis, Dr. rer. nat. Christian Ippen of the Fraunhofer Institute for Applied Polymer Research IAP synthesized cadmium-free quantum dots based on indium phosphide and zinc selenide. At the same time, he examined their utility in organic light emitting diodes (OLEDs). The new compounds showed excellent properties:



with them, the entire spectrum of visible light could be covered with excellent color saturation. The economic relevance of the studies has been illustrated for the past two years by the commercialization of quantum dot materials for displays and various other fields of application. He was awarded the 2015 Hugo Geiger Prize for this development.

How people and machines understand one another 2

Computers are capable of doing many things that people cannot do, and people can do many things computers cannot. That's why it is so important that both people and computers can work well together. The human-computer interface is the primary research area in the NeuroLab, which was opened in 2015 at the Fraunhofer Institute for Industrial Engineering IAO. Here, Fraunhofer has created a test environment for questions in the field of neuro-ergonomics. Scientists are particularly interested in what happens in the brain when people use technological devices. Based on these findings, the researchers want to develop optimized human-computer interfaces. For example, in the EMOIO project, partners in research and industry can investigate how emotional experiences can be detected and classified while one is interacting with a device. The goal is to develop emotionally-sensitive assistance systems, which can adapt to the emotional state and the individual needs of users.

The television sound of the future 3

The next generation TV – Ultra High Definition Television (UHDTV) – is coming soon and with it, crisp images on TV sets. Equally crisp sound is being developed at the Fraunhofer Institute for Integrated Circuits IIS. The significant contributions from the Erlangen audio experts combined with MPEG-H 3D Audio standard, has laid the foundation for the TV sound of the future. Thanks to 3D sound, viewers will be acoustically transported into the action on screen. Furthermore, MPEG-H 3D Audio viewers will be able to personalize the audio signal: the volume of background noises or dialog on the TV and other device can be adjusted individually. The new technology will be used in television and with online-streaming services.



1

PROTECTION AND SECURITY

Network for health 1

Ideally, maintaining a healthy lifestyle will not only keep diseases at bay, but even foster joy – especially when people use the latest technologies to support these aims. Together with industry partners and consumers, the Fraunhofer Institute for Computer Graphics Research IGD is testing and developing TakeCare, a new network of technologies and products that help people stay healthy in their private and work lives. The basis of the technologies is formed by a person's activities and vital signs, such as breathing, pulse, body movements, blood pressure or biometric information. A smartwatch, for instance, provides this kind of digital life assistance via sensors worn on the body. The cooperation network is funded by the German Federal Ministry for Economic Affairs and Energy (BMWi) and maintained by VDI/VDE Innovation + Technik GmbH.

Autonomous window guards

The little helpers at home would be much more helpful if we didn't have to provide power and monitor them too. An example of this is the radio chip, which was created at the Fraunhofer Institute for Microelectronic Circuits and Systems IMS. Its job is to let users know when a window has been left open, so heat doesn't inadvertently escape. It will immediately report any attempted break-ins as well. Best of all: a power supply is unnecessary. The wireless sensor requires no batteries – it collects electricity from a small solar cell.



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3

Gas sensors as fire detectors 2

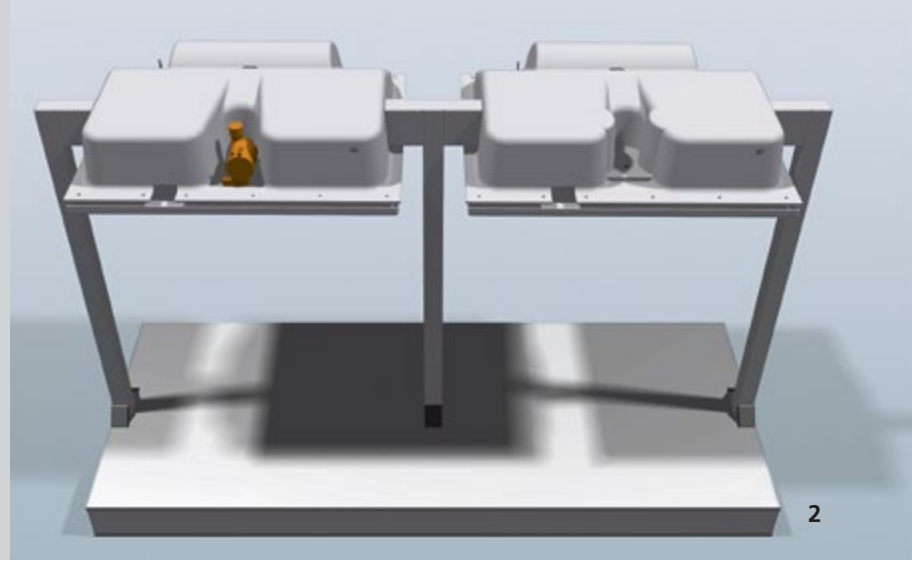
While today's conventional smoke detectors in buildings have become quite affordable, they only react to smoke. But especially with smoldering fires, there is initially almost no smoke. Instead, there's a particularly dangerous gas – carbon monoxide – that can choke a sleeping person. In this instance, a gas detector would be safer, but until now they were either too expensive to produce or too costly to power. Therefore, they're not suitable for detecting gas fires. Now the Fraunhofer Institute for Physical Measurement Techniques IPM has developed a new kind of sensor that responds specifically to carbon monoxide and nitrogen dioxide, and ignores all other gases. In addition, the researchers have developed a production process ensuring a sale price in the same range of existing smoke detectors.

Smart Home: Software against hackers

Security means thinking ahead. The Smart Home promises a very efficient, and connected building management system in which with more and more of its functions can be controlled via the Internet. Experiments have shown that building-information technology is not yet sufficiently protected against attacks from the Internet. Therefore, researchers from the Fraunhofer Institute for Communication, Information Processing and Ergonomics FKIE are working on a software that can be switched between the Internet and building IT, and that protects against hacker attacks. The technology filters out potential attacks from communication protocols before they arrive in one's home or office building. This means people can organize a line of defense without waiting for criminals to exploit the system first.

Inspecting turbine disks 3

Aircraft turbines are exposed to very high thermal and mechanical loads during operation. For this reason, they cannot have any damage to their structure, surface or geometry. Elaborate inspections are a necessity. In the future, a test system developed by researchers from the Fraunhofer Institute for Industrial Mathematics ITWM in collaboration with Hexagon Metrology GmbH and the Hexagon Technology Center GmbH will be of help. Results from optical and mechanical sensors are added together with the CAD data of the turbine in the new inspection report. Then, the human inspector can check it point by point to understand, document and evaluate any identified defects. The new test is more efficient and offers more security.



Quick check for banknotes

When it comes to quality inspection for security printing – for instance banknotes – speed and accurate image analysis are the most important criteria. Now, Fraunhofer researchers have developed a line sensor that works twice as fast as conventional image sensors to deliver high-quality images and identify notes with any faulty safety printing. In cooperation with the Austrian Institute of Technology, the world's leading manufacturer of such test systems, researchers at the Fraunhofer Institute for Microelectronic Circuits and Systems IMS developed a 60-line sensor which takes 200,000 frames per second. This system allows objects to be detected from different angles, so that for the first time, 3D surface structures can be checked, such as the tilting effects of holograms. The enormous power of this technology opens up other potential fields of application. For example, near-Earth satellites with such a sensor could take color photographs of the Earth's surface with a resolution of three centimeters.

Smooth airport operations 1

Operating an airport requires perfect organization, not only in the air, but also on the ground. Passengers, baggage, fuel, maintenance – logistics on the apron is very demanding and any disruption quickly results in noticeable delays. In the future, an improved tracking system will increase airport safety and streamline logistical processes so that existing airport capacities are better utilized. Researchers at the Fraunhofer Institute for Factory Operation and Automation IFF in Magdeburg collaborated with various European partners on this in the EU project e-Airport. The technical basis is the European satellite system Galileo, which permits an exact positioning of the individual vehicles on the airport apron. The project is funded by the European GNSS Agency as part of the EU research and innovation program Horizon 2020.

More safety with minimal weight 2

In the aviation industry, safety features generally play the most important role. Nevertheless, engineers are happy when they can save weight in the process. Researchers at the Fraunhofer Institute for Machine Tools and Forming Technology IWU found a compelling new solution for the oxygen masks in the passenger cabin: the innovative mask release mechanism is based on shape-memory alloys. The new system weighs only about 10 percent of the conventional release and requires only 20 percent of the original installation space. Extrapolated to an entire aircraft, the saving of space and fuel plays a considerable role. The Smart-FLUOX project also convinced the jury of the most important industrial prize for innovation in aircraft cabin interiors: the new system was among the three finalists in the Materials & Components category for the Crystal Cabin Award.

MOBILITY AND TRANSPORTATION

Heating for electric cars

In a conventional car, heating is usually not a problem because the engine produces waste heat in abundance. In electric vehicles the situation is different: heat has to be produced with power from the battery, which uses up capacity, and then drivers must find out outlet that much sooner. At the Fraunhofer Institute for Manufacturing Engineering and Automation IPA, researchers came up with a solution: a radiant heating system based on thin foil that ensures cozy warmth in electric cars. It is especially good for short trips and more effective than a conventional electric heater. The films are very thin and flexible and can be applied to different surfaces. Its low weight also helps to save energy and money.

Axis module for e-mobility

The trend towards electromobility is undeniable. But there are many challenges in need of detailed solutions along the way. For example, driving axles are still too heavy, too expensive and too big. This is where the ESKAM project comes in. The name stands for: electric, scalable axis module, and was funded by the German Federal Ministry of Education and Research (BMBF). In collaboration with ten other partners, Fraunhofer researchers designed an optimized axis module for commercial vehicles. It is powerful, lightweight, compact and affordable; the motor is directly integrated into the axle. Not only did the researchers and developers construct the axis module, but they simultaneously developed the required series production technologies. The innovative concept offers much flexibility – small quantities are just as easy to produce as larger ones – and the geometry is scalable, so the same concept can be used in a small van or municipal vehicle as well as in a bus or truck.



Safer control devices for motor vehicles

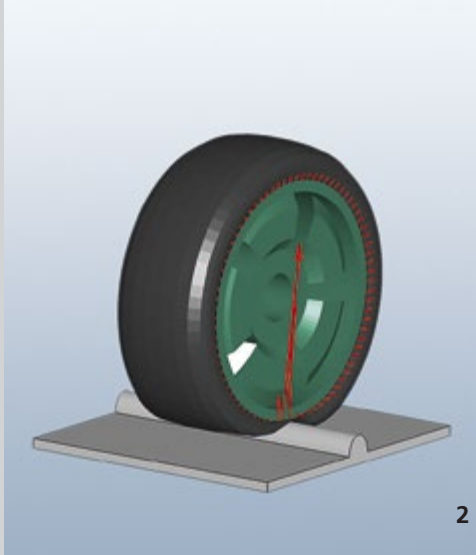
The car is often referred to as a computer on wheels, and that's not far from the truth. Myriad sensors and electronic control devices affect the engine, steering, braking performance, entertainment systems and lighting. More than 100 small computing units ensure greater driving safety, but the integrated technical data could also be a potential target of unauthorized access. This in turn increases the need for more secure vehicle IT. To this end, the Fraunhofer Institute for Secure Information Technology SIT developed a software platform based on the safe open standard Trusted Platform Module 2.0. It allows all the necessary hardware and software components of the vehicle's control units to simulate and implement almost any requirement. In light of the future with autonomous driving, the issue of IT security is of vital importance.

Efficient freight transport 1

Global trade happens on the high seas: 90 percent of transport volume is handled by the international shipping industry. The fuel consumption is just as large, hence the efforts to save costs here. One solution for saving on consumption, emissions and costs is to create a new kind of ship that relies on natural gas and wind power rather than heavy oil. Terje Lade, a Norwegian engineer and CEO of Lade AS, has done just that with the Vindskip™. The freighter's hull serves as a sail. Researchers from the Fraunhofer Center for Maritime Logistics and Services CML developed software that ensures the ship optimizes available wind energy potential and offers a choice of routes when the wind direction indicates a particularly fuel-efficient locomotion.

So tires can roll a bit farther ...

Retreaded tires play an important economic role, especially when it comes to truck transportation. The EKORUND research project, which is nearing completion, is concerned with the retreading of truck tires. Together with industry partners, the research is taking place at the Pilot Plant Center PAZ in Schkopau, operated by the Fraunhofer Institutes for Applied Polymer Research IAP and for Microstructure of Materials and Systems IMWS. The researchers are examining how rubber can be conserved without negatively impacting the tire's performance. An important approach here is improving tire treads by using new recycled composites. Tires that are retreaded this way use recycled rubber, which saves rubber in production and reuses old tires at the same time.



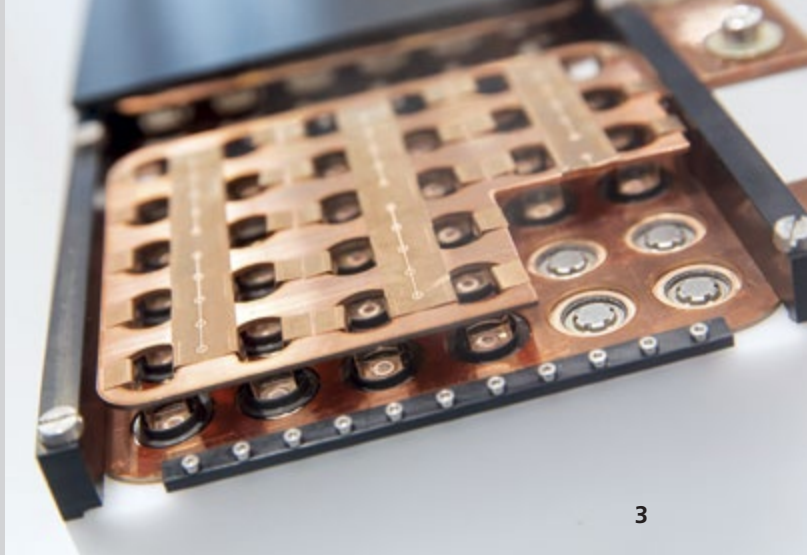
2

So tires can roll a bit better ... 2

Simulation of tires is a technological challenge because in mathematical models they behave in a complex, non-linear manner. In the simulation of a complete moving vehicle, the tire model is the most important component, but also the most difficult. Researchers at the Fraunhofer Institute for Industrial Mathematics ITWM in Kaiserslautern have developed a simulation tool called CDTire/3D that addresses these challenges. The program is fast yet realistic. It also takes into account the heat generated when driving or braking, and any changes to the tire's properties. A particular feature of this simulation is that the geometry and material properties are completely separated from each other, which in practice means that you can change the geometry of the tire without having to adjust the model. Automakers appreciate this: the simulation is already being used worldwide by Toyota and other manufacturers.

Efficient wireless charging

Electric cars may take longer to refuel than conventional cars, but a recent development now makes it easier and more comfortable than ever. Thanks to a wireless charging system that researchers at the Fraunhofer Institute for Wind Energy and Energy System Technology IWES contributed to, electric vehicles will not only be able to recharge, but also feed energy back into the power grid. In this way, they can help stabilize the grid – playing an important role when power is erratically generated by wind and solar energy. The charging system is cost effective and works with an efficiency of about 95 percent. The distance between the car and the charging coil can be up to 20 centimeters.



3

Lasers for electric cars 3

Efficient battery technology is a critical point for the future acceptance of electric mobility. This concerns not only a battery's capacity but also its weight. Both have significant influence on the range of the vehicle. The Fraunhofer Institute for Laser Technology ILT is working on a new laser-based production process for lightweight battery packs. Precisely controlled laser welding and joining improve the processing quality and make it suitable for use with high-quality lightweight materials, such as multi-material composites. In turn, oscillation welding creates a secure connection between the individual battery cells. Fraunhofer ILT is also working with the Fraunhofer Institute for Ceramic Technologies and Systems IKTS on the DRYLAS project to develop a particularly energy-efficient, laser-based drying of electrode coatings for lithium ion batteries.

PRODUCTION AND SERVICES

Joseph von Fraunhofer Prize 2015

Hard coatings for machinery

Even before the European Commission set ambitious targets for CO₂ emissions for mobility and made them compulsory, reducing fuel consumption has been one of the main goals in vehicle development. In order to reduce friction in machines, hydrogen-free carbon coatings (ta-C coatings) on the stressed surfaces would be highly advantageous, but so far they could not be produced commercially at the required quality. Prof. Dr. Andreas Leson, Dr. Hans-Joachim Scheibe and Dr.-Ing. Volker Weihnacht from the Fraunhofer Institute for Material and Beam Technology IWS have developed a ta-C coating process that meets the demanding requirements of the industry in terms of quality and cost. They modified the laser arc method so that it can be precisely controlled and the desired layers can be applied with a high rate of deposition. The method is already being used to produce high quality components by numerous large automotive, supplier and tool manufacturers. For this development work the three researchers received the 2015 Joseph von Fraunhofer Prize.



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Recyclable steel rotors 1

Wind power has become an indispensable renewable source for our energy needs. But wind turbines will not last forever, which raises questions about production cost and reusability of the material. Fiber-reinforced plastics are still very expensive to produce and recycle. In contrast, reusing the materials in steel rotors is relatively easy. To put this effect to good use, researchers at the Fraunhofer Institute for Machine Tools and Forming Technology IWU have now developed a new and more efficient process for preparing blades made of steel. In this case, the final shape is produced by inflating double-layer welded sheets of steel into the profiled tool. The blades match the airfoil of the tool within 0.1 millimeter. The method has been adapted and successfully tested.

Hugo Geiger Prize 2015

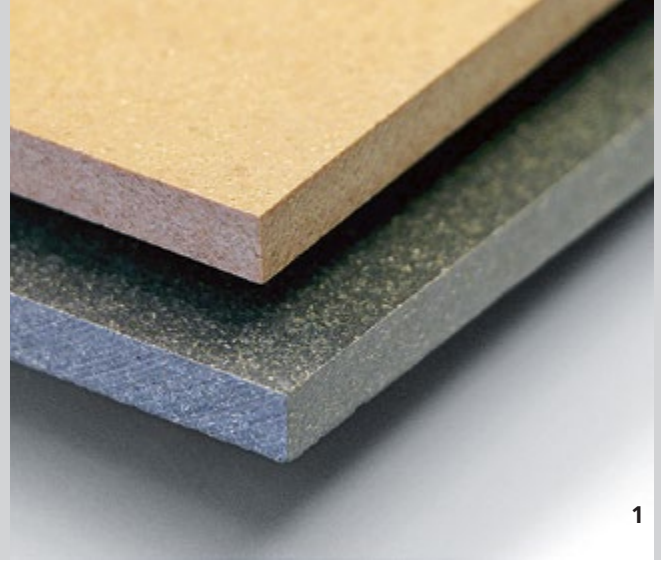
More power for diode lasers

Diode lasers are cost-effective, industry-standard beam sources with the greatest efficiency of all laser beam sources. Compared to traditional solid-state lasers however, they have significantly smaller power, radiance and brilliance, which until now, has greatly limited their field of application. As part of his doctoral thesis, Dr.-Ing. Stefan Hengesbach of the Fraunhofer Institute for Laser Technology ILT has now developed a method that can significantly increase diode laser power and radiance. The new findings from his scientific work are based on improved frequency stability and a new high-multiplexing process. The economic benefits go far beyond the potential savings of electricity. For industry, this radiation source type opens up a path toward flexible production without maintenance and tooling times. Because of their high

efficiency, compact design and large number of available wavelengths, these beam sources can tap many new areas of application. Hengesbach was awarded the Hugo Geiger Prize 2015.

Speedy mirrors deflect laser beams 2

Edit, cut, weld – laser technology is an established procedure for manufacturing's demanding environment. Usually, high-energy laser beams require special optics to deflect the beam to the desired degree of precision. Now, special microlaser mirrors – jointly developed at the Fraunhofer Institutes for Silicon Technology ISIT and for Material and Beam Technology IWS – allow for more flexibility in laser processing. Previously, only laser power of a few milliwatts could be used with such mirrors. This was enough for head-up displays on car windshields for example. Thanks to a new protective coating and a special mounting, the mirrors can now withstand laser power in the kilowatt range – and thus cut sheet metal. The new micromirror can be moved at 100 kilohertz and allow unprecedented processing precision and flexibility.



Gecko model

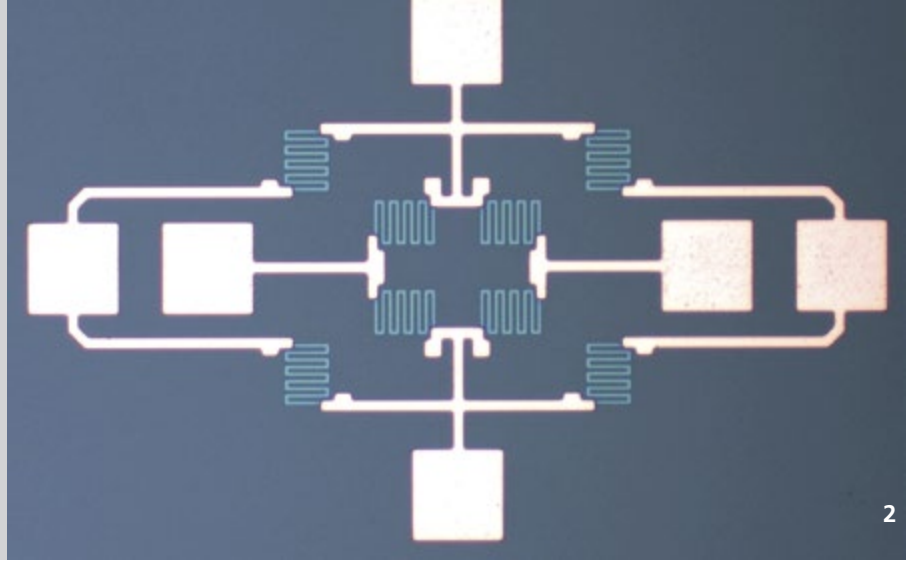
What do the lotus leaf and geckos have in common? Both possess unique properties due to special chemical compositions within their structured outer surfaces that measure in the micrometer and nanometer range. The lotus leaf repels water and any surface pollutants along with it. The gecko can run on completely flat surfaces without slipping. In cooperation with five chemical companies, the Fraunhofer Institute for Microstructure of Materials and Systems IMWS plans to develop similarly powerful surfaces. This includes such products as packaging materials with custom properties or archival films meant to last 500 years. The method to be used for molding tools (stampers), in which the material is hot stamped into the desired structure, has already been patented.

New material for making furniture 1

Wood is the most popular raw material used for building furniture. However, it also has disadvantages in this capacity because wood can absorb moisture, become blotchy and even rot. A new composite – comprised of 60 percent wood particles and 40 percent plastic – results in a material that can even be used without problems for bathroom furniture. The researchers at the Fraunhofer Institute for Wood Research, Wilhelm-Klauditz-Institut, WKI, improved the recipe with flame retardants and other additives, so that in many ways, the characteristics are as good or even better than that of furniture made of wood or particle board – right up to its recyclability.

Workers with a steady hand

Modern craftsmen could cry a river about it: power tools are noisy and vibrate so much that after a while they are uncomfortable to use. The researchers at the Fraunhofer Institute for Structural Durability and System Reliability LBF have a remedy: together with their colleagues from the C. & E. Fein GmbH, they have developed a technology that greatly reduces such vibrations. The new device moves back and forth almost 19,500 times per minute. It can saw, grind, polish, scrape, cut, split, sharpen or hone – with significantly less noise and vibration than usual. The developers used simulations to calculate the optimal decoupling of the motor and housing with elastomer elements. The power tool now belongs in the zero vibration class and can be used by artisans or automotive workers for up to eight hours a day.



Cheap magnetic sensors 2

Magnetic field sensors play a role in many different technologies. In smartphones, for example, they monitor the position of the device compared to the Earth's magnetic field, and in cars they register the position of levers and other controls. In addition to the sensitivity and the magnetic field, the price of the sensors is an important criterion. That is why the new, monolithic manufacturing method for multidimensional sensors, devised at the Fraunhofer Institute for Electronic Nano Systems ENAS, is of particular importance. At the heart is a local laser manipulation on the layered microstructure sensor stack, which allows for the preferential magnetic directions of the material and thus, the rotation sensitivity.

Cost-effective, lightweight motor

For lightweight design, fiber-reinforced plastic has distinct advantages over aluminum: it is one-third lighter and its properties are readily adjustable, depending on which plastic, which fibers, and which method is used to form it. With appropriate design and metallic inserts, even an internal combustion engine made of plastic is feasible, as demonstrated at the Fraunhofer Institute for Chemical Technology ICT. Modern injection molding also allows for automated production of such parts, so that large-scale production is economically feasible. Once the researchers have constructed a single-cylinder plastic engine as prototype, they also plan to manufacture a multi-cylinder engine using plastics, including a crankshaft bearing.

Fraunhofer Zukunftsstiftung (Fraunhofer Future Foundation)

Top performing diamonds

Artificial diamonds are an important field of competence of the Fraunhofer-Gesellschaft. Expanding and applying this expertise to power electronics is the aim of a project funded by the Fraunhofer Zukunftsstiftung (Fraunhofer Future Foundation). It is called Green Electronics with Diamond Power Devices and will open up a new field of competency for Fraunhofer with power electronic components made using single crystal diamonds. The Fraunhofer Institute for Applied Solid State Physics IAF coordinates the consortium, which also houses the Fraunhofer Institutes for Integrated Systems and Device Technology IISB, for Surface Engineering and Thin Films IST, for Mechanics of Materials IWM, and for Material and Beam Technology IWS. Each institution has unique features. Together, they represent a globally unique expertise that will lead to important new patent families.



ENERGY AND MATERIALS

Coating instead of sawing 1

Since today's market for rooftop solar modules is based largely on price, manufacturing cost is a crucial factor. When the cells for the modules are sawed from the silicon block, about half of the expensive material is lost in the process. Not so with a new method that the researchers at the Fraunhofer Institute for Solar Energy Systems ISE have developed. Instead of cutting the desired layer of a block, they let the heated chlorosilane grow directly into the desired shape on a reusable pad. Solar panels equipped with such cells cost about 20 per cent less to produce – but come with the same performance and service life.

Raw materials from exhaust gases 2

Carbon monoxide-rich gases from industrial production are only being reclaimed to a minor extent as power or heat. Now Fraunhofer researchers have developed a new recycling process for this substantial yet unused carbon resource: they ferment the gases using genetically modified bacterial strains to create alcohols and acetone. Then they convert both substances catalytically into an intermediary diesel-like product, and from this they produce kerosene and specialty chemicals. Participants in this research include the Fraunhofer Institutes for Molecular Biology and Applied Ecology IME, for Environmental, Safety and Energy Technology UMSICHT and for Chemical Technology ICT. The technology came about during one of Fraunhofer's internal pre-competitive research projects and through individual projects with industrial partners.



Electronic scraps into raw materials

In Germany, value creation in manufacturing industries is highly dependent on a stable supply of metallic and mineral resources. An alternative source under discussion is urban mining, in which raw materials are recovered from modern residential waste. One example is antimony, a rare element found in the Earth's crust. It is mainly used as an additive in flame retardants for flammable materials such as plastic, rubber or textiles. Currently, the only recovery technology for such waste is the CreaSolv® process, developed at the Fraunhofer Institute for Process Engineering and Packaging IVV. It is being further developed into a process for use on an industrial scale under economically viable conditions.

Fraunhofer Zukunftsstiftung (Fraunhofer Future Foundation) Efficiency with new coils

Electric motors in plants will soon require higher power density in light of new energy efficiency classes, which can hardly be achieved with conventional coils. In the Innovative Manufacturing Technologies for Electric Machines – IFEM project, the Fraunhofer Institutes for Manufacturing Technology and Advanced Materials IFAM and for Machine Tools and Forming Technology IWU have developed processes for large production-ready manufacturing for the production of coils for electrical machines. Such coils are used in vehicles, but also in machinery and equipment. The processes developed by the two institutes are based on casting and forming techniques in order to provide solutions for various spool sizes and applications. The project is funded by the Fraunhofer Zukunftsstiftung (Fraunhofer Future Foundation).

Storing energy where storage already exists

The transition to a new energy economy using renewable energy sources is only possible with new stores and storage concepts. Researchers from the Fraunhofer Institute for Solar Energy Systems ISE have successfully tested a new concept – hybrid storage – in which an agent-based operating system aggregates thousands of small batteries and heat storage systems into a virtual storage system. Intelligent decentralized systems coordinate the local storage without affecting consumers' individual storage and make it available in bundles at the distribution level. The control system was developed in cooperation with the Fraunhofer Institutes for Environmental, Safety and Energy Technology UMSICHT and for Optronics, System Technologies and Image Exploitation IOSB. It links the distributed storage components in the control room to a decentralized virtual power plant.



Façades conserve energy

Glass-fronted office buildings are some of the biggest energy consumers, because they must be kept cool in the summer and must be heated accordingly in the winter. To reduce energy waste in glass fronts, researchers at the Fraunhofer Institute for Machine Tools and Forming Technology IWU teamed up with the Department of Textile and Surface Design at the Berlin Weissensee School of Art to develop façade components that respond autonomously to sunlight and its thermal energy. This is done by using shape-memory actuators: when warmed by the sun, they flatten into the hexagonal shading elements and provide a shield independently. Should the amount of sunlight decrease, the cooled elements reopen and let daylight shine through unhindered.

Recycling LEDs 1

Recycling is a way to protect the environment. When valuable substances are recovered that would otherwise be expensive to buy on the world market, recycling becomes economically interesting. LEDs contain such valuable materials: indium and gallium in the semiconductor diode and rare earths such as europium or terbium in the phosphor. The Project Group for Materials Recycling and Resource Strategies IWKS of the Fraunhofer Institute for Silicate Research ISC is now developing suitable methods to mechanically separate these substances from old LEDs. In this way, they are exploring the conditions that could make recycling methods economically attractive, since in the foreseeable future it will become very important. The Project Group IWKS is also part of the German Resource Research Institute (GERRI) joint project, which was designed to strengthen German raw materials research for international competition in the future and was funded by the German Federal Ministry of Education and Research (BMBF).

Surveying underwater

While measuring objects can be carried out with the highest precision under normal conditions, measuring objects underwater is another matter. Ambient and operating conditions – such as pressure and temperature – make the operation of measuring systems more demanding. Divers are also restricted by their suits. Yet many important components for offshore oil and gas conveying systems are underwater, and these must be checked and maintained. In cooperation with industrial



partners, researchers at the Fraunhofer Institute for Applied Optics and Precision Engineering IOF have developed a measuring device about the size of an underwater camera that divers can easily use to capture 3D data. Each measurement takes 0.2 seconds and the diver can tell immediately whether it was successful.

Energy-saving chips of the future 2

Semiconductors based on gallium nitride convert power more efficiently than conventional silicon chips. This offers enormous potential for smartphones, laptops, solar panels and many other applications. The Fraunhofer Institute for Microstructure of Materials and Systems IMWS, the Fraunhofer Technology Center for Semiconductor Materials THM and the Fraunhofer Research Institution for Microsystems and Solid State Technologies EMFT are helping the European ECSEL PowerBase research project to bring this future technology to market. More than 30 other partners are involved in the project, which is led by Infineon Technologies. The next goal of the consortium is the construction of pilot plants in Regensburg, Germany, and Villach, Austria, by 2018.

My car – my sun stream 3

Powering electromobility with renewable sources makes it particularly interesting. Since photovoltaic systems on house roofs generally provide more energy than the inhabitants can consume, the surplus electricity can be fed back into the grid or used for short trips with one's own electric car. This ideal scenario is already a reality for row houses in Baden-Württemberg, Germany. To efficiently integrate electric mobility into daily life, a research team at the Fraunhofer Institute for Solar Energy Systems ISE has developed a fast charging home energy management system (HEMS) with a charging capacity of 22 kilowatts for five of the seven households. The project is funded by the Showcase for Electromobility program, an initiative of the German Federal Government.

INITIATIVES AND HIGH PERFORMANCE CENTERS

Industrial Data Space initiative **Data sovereignty for industry**

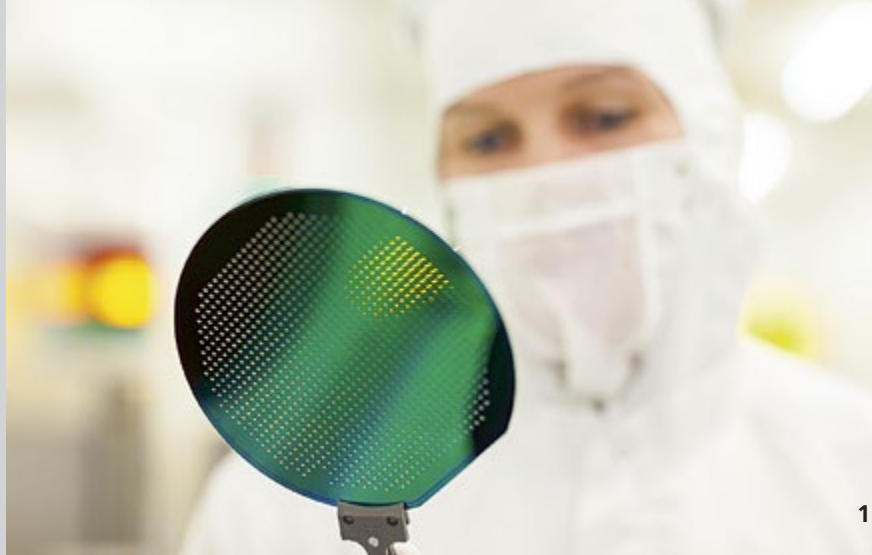
The Industrial Data Space initiative, launched by Fraunhofer early 2015, aims to create a secure data space where companies from various industries and of all sizes can exercise sovereign management of their data assets. The concept is aimed at establishing comprehensive cross-sector connectivity, making it easier for companies to utilize the potential of digitalization in their business models without relinquishing control over their data. It will help companies make their manufacturing and business processes fit for digitalization and create a foundation for new business models.

Digital sovereignty over data as well as data security are key issues in the Industrial Data Space. Data is only shared between certified partners when it is truly required by the user of that data for value-added service. Community governance in the form of common rules that each participant undertakes to follow, is at the core of the secure data space. The data services of the Industrial Data Space should serve as a basis for developing their own value-added services.

Funded by an initiative from the German Federal Ministry of Education and Research (BMBF), Fraunhofer developed a reference architecture model for the Industrial Data Space and pilot projects for application scenarios in industry.

On January 26, 2016 in Berlin, Fraunhofer and business users also founded a non-profit association for Industrial Data Space. It combines the requirements for the Industrial Data Space, organizes a professional exchange of ideas and develops guidelines for the certification, standardization and application of the research project results.

The Industrial Data Space Association is international. Initial members include: Allianz, Atos, Bayer, Boehringer Ingelheim, Bosch, Fraunhofer, KOMSA, LANCOM, PricewaterhouseCoopers, REWE, Salzgitter, Setlog, Schaeffler, SICK, Thyssen-Krupp, TÜV Nord, Volkswagen and ZVEI.



High Performance Center for Functional Integration of Micro- and Nanoelectronics

System integration creates performance 1

With the Internet of Things and industry 4.0, the demand for systems – and the demands on systems – continues to grow. The components must integrate ever more functions, be even smaller and be more densely networked. How competitive and innovative today's electronics companies are is determined by how much and how quickly they can access the latest technological developments.

Now, the Fraunhofer Institutes for Photonic Microsystems IPMS, for Electronic Nano Systems ENAS, for Integrated Circuits IIS and for Reliability and Microintegration IZM join together with the Technical Universities of Dresden and Chemnitz and the University of Applied Sciences Dresden to form the High Performance Center for Functional Integration of Micro- and Nanoelectronics. Working in close cooperation with local companies to enhance their research expertise, the center enables them to bring innovative products and applications to market more rapidly, which ultimately leads to a strengthening of the whole region.

In the two-year pilot phase, the High Performance Center's work focuses on microelectromechanical systems (MEMS), such as sensors and actuators, as well as system integration in industrial automation. Important research areas include: sensor nodes for networked systems, adaptive systems for condition monitoring and diagnostics, or in measurement and control systems that minimize energy consumption in production. After two years, other applications such as energy, medical and mobility are to be added.

To date, more than twenty companies have expressed interest in participating in the project. By the end of the pilot phase, a virtual center will be developed through the close networking of universities, Fraunhofer and local industries. Ultimately, if the center succeeds, the goal is to then convert it into a permanent center in a high-profile region, which the German Federal Ministry of Education and Research (BMBF) would continue to develop.

Initiatives and High Performance Centers

High Performance Center for Sustainability Research with responsibility for the future

Sustainability is a key topic for the German economy. Via a pilot project in Freiburg for a High Performance Center, Fraunhofer has now paved the way to put the region's potential more intensively to use. Already known for its pioneering role in environmental issues, the city will be home to the new High Performance Center for Sustainability.

As part of current projects of the High Performance Center, experts are examining how resource-efficient LED technology could comprehensively lower production costs, if and how CO₂ could be recycled as a raw material, and what we can learn from self-repair mechanisms in the plant kingdom.

The pilot projects and Performance Center will be financed with a total of 7.2 million euros by the Baden-Württemberg's Ministry of Science, Research and the Arts and the Ministries of Finance and of Economic Affairs and the Fraunhofer-Gesellschaft. Furthermore, industrial partners participating in the transfer of research results into practice are expected to contribute an additional 6 million euros over the next three years.

The five Fraunhofer Institutes in Freiburg and the University of Freiburg plan to coordinate their future plans even more. For the Performance Center, this includes the targeted development of the following topics: sustainable materials, energy systems, resilience and how society views change processes. Since October 2015, the heart of the High Performance Center is the engineering faculty from the Department of Sustainable Systems (INATECH) at the University of Freiburg. Together with the Freiburg Fraunhofer Institutes, the university will create up to 14 new professorships, and combine the three research topics – materials, energy and resilience – in a unique way.

Dialog with the public is of particular importance for the scientific organizations. Scientific results should be put into practice as quickly as possible, and that is only possible if the researchers know what motivates people and how to help them. Therefore, the High Performance Center will host events in the future that foster an exchange between the scientific community and the public.



High Performance Center for Electronic Systems

Efficiency for electronic systems 1

The Nuremberg Metropolitan Region is on its way to becoming the leading center for electronics systems in Germany. Now, both Erlangen-based Fraunhofer Institutes for Integrated Circuits IIS and for Integrated Systems and Device Technology IISB and the University of Erlangen-Nürnberg (FAU) have teamed up with Siemens AG and other partners from industry and research to combine strengths in the new High Performance Center for Electronic Systems. The center focuses on two main areas: power electronics, such as for power supply and drive technology, and low-power electronics that have to make do with minimal amounts of energy when in use. The alliance with industry ensures that new technologies will have a good chance to make it to market as successful products.

Two current research topics: in the Wireless Power and Data Transfer in Systems with Fast-Moving Parts project, the inductive common transmission of power and data is the aim. Application examples include wind turbines with integrated electronics in the rotor blades, highly automated production plants such as those envisioned for industry 4.0, or robotic systems in which power and information have to be transmitted to the joints. Based on the RedFIR® real-time positioning system technology and FitnessSHIRT, which measures pulse and respiration, the partners are developing the first step towards an advanced prototype that combines the two technologies in the Low-Power Electronics for Sports and Fitness Applications project. The shirt will record position and motion data simultaneously with vital data, such as ECG or respiration.

The Bavarian Ministry of Economic Affairs and Media, Energy and Technology is supporting the pilot phase of the High Performance Center with 5 million euros. A further 5 million euros will come from industry, and 4.8 million euros from Fraunhofer.

Cluster of Excellence MIRO

Seeing more with infrared light

People cannot see infrared light. However, exactly this spectral region has a very high potential for use for various technical applications. For instance, for agriculture and food processing, infrared sensors can quickly identify the condition of organic products. The respective optical systems are able to monitor quality and detect pollutants. They could contribute to improved traffic safety, for instance as night vision sensors. Further application areas include the development of personalized therapies and diagnostic tools in the medical sector, and in the ground-based astronomy and satellite-based Earth observation research fields.

The Fraunhofer Institute for Applied Optics and Precision Engineering IOF and the Jena University of Applied Sciences (EAH Jena) have begun collaborating on researching micro- and nanostructured infrared optics. With MIRO, the expertise of both research facilities are combined for the production of micro-optics and their applications in the infrared range. In the next three years, micro- and nanooptics for the infrared range of optical components, modules and complete systems will be developed to far exceed the present options in terms of performance, space and cost. The cooperation is funded by the German Federal Ministry of Education and Research (BMBF) and supported by the Thuringian Ministry of Economy, Science and the Digital Society with a total of 1.8 million euros.

AWARDS 2015

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.

Karl Heinz Beckurts Prize

Electronics for new mobile networks 1

Mobile devices have dramatically changed the way we communicate in the last few years. Not only do we make mobile phone calls, we also upload music, photos and movies on the go using our smartphones, tablets and notebooks. This development is progressing rapidly and the mobile infrastructure needs to be addressed to accommodate the necessary data amounts for the future. This is only possible with more efficient technology. Prof. Dr. Oliver Ambacher of the Fraunhofer Institute for Applied Solid State Physics IAF and his team have made a decisive contribution to this. Together with industrial partners, he developed a power amplifier based on the innovative semiconductor material gallium nitride (GaN) for cellular base stations and brought

them to deployment. For his pioneering scientific work, Oliver Ambacher was awarded the Karl Heinz Beckurts Prize and endowed with 30,000 euros. Every year since 1989, the Karl Heinz Beckurts Foundation honors outstanding scientific and technical services that bring significant impulses for industrial innovations in Germany.



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ERC Advanced Grant

Shaping the future with laser light 2

With its awards, the European Research Council ERC promotes its goal of supporting pioneering research with scientific excellence. The ERC Advanced Grant is awarded to outstanding European scientists in any discipline who are already established in their fields to support the implementation of visionary research projects that are expected to yield highly innovative applications. The Advanced Grant is one of the most highly endowed international research prizes.

In 2015, the Research Council bestowed this prize on Prof. Dr. Andreas Tünnermann, the director of the Fraunhofer Institute for Applied Optics and Precision Engineering IOF in Jena. His research specialty is fiber lasers. These fiber optic-based solid state lasers are very robust, can be amplified well and have a high level of efficiency. Among other things, they are used

for materials processing, medical engineering, in particular for diagnosing, and in space for precise measuring. Over the next five years, Andreas Tünnermann will receive up to 2.5 million euros in funds for basic research.



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ERC Consolidator Grant**Repairing by copying 1**

Some biological systems have the ability to duplicate their own structures. The most important example is DNA. All cells of an organism can have the same genetic information only when genetic information is duplicated. Prof. Dr. Alexander Böker, director of the Fraunhofer Institute for Applied Polymer Research IAP, wants to transfer the principle of self-duplication to technical systems. In doing so, colloidal polymers should be capable of arranging themselves into tiny lattice structures with high diffraction symmetries. These allow only light rays of a single wavelength to be transmitted, and only in a specific direction. The effect is used in photonics to store or transfer information. Once a colloid has been developed into a “programmable building block”, it could independently arrange itself into identical copies using a master of the original structure. Large scale colloidal formations could be produced in the laboratory with comparatively little effort. For industry, this would lead to a resource-efficient, tailored

fabrication of components within the framework of the fourth industrial revolution. Conceivable are components for displays and storage media, but also transport capsules in the pharmaceutical industry and security features to combat product piracy. With this award, the project will be endowed with a research grant of 1.9 million euros.



Eduard Rhein Prize

mp3 and the beautiful new music world 2

The development of the mp3 audio file format is closely linked to the Fraunhofer-Gesellschaft, with its spirit of invention and with Karlheinz Brandenburg (pictured), the current director of the Fraunhofer IDMT in Ilmenau, as well as researchers Bernhard Grill and Jürgen Herre from the Fraunhofer Institute for Integrated Circuits IIS. With their team, they invented a technology that revolutionized the entire music industry. Even 25 years ago, no one could have imagined it and yet today everyone has become accustomed to the option of carrying around thousands of songs in top sound quality on small players and smartphones. We use digital broadcasting and enjoy perfect sound quality at the movies and while driving. All of these are based on mp3 and other inventions from Erlangen.

The Eduard Rhein Award and mp3 fit together perfectly: In 1976, Eduard Rhein launched his foundation with 2 million Deutsche Marks from his personal savings, with the aim of supporting technological innovations in the field of television and radio broadcasting. Since then, leading figures such as Andrew Viterbi, for the Viterbi algorithm, and World Wide Web creator Tim Berners-Lee have been presented with the Eduard Rhein Award for outstanding achievements in research, education, art and culture – inventors who have also changed the world with their work. This success story is not over yet: Fraunhofer's expertise in audio systems leads to increasingly fascinating discoveries that enhance our musical enjoyment in concert halls, living rooms, cars, and through headphones.

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.



JUN.-PROF. DR.-ING. DELPHINE REINHARDT

Engineer | Head of the Working Group on Privacy and Security in Ubiquitous Computing at the Fraunhofer Institute for Communication, Information Processing and Ergonomics FKIE in Wachtberg

Delphine Reinhardt, whose academic qualifications include degrees in both engineering and computer science, specializes in questions of data protection and personal privacy. Her work as a teaching professor and researcher revolves around the dynamic interaction between opportunities, risks and threats in the virtual world.

After obtaining a first degree in electrical and electronic engineering, Delphine Reinhardt switched to computer science for her postgraduate studies. She holds master's degrees from the French Ecole Nationale Supérieure de l'Electronique et de ses Applications in Cergy, and from Technische Universität Darmstadt (TU Darmstadt) in Germany. She was awarded a PhD by TU Darmstadt for her thesis entitled "Privacy in Participatory Sensing: User-controlled Privacy-preserving Solutions for Mobile Sensing Applications".

This groundbreaking work, for which she received many accolades, set the course for her future career. In February 2014, she was engaged as an assistant professor specializing in IT security at the University of Bonn, and at the same time accepted the post as head of the Working Group on Privacy and Security in Ubiquitous Computing at the Fraunhofer Institute of Communication, Information Processing and Ergonomics FKIE. The duties associated with these posts not only include acquiring and conducting research projects, but also the organization of scientific events to disseminate scientific results.

The vision that motivates Delphine Reinhardt in her work is that of helping users of modern-day technology to preserve their personal privacy: "I want to enable people to take

advantage of the benefits offered by new technologies without the risk of compromising their personal privacy. The rapid pace of technological change makes this objective very difficult to reach. A case in point is the concept of smart cities, which not only offers business opportunities for the IT industry but also promises to improve our quality of life. The downside of this trend is that it makes it more and more difficult for people to protect their personal data on the Internet, especially when shared involuntarily. In the past, all one had to do to escape intrusion by prying eyes was to shut the door and switch off their computer. In the city of the future, in which more and more data are collected by various sensors, it will become almost impossible to preserve a zone of privacy. The aim of our research and development work is to find solutions to this problem that will help to improve the present situation." In order to achieve this objective, Delphine Reinhardt has chosen an interdisciplinary approach, in which both technological issues and the often neglected human factor are considered equally.

The path to better privacy is a long and arduous journey that involves battling against constantly changing risks and dangers – and often calls for a great deal of perseverance. The fact that Delphine Reinhardt participates in endurance sports in her spare time and has many years of judo training under her belt could well turn out to be an advantage that will help her to win this battle: after all, one of the things this training has taught her is to get up again after a defeat and recognize that patience is a virtue when striving for perfection.

DR.-ING. STEFAN HENGESBACH

Engineer | Research associate at the Fraunhofer Institute for Laser Technology ILT in Aachen

Laser light is one of those physical phenomena that can be complicated to master in an engineering context. In order to keep an eye on the broader aspects of this interdisciplinary technology and its potential applications, it is useful for laser experts to widen their viewpoint by talking to non-specialists on a regular basis. Stefan Hengesbach sees teaching as an ideal way of doing this. Having to answer questions by students forces him to think about his research in new ways – thereby enriching his own specialized scientific work: “Teaching and transmitting knowledge to students are important aspects of professional research, which also bring benefits for me. Seneca’s well-known aphorism ‘by teaching, we learn’ (docendo discimus) sums this up perfectly.”

Teaching has played an important role in Stefan Hengesbach’s career from the very beginning. From 2002 to 2008 he studied mechanical engineering at RWTH Aachen University, and by 2004 was already leading a working group for students and young engineers as a member of The Association of German Engineers (VDI). He subsequently participated in diverse teaching programs at the university, including collaboration with the Photonik-Akademie and the RWTH Children’s University – all highly appreciated by the students and university administrators. For this work, the young lecturer and his colleagues at the Chair for Laser Technology LLT won several prizes awarded by the university’s faculty of mechanical engineering.

The combination of a passion for optical technologies and the satisfaction of receiving public accolades almost inevitably points to applications in the field of film and photography – two areas of particular interest to Stefan Hengesbach.

Technical photography forms part of this repertoire of skills, which he also applies as a member of the production team for Fraunhofer ILT’s annual “Christmas video” – an amateur movie that has already risen to cult status among his past and present coworkers.

The focus of Stefan Hengesbach’s research is diode lasers. These beam sources are cheap to manufacture and have a high power efficiency, but until now they have been unable to match the output, beam density and brilliance of more conventional solid-state lasers. As part of his doctoral thesis, Hengesbach devised methods allowing the performance of diode lasers to be significantly increased. As a result, industry will soon be able to use high-power diode lasers in flexible manufacturing processes that eliminate downtime for maintenance and retooling. This research generated considerable interest among experts. The many awards he received for this ground-breaking work include the Hugo Geiger Prize 2015 awarded by the Bavarian Ministry of Economic Affairs, the Borchers Medal awarded by the Rector of RWTH Aachen, and the 2015 WLT Award conferred by the Scientific Society for Laser Technology.

Such prizes awarded by scientific institutions and other official bodies are not only intended to honor past achievements but also to encourage the recipient to continue working in this direction in the hope that their future achievements will be equally outstanding. Stefan Hengesbach regards these prizes as a challenge to meet the high expectations of the research community and academia regarding his future work, and there is every chance that he will succeed in doing so.





PROF. DR.-ING. FRAUKE STEINHAGEN

Engineer | Head of the Sensor Systems research group at the Fraunhofer Institute for Applied Solid State Physics IAF in Freiburg and professor of electrical engineering at the Baden-Wuerttemberg Cooperative State University (DHBW)

The Fraunhofer-Gesellschaft's mission can be summed up as creating links between research and real-world applications, while the purpose of a cooperative university is to combine academic studies and professional training. The two institutions share the common goal of linking theory and practice to produce results that it would rarely be possible to achieve by either one of these approaches alone.

This fertile ground provides the framework for Frauke Steinhagen's professional interests. Between 1985 and 1991, she studied electrical engineering and communications technology at Technische Universität Darmstadt and the Grenoble Institute of Technology (INP). After graduation she received a research grant from Deutsche Telekom to study the properties of directly modulated laser diodes and their potential applications in high-speed, digital data transmission, and obtained a PhD for this work. This first intensive encounter with the world of research had a productive sequel: for the next five years, the Fraunhofer Institute for Applied Solid State Physics IAF benefited from Frauke Steinhagen's contribution to its research in the field of high-frequency semiconductor integrated circuits.

In this early stage of a researcher's career, short-term employment contracts are the norm. So when in 2001 Frauke Steinhagen was offered a permanent teaching post as a professor at the Baden-Wuerttemberg Cooperative State University (DHBW) in Lörrach, she jumped on the occasion, given that she enjoys teaching just as much as scientific research.

At that time, the cooperative state university provided few direct opportunities for research per se. Having once experienced the satisfaction that can be gained from seeing research results transformed into practical product applications, Frauke Steinhagen was very tempted by an offer that would allow her to return to her previous employer: Professor Oliver Ambacher, director of Fraunhofer IAF, wanted to win her back as a member of his institute's research staff – in parallel with her teaching activities at the university.

Frauke Steinhagen decided to keep a foot in both camps: teaching as a professor in Lörrach and at the same time heading up a research group at Fraunhofer IAF in Freiburg that develops sensor systems for production lines in collaboration with the state university. She devotes her heart and soul to this work: "It is a daunting challenge, but also exciting: I am responsible for leading a major collaborative research project, picking out thematic areas for Fraunhofer IAF's work in connection with industry 4.0 and establishing contact with industrial partners, in the hope that this will also generate ideas for interesting projects that can be carried out at the university."

This collaborative venture, co-financed by Fraunhofer to the tune of 1.2 million euros, serves diverse interests but also represents a classic win-win situation in which all participants benefit from its outcome. Frauke Steinhagen therefore has every reason to be content.

PROF. DR.-ING. BORIS OTTO

Engineer | Director of the division of Information Management & Engineering at the Fraunhofer Institute for Material Flow and Logistics IML and the Fraunhofer Institute for Software and Systems Engineering ISST in Dortmund, and holder of the Audi-endowed Chair for Supply Net Order Management at TU Dortmund University

The personal qualities needed by a first-class researcher are remarkably similar to those of a high-caliber athlete: talent, ambition and training. Boris Otto was naturally endowed with the first, while his ambition could be formulated as “the will to succeed” and training in this context equates to repeated experimentation. This multidisciplinary expert has a wide range of interests spanning from engineering science to business administration, which leads him to switch back and forth between research and its practical applications. This open-minded attitude promotes creativity and is totally in line with the Fraunhofer system that is based on the interaction between pure science and practical applications.

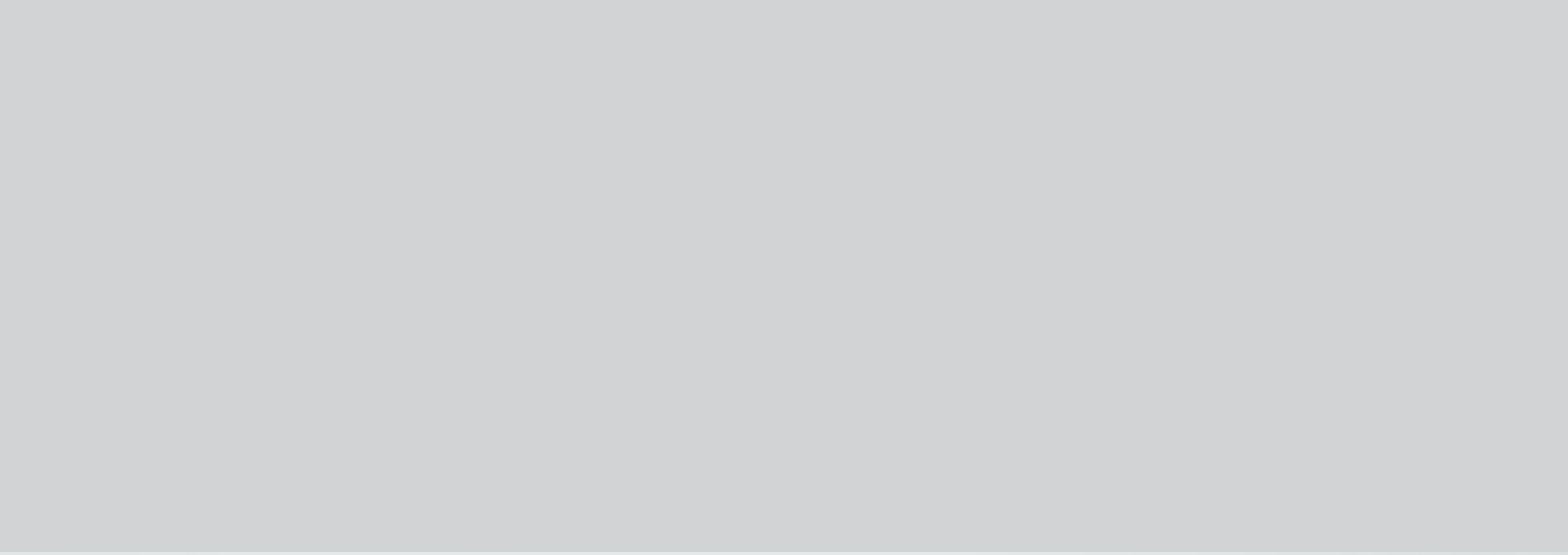
After graduating from the University of Hamburg, Boris Otto pursued further studies at the University of Stuttgart under the supervision of Professor Hans-Jörg Bullinger and obtained a PhD that was accredited by the University of St. Gallen in Switzerland, allowing him to accept a professorship at TU Dortmund University. Meanwhile, he gathered experience in various other roles including consultant for the PricewaterhouseCoopers agency in Hamburg, researcher and project manager at the Institute of Human Factors and Technology Management (IAT), University of Stuttgart, and then at the Fraunhofer Institute for Industrial Engineering IAO – where he later became head of the Electronic Business Integration competence center – consultant for SAP Deutschland, research fellow at the Tuck School of Business at Dartmouth College, USA, and head of the Corporate Data Quality center at the University of St. Gallen.

This versatility brought Boris Otto to his present location, Dortmund, where he heads the Fraunhofer Innovation Center for Logistics and IT as part of his work at the Fraunhofer Institutes for Material Flow and Logistics IML and for Software and Systems Engineering ISST, in addition to his professorship at TU Dortmund University.

Above all, he is the brain behind Fraunhofer's Industrial Data Space initiative, which aims to create a secure network of trusted data that allows companies of all sizes in all sectors of industry to retain sovereign control over their data assets – a prerequisite for smart services, innovative service offerings and automated business processes. It is precisely for this aspect of his work that Boris Otto today enjoys a reputation that extends beyond Fraunhofer.

Fraunhofer provides the ideal working environment for this multi-talented expert: “I never cease to be astonished by the innovative spirit of the researchers here and their ability to generate so many exciting new ideas: all the more so, given that Fraunhofer has grown to the size of a large corporation, with all that this implies in terms of complex management and coordination.”

To complete the picture, we ought to mention that Boris Otto is also an entrepreneur who founded a company in Switzerland a few years back. CDQ AG provides management consulting, solutions and training services in the area of corporate data quality. Is this too much for one person? Not if you compare Boris Otto's performance to that of a decathlete, a sporting discipline that is described – not without reason – as the sport of kings.





PROF. DR. RER. NAT. CHRIS EBERL

Materials scientist | Deputy director of the Fraunhofer Institute for Mechanics of Materials IWM in Freiburg, head of the department of Materials and Micromechanics at the University of Freiburg

Why do people work? Some will say it's because they enjoy it, others are motivated by success and recognition, and of course it also enables them to earn a living. But the strongest motivating factor is the feeling of creating something of lasting value, achieving progress that will make the world a better place for future generations to live in. This is the motive that drives Chris Eberl most of all, thus explaining the pragmatic way in which he views all other aspects of his work and manages his career.

Take, for example, the question of choosing between fundamental science and applied research. In Chris Eberl's view, they are equally important because they can both serve the overriding purpose of sustainable development. This duality is also reflected in his academic and professional career. In 2001, after graduating from the University of Stuttgart with a degree in materials science, he joined the Max Planck Institute for Metals Research (since renamed Max Planck Institute for Intelligent Systems) as a PhD student. His thesis project – investigating the micromechanical properties of aluminum thin films – was thus conducted at a basic research organization but was funded by an industrial sponsor. The results won him recognition from both sides: The Max Planck Society awarded him its Otto Hahn Medal for his explanation of the mechanisms involved, and the project's industrial partner started using the optimized materials in its production process shortly afterward.

After that, Chris Eberl continued to focus his attention on micro- and nanostructures because many issues concerning his key objective of sustainability can be resolved at this level. By slowing the degradation of microstructures, the service life of the components or products in which the materials are used can be

prolonged. And many sensors, actuators and control circuits can be developed on this basis to enable machines, vehicles and manufacturing systems to be operated with minimum consumption of natural resources. Chris Eberl studied the behavior of micro- and nanostructured materials for two years as a postdoc researcher at Johns Hopkins University in Baltimore, before returning to Germany to set up a corresponding research group at the Karlsruhe Institute of Technology (KIT).

Chris Eberl's path led him to Fraunhofer in 2012, where he and his colleagues proceeded to set up an Attract group at the Fraunhofer Institute for Mechanics of Materials IWM. In 2014, he was appointed deputy director of Fraunhofer IWM and at the same time accepted a professorship in the Department of Microsystems Engineering – IMTEK at the University of Freiburg.

Chris Eberl appreciates the pragmatic mindset of his coworkers at Fraunhofer: "Their goal is to find all-round solutions, rather than simply focusing on a specific problem. And the structured system of professional development creates a sound basis for efficient project management." His only criticism is that he would like to see a greater emphasis on pre-competitive research, which is dependent on a higher allocation of base funding.

For the future, Chris Eberl hopes for wider and more systematic use of digital techniques in the study of the micro- and nanoscale behavior of materials. This will allow the behavior of such materials to be predicted with more certainty, improving their performance and allowing their real-time monitoring. The end result is greater durability and reliability of components – two major factors that promote sustainable development – and motivate Chris Eberl along with everyone else at Fraunhofer.



DR. RER. NAT. ANTJE LIESKE

Chemist | Head of the Polymer Synthesis department at the Fraunhofer Institute for Applied Polymer Research IAP in Potsdam-Golm

Fraunhofer conducts real research for real people and, as Antje Lieske's example proves, Fraunhofer's motto for 2015 of "focus on people" is also a fundamental principle of the way our organization works. This philosophy naturally includes family-friendly working-time models which, in this case, also make it possible for parents to combine a part-time job with management functions – because nobody should be denied a promotion merely on the grounds that they have children to care for. On the contrary, they can take on even more responsibilities, and everything else is mainly a question of time management.

Antje Lieske's career has progressed in a straight line. She studied synthetic chemistry at Humboldt-Universität zu Berlin and then moved on to the Fraunhofer Institute for Applied Polymer Research IAP as a postgraduate student to work on her doctoral thesis. What appealed to her most about the proposition of researching polymer tensides was that it was directly related to an industrial application. The initial focus of her work was water-soluble polymers, followed by flocculants for use in wastewater purification.

In the year 2000, her daughter was born and immediately became the central focus of her life. Being a mother was a new challenge for Antje Lieske – and for everyone around her. For Fraunhofer it meant having to organize parental leave in the research group for polymer synthesis. When Antje Lieske returned to work – on a part-time basis to this day – her area of responsibility was by no means reduced: on the contrary it was expanded. In 2005 she took on additional tasks as the

head of the working group on polymer synthesis, including building up a new research area: the synthesis of polymers based on renewable resources. Today this working group is a fully fledged department.

Antje Lieske draws the motivation for working as an applied scientist from the visible results of her research: "I am convinced that finding solutions to the sustainable use of our planet's finite resources will play a vital role in determining the kind of world our children will live in. I find it exciting and very satisfying to be participating in this process of improvement." Another aspect of working for Fraunhofer that this ambitious researcher greatly appreciates is that the search for solutions requires both a creative and a pragmatic approach. The results must be based on exact scientific evidence but at the same time allow their industrial application within the very near future.

Antje Lieske's own experience has taught her how important it is to place human interests first, and to cater for each person's individual capabilities and needs. By transmitting this experience to the members of her team, she has successfully created a department consisting of highly motivated people with strong communication skills who take pleasure in their work and produce outstanding results in every way.

FRAUNHOFER INSTITUTE SPIN-OFFS

FRAUNHOFER INSTITUTES ARE PRIZED BY BUSINESS AND GOVERNMENT ALIKE BECAUSE THEY DRAW EXISTING COMPANIES INTO THEIR ORBIT AND PROVIDE THE SEEDBED 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 WE PRESENT JUST SOME OF THE COMPANIES FOUNDED BY FRAUNHOFER EMPLOYEES.



NexWafe GmbH**Low-cost, high-performance solar modules**

They are a familiar sight on the roofs of many private homes and commercial buildings today – solar panel arrays that generate electricity from solar energy. Although the photovoltaics market is expected to keep growing fast in the years to come, competition is ferocious, and the solar-power industry is looking for ways to improve product efficiency and make manufacturing cheaper. The key challenge lies in the fabrication of the thin silicon wafers used in the construction of the solar cells. Roughly half of the raw silicon material is lost during the production process, resulting in higher wafer costs. These costs add up to no less than 40 percent of the total cost for manufacturing a solar module. This is most strongly seen in the still very expensive to produce high-output solar cells.

Now NexWafe GmbH offers an alternative. Founded as a spin-off from the Fraunhofer Institute for Solar Energy Systems ISE in May 2015, the company has developed an innovative technology that allows high-quality silicon wafers for high-output solar cells to be manufactured with almost zero material wastage and thus at far lower cost. The new technique, developed at Fraunhofer ISE, replaces the conventional wafer sawing method in which nearly 50 percent of the expensive silicon material is lost as waste. In addition to cutting production costs, the new silicon wafers also reduce installation and energy costs because their output is higher than standard solar modules with the same surface area.

The young company is still looking for investors to help finance its technical infrastructure, and plans to start pilot production later this year. Many potential customers have shown an interest in the new technique, and managing director Dr. Stefan Reber is optimistic that the new process will be ready to go into mass production in 2017.



COSEDA GmbH**Efficient chip design tool**

Integrated circuits are getting smaller but more multifunctional. This trend poses huge challenges to research and development, because sources of errors have to be eliminated before the chips go into production. Since preparing the masks for use in the chip fabrication process costs millions of euros, this is a major cost issue. Time is equally important because conventional modeling and simulation systems are quickly reaching their limits when it comes to designing chips of increasing complexity within a shorter timeframe.

COSEDA GmbH, founded in June 2015 as a spin-off from the Fraunhofer Institute for Integrated Circuits IIS, division Engineering of Adaptive Systems, aims to simplify the work of IC designers through the COSIDE® platform, a multi-featured software tool that enables even highly complex chips to be modeled and simulated in a very short time. In collaboration with European semiconductor manufacturers, the four founding members of the management team led by CEO Karsten Einwich – all former employees of the Fraunhofer IIS – began by developing an analog extension to the established SystemC description language (SystemC AMS) to enable its use in the systemlevel modeling and simulation of analog and mixed digital-analog ICs. This preliminary work led to the development of the COSIDE® software solution, which makes it far easier for designers to work with this complex description language.

The software is already being used by several major semiconductor manufacturers, at present mainly for applications in the automotive industry. In the future, COSEDA GmbH intends to branch out into other areas, such as medical devices. The company also aims to expand its presence in international markets, with a special focus on the United States and Japan.



Volterion GmbH**Storing solar electricity for individual homes**

Many home-owners are attracted by the idea of having their own power generating plant on the roof. But today's photovoltaic systems can only cover their electricity needs to a limited extent: at night, there is no sunlight to supply energy, and so far no suitable storage technologies have been available to deliver power around the clock. The currently available storage batteries have a short service life and a low cycle durability, and are often too expensive for use by domestic users.

Volterion GmbH, founded in September 2015 as a spin-off from the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT, aims to fill this gap by offering compact, low-cost redox flow batteries. This technology has thus far been used only in large housing units, because although this type of battery has a high cycle life and is extremely durable, it is very costly to manufacture due to the high number of components and manual procedures required.

Researchers at Fraunhofer UMSICHT were able to drastically reduce the cost of materials and manufacturing costs by developing a novel technique in which the cell stack, which forms the core of the battery, is produced using a fully automated welding process – thus making such batteries an affordable solution for individual homes. By incorporating these relatively small batteries in photovoltaic systems, it would be possible to increase the extent to which they cover a private household's electricity needs from around 30 percent at present to nearly 80 percent.

Up to now, the only product marketed by Volterion GmbH was the battery stack. As of 2016, the founders and managing directors Thorsten Seipp, Sascha Berthold and Thomas Gebauer plan to offer complete systems to private customers through a sales network of system integrators, energy providers and communal utility companies. A number of energy providers in North Rhine-Westphalia have already agreed to test the systems. In addition, a further round of talks with interested investors is to take place in the first half of 2016.

Ceragen GmbH**Fuel cells for private homes**

High-temperature fuel cells are ideally suited for use in decentralized power systems. In addition to their high conversion efficiency of over 60 percent, they have a long, maintenance-free operating life of up to 70,000 hours. However, until now these small-scale power generators have been expensive and complicated to manufacture. Another weak point is their susceptibility to damage due to repeated thermal cycling, which means that as a rule they are unable to survive more than a two-digit number of cold starts.

Ceragen GmbH, founded in October 2014 as a spin-off from the Fraunhofer Institute for Ceramic Technologies and Systems IKTS, markets a new generation of high-temperature fuel cells that are not only capable of supporting over 1000 heating and cooling cycles but are also significantly cheaper to produce. They are based on a patented technology developed at Fraunhofer IKTS, in which the liquefied-gas fuel cells are constructed from thin, stamped and coated plates of sheet steel and zinc oxide welded together with glass solder to form

a stack. Because the components are thin and elastic, they are more easily able to withstand even extreme or rapid changes in temperature without damage. Moreover, the cost of materials and the manufacturing costs are very low.

The company's founders are targeting co-generation plants for single-family dwellings as the main application for their product. Fuel-cell systems of this type could produce 50 percent of the annual electricity supply required by a four-person household and 100 percent of the heating energy required for domestic hot water. But they could be equally useful as off-grid power sources for many different devices.

In 2015, the Fraunhofer-Gesellschaft helped to finance an increase in Ceragen's equity capital. The next round of financing is scheduled for 2016 and several investors in Europe and Asia have already shown an interest in the company.

PIA gGmbH

A clearer overview of private pension plans

A peaceful retirement with no financial worries – isn't that something we all wish for? More and more German citizens are therefore taking out private insurance policies, subsidized by the government under the Riester scheme, to top up their state pensions. To make it easier for consumers to choose the product best suited to their needs, a new law that comes into effect in 2017 requires supplementary pension providers to publish a product information sheet in a standard format explaining the main features of their insurance products. This includes an opportunity-risk matrix that compares the expected yield with the risk of loss.

The non-profit limited-liability company "Produktinformationsstelle Altersvorsorge gemeinnützige GmbH" (PIA) has been tasked with evaluating certified Riester products in terms of opportunity and risk categories as an independent advisor appointed by the German Federal Ministry of Finance (BMF). The company was created in October 2015 as a wholly owned subsidiary of the Fraunhofer-Gesellschaft, after the bid for this BMF project, prepared on behalf of Fraunhofer by Professor Ralf Korn and his project team, was accepted.

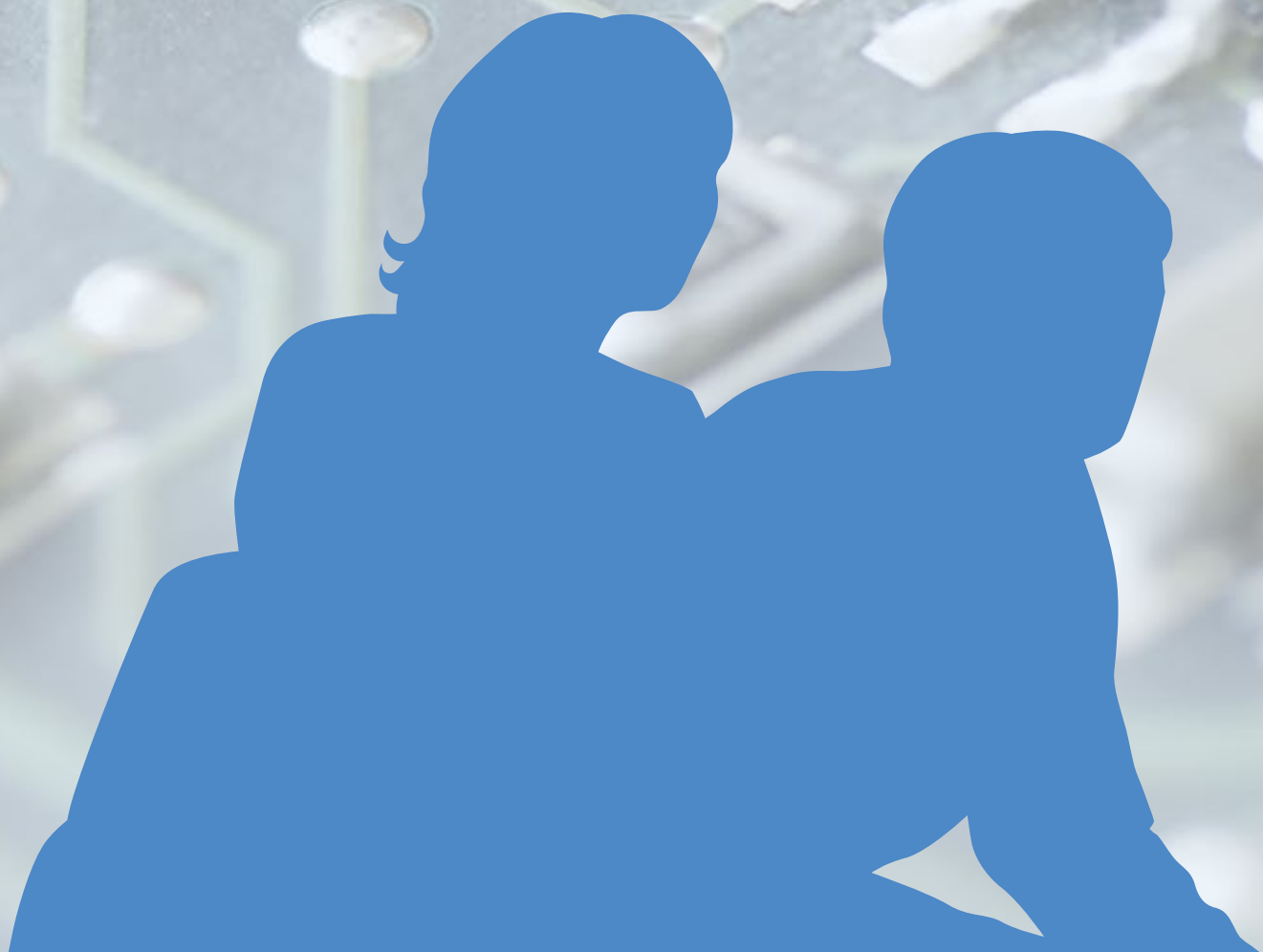
The financial products are analyzed using actuarial simulation methods developed at the Fraunhofer Institute for Industrial Mathematics ITWM, such as the ALMSim asset-liability management software tool. The institute is working on enhancements to these methods so as to adapt them to the specific nature of pension insurance products. Because economic factors such as capital market conditions are subject to fluctuation, the researchers at Fraunhofer ITWM update their calculations once a year. The certified actuary Dr. Melissa Ruby is responsible for operational management.

PIA gGmbH has been granted BMF funding for an initial period of five years, in order to build up the advice center, with an option to renew the contract for a further five years.





FINANCIAL REPORT





**BALANCE SHEET
AT DECEMBER 31, 2015**

**INCOME STATEMENT FOR THE
FINANCIAL YEAR 2015**

**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, 2015

FRAUNHOFER-GESELLSCHAFT

ZUR FÖRDERUNG DER ANGEWANDTEN FORSCHUNG E. V., MÜNCHEN

| ASSETS | € | € | 2015 € | 2014 €(1000) |
|---|-----------------------|----------------------|--------------------------------|-------------------------|
| Current assets | | | | |
| Cash and cash equivalents | | 53,006,441.54 | | 31,178 |
| Marketable securities | | 231,201,899.59 | | 198,822 |
| Accounts receivable and other current assets | | | | |
| Trade receivables | 210,680,992.02 | | | 197,135 |
| Receivables from the federal and state governments relating to base funding | 29,163,377.62 | | | 28,968 |
| relating to project billing | | | | |
| including contract research | 121,620,109.12 | | | 189,761 |
| relating to pension | | | | |
| and compensated absence provisions | <u>62,000,484.00</u> | | | <u>62,846</u> |
| | 212,783,970.74 | | | 281,575 |
| Accounts receivable from associated companies | 383,406.75 | | | 1,010 |
| Other current assets | <u>117,931,805.01</u> | | | <u>120,445</u> |
| | | 541,780,174.52 | | 600,165 |
| Inventories | | 21,042,839.26 | | 39,884 |
| Prepaid expenses and deferred charges | | <u>14,426,751.26</u> | | 10,456 |
| Total current assets | | | 861,458,106.17 | 880,505 |
| Intangible assets | | | 11,881,723.79 | 12,270 |
| Property, plant and equipment | | | 1,961,400,596.86 | 1,932,239 |
| Financial assets | | | <u>21,084,032.17</u> | <u>16,838</u> |
| Total assets | | | <u>2,855,824,458.99</u> | <u>2,841,852</u> |
| Trust assets | | | 51,055,840.17 | 44,818 |

| LIABILITIES AND EQUITY | | | 2015 | 2014 |
|---|----------------------|----------------------|--------------------------------|-------------------------|
| | € | € | € | €(1000) |
| Current liabilities | | | | |
| Trade payables | | 72,625,637.55 | | 95,651 |
| Unappropriated grants from the federal and state governments relating to base funding | 55,153,602.35 | | | 29,923 |
| relating to project billing | <u>38,469,722.63</u> | | | <u>39,225</u> |
| | | 93,623,324.98 | | 69,148 |
| Accounts payable to associated companies | | 188,968.00 | | 74 |
| Other current liabilities | | <u>10,421,765.23</u> | | <u>26,018</u> |
| Total current liabilities | | | 176,859,695.76 | 190,891 |
| Deferred income | | | 4,670,242.64 | 6,883 |
| Provisions for pensions and similar obligations | | | 9,550,484.00 | 10,026 |
| Other provisions | | | 137,008,153.00 | 141,618 |
| Special reserves | | | | |
| License-fee revenue reserve | | 258,208,285.76 | | 229,008 |
| Grants relating to fixed assets | | 1,978,908,760.25 | | 1,946,287 |
| Grants used to finance current assets | | 194,479,013.78 | | 221,356 |
| Present value of deferred income from patent deal | | <u>79,869,225.00</u> | | <u>79,934</u> |
| | | | 2,511,465,284.79 | 2,476,585 |
| Equity | | | | |
| Capital of the non-profit organization | | | | |
| Carried forward | 14,692,783.26 | | | 14,281 |
| Retained earnings | <u>235,201.42</u> | | | <u>412</u> |
| | | 14,927,984.68 | | 14,693 |
| Restricted reserve | | <u>1,342,614.12</u> | | <u>1,156</u> |
| Total equity | | | <u>16,270,598.80</u> | <u>15,849</u> |
| Total liabilities and equity | | | <u>2,855,824,458.99</u> | <u>2,841,852</u> |
| Trust liabilities | | | 51,055,840.17 | 44,818 |

INCOME STATEMENT FOR THE FINANCIAL YEAR 2015

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

| | € | € | 2015 € | 2014 €(1000) |
|---|----------------|------------------|-------------------------|------------------|
| Revenue from base funding | | | | |
| Federal government | 580,900,075.68 | | | 587,362 |
| State governments | 109,796,925.57 | | | 125,971 |
| | | | 690,697,001.25 | 713,333 |
| Revenue from own activities | | | | |
| Revenue from research and development activities | | | | |
| Federal government: Project funding | 357,068,462.58 | | | 328,247 |
| Contracts | 9,775,851.52 | | | 11,701 |
| State governments: Project funding | 174,604,688.91 | | | 250,694 |
| Contracts | 812,918.03 | | | 4,129 |
| Business, industry and trade associations | 640,705,642.42 | | | 623,693 |
| Research funding organizations and other sources | 181,065,709.48 | | | 134,229 |
| | | 1,364,033,272.94 | | 1,352,693 |
| Decrease in work in progress | -12,891,707.40 | | | -12,957 |
| Other internally constructed and capitalized assets | 8,702,521.02 | | | 4,387 |
| Other operating income | 38,359,470.51 | | | 42,119 |
| Other interest and similar income | 1,602.84 | | | 28 |
| | | | 1,398,205,159.91 | 1,386,270 |
| Total base funding and revenue from own activities | | | 2,088,902,161.16 | 2,099,603 |
| Changes in special reserves | | | | |
| License-fee revenue reserve | -29,200,000.00 | | | 15,134 |
| Grants relating to fixed assets | -35,956,619.81 | | | -99,454 |
| Grants relating to finance current assets | 26,876,400.58 | | | -37,436 |
| | | | -38,280,219.23 | -121,756 |
| Total income available to cover expenditure | | | 2,050,621,941.93 | 1,977,847 |

| | € | € | 2015 € | 2014 €(1000) |
|--|---------------------|---|-------------------------|------------------|
| Cost of materials | 309,438,747.78 | | | 298,271 |
| Personnel expenses | 1,130,212,659.80 | | | 1,081,919 |
| Amortization of intangible assets and depreciation of property, plant and equipment | 295,407,570.46 | | | 295,425 |
| Other operating expenses | 314,044,052.44 | | | 298,940 |
| Amortization of financial assets and current marketable securities | <u>1,096,935.03</u> | | | <u>1,739</u> |
| Total expenditure | | | <u>2,050,199,965.51</u> | <u>1,976,294</u> |
| Net income for the year | | | 421,976.42 | 1,553 |
| Transfer from reserves | | | 5,000.00 | – |
| Transfer to reserves | | | <u>– 191,775.00</u> | <u>– 1,141</u> |
| Retained earnings | | | 235,201.42 | 412 |
| Allocation to capital of the non-profit organization | | | <u>– 235,201.42</u> | <u>– 412</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 | 691,542,614.25 | | –845,613.00 | 690,697,001.25 |
| from research and development activities | 1,351,118,069.57 | | 12,915,203.37 | 1,364,033,272.94 |
| Decrease in work in progress | | | –12,891,707.40 | –12,891,707.40 |
| Other internally constructed and capitalized assets | 8,702,521.02 | | | 8,702,521.02 |
| Other income | 37,651,913.62 | 732,655.70 | –23,495.97 | 38,361,073.35 |
| Total income/receipts | 2,089,015,118.46 | | | |
| Changes in special reserves | | | | |
| License-fee revenue reserve | | | –29,200,000.00 | –29,200,000.00 |
| Grants relating to fixed assets | | | | |
| Allocations to special reserves (capital expenditure) | | | –332,226,004.20 | –332,226,004.20 |
| Reversal of special reserves (depreciation) | | 43,762.92 | 296,225,621.47 | 296,269,384.39 |
| Grants used to finance current assets | 26,876,400.58 | | | 26,876,400.58 |
| Change in grants receivable relating to pension and compensated absence provisions | –845,613.00 | | 845,613.00 | |
| Total business volume (cash basis) | 2,115,045,906.04 | <u>776,418.62</u> | <u>–65,200,382.73</u> | <u>2,050,621,941.93</u> |

| Expenditure/disbursements | Performance statement € | Non-profit organization capital € | Reconciling items € | Income statement € |
|--|-------------------------------|--|---------------------------|--------------------------|
| Expenditure/disbursements | | | | |
| Cost of materials | 312,866,760.88 | 31,016.96 | –3,459,030.06 | 309,438,747.78 |
| Personnel expenses | 1,141,847,390.02 | 5,640.00 | –11,640,370.22 | 1,130,212,659.80 |
| Amortization of intangible assets and depreciation of property, plant and equipment | | 195,964.77 | 295,211,605.69 | 295,407,570.46 |
| Other operating expenses | 298,898,990.70 | 121,820.47 | 16,120,176.30 | 315,140,987.47 |
| Expenditure as per the income statement | | | | 2,050,199,965.51 |
| Changes in special license-fee revenue reserve | 29,200,000.00 | | –29,200,000.00 | |
| Capital expenditure (current and major infrastructure) | 332,232,764.44 | | –332,232,764.44 | |
| Net income for the year | | 421,976.42 | | 421,976.42 |
| Total business volume (cash basis) | 2,115,045,906.04 | | | |
| | | <u>776,418.62</u> | <u>–65,200,382.73</u> | <u>2,050,621,941.93</u> |

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, 2015, 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 | | | |
| | | | 2014 €(1000) | 2015 €(1000) | 2014 €(1000) | 2015 €(1000) | 2014 €(1000) | 2015 €(1000) | 2014 €(1000) | 2015 €(1000) |
| Fraunhofer ICT Group | | | | | | | | | | |
| Algorithms and Scientific Computing SCAI | Sankt Augustin | | 9,758.3 | 10,562.7 | 911.5 | 234.7 | 7,404.5 | 7,003.8 | 3,265.3 | 3,793.5 |
| Applied and Integrated Security AISEC | Garching | | 6,432.8 | 6,701.6 | 198.0 | 215.8 | 4,968.0 | 5,618.9 | 1,662.7 | 1,298.4 |
| Applied Information Technology FIT | Sankt Augustin | | 11,179.2 | 12,346.8 | 257.5 | 263.7 | 9,094.9 | 10,659.8 | 2,341.7 | 1,950.7 |
| Communication, Information Processing and Ergonomics FKIE | Wachtberg | | 6,914.2 | 6,623.6 | 168.2 | 205.1 | 5,775.5 | 6,021.4 | 1,306.9 | 807.2 |
| Computer Graphics Research IGD | Darmstadt, Rostock | | 15,806.6 | 17,178.8 | 939.1 | 1,237.5 | 11,498.7 | 11,275.1 | 5,247.0 | 7,141.3 |
| Digital Media Technology IDMT | Ilmenau, Oldenburg | | 12,666.3 | 13,698.6 | 162.6 | 293.4 | 9,305.5 | 10,214.5 | 3,523.4 | 3,777.5 |
| Embedded Systems and Communication Technologies ESK | München | | 7,004.6 | 5,848.7 | 315.7 | 286.6 | 5,007.9 | 4,150.5 | 2,312.4 | 1,984.8 |
| Experimental Software Engineering IESE | Kaiserslautern | | 11,431.5 | 12,056.9 | 473.2 | 750.0 | 8,739.3 | 9,721.0 | 3,165.4 | 3,085.9 |
| Industrial Engineering IAO | Stuttgart | | 27,248.6 | 29,120.1 | 1,428.3 | 1,301.4 | 22,513.7 | 25,115.3 | 6,163.1 | 5,306.2 |
| Industrial Mathematics ITWM | Kaiserslautern | | 21,696.8 | 21,008.9 | 3,334.9 | 905.1 | 15,894.6 | 14,375.8 | 9,137.1 | 7,538.2 |
| Intelligent Analysis and Information Systems IAIS | Sankt Augustin | | 13,013.2 | 14,482.5 | 121.9 | 843.9 | 8,710.0 | 12,319.3 | 4,425.1 | 3,007.1 |
| Medical Image Computing MEVIS | Bremen, Lübeck | | 9,404.4 | 8,951.5 | 413.6 | 206.9 | 7,143.3 | 4,625.1 | 2,674.8 | 4,533.3 |
| Open Communication Systems FOKUS | Berlin | | 30,316.5 | 29,267.3 | 927.7 | 676.2 | 22,941.3 | 20,266.8 | 8,303.0 | 9,676.7 |
| Optronics, System Technologies and Image Exploitation IOSB | Karlsruhe, Ettlingen | | 26,910.9 | 27,882.6 | 2,350.7 | 1,802.1 | 20,001.7 | 22,569.2 | 9,259.9 | 7,115.5 |
| Secure Information Technology SIT | Darmstadt | | 9,664.8 | 10,338.1 | 124.1 | 220.8 | 6,321.8 | 8,580.3 | 3,467.0 | 1,978.6 |
| Software and Systems Engineering ISST | Dortmund | | 4,282.6 | 3,630.8 | 84.3 | 8.6 | 742.6 | 1,152.0 | 3,624.2 | 2,487.4 |
| Transportation and Infrastructure Systems IVI | Dresden | | 7,759.3 | 9,216.2 | 1,078.2 | 1,264.3 | 7,141.6 | 8,094.0 | 1,696.0 | 2,386.5 |

Fraunhofer Institute/
Research Institution for

Expenses

Operating expenses

Capital expenditure

Income

From external sources

Base funding

2014
€(1000)

2015
€(1000)

2014
€(1000)

2015
€(1000)

2014
€(1000)

2015
€(1000)

2014
€(1000)

2015
€(1000)

**Fraunhofer Group for
Life Sciences**

| | | | | | | | | | |
|---|-----------------------|----------|-----------------|---------|----------------|----------|-----------------|---------|----------------|
| Biomedical Engineering IBMT | St. Ingbert | 15,091.9 | 15,203.5 | 1,151.9 | 798.3 | 11,136.6 | 10,830.4 | 5,107.3 | 5,171.4 |
| Cell Therapy and Immunology IZI | Leipzig, Potsdam-Golm | 23,361.0 | 26,911.2 | 7,953.6 | 5,896.9 | 23,253.3 | 24,360.5 | 8,061.2 | 8,447.7 |
| Interfacial Engineering and Biotechnology IGB | Stuttgart, Leuna | 23,883.1 | 26,037.3 | 1,563.2 | 1,834.7 | 19,470.8 | 19,660.4 | 5,975.5 | 8,211.7 |
| Marine Biotechnology EMB | Lübeck | 3,095.3 | 3,169.4 | 24.9 | 102.8 | 2,314.6 | 1,127.4 | 805.7 | 2,144.8 |
| Molecular Biology and Applied Ecology IME | Aachen, Schmallenberg | 29,050.1 | 33,856.0 | 6,420.9 | 8,066.1 | 27,890.0 | 34,341.8 | 7,581.0 | 7,580.3 |
| Process Engineering and Packaging IVV | Freising, Dresden | 16,699.2 | 16,228.3 | 809.4 | 2,189.2 | 10,032.9 | 12,503.7 | 7,475.6 | 5,913.8 |
| Toxicology and Experimental Medicine ITEM | Hannover | 23,924.4 | 25,418.2 | 5,875.6 | 2,479.5 | 24,793.7 | 18,685.7 | 5,006.3 | 9,212.1 |

**Fraunhofer Group for
Light & Surfaces**

| | | | | | | | | | |
|--|--------------|----------|-----------------|---------|----------------|----------|-----------------|----------|-----------------|
| Applied Optics and Precision Engineering IOF | Jena | 24,953.1 | 24,646.7 | 4,254.4 | 4,780.8 | 22,629.5 | 21,457.7 | 6,577.9 | 7,969.7 |
| Electron Beam and Plasma Technology FEP | Dresden | 23,386.9 | 24,416.8 | 2,422.9 | 3,393.5 | 17,354.2 | 17,350.6 | 8,455.6 | 10,459.7 |
| Laser Technology ILT | Aachen | 31,074.0 | 30,960.6 | 3,370.6 | 4,635.9 | 24,141.2 | 24,069.3 | 10,303.4 | 11,527.2 |
| Material and Beam Technology IWS | Dresden | 24,072.3 | 27,446.6 | 2,830.9 | 3,576.8 | 18,818.6 | 22,145.3 | 8,084.6 | 8,878.1 |
| Physical Measurement Techniques IPM | Freiburg | 14,666.4 | 17,043.8 | 1,177.1 | 667.9 | 10,246.0 | 12,433.0 | 5,597.4 | 5,278.8 |
| Surface Engineering and Thin Films IST | Braunschweig | 12,218.3 | 12,425.4 | 899.2 | 523.2 | 8,141.1 | 9,447.1 | 4,976.4 | 3,501.6 |

Performance statement for
individual Fraunhofer entities

| Fraunhofer Institute/ Research Institution for | | Expenses | | Capital expenditure | | Income | | Base funding | |
|--|-------------------------------------|--------------------|-----------------|---------------------|-----------------|-----------------------|-----------------|-----------------|-----------------|
| | | Operating expenses | | | | From external sources | | | |
| | | 2014 €(1000) | 2015 €(1000) | 2014 €(1000) | 2015 €(1000) | 2014 €(1000) | 2015 €(1000) | 2014 €(1000) | 2015 €(1000) |
| Fraunhofer Group for Materials and Components – MATERIALS | | | | | | | | | |
| Applied Polymer Research IAP | Potsdam-Golm | 16,785.0 | 16,350.6 | 2,106.4 | 1,323.3 | 12,635.4 | 10,779.6 | 6,256.0 | 6,894.3 |
| Building Physics IBP | Stuttgart, Holzkirchen | 29,375.1 | 27,629.2 | 2,618.1 | 3,056.4 | 22,402.9 | 22,307.7 | 9,590.3 | 8,377.9 |
| Ceramic Technologies and Systems IKTS | Dresden, Hermisdorf | 50,162.3 | 48,818.3 | 4,074.6 | 5,357.7 | 37,027.2 | 36,148.1 | 17,209.7 | 18,027.8 |
| Chemical Technology ICT, Polymer Engineering Department | Pfinztal, Augsburg, Karlsruhe | 42,506.8 | 41,524.9 | 4,391.6 | 3,282.5 | 38,748.1 | 34,983.7 | 8,150.4 | 9,823.6 |
| High-Speed Dynamics, Ernst-Mach-Institut, EMI | Freiburg | 8,395.9 | 8,002.2 | 1,089.8 | 459.2 | 7,357.0 | 6,596.8 | 2,128.7 | 1,864.6 |
| Manufacturing Technology and Advanced Materials IFAM | Bremen, Dresden, Stade | 39,769.9 | 41,481.2 | 5,176.2 | 3,177.1 | 33,229.8 | 34,252.8 | 11,716.3 | 10,405.4 |
| Mechanics of Materials IWM | Freiburg, Halle | 37,720.5 | 40,073.9 | 3,643.8 | 3,998.0 | 26,157.3 | 30,278.3 | 15,207.1 | 13,793.7 |
| Nondestructive Testing IZFP | Saarbrücken | 14,875.4 | 13,867.0 | 659.1 | 1,154.9 | 9,960.1 | 9,564.1 | 5,574.4 | 5,457.8 |
| Silicate Research ISC | Würzburg, Bronnbach, Bayreuth | 27,571.8 | 29,834.7 | 2,844.6 | 5,265.4 | 21,504.1 | 22,484.6 | 8,912.2 | 12,615.4 |
| Solar Energy Systems ISE | Freiburg | 74,313.9 | 73,160.2 | 11,880.8 | 10,831.9 | 62,858.2 | 67,802.8 | 23,336.4 | 16,189.3 |
| Structural Durability and System Reliability LBF | Darmstadt | 29,203.9 | 30,069.5 | 1,738.8 | 1,664.1 | 23,394.8 | 22,032.3 | 7,547.9 | 9,701.3 |
| Systems and Innovation Research ISI | Karlsruhe | 22,948.7 | 20,644.5 | 335.9 | 228.2 | 17,048.9 | 15,419.1 | 6,235.7 | 5,453.7 |
| Wind Energy and Energy System Technology IWES | Bremerhaven, Kassel | 32,122.0 | 34,685.7 | 12,463.8 | 11,158.3 | 38,360.2 | 38,725.8 | 6,225.5 | 7,118.2 |
| Wood Research, Wilhelm- Klauditz-Institut, WKI | Braunschweig | 11,297.0 | 13,105.7 | 1,636.3 | 981.8 | 10,204.9 | 11,036.8 | 2,728.4 | 3,050.8 |

Fraunhofer Institute/
Research Institution for

Expenses

Operating expenses

Capital expenditure

Income

From external sources

Base funding

2014
€(1000)

2015
€(1000)

2014
€(1000)

2015
€(1000)

2014
€(1000)

2015
€(1000)

2014
€(1000)

2015
€(1000)

Fraunhofer Group for Microelectronics

| | | | | | | | | | |
|---|-----------------------------------|-----------|------------------|---------|----------------|-----------|------------------|-----------|-----------------|
| Applied Solid State Physics IAF | Freiburg | 10,368.2 | 10,375.9 | 1,948.9 | 2,895.6 | 7,982.7 | 8,322.4 | 4,334.4 | 4,949.2 |
| Electronic Nano Systems ENAS | Chemnitz | 12,399.3 | 12,653.4 | 1,801.8 | 2,019.2 | 10,718.6 | 10,327.9 | 3,482.5 | 4,344.8 |
| High Frequency Physics and Radar Techniques FHR | Wachtberg | 4,633.9 | 13,283.7 | 262.3 | 724.8 | 4,141.9 | 14,113.4 | 754.2 | -104.8 |
| Integrated Circuits IIS | Erlangen, Nürnberg, Dresden | 131,945.0 | 154,594.9 | 6,937.9 | 8,849.8 | 150,669.6 | 129,477.0 | -11,786.7 | 33,967.7 |
| Integrated Systems and Device Technology IISB | Erlangen | 20,318.9 | 22,378.4 | 2,579.2 | 2,971.4 | 20,723.6 | 19,998.7 | 2,174.5 | 5,351.0 |
| Microelectronic Circuits and Systems IMS | Duisburg | 24,346.9 | 28,195.9 | 2,020.6 | 2,713.5 | 16,545.8 | 20,937.2 | 9,821.7 | 9,972.2 |
| Microsystems and Solid State Technologies EMFT | München | 10,553.5 | 10,561.5 | 295.3 | 196.4 | 7,390.3 | 7,688.2 | 3,458.4 | 3,069.7 |
| Photonic Microsystems IPMS | Dresden | 31,894.5 | 32,530.7 | 2,534.2 | 3,111.2 | 25,650.0 | 22,880.4 | 8,778.8 | 12,761.5 |
| Reliability and Microintegration IZM | Berlin, Dresden | 27,729.8 | 28,132.5 | 742.6 | 1,836.0 | 22,757.4 | 21,548.0 | 5,715.0 | 8,420.5 |
| Silicon Technology ISIT | Itzehoe | 25,244.1 | 24,893.4 | 2,575.7 | 1,012.0 | 17,662.4 | 16,514.9 | 10,157.4 | 9,390.4 |
| Telecommunications, Heinrich-Hertz-Institut, HHI | Berlin, Goslar | 43,227.4 | 43,047.9 | 4,138.3 | 6,164.7 | 39,134.4 | 36,939.0 | 8,231.3 | 12,273.6 |

Performance statement for
individual Fraunhofer entities

| Fraunhofer Institute/ Research Institution for | | Expenses | | Income | | | | | |
|--|--------------------------------|--------------------|-----------------|---------------------|-----------------|-----------------------|-----------------|-----------------|-----------------|
| | | Operating expenses | | Capital expenditure | | From external sources | | Base funding | |
| | | 2014 €(1000) | 2015 €(1000) | 2014 €(1000) | 2015 €(1000) | 2014 €(1000) | 2015 €(1000) | 2014 €(1000) | 2015 €(1000) |
| Fraunhofer Group for Production | | | | | | | | | |
| Environmental, Safety and Energy Technology UMSICHT | Oberhausen, Sulzbach-Rosenberg | 36,360.2 | 36,463.8 | 1,760.4 | 2,659.5 | 25,999.2 | 29,268.3 | 12,121.4 | 9,855.0 |
| Factory Operation and Automation IFF | Magdeburg | 17,745.5 | 17,749.9 | 778.6 | 862.3 | 12,550.6 | 12,296.1 | 5,973.5 | 6,316.0 |
| Machine Tools and Forming Technology IWU | Chemnitz, Augsburg | 37,188.5 | 39,589.5 | 2,927.6 | 4,536.1 | 30,437.6 | 30,807.4 | 9,678.5 | 13,318.2 |
| Manufacturing Engineering and Automation IPA | Stuttgart | 57,817.2 | 64,167.2 | 3,578.5 | 4,042.4 | 42,965.1 | 49,969.1 | 18,430.6 | 18,240.5 |
| Material Flow and Logistics IML | Dortmund | 24,414.0 | 25,548.5 | 973.2 | 1,010.0 | 19,461.2 | 19,094.1 | 5,926.0 | 7,464.4 |
| Production Systems and Design Technology IPK | Berlin | 17,372.4 | 17,357.3 | 1,354.1 | 2,754.0 | 13,198.6 | 12,101.7 | 5,527.9 | 8,009.6 |
| Production Technology IPT | Aachen, Paderborn | 31,637.4 | 33,026.5 | 3,484.4 | 4,334.9 | 25,860.0 | 26,561.4 | 9,261.8 | 10,800.0 |
| Fraunhofer Group for Defense and Security VVS | | | | | | | | | |
| Applied Solid State Physics IAF | Freiburg | 14,369.9 | 15,145.4 | 6,273.9 | 4,775.9 | 12,272.6 | 10,940.8 | 8,371.3 | 8,980.5 |
| Chemical Technology ICT, Department of Energetic Materials | Pfintzal | 12,627.5 | 13,469.0 | 1,167.4 | 1,168.1 | 4,180.5 | 4,394.2 | 9,614.4 | 10,242.9 |
| Communication, Information Processing and Ergonomics FKIE | Wachtberg | 20,989.5 | 23,369.9 | 2,551.5 | 2,435.5 | 11,499.3 | 13,834.5 | 12,041.7 | 11,970.9 |
| High Frequency Physics and Radar Techniques FHR | Wachtberg | 15,267.8 | 14,440.0 | 1,736.9 | 2,449.5 | 6,929.5 | 6,109.2 | 10,075.3 | 10,780.3 |
| High-Speed Dynamics, Ernst-Mach-Institut, EMI | Freiburg | 13,786.2 | 15,391.9 | 1,879.5 | 3,447.4 | 5,995.2 | 8,626.9 | 9,670.5 | 10,212.4 |
| Optronics, System Technologies and Image Exploitation IOSB, Ettlingen branch | Ettlingen | 19,309.5 | 20,452.2 | 2,033.3 | 3,216.9 | 15,653.6 | 17,399.1 | 5,689.1 | 6,270.0 |
| Technological Trend Analysis INT | Euskirchen | 5,686.6 | 6,186.9 | 332.1 | 1,007.2 | 1,383.7 | 2,407.6 | 4,635.0 | 4,786.4 |

| Fraunhofer Institute/ Research Institution for | | Expenses | | Capital expenditure | | Income | | Base funding | |
|---|----------------|--------------------|-------------------------|---------------------|-------------------------|-----------------------|-------------------------|-----------------|-------------------------|
| | | Operating expenses | | | | From external sources | | | |
| | | 2014 €(1000) | 2015 €(1000) | 2014 €(1000) | 2015 €(1000) | 2014 €(1000) | 2015 €(1000) | 2014 €(1000) | 2015 €(1000) |
| Other entities, not included in the Fraunhofer Groups | | | | | | | | | |
| Center for International Management and Knowledge Economy | Leipzig | 5,196.8 | 4,601.1 | 338.0 | 75.9 | 2,851.5 | 2,055.9 | 2,683.2 | 2,621.1 |
| Information Center for Planning and Building IRB | Stuttgart | 7,051.2 | 7,210.7 | 76.6 | 123.3 | 2,731.5 | 2,557.8 | 4,396.4 | 4,776.2 |
| Polymeric Materials and Composites PYCO | Teltow | 4,154.7 | 3,830.5 | 811.9 | 351.4 | 3,471.3 | 2,808.7 | 1,495.3 | 1,373.2 |
| Technological Trend Analysis INT | Euskirchen | 2,341.0 | 2,456.5 | 40.3 | 109.0 | 1,752.3 | 2,118.4 | 629.0 | 447.1 |
| Centrally managed entities | | | | | | | | | |
| Fraunhofer headquarters | München | 113,920.7 | 23,204.4 | 4,577.4 | 3,518.8 | 5,441.9 | 3,039.7 | 113,056.2 | 23,683.5 |
| Fraunhofer Institute for Integrated Publication and Information Systems | Darmstadt | 96.1 | 243.5 | 0.0 | 0.0 | 0.0 | 0.0 | 243.5 | 243.5 |
| Institute Center Birlinghoven | Sankt Augustin | 886.6 | 989.6 | 35.0 | 27.3 | 104.2 | 261.1 | 817.4 | 755.8 |
| Institute Center Stuttgart | Stuttgart | -10.8 | -15.5 | 42.0 | 346.8 | 34.0 | 37.1 | -2.8 | 294.2 |
| General overhead costs | | -70,455.7 | 55,359.4 | 734.2 | 1,624.7 | 7,520.6 | 30,386.6 | -77,389.4 | 26,597.5 |
| Major infrastructure capital expenditure | | | | 225,863.7 | 153,260.9 | 54,436.0 | 29,061.7 | 171,427.7 | 124,199.3 |
| Performance statement | | 1,664,428.9 | 1,782,813.1 | 395,890.8 | 332,232.8 | 1,384,422.7 | 1,397,472.5 | 675,896.9 | 717,573.4 |

EXCERPTS FROM THE NOTES TO THE FINANCIAL STATEMENTS

I. Accounting principles

The annual financial statements for the year ending December 31, 2015 were prepared in accordance with the German Commercial Code (Handelsgesetzbuch, 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 expenses 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 expenses do 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. 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. On the face of the balance sheet, these reconciliation items are included in the special reserves for grants relating to fixed assets and for grants used to finance current assets.

Presentation of annual accounts of the Fraunhofer-Gesellschaft

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

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 straight-line basis.

Since in most cases fixed assets are financed by government grants, the special reserve for grants relating to fixed assets is reduced by an amount corresponding to the depreciation/amortization of these assets. Therefore, these adjustments have no impact on equity.

Financial assets 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. Advance payments received (including VAT) are recognized under inventories.

Trade receivables and other current assets are recognized at their nominal value. Irrecoverable debts are revalued at the reporting date. The overall non-payment risk is limited by creating a provision for doubtful debts corresponding to 2 percent of the total amount of accounts receivable.

Current marketable securities are measured at the lower of cost of acquisition or fair value.

Cash and cash equivalents are recognized at their nominal value.

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

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.

**Excerpts from the notes
to the financial statements**

The Fraunhofer-Gesellschaft made use of the instrument provided 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.

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. If there is no reinsurance policy in place, 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 similar residual maturity as calculated by the Deutsche Bundesbank in December 2015, 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. In the annual financial statements, foreign currency holdings are translated at the average spot 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, 2015. 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 17, 2016

Rödl & Partner GmbH

Wirtschaftsprüfungsgesellschaft, Steuerberatungsgesellschaft
(Auditors, Tax Consultants)

Vogel

Wirtschaftsprüfer (Auditor)

Hahn

Wirtschaftsprüfer (Auditor)

The background is a blurred image of industrial machinery, featuring large metal gears and a blue component with the text "OLF 320/100". Overlaid on the top left is a green shape resembling a stylized 'L' or a control panel with a white rectangular area and a small white circle. The word "SERVICE" is centered in the upper half of the image, flanked by horizontal dashed lines.

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 67 **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.

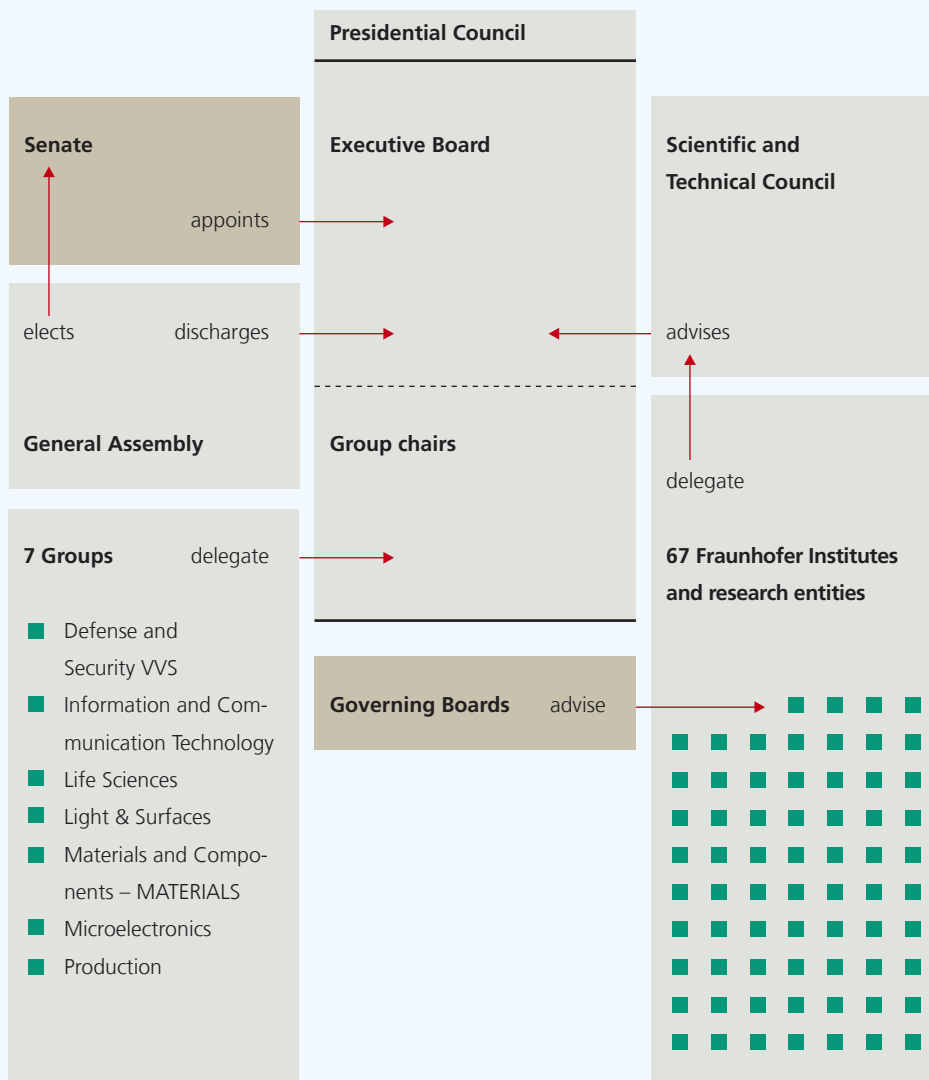
The **Senate** has around 30 members, who are eminent figures from the worlds of science, business and public life, plus representatives of the German federal and state governments, and members of the Scientific and Technical Council. The Senate is responsible for decisions concerning basic science and 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 1130 members, composed of 213 ordinary members, 907 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. Heinz Jörg Fuhrmann
Chairman of the Senate of the Fraunhofer-Gesellschaft, Chairman of the Executive Board, Salzgitter AG
- Prof. Dr. phil. nat. Hermann Requardt
Deputy Chairman of the Senate of the Fraunhofer-Gesellschaft, Former member of the Managing Board, Siemens AG
- Dr. Lutz Bertling
Former 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
- Dr. Sabine Herlitschka
Chairwoman of the Managing Board, Infineon Technologies Austria 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
Former 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
- 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. Wiltrud Treffenfeldt,
Chief Technology Officer Europe, Middle East, Africa and India, Dow Europe GmbH

- Prof. Dr. rer. nat. Christiane Vaeßen
Managing director, Zweckverband Region Aachen
- Michael Vassiliadis
National Chairman of the industrial trade union IG Bergbau, Chemie, Energie
- Prof. Dr.-Ing. Hubert Walzl
Member of the Production Board, Audi AG
- Prof. Dr. Dr. h. c. mult. Martin Winterkorn
Former Chairman of the Board of Directors, Volkswagen AG

Members representing government institutions

- Dr. Thomas Grünewald
State secretary, Ministry of Innovation, Science and Research, Nordrhein-Westfalen
- Hans-Joachim Hennings
Director, Ministry of Research and Economy of the State of Sachsen-Anhalt
- Dr. Ole Janssen
Director, German Federal Ministry of Economics and Technology (BMWi)
- Dr. Ronald Mertz
Director, Bavarian Ministry of Economic Affairs and Media, Energy and Technology

- Thomas Rachel
Parliamentary secretary,
German Federal Ministry of
Education and Research
(BMBF)
- 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 Mathe-
matics ITWM,
Chairman of the Scientific and
Technical Council
- Stefan Schmidt
Fraunhofer Institute for
Material Flow and Logistics IML,
Deputy Chairman of the Scien-
tific 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. Rolf Bernhardt
Director, Hessen State
Ministry of Higher Education,
Research and the Arts
- Prof. Dr. Pascale Ehrenfreund
Chairwoman of the Executive
Board, German Aerospace
Center (DLR)
- Dipl.-Ing. Wolfgang Lux
Deputy Chairman,
Fraunhofer-Gesellschaft
general works council
- Prof. Dr. Manfred Prenzel
Chairman, German Council of
Science and Humanities
- Dr. Hans Reckers
State secretary, Senate
Department for Economics,
Technology and Research,
Berlin
- Manfred Scheifele
Chairman,
Fraunhofer-Gesellschaft
general works council
- Prof. Dr. Martin Stratmann
President of the Max Planck
Society for the Advancement
of Science

Governing Boards

A total of 801 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 150 members, 85 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 Executive Board members
and the seven chairs of the
Fraunhofer Groups listed below:

- Prof. Dr.-Ing. Peter Elsner
Fraunhofer Institute for
Chemical Technology ICT
- Prof. Dr. techn. Dieter W. Fellner
Fraunhofer Institute for Com-
puter Graphics Research IGD
- Prof. Dr. Rainer Fischer
Fraunhofer Institute for
Molecular Biology and
Applied Ecology IME
- Prof. Dr.-Ing. Dipl.-Phys.
Hubert Lakner
Fraunhofer Institute for
Photonic Microsystems IPMS

- Prof. Dr. rer. nat.
Reinhart Poprawe
Fraunhofer Institute for Laser
Technology ILT
- Prof. Dr.-Ing. habil. Prof. e. h.
Dr. h.c. mult. Michael Schenk
Fraunhofer Institute for
Factory Operation and Auto-
mation IFF
- Prof. Dr.-Ing. Jürgen Beyerer
(Guest member)
Fraunhofer Institute for
Optronics, System Technolo-
gies and Image Exploitation
IOSB

Executive Board

- Prof. Dr.-Ing. habil. Prof. E. h.
Dr.-Ing. E. h. mult. Dr. h. c.
mult.
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
(until August 31, 2015)
- Prof. Dr. rer. nat.
Georg Rosenfeld
(since April 1, 2016)

As of March 1, 2016

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.

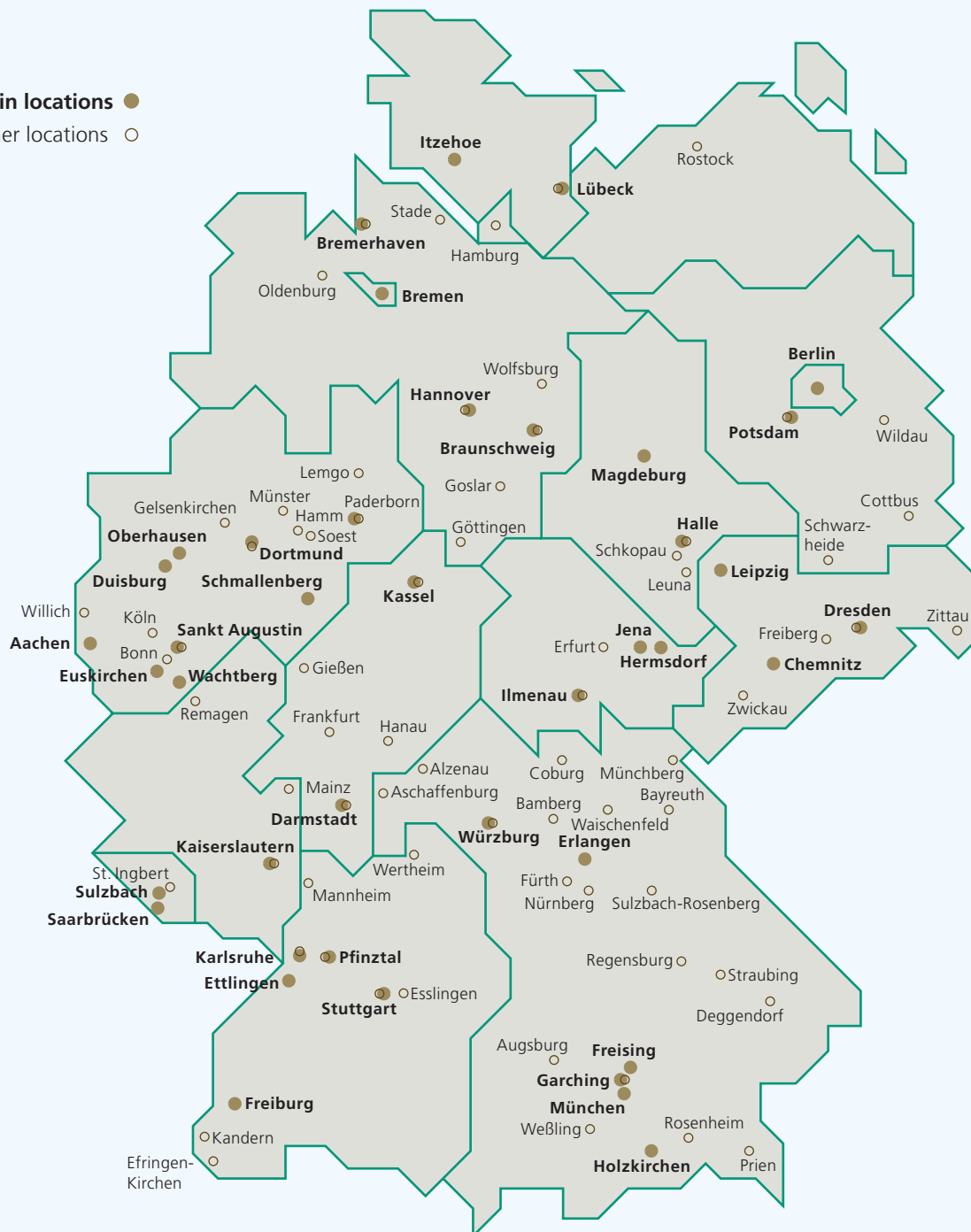
Fraunhofer Adaptronics Alliance
Fraunhofer Additive Manufacturing Alliance
Fraunhofer AdvanCer Alliance
Fraunhofer Ambient Assisted Living Alliance AAL
Fraunhofer Automobile Production Alliance
Fraunhofer Battery Alliance
Fraunhofer Big Data Alliance
Fraunhofer Building Innovation Alliance
Fraunhofer 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

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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. rer. nat. Georg Rosenfeld
(Senior Vice President Technology Marketing and
Business Models)

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for all Fraunhofer Institutes and Groups are
available in English and German on the Internet:

www.fraunhofer.de



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Fraunhofer International

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International Business Development
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raoul.klingner@zv.fraunhofer.de
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80686 München
Germany

The Fraunhofer-Gesellschaft has subsidiaries in Europe, North America and South America. Fraunhofer Representative Offices and Fraunhofer Senior Advisors form a bridge to local markets worldwide. An office in Brussels, Belgium, acts as an interface between Fraunhofer and the institutions of the European Union. For contact addresses, please consult our website:

www.fraunhofer.de

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Forschung e. V., München 2016



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