Fraunhofer

RESEARCH NEWS – SPECIAL ISSUE

05 | 2016 ||

Research awards in brief

Four science prizes will be presented at this year's annual conference of the Fraunhofer-Gesellschaft in Essen. The first, the Stifterverband Science Prize, is awarded for scientific excellence in collaborative applied research projects. The Joseph von Fraunhofer Prize will be awarded to three teams of researchers in recognition of outstanding scientific work leading to the solution of application-oriented problems.

1 Tailor-Made Radiation Therapy

Radiation therapy is one of the most essential elements in cancer treatment. But properly planning radiation therapy is a highly complex task. Fraunhofer mathematicians have joined an alliance with medical physicists and physicians to improve the therapy planning process. In doing so they have helped improve patient's chances of recovery.

2 Changes in Solar Cell Technology

A laser-based manufacturing process from the Fraunhofer ISE in Freiburg, Germany is revolutionizing the photovoltaics market. For the first time point-contacted solar cells can be manufactured in series. Several million cells with significantly higher efficiency levels are already on the market.

3 Little Projectors that Pack a Big Punch

An image projected on a slanted or curved surface appears distorted and can appear out of focus in some areas. A high-intensity mini-projector about the size of a Euro cent coin from the Fraunhofer IOF in Jena, Germany can now correct for this effect. The projector's secret: Hundreds on tiny lenses inspired by the model of an insect's compound eye.

4 Digital Radio for the World

Digital radio makes spherics and crackling interference in radio broadcast a thing of the past. New technologies from Fraunhofer IIS make it possible for digital radio to replace analogue short and medium wave broadcasting around the world. Even local FM transmissions are being converted to digital. As a result, Digital radio listeners benefit from clear reception, a wider range of programming, and additional information via data services without having to pay for a costly Internet connection.

The Fraunhofer-Gesellschaft is the leading organization for applied research in Europe. Its research activities are conducted by 67 institutes and research units at locations throughout Germany. The Fraunhofer-Gesellschaft employs a staff of 24,000, who work with an annual research budget totaling more than 2.1 billion euros. Of this sum, more than 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. 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.

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Research awards in brief

Stifterverband Science Prize

The Stifterverband is a consortium of approximately 3,000 companies, corporate associations, foundations and private individuals formed to jointly support progress in science and education. The Stifterverband uses subsidy programs, analyses and recommendations for action to ensure the proper infrastructure for innovation: high-performance universities, strong research institutes and productive exchange between business and science. The Stifterverband is a visionary body and an initiator of reforms - the model projects it supports drive changes in the system of innovation. The Stifterverband is a renowned voice in economics and in science and is an important partner to politics in matters concerning science and education.

For more than ten years, Stifterverband has supported the Fraunhofer-Gesellschaft through its Science Prize, endowed with prize money of 50,000 euros. This prize is awarded for scientific excellence in applied research projects conducted by Fraunhofer Institutes in collaboration with industry and/or other research organizations (topic 1)

Joseph von Fraunhofer Prize
Since 1978, the Fraunhofer-Gesellschaft has awarded prizes every year in recognition of outstanding scientific work by members of its staff that solve application-oriented problems. To date, over 200 researchers have seen their work honored in this way. This year, three of these prizes will be awarded, each worth 50,000 euros (topics 2 through 4).

The prizewinners also receive a silver lapel pin bearing the face of the man for whom the award was named, as illustrated in the logo of the topics.

Juries for the Stifterverband Science Prize and the Joseph von Fraunhofer Prize in 2016

Dr. Reinhold E. Achatz, ThyssenKrupp AG
Prof. Dr. Karsten Buse, Fraunhofer Institute for Physical Measurement Techniques IPM
Prof. Dr. Michael Dröscher, Evonik Degussa GmbH
Prof. Dr. Jörg Eberspächer, Technical University of Munich
Prof. Dr. Horst Hahn, Fraunhofer Institute for Medical Image Computing MEVIS
Prof. Dr. Hartmut Hoffmann, Technical University of Munich
Dr. Monika Kursawe, Merck KGaA
Dr. Gyula Meleghy, Meleghy Automotive GmbH & Co. KG
Prof. Dr. Erich R. Reinhardt, Medical Valley Europäische Metropolregion Nürnberg e.V.
Prof. Dr. Paul Schönsleben, ETH Zürich
Prof. Dr. Marion Weissenberger-Eibl, Fraunhofer Institute for Systems and Innovation Research ISI

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Tailor-Made Radiation Therapy

Professor Karl-Heinz Küfer was amazed when he saw for the first time how radiation therapy for cancer patients was planned: »The processes physicians and physicists used in jointly planning radiation therapy reminded me of looking for objects in a dark room, groping around and then trying again,« recalls Küfer, a mathematician at the Fraunhofer Institute for Industrial Mathematics ITWM in Kaiserslautern, Germany. He recognized the potential for improvement and got together with physicians, physicists and information scientists to develop an alternative solution. The result was an interactive and easy-to-operate software product. It shortens the duration of radiation therapy planning, makes finding a good balance between therapy potentials and possible side-effects easier and ultimately increases the patient's chances of recovery.
Every year in Germany approximately 483,000 people are diagnosed with cancer, with 222,000 cases ending fatally. This makes cancer Germany's second most common cause of death. Radiation therapy is used to treat more than half the cases. The radiation used damages cell DNA and thus inhibits their cell division or results directly in the death of the cell.

From a Trial-and-Error Strategy to a Predictable Solution

The objective of the therapy is to kill tumor cells while protecting healthy tissue. In the past the physician formulated his wishes and the radiation physicist turned these demands into a therapy plan. If the physician wasn't satisfied with the results, the physicist did follow-up work. Gradually the optimum solution was found. »The new thing about the mathematical approach is that from the very beginning a variety of solutions is calculated; the physician can then choose the best solution for the patient,« explains Professor Jürgen Debus, radio-oncologist at Heidelberg University Hospital, who tested the developed software in clinical use.

In order to improve the process, Fraunhofer researchers Karl-Heinz Küfer, Dr. Michael Bortz, Dr. Alexander Scherrer, Dr. Philipp Süss and Dr. Katrin Teichert considered therapy planning as a multi-criterion optimization task, in this case a balanced compromise involving around ten to fifteen in part contradictory planning goals. »The principle of the Pareto solution is a better concept here than the previous trial-and-error strategy,« Karl-Heinz Küfer emphasizes. Such a solution which cannot be improved in terms of all criteria simultaneously. When one criterion improves, another criterion has to worsen in compensation. In the case of radiation therapy this means that if the tumor is to receive a higher dose of radioactivity, the surrounding tissue will be damaged more severely.

Research Partnership Leads to Successful Application

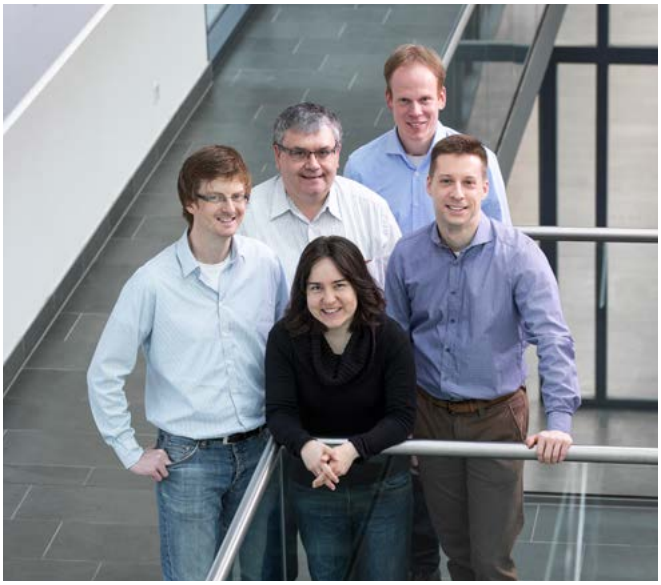
The software was developed under the leadership of the ITWM together with the German Cancer Research Center, Heidelberg University Hospital and Massachusetts

General Hospital in a Harvard Medical School research partnership.

»With the new planning system the tumor can be better brought under control, since we can irradiate the tumor with a higher dose. This means the probability of permanently eradicating the tumor is also higher, and at the same time we can protect normal tissue which we might not have been able to protect at all in the past,« remarks Professor Thomas Bortfeld, who in 2011 put the multi-criterion optimization approach to clinical use at Massachusetts General Hospital in Boston for the first time, together with RaySearch Laboratories.

With additional licensing through world market leader Varian Medical Systems starting in 2016, the technology will in the future be available at over 20,000 therapy planning stations around the world.

Development of the interactive multi-criterion radiation therapy planning system earned the Fraunhofer researchers Karl-Heinz Küfer, Michael Bortz, Alexander Scherrer, Philipp Süss and Katrin Teichert and their research partners Thomas Bortfeld, Jürgen Debus, Wolfgang Schlegel and Christian Thieke the Stifterverband for German Science's 2016 award. The jury specifically recognized »the broad viability of the method in treating the widespread illness of cancer as well as the relevance to international markets.«



By developing an interactive and easy-to-use software product, Dr. Philipp Süss, Prof. Dr. Karl-Heinz Küfer, Dr. Katrin Teichert, Dr. Michael Bortz and Dr. Alexander Scherrer (from the left) have helped improve cancer patients' chances of recovery. (© Dirk Mahler/ Fraunhofer) | Images in color and print quality: www.fraunhofer.de/press/research-news

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Changes in Solar Cell Technology

RESEARCH NEWS
SPECIAL ISSUE
05 | 2016 || topic 2

The transformation of our energy system towards the goal of more electricity from renewable energy sources is one of the major challenges facing our society for the upcoming decades. Solar technology will play a decisive role in reaching that goal. »The total amount of electric energy from photovoltaic sources is more than 250 terawatt hours, approximately equivalent to the amount produced by 30 nuclear power plants. In order to help meet international climate objectives, the amount of photovoltaic power newly installed each year will have to increase by ten times over the next 15 years. On the whole, solar technology will have to become more efficient and cost-effective in order to meet the demands of this market,« explains Dr.-Ing. Ralf Preu, Director of the Division ‚PV Production Technology and Quality Assurance' at the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg. The researcher and his colleague Dr. Jan Nekarda have already made an important contribution to climate protection with the development of Laser-Fired Contact (LFC) technology, enabling the manufacture of more efficient solar cells at lower cost.

Today most solar cells are equipped with a wide-surface metallic contact, covering the entire backside of the silicon wafer and allowing electricity to flow from the cell to the electrode. This configuration however limits efficiency. A more high-performance alternative, discovered in 1989, is the Passivated Emitter and Rear Cell technology (PERC). In contrast to conventional cells, this technology includes an additional reflective layer on the backside of the cell and thousands of electric contact points. The LFC process developed by the Fraunhofer researchers has enabled the first industrial mass production of PERC solar cells.

Series Production of Highly Efficient Cells

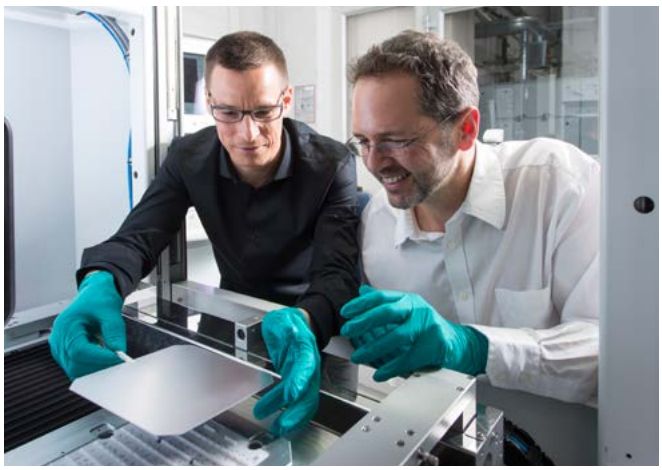
A very thin non-conductive layer is deposited on the underside of a PERC solar cell between the contact layer and the wafer. Acting as a mirror, this layer reflects the share of sunlight not absorbed when penetrating the wafer back into the silicon wafer. Since the front side also reflects this light back into the wafer, it is also captured in the silicon wafer and the efficiency level of the solar cell increases. Drawing the electricity from the wafer requires many small apertures in the non-conductive layer in order to establish contact between the electrode metal and the silicon wafer. The LFC procedure creates each of these approximately 100,000 contacts per wafer with a single laser pulse. »The challenge was to coordinate the pulses in such a way that contact is completely established, while damage to the silicon is kept to minimal levels. Here it's crucial that the laser light effect is limited to between 50 and 2,000 nanoseconds,« explains Dr. Jan Nekarda, group manager at the Fraunhofer ISE. An innovative system for guiding the laser beams makes it possible to create all the contacts in approximately one second.

»PERC solar cells made this way have an improved efficiency level of one percent absolute. With today's solar cell efficiency of approximately 20 percent, that's about five percent relative. We gain an additional two percent in the system, which means we increase the overall energy yield by seven percent,« Ralf Preu is happy to report. The efficiency level is of enormous importance since the majority of costs in photovoltaics are directly proportional to surface area. »Where we need 100 square meters of solar cells today, in the future we'll only need 93 square meters to produce the same amount of electricity. This not only means less silicon, but also less module material, less material in the systems and ultimately also savings in terms of planning costs.«

Successful Implementation in Industry

Solar cell manufacturers can easily and inexpensively integrate the laser procedure in existing production processes. According to company information, Hanwha Q Cells has already made 20 million cells¬ using LFC technology since beginning production. Companies around the world have in the meantime put PERC technology into mass production. »In the current year alone manufacturers have invested more than 200 million Euro in the implementation. This finally means the establishment of the next evolutionary stage of the silicon solar cell,« Ralf Preu is excited to report.

Ralf Preu and Jan Nekarda have received the 2016 Joseph-von-Fraunhofer prize for their role as initiators and drivers of this change. The jury based the award among other things on the fact that »the researchers' development helps German companies continue to succeed in the highly competitive photovoltaics market.«



Dr. Jan Nekarda and Dr.-Ing. Ralf Preu (from the left) developed the Laser Fired Contact process for series manufacturing of highly efficient PERC solar cells. (© Dirk Mahler/Fraunhofer) | Images in color and print quality: www.fraunhofer.de/press/research-news

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Little Projectors that Pack a Big Punch

RESEARCH NEWS
SPECIAL ISSUE
05 | 2016 || topic 3

It took only a few years for Fraunhofer researchers to develop a miniature projector, from concept to series production. Compared to conventional models with one channel projecting one image, the LED array projector from the Fraunhofer Institute for Applied Optics and Precision Engineering IOF in Jena creates a bright and crisp image by overlaying hundreds of channels on one another, exact down to the pixel. »Our array projector can represent sharply focused and undistorted images on almost any curved or slanted surface. At the same time, we've succeeded in redefining the typical scaling rules of classic projection systems and consequently we've created extremely compact projectors,« explains Dr. Peter Schreiber, responsible for micro-optical illumination systems at the IOF.

Array Projector Rolls out a Carpet of Light for the BMW 7 series

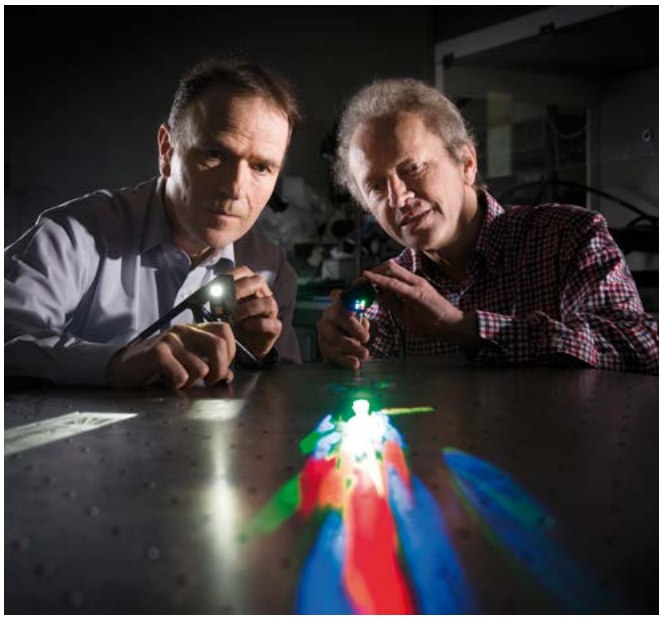
As more and more technology is built into cars, these properties are particularly interesting to the automotive industry: Individual components have to be small and very thrifty when it comes to energy consumption. This also applies to illumination, both in and on the vehicle. The LED array projector masters these challenges. »The technical advantages, particularly in automotive applications, include for example the small dimensions and ruggedness of the microoptics,« points out Marcel Sieler, former project manager at the IOF. Sieler was among those responsible for realizing the projector on an industrial basis, which has been featured in 7 series BMWs since mid-2015, creating a light carpet about four meters in length along the side of the car, illuminating obstacles and irregularities on the ground. »This is the world's first implementation of a complex microoptics module in a series-production car,« says Dr. Peter Dannberg, who developed the projector's manufacturing process. The light module is built into the BMW below the door and not in the door, as is the case with other manufacturers. Here the BMW is taking advantage of another special feature of the Fraunhofer development: »An array projector is capable of projecting bright and sharply focused images without slanted optical elements, even at very small angles of incidence,« says Peter Schreiber.

The IOF illumination system consists of an array of several micro-projectors. Each projector consists of a micro-lens for illumination and a second lens for projection, with a slide between them. An array projector arranges hundreds of such micro-projectors together. »Array projection overlays the individual images of the micro-optical projectors so that they form a bright complete image on the screen and ensure even illumination at the same time,« Sieler explains. The projected image is made brighter by simply increasing the number of the deployed "projectorlets". This means the array projector size only needs to increase in terms of surface area, while the thickness of only about three millimeters remains the same. A conventional system on the other hand would have to increase its overall volume in order to increase light flow.

Also Suitable for Use in Data Glasses and Measurement Technologies

Peter Schreiber also sees potential in additional applications: »We're thinking about whether the array projector might be suitable for use in ultra-compact data glasses or as a spotlight with special light distribution. I also see the possibility of generating efficient and highly dynamic light patterns in measurement technologies.«

Peter Schreiber, Marcel Sieler and Peter Dannberg have received this year's Joseph-von-Fraunhofer prize for their work on the development of the LED array projector. Among other things the jury based its decision on »the development of another German automotive engineering component that will help position German manufacturers as premium vendors.«



The array projector developed by Peter Dannberg, Peter Schreiber (from the left) and Marcel Sieler (not shown) projects an extremely bright image in spite of its minimal size.
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Digital Radio for the World

RESEARCH NEWS
SPECIAL ISSUE
05 | 2016 || topic 4

Alexander Zink, researcher at the Fraunhofer Institute for Integrated Circuits IIS based in Erlangen, Germany, would like to provide clarification around a common misunderstanding: »Digital radio works the same way as terrestrial FM radio via air waves, but with better quality, more variety and innovative extra features. Digital Radio is independent of the Internet and available to the listener free of charge.« Together with Martin Speitel, Max Neuendorf and an extensive team, Zink developed several necessary basic technologies, as well as transmission and receiving solutions for digital radio applications. Today, these technologies are utilized around the world in nearly all digital radio systems.

Digital Radio Already Established Worldwide

Digital radio is already implemented throughout the majority of Europe. Many developing countries are in the planning stage to convert from analog to digital for short and medium wave, and the digitalization of local FM broadcasts is in development as well. For instance, India is among the front-runners for digitalization, and on its way to becoming the world's largest digital radio market.

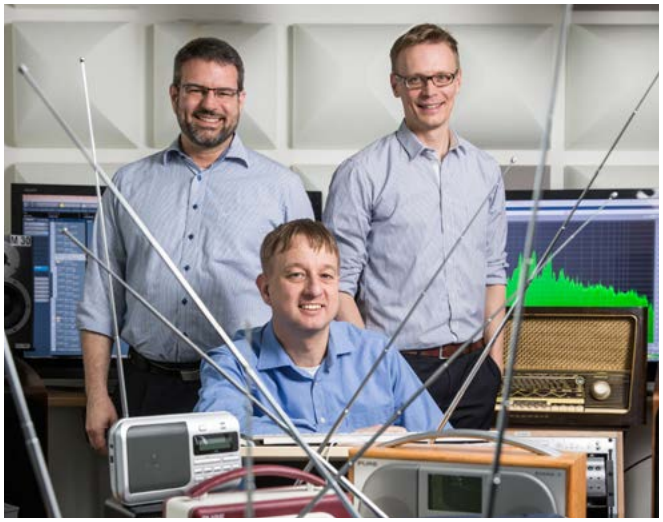
In addition to audio quality, digital radio's innovative technology offers critically important advantages to radio listeners, manufacturers and radio broadcasters. For example, the data service Journaline makes it possible for listeners to interactively access and read text information such as news, weather, and traffic or airport updates directly from the radio receiver's screen. »Even in the age of the Internet, radio systems continue to serve as the most reliable distribution medium for news and emergency alarms. Especially in countries where Internet infrastructure is poor or non-existent, the new solutions allow access to information and education on a wide-scale basis and free of charge,« says Alexander Zink, emphasizing the political dimension of the Fraunhofer development. For broadcasters, Digital radio offers benefits such as more efficient program transmission, which cuts costs by reducing broadcast energy consumption and also allows for transmitting a larger number of programs. Deutschlandradio, the national German public radio broadcaster, has benefited from the advantages of Digital radio for several years. »There aren't enough FM frequencies available. Digital broadcasting is the only way we can cover the entire area,« says Deutschlandradio director Dr. Willi Steul.

Technologies for the Entire Broadcast Chain

The Fraunhofer IIS scientists design technologies and components along the entire digital radio broadcast chain. These technologies and components include innovative audio encoding methods, as well as server solutions for coding and generating digital radio transmission signals and software components for radio receiver devices. The

MPEG audio codecs xHE-AAC and HE-AAC process data intelligently, reducing data volumes drastically while retaining quality levels. »The xHE-AAC and HE-AAC codecs are the foundation of digital radio's excellent sound quality. Our experience with mp3 and the subsequent technologies served as a good measure for those developments,« says Max Neuendorf, group manager of the IIS Audio and Speech Coding team.
For radio receivers, new software solutions were developed to support reception and playback of digital radio. »The signal you receive via the antenna in digital form is then reconverted back into audible form, just like the principle used in every conventional radio. Thanks to our flexible solution, radio and chip set manufacturers can easily support a large number of digital radio standards in parallel,« explains Martin Speitel, manager of the Software Defined Radio project at the IIS. To support broadcasters with the introduction and operation of Digital radio, the scientists developed an easy-to-operate server solution. »Our ContentServer technology today is one of the most widely used professional broadcast systems. It combines the individual components such as audio encoding, data applications and signaling management, as well as multiplex generation in a single device. This makes it easy for broadcasters and network providers to configure digital radio transmission signals. It also allows broadcast and network providers to take advantage of the entire range of Digital radio functionality,« explains Alexander Zink, responsible for the worldwide standardization and market development of digital radio.

Alexander Zink, Martin Speitel, Max Neuendorf and the entire development team accepted the Joseph-von-Fraunhofer Prize 2016 for developing the foundations of digital radio and its continuation to market roll-out. The jury recognized „the steady advancement of fundamental technologies and standards established in this area. For several years, Fraunhofer IIS has been able to make progress and develop groundbreaking technologies for digital radio."



In order to help digital radio make a worldwide market breakthrough, Alexander Zink, Martin Speitel and Max Neuendorf (from the left) developed technologies for the entire broadcast chain. (© Dirk Mahler/Fraunhofer) | Images in color and print quality: www.fraunhofer.de/press/research-news

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