

# FRAUNHOFER IN INDIA NEWSLETTER - ISSUE 1 / 2015



# **200 YEARS OF FRAUNHOFER LINES**

# New World Record for Concentrator Photovoltaics

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Intelligent Rotor Blade for Future Turbine Generation Page 12

# 3<sup>rd</sup> FIT platform 2014 on 'Powering a Greener Future'

The two-day Event kicked off on 21st Nov 2014 with a high-profile Panel discussion Page 14-16

# "We are surely looking forward to a fruitful Partnership with Fraunhofer."

Dr. Kapur talks about Sona Group and its association with Fraunhofer Page 17-18

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# FOREWORD

# INNOVATION AND TECHNOLOGICAL CLUSTERS: A CRITICAL PART OF THE R&D ECOSYSTEM

"Fraunhofer Clusters are not meant for mere networking, they are project clusters with a clear objective, deliverables, defined roles of each stakeholder, and a strong Monitoring and Evaluation designed to ensure fast results. The cornerstone of this initiative is a long term relationship between Industry, Government and Universities and Research organizations on a specific thematic focus. All the stakeholders contribute to the finance with typically Government allocating 40% of the total Budget and the others contributing the remaining 60% of the Budget. Industry has always played a very strong role in these clusters and interestingly the Small and Medium Enterprises (SME) have been actively participating in the clusters."

Ms. Anandi Iyer, Director, Fraunhofer Office India

# Dear Readers

There is a palpable excitement in the air! There is hope for an economic revival buoyed by the Prime Minister Shri. Narendra Modi's pro-reform stance. Industrial Production in India increased 3.80 percent in November of 2014 over the same month in the previous year, beating market expectations. Manufacturing expanded 3 percent; Mining rose 3.4 percent and Electricity Output went up 10 percent. Inflation has also been showing marked signs of coming down, with the figures of November 2013 – November 2012 being a staggering 9.12% whereas November 2014 to November 2013 being a mere 4.12%. The 'Make-In-India' campaign clarion call by the Prime Minister has captured the imagination of many Indian and Foreign Investors, reflecting in the Stock Market being bullish on India. So what can be done to augment this positive trajectory? Focus and strengthen Innovation and Research & Development (R&D) initiatives, which are piggybacking on these strong signals can accelerate the Indian Growth Story to greater heights.

One initiative that can greatly enhance the efforts in this direction is Innovation and Technology clusters. Clusters support the shared objectives of a larger stakeholder community in one focus area, and enable a multipronged development to greatly shorten the development period, thus bringing results faster to the market. Fraunhofer is probably the only Research Organization in the world which coordinates more than 20 Innovation Clusters in Germany, and has developed its own model of clusters. These clusters are in a variety of areas such as Polymer Technology, Digital Production, Personal Health, Nano for Production, Optics, Electronics for Sustainable Energy Use, Bioenergy, Digital Commercial Vehicle Technology etc to name just a few. These clusters have not only accelerated the development of the specific thematic area enormously, but also resulted in institutional capacity building and increased Industry investments. For example, Fraunhofer innovation cluster Digital Commercial Vehicle Technology led to the establishment of the John Deere research center in the region. The Fraunhofer innovation cluster Secure Identity Berlin-Brandenburg resulted in the Collaborative "Electronic ID Card" system. Fraunhofer innovation cluster Optical Technologies, Jena Optical Innovations JOIN brought about the Hand-held 3D scanners for applications in Medicine, Archaeology and Criminalistics. Fraunhofer innovation cluster Future Security BW catalyzed the safe construction of high-rise buildings with a service core. Fraunhofer innovation cluster Multifunctional Materials and Technologies MultiMaT (Bremen) was instrumental in joining of fiber-reinforced composite structures in collaboration with Optoprecision and Airbus. Fraunhofer India is working together with the Ministry of Micro, Small and Medium Enterprises to strengthen the Technology Centres in India, not only with a view to ushering in R&D but also strengthening manufacturing, creating shared resources for Indian Industry, particularly the SME and developing skills for all levels of Human Resources. Watch this space for more exciting news on this front !!

Happy Reading! Anandi Iyer



# Bringing Path-breaking Research through Fraunhofer Model

It has been more than five years since the Brand Fraunhofer came to India and started its operations through its Bangalore Office in 2008. With the stated aim of providing cutting edge Applied Research to India, Fraunhofer has been making headways by signing several Research & Development (R&D) projects in sectors ranging from Automotive, Energy to Aerospace and has also been exploring new areas such as Food, Electronics and Infrastructure for future collaborations.

Like every year, Fraunhofer has been taking part in various Industry specific events to present some of its latest Technologies relevant to Indian Industries. To give a snapshot of them, Fraunhofer Experts took part and contributed in the second Indo-German SME Forum held in September 2014. The Forum revolved around the theme of "Cluster Internationalisation" and provided a platform to foster linkages between public authorities, cluster / industry associations and other service providers from India and Germany. Dr. Mark Buecking, Fraunhofer Institute for Molecular Biology and Applied Ecology IME was one of the invited speakers who presented on, "Managing Safety, Quality and Testing standards in the Food Processing Sector." Other Fraunhofer Experts who were also present at this Forum were Dr. Joachim Pelka, Fraunhofer Group for Microelectronics, Mr. Axel Demmer, Fraunhofer Institute for Production Technology IPT and Ms. Anandi Iyer, Director, Fraunhofer Office India.

On September 18, 2014, the Confederation of Indian Industry (CII) organised its 6th Edition on Manufacturing Excellence in Aurangabad. Mr. Peter Blau, Fraunhofer Institute for Machine Tools and Forming Technology IWU was invited as a Keynote Speaker for the Panel discussion on "Customer Delight by Raising the Bar of Excellence." The Conference provided a platform to share and deliberate on the best practices, accelerate the efficiency and competitive performance of the Manufacturing Industry.

The presence of Fraunhofer in India for the last few years paved way for the Indian Industry and Government to take keen interest in exploring the Fraunhofer's R&D ecosystem in Germany. Two separate high level Delegations led by Secretary of Micro, Small & Medium Enterprises MSME, Government of India and the other led by Secretary, Ministry of New and Renewable Energy MNRE, Government of India visited Fraunhofer Institutes in 2014. In June 2014, CII in partnership with Fraunhofer led a high-profile Delegation on a Study Mission to Institutes in Germany. The Delegates were largely from Automotive and

# Fraunhofer Delegation visits to India 2014:

- Mr. Rüdiger Heim, Fraunhofer LBF
- Dr. Andreas Sterzing, Mr. Peter Blau & Mr. Sven Schiller, Fraunhofer IWU
- Dr. Julian Schwenzel, Fraunhofer IFAM
- Dr. Mark Buecking, Fraunhofer IME
- Dr. Joachim Pelka, Fraunhofer Group for Microelectronics
- Mr. Axel Demmer, Fraunhofer IPT
- Mr. Alexander Zink, Fraunhofer IIS
- Prof. Dr. Eicke Weber, Mr. Gerhard Stryi-Hipp and Dr. Thomas Schlegl, Fraunhofer ISE
- Prof. Dr. Andreas Hornung and Mr. Thorsten Hornung, Fraunhofer UMSICHT
- Prof. Dr. Andreas Reuter and Dr. Antje Wagenknecht, Fraunhofer IWES
- Mr. Hans Erhorn, Fraunhofer IBP
- Dr. Mihails Kusnezoff, Fraunhofer IKTS
- Dr. Raoul Klingner and Mrs. Annika Wust, Fraunhofer HQ, Munich
- 1 & 2: CII and MNRE Delegation in Fraunhofer, Germany



### Forthcoming Activities in India

- Fraunhofer Stand at Indian Metalcutting Machine Tool Exhibition IMTEX 2015, 22-28 January 2015, BIEC, Bangalore. Fraunhofer IWU Experts' Keynote Address at 'International Seminar on Machining Technologies,' coinciding with IMTEX 2015, January 21, 2015.
- Fraunhofer with Messe Muenchen International India (MMI India Pvt. Ltd.) and Builders' Association of India organising a special India delegation visit to BAU 2015, the World's Leading Trade Fair for Architecture, Materials and Systems: 19-24 January 2015, Messe München Exhibition Center, Munich, Germany.
- Fraunhofer participation at the Renewable Energy Global Investors Meet & Expo (RE-Invest) 2015 organised by the Ministry of New and Renewable Energy MNRE, Government of India: 15-17 February 2015, New Delhi.
- Fraunhofer Office India participation at Hannover Messe 2015, the world's leading Trade Fair for Industrial Technology: 13-17 April 2015, Hannover, Germany.
- Fraunhofer and the German Research Foundation DFG will organise a twoday workshop on "Water Resources-Ensuring Sustainability through Technology," in Q3'15.

3. The Fraunhofer-CEO Roundtable Meeting in Delhi

4. Mr. Peter Blau, Fraunhofer IWU at CII Manufacturing Excellence

Electronics sector. Apart from this, Fraunhofer Office India also arranged separate visits for senior representatives of Organizations such as Bosch, Anand Automotive, Central Manufacturing Technology Institute CMTI and Sundaram Clayton to Institutes of specific interests. These visits resulted in dialogues with Fraunhofer to collaborate on varied spectrum of projects. Fraunhofer Office India has also been taking concrete steps in building and enabling a network for Research. In 2014, it organized two exclusive Roundtable Meetings for Federal Ministry of Education and Research (BMBF) with the top level CEOs, MDs and senior management of companies in India. The objective was to exchange opportunities for R&D and Innovation between India and Germany in high-tech fields. The annual Flagship event of Fraunhofer in India, the 3rd Fraunhofer Innovation and Technology Platform (FIT) on 'Powering a Greener Future' was held on 21st and 22nd November 2014 in Taj West End, Bangalore. The event was a great success, with eminent guest speakers from India and Institutes of Fraunhofer Energy Alliance, nearly 200 participants representing various Countries, Organizations, Government etc. participating in the event.

Taking note of Fraunhofer's contribution to the R&D Ecosystem in India, Ms. Anandi Iyer was invited to share her thoughts on various platforms. In August 2014, she attended the MEA - Germany Export Control Awareness Seminar organized by the Ministry of External Affairs (MEA) and Minister of Heavy Industry (MHI), Government of India. At a Roundtable Meeting with CEOs of German companies held in Delhi, she presented the competencies of Fraunhofer Institutes in Electronics & ICT. She was also one of the speakers at CII Bangalore's 7th Annual Manufacturing Conference 2014 themed, "Make in India – Rejuvenating Indian Manufacturing."

It is indeed a proud moment for Fraunhofer to have received the German Future Prize 2014 (or *Deutscher Zukunftspreis*). Fraunhofer scientists Dr. Stephanie Mittermaier, Dr. Peter Eisner and Prolupin GmbH's Ms. Katrin Petersen who received this award, created a process that extracts ingredients similar to animal proteins from Lupin seeds for use in vegetarian and vegan food products. A clear indication of the growing stature of Fraunhofer in India is that recently in the Lok Sabha Session, the Union Minister for Power, Coal and New and Renewable Energy Shri. Piyush Goyal acknowledged Fraunhofer Institute for Solar Energy Systems ISE as a partner for India in Solar energy. Fraunhofer has also signed a Memorandum of Understanding (MoU) with BML Munjal University BMU for setting up advanced qualification courses. With the Industry's mood upbeat and the financial machine gearing up to the next level, Fraunhofer is all set to propel itself for a much more productive 2015 in India!





# Solutions for Future Food Logistics

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Dr. Andreas Hengse, the Deputy Managing Director & Coordinator, Fraunhofer Food Chain Management Alliance talks about the Technologies available for the Food Logistics with few examples relevant for the Indian market.

Politically and economically, India is one of the major Global players. Over the last couple of decades, poverty has been alleviated significantly. However, due to critical roadblocks such as chronic malnutrition, diseases of civilization and lack of dietary minerals, India still faces the humongous task to feed over a billion people with nutritious Food. Although the Food Industry in India is not matured, it can still play a pivotal role in addressing these issues. As of FY'11 and '12, the Gross Domestic Product (GDP) contribution of the Food sector was approximately 9.4% of the total GDP. Some of the major challenges in this sector are the inadequate support infrastructure, long fragmented supply chain, lack of proper storage facilities both in private and Government sectors causing tremendous Food wastage. The Fraunhofer-Gesellschaft can make important contributions as Technology Developers in these areas and thereby reduce Food wastage and improve productivity. The following three examples are the Solutions provided by the Fraunhofer Food Chain Management Alliance in the field of Food Logistics that can be analogous to the Indian context:-

# 1) Urban Retail Logistics – Smart and Collaborative Approaches for Urban Supply (Fraunhofer Institute for Material Flow and Logistics IML):

Urbanization and demographic changes are impacting on the local and direct ways of supplying people with goods in future. Since the mobility of the elderly generation is sometimes limited, there will be more demand for shopping facilities located closer to the customers. Consumers also expect ordering via smartphone or the Internet to improve and to be offered flexible deliveries until late in the evening. Innovative Retail Concepts have to correspond to these increasingly individual customer requirements. In this scenario, maintaining current logistics concepts would lead to an increase in traffic volume as we see delivery quantities becoming smaller while the frequency of deliveries rises. At the same time, the increasing number of traffic jams and traffic restrictions means efficient deliveries are becoming more difficult. The Urban Retail Logistics project investigates the topic of Urban Supply with a focus on the constant spread of Urbanization and its complex living environments which call for more Intelligent Supply and Waste-Management Systems. Urban Supply is one of the seven main topics within the scope of *EffizienzCluster LogistikRuhr* and combines five associated Research projects. Besides the Urban Retail Logistics project, Urban Supply consolidates Research areas e.g.

"A well-developed Food Processing industry is a prerequisite to increase the farm gate prices, reduce wastages, ensure value addition, promote crop diversification, generate employment opportunities as well as increase export earnings."

Dr. Andreas Hengse

1: Urban Hub - Hot Spot for Urbane Delivery Rights: Georgios Katsimitsoulias, Fraunhofer IML 2: Convertible Logistics Systems

Rights: Georgios Katsimitsoulias, Fraunhofer IML



#### Fraunhofer Food Chain Management Alliance

Food Chain Management focuses on the chain of Food Manufacturing as an integral process. The aim is to analyze and optimize these processes in order to finally supply consumers with qualitatively spotless Food. The Fraunhofer Food Chain Management Alliance is a platform that merges the Expertise of 12 Institutes. It aims at introducing latest scientific know-how in new products and solutions of this field by means of mutual projects. One of its light house projects in Germany is "Fresh Food on the Table" which researches on how to improve the efficiency of the Food Chain and Logistics. This has been an extremely successful project, particularly since Germany imports Food items from all over the world. Dr. Mark Buecking, the Spokesman of the Alliance and the Department Head, Environmental and Food Analysis, Fraunhofer IME visited India in September 2014 and met with some of the leading companies in Retail Industry to explore possible collaborations.

3: Micro Near Infrared Spectrometer Rights: Fraunhofer IPMS

4: Multiple Reflection Cell Rights: Fraunhofer IPM designing infrastructures for electric vehicle charging points or developing navigation systems especially for delivery and services vehicles.

## 2) No more buy a pig in a poke (Fraunhofer Institute for Photonic

**Microsystems IPMS):** The sight of a pineapple in the supermarket makes your mouth water. But once the fruit is purchased, you realize that it is neither sweet nor juicy. Whether fruit, meat or cheese - the quality of Food is not always as consumers would like it to be. Buying the right Food is often a question of sheer luck for consumers. But, in future, a Spectrometer will allow them to gage the quality of Food before they buy it. No bigger than a sugar cube, the Device is inexpensive to manufacture and could one day even be installed in smartphones. It is based on a Near-Infrared Spectrometer that was developed by Researchers at Fraunhofer IPMS. It allows one to measure the amount of water, sugar, starch, fat and protein present in the products. The system "looks" several centimeters below the outer surface of the foodstuff – which means it can detect, for instance, whether the core of an apple is rotting. Thin packaging film is no problem for the Device as it takes measurements straight through it. By shining a broad-bandwidth light on the item to be tested – for instance, consider a piece of meat. Depending on the meat's composition, it will reflect different wavelengths of light in the near infrared range with different intensities. The resulting spectrum tells scientists what amounts of which substances are present in it. In the future, all the customer needs to do is to hold his smartphone near the product in guestion, activate the corresponding app, and choose the food type from the menu – e.g. pear – and straight away the device will make a recommendation: the Fructose content of the pear is high, so buy it!

# 3) Fruit Ripening Monitoring (Fraunhofer Institute for Physical

**Measurement Techniques IPM):** Fruits such as bananas, apples or tomatoes emit Ethylene during storage and transport. This plant hormone affects the metabolism of neighbouring crops and vegetables, accelerates the fruit ripening, thus causing faster spoilage. By monitoring the concentration of Ethylene and thus the fruit ripening during storage or in transit to the thus formed, considerable economic damage is specifically counteracted. The compact Ethylene-Measuring System is to be monitored continuously in position to the Ethylene concentration and thus the Fruit Ripening. It is based on a miniaturized Filter Photometer at 10.6 microns, which consists of an Infrared (IR) Emitter, a long path and a detector unit. Thus, with the help of the measuring system, tightly controlled ripening processes and, for example, ventilation systems are controlled to adjust a low Ethylene levels in storage or carry out a controlled ripening process by Ethylene treatment.



# Fraunhofer Spectrum: New & Emerging Technologies

# Light in new shape

BMBF-funded joint project R2D2 which was initiated in November 2014 aims at the investigation of production-related processes and Technologies for the manufacturing of flexible OLED. The Organic Light-Emitting Diode, in short OLED, is characterized by specific features, which distinguishes it significantly from other light sources. The OLED light's up the entire area, whereas light bulbs, Energy-saving lamps and classical LED are point light sources. It allows for transparent light sources with very low Energy consumption, which furthermore can be applied to flexible and pliable substrates. The innovative world of light and design possibilities related to this progress had an important influence on the efforts for the development of OLED lighting technologies worldwide. The progresses of the last five years have proven the technical feasibility of this vision in the form of first flexible demonstrators. "The BMBF-funded project R2D2 investigates production-related processes and technologies for the manufacturing of flexible and shapeable OLED. The Piecewise manufacturing as well as the Roll-to-roll technology approaches will be pursued," says the consortium leader Dr. Christian May from Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP. The Consortium partners are: Fraunhofer FEP (Consortium leader), AUDI AG, Diehl Aerospace GmbH, Hella KGaA Hueck & Co., Novaled GmbH, OSRAM OLED GmbH and VON ARDENNE GmbH.

## Fewer surgeries with Degradable Implants

Until now, in cases of bone fracture, doctors have used implants made of Steel and Titanium, which have to be removed after healing. The disadvantages were either they remain in the body even after healing or doctors have to remove them in a second procedure. To avoid this, Researchers at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM in Bremen have developed load bearing, biodegradable implants that are completely degraded in the body. In the first step, they have used powder injection molding to manufacture a suture anchor, which is available as a demonstrator. "With the implant, severed tendons can be anchored to the bone until they have grown again. Since the function of the fixing element is satisfied after the healing process, it is no longer needed in the body. If implants or protheses that are as wear resistant as possible are required – such as in an artificial hip joint – metallic alloys such as Titanium will certainly continue to be used. However, for plates, screws, pins and nails which should not remain in the body, there are other requirements," says Dr. Philipp Imgrund, Manager of the Medical Technology

1: Flexible OLED processed with Roll-to-roll technology © Fraunhofer FEP

2: The demonstrator for a suture anchor made of iron-tricalcium phosphate (FE-TCP) is only slightly larger than a match head. © Fraunhofer IFAM



and Life Sciences business field at IFAM. The Researchers at IFAM are relying on metal-ceramic composites. A metal component based on an iron alloy is being combined with Beta-Tricalcium Phosphate (TCP) as the ceramic component. "Iron alloys corrode slowly and ensure high mechanical strength, while ceramic decomposes quickly, stimulates bone growth and aids the ingrowth of the implant", Imgrund says to explain the advantages of this material combination.

### **Electric cars without drivers**

E-Mobile will park independently in the future and will also be able to find the next charging station without a driver. Researchers are working on electric cars that can travel short distances autonomously. On the basis of cost-effective sensors, they are developing a dynamic model that perceives the environmental situation. The speciality of the Researchers at the Fraunhofer Institute for Manufacturing Engineering and Automation IPA is the development of Robots. In the Institute building, there is a prototype that independently finds its way on its four wheels through unknown territory. The challenges that are to be mastered are similar to those for automated driving. Here, as well, sensors need to recognize the environment so that the vehicle can navigate around obstacles and find its goal. Why not take advantage of that experience and apply it to the car, say the Engineers in Stuttgart. That is why, one and a half years ago, an interdisciplinary team of Computer Scientists, Mathematicians, Electrical Engineers and Mechatronics Engineers launched the project Afkar (a German abbreviation for "autonomous driving and intelligent chassis concept for an allelectric vehicle"). In a first step, the Electric car is intended to learn to find a parking space and to park without a scratch. The idea behind this is that the car should be able to recharge itself with electricity without human help. This would be particularly important for car-sharing. Imagine the following scenario: The driver easily parks the car in a properly equipped parking garage on any randomly available parking space. The car takes care of everything else by itself. It communicates via a wireless interface with the charging station and the parking garage management. In this process, it provides information about its charge level and its location. If the battery is empty and a charging station is free, it maneuvers in the corresponding parking bay and is charged inductively, without a cable. Then it makes room for the next electric car and rolls to a free parking space. In this way, the few existing charging stations can be used effectively. "The technology needed for this scenario is already available," says Afkar project manager Benjamin Maidel. He is referring to the Robots of the Institute that find their way easily in a known environment, such as a factory floor. Rebuilding a similar car does not take a lot of effort. Many modern cars already have most of the sensors that are required for this. The data that these devices collect just have to be combined and interpreted accordingly so that they provide a picture of the environment.

**New World Record for Concentrator Photovoltaics** 

The Fraunhofer Institute for Solar Energy Systems ISE has been successfully developing Concentrator

3: Autonomous vehicle in the car-sharing operation: After the renter has called for the car, it navigates autonomously to the pick-up area. © Fraunhofer IPA



Photovoltaic (CPV) technology for many years. In this Technology, Fresnel lenses are used to bundle sunlight and focus it onto miniature, highly efficient Solar cells. The FLATCON® Module Technology originates from Fraunhofer ISE and is continually under further development at the Institute. Now with their newest CPV Module Technology, the Freiburg Researchers announce a world record module efficiency of 36.7 %, achieved by adapting the concentrating lens to a new Solar cell structure. The high module efficiency was measured under Concentrator Standard Testing Conditions, or CSTC, and marks the best value ever achieved for a Photovoltaic Module. Concentrator Photovoltaic Systems (CPV) are installed in sunrich regions, where such systems produce Solar electricity for less than 8 Eurocents per kilowatt-hour. Key to this Technology is the Solar Cell Efficiency and the Concentrating Optic. In the record module, the newly developed four-junction Solar cell was combined with Fresnel lenses, which were manufactured by the Industry partner ORAFOL Fresnel Optics based on a new design developed at Fraunhofer ISE. The successful transfer of this high module efficiency to commercially manufactured modules is expected within one to two years.

### Versatile bonding for Lightweight Components

New materials are making cars, planes and all sorts of other things lighter. The catch is that many of these materials can't be welded. Now there's an alternative joining method available - Gradient Adhesives provide an extremely good way of ensuring joined parts stay joined for their entire service life and hold up well in the event of a crash. Shedding pounds is all the rage these days and the Global trend towards Weight Reduction has even spread to the Automobile Industry. Cars are to get even lighter - using new materials such as Ultra-High-Strength Steels or Carbon, and Carbon-Fiber Reinforced Plastics (CFRP). But no matter which diet regime and which Lightweight Components manufacturers choose, they all want the same thing: the best and longest-lasting joining method for vehicle components. Since Duroplast, which often serves as the matrix component for CFRPs, can't be welded, another joining technique is called for. Bonding is the best solution. "We work primarily with Structural Adhesives, which bond components permanently and create additional shape stability," says Dr.-Ing. Jan Spengler, a chemical analyst in the Plastics division at the Fraunhofer Institute for Structural Durability and Reliability LBF in Darmstadt. These Adhesive bonds offer a particular advantage; they hold up considerably better in crashes than other types of bonds. What's more, Adhesives possess better damping characteristics than metal and improve Noise Vibration Harshness (NVH). NVH is the term for what car occupants perceive as vibration or hear as noise. "The adhesive layer functions like a classic damper, which saves on insulation material and reduces weight," says Dr.-Ing. Halvar Schmidt from the LBF's Structural Durability division.

4: Newest FLATCON® Concentrator Module with an efficiency of 36.7 %. ©Fraunhofer ISE/ Photo: Alexander Wekkeli

5: The variable elasticity offered by dual-cure adhesives provides significantly longer-lasting Adhesive Bonds. © Fraunhofer LBF



# Fraunhofer Energy Alliance: A Powerhouse of Expertise across the Energy Domain

Technology Showcase Fraunhofer UMSICHT: The Biobattery

Sewage sludge, green waste, production residue from the Food Industry, straw or animal excrement – with the »Biobattery's« modular concept, a much larger range of Biomass can be utilized for Energy recovery than previously. Researchers at Fraunhofer UMSICHT show that they can convert organic residues into electricity, heat, purified gas, engine oil and high quality biochar using this process. The Biobattery process developed by them not only supplies electricity and heat but also high quality products such as gas, oil and vegetable carbon. These can be utilized as required, for example to produce electricity, as Marine or Aviation fuel, as an admixture for fuels or as a fertilizer. If further processed they even provide basic substances for the Chemical Industries.

By bundling its competences in the Energy field, the Fraunhofer Gesellschaft aims to develop futuristic and competitive products on the system level for its customers, ensuring good investments. With the collective expertise of over 2,000 employees, the Fraunhofer Energy Alliance is one of Europe's largest Energy Research organizations.

With the combined knowledge and expertise of the 18 member Institutes in Germany and the USA, the Fraunhofer Energy Alliance provides a comprehensive and efficient one-stop service worldwide. For small and medium-sized companies as well as for Industry and the Energy economy, the Alliance provides access to a wide ranging spectrum on R&D, offering assistance towards product's success and in opening up new markets. It also offers consulting services for Policy Makers, Communal Government officials and Institutes. The Alliance co-operates with the Fraunhofer networks Microenergy Technology, Wind Energy, Direct-Ethanol-Fuelcell and Intelligent Energy Nets.

The members of Fraunhofer Energy Alliance are Institutes for Building Physics IBP, Chemical Technology ICT, Factory Operation and Automation IFF, Interfacial Engineering and Biotechnology IGB, Integrated Circuits IIS, Integrated Systems and Device Technology IISB, Ceramic Technologies and Systems IKTS, Optronics, Systems Technology, Image Exploitation IOSB AST, Manufacturing Engineering and Automation IPA, Physical Measurement Techniques IPM, Silicate Research ISC, Systems and Innovation Research ISI, Silicon Technology ISIT, Solar Energy Systems ISE, Environmental, Safety and Energy Technology UMSICHT, Wind Energy and Energy System Technology IWES, Mechanics of Materials IWM and Center for Sustainable Energy Systems CSE.

The Alliance's work is chiefly focused on: Renewable Energy Sources (Solar Energy, Biomass, Wind Power); Energy-Efficient Technologies (fuel cells, Combined Heat and Power CHP systems and gas delivery, building-service Technologies, power electronics); Buildings and Components (low-Energy-houses, building Energy technology); Intelligent Energy Nets (p.e. system technological net integration of distributed generators); Electrical Energy Storage and Micro-Energy Systems (Lithium battery technology, fuel-cell systems).



### **Renewable Energies**

Renewable Energy is no longer an option for the future, but rather today already offers attractive growth potential in many markets. In close cooperation with Industry and the Energy economy, the Alliance develops innovative technologies for Electricity, Heat and Fuel production.

The core competences in the field of Renewable Energies are Biomass, organic residues, sludge, Biogenic gases, Substitute fuels, Photovoltaics, Solar thermal power plants, Wind power plants, Fuels for combined heat and power generation, Solar heat and cold generation, Delivery and integration of Renewable Energy, Decentralized system concepts, Inverters for Photovoltaic systems and Fluidized bed combustion.

For these areas, the Alliance develops new materials, components and production processes as well as the Related System Technology. Its range of services comprises demand and potential analyses as well as market and branches surveys. It also provides Consultancy services and carries out studies on climate change and climate protection.

## **Energy Efficiency Technologies**

Currently it is more important than ever to make Energy supply and consumption more efficient. The reasons for this lie not only in the Global protection of our climate and environment but also in the resulting cost reductions for Industry and consumers. Fraunhofer Energy Alliance focuses on stationary decentralized Energy production and conversion. The core competences in the field of Efficiency Technologies are Efficient Energy use in production, Energy efficiency in cities and regions, Hybrid urban Energy storage, Energy and climate policy, Energy economic analyses, Exergy analyses, Combined heat, power and cold production, Power plant technology, Power electronics, Organic Rankine Cycle – power from waste heat and Sorptive thermal storage

### **Buildings and Components**

About one third of Germany's Energy demand is used for heating buildings. In the future, air-conditioning will increase in significance. The rational efficient use of Energy has highest priority. The members of the Fraunhofer Energy Alliance bundle their technical competence in the fields of Materials, Processes and Buildings. In the business area "Buildings and Components," they are active in all areas of rational Energy use, from lowest-Energy houses through building materials up to facades and shading systems.

Technology Showcase Fraunhofer IKTS: Nanoporous Ceramic Membranes

Nanoporous Ceramic Membranes allow the separation of liquid, vaporous and gaseous material mixtures by filtration using the differences in size, shape or adsorption behavior. Membrane development ranges from material synthesis, testing and manufacturing methods to sample production on an industrial-scale and the equipment of pilot plants. In Membrane development, various membrane materials are produced by Sol-gel Technology, hydrothermal crystallization, CVD or tape casting. Due to these technologies, membranes can be produced in onechannel or multi-channel geometry, as capillary as well as flat membrane. Current Research is focusing on the use of hollow fiber bundles and honeycomb ceramics as support structures. The Nanoporous Membranes developed at Fraunhofer IKTS can be used for effective separation in environmental engineering (waste water treatment), the Food, Chemical and Pharmaceutical as well as Fuel Industry.



# Technology Showcase Fraunhofer IWES: Smart Blades

The "Smart Blades" project is developing intelligent Rotor Blades for future turbine generations. Smart-Blade technologies cause Researchers to expect a considerable reduction in the loads, which affect Rotor Blades. This enables an aerodynamically optimized and lighter design of Wind Energy turbines so that less material will be used for turbine construction. Through design changes, cost savings for material and logistics can be achieved and the turbine's service life increased. This Technology includes Rotor Blade trailing edges, which can change shape and flaps, which, if required, can deflect wind. Extremely large Rotor Blades equipped with such mechanisms can actively regulate gusts of wind and thus reduce performance fluctuations. Through this, damage susceptibility can be reduced and longer service life achieved. The Technology has been successfully tested in the Aviation field and is now to be used in Wind Energy. Hence, the Rotor Blades equipped with these mechanisms should not become more fault-prone, heavier or more maintenance intense and so increase electricity production costs. The aim of the Research Project is therefore to prove the Feasibility, the Efficiency and Reliability of Smart Blades.

Through the analysis, modeling and simulation of complex building systems and Energy systems, they support their customers in the development of innovative operating strategies. Their developments and products are meant to realize a reliable and economically optimized operation. The core competences in the field of Buildings and Components are Insulation materials, Energy efficiency in cities and regions, Thermal and electric Energy management, Façade and shading elements, Prefabricated components for building renovation, Building services engineering, Light guiding systems, Lowest Energy houses, Solar cooling and air-conditioning and Heat pumps.

# **Intelligent Energy Grids**

The Fraunhofer Energy Alliance offers various expertise for the planning, construction and operation of integrated and decentralized Energy systems. This also includes methods and algorithms for control technology and simulation tools. Furthermore, they run test stands and demonstration projects in which monitoring and control systems as well as Energy management systems can be tested and optimized. The customers benefit from their technical support on all system levels: from controlling a single component to managing combined regional systems, from real-time controls reacting within seconds to long-term portfolio optimization. The core competences in the field of Intelligent Energy Grids are Smart Grids, Smart Cities, Smart Markets, Business models, System analysis, Simulation, Prognosis, Optimization, Energy data management, Monitoring and control systems, Measurement and Control technology, Grid protection, Communications technology and Inverters.

# **Energy Storage**

Our society is becoming increasingly mobile. Many of the modern devices need a gridindependent Energy supply. These devices need low-weight and low-volume electricity producers as well as sufficient Energy and power density at affordable costs. Innovative Energy converters are necessary for wireless measurement equipment for the Transport sector, Environment and Industry. The Alliance supports its customers by choosing the appropriate Energy storage solution and in developing customized system solutions. Examples are Micro fuel cell systems, Lithium ion accumulators and Supercaps. The core competences in the field of Energy Storage are Lithium ion batteries, Batteries (LiS, LiO, NiMH, NiCd, Pb, NaS), Redox flow batteries, Battery material development, Performance and safety investigations, Battery management and monitoring, Battery thermal management, SuperCaps, Fuel cells (PEM, SOFC, DMFC, DEFC), Hybrid cold / heat transfer media, Micro Energy Harvesting, Flexible, Compressed Air Energy storage, and Phase



change materials.

Fraunhofer Institutes namely Institute for Solar Energy Systems ISE, Institute for Environmental, Energy and Safety Technology UMSICHT, Institute for Ceramic Technologies and Systems IKTS, Institute for Wind Energy and Energy System Technology IWES and Institute for Building Physics IBP took part in the recent 3rd Fraunhofer Innovation & Technology Platform: 'Powering a Greener Future' held in November 2014 in Bangalore. One of the key highlights of this event was the Information Booth which ran presentations on three large plasma screens in a continuous loop underlining the concrete examples of Technology breakthroughs by Fraunhofer. Technology Showcase Fraunhofer IBP: Plus Energy Buildings

Plus-Energy buildings represent special challenges to the design and operation of the building as well as to the complete engineering systems for maximising the Energy generation from Renewable Energy sources. In accordance with this, the optimal adjustment of Energy supply and Energy demand of the building is required. As part of the project, which has been supported by the European Union and led by the Technical University of Crete, new control systems have been developed which combine model based forecast algorithms with cognitive user feedback. For this purpose, the Centre for Sustainable Building in Kassel and two other European buildings are being evaluated. As part of detailed numerical simulations, optimised control concepts have been developed for these buildings and integrated in the respective Building control system. The Building control system is supported by the installation of new user interfaces. As part of the longterm measurement campaign, the influence of the control system on the operational performance is being analysed, offering a comparison with the numerically developed assumptions.



# **Powering a Greener Future**

Fraunhofer's annual Flagship Event, the 3rd Fraunhofer Innovation and Technology platform (FIT): 'Powering a Greener Future' was held on 21st and 22nd November at Taj West End, Bangalore. The Event was a huge success and attended by almost 200 participants from Industry, Government, Media and Research Institutes. More than 10 Fraunhofer experts from various Institutes participated and showcased Technology solutions for the Energy situation in India. Prof. Dr. Eicke Weber, Director, Fraunhofer Institute for Solar Energy Systems ISE and a leading luminary in the Global Energy field lead the Fraunhofer Delegation and were present on both the days. Eminent guest speakers representing various organizations and Government were also present at the event who spoke on a range of topical issues of Energy, Sustainability and Smart Cities amongst others.

# Experts Speak:

"We do not have many choices and Green Energy Future is inevitable. The future Energy requirements would be met by Wind, Solar, Thorium, Fusion, Biodegradable solid waste management, Fission thermal reactors, Fission fast reactors and Thermal." Dr. Anil Kakodkar

"Fraunhofer Institute could provide the blueprints for photovoltaic production as 18 Fraunhofer Institutes were involved in Energy Systems." Prof. Dr. Eicke Weber

1: Dr. Katragadda sharing his views during the Panel Discussion on 'Powering a Greener Future'

2: Dignitaries during the Lamp Lighting Session on 22nd November 2014 The Event kicked off on the evening of 21st November 2014 with a high-profile Panel discussion on the subject 'Powering a Greener Future' followed by Networking Dinner and cultural performance. The objective of the Panel discussion was to energise and warm up the audience to the subject using high profile experts and draw a framework around the issues that were discussed the following day. Dr. Gopichand Katragadda (Group CTO, TATA Sons), Prof.Dr. Eicke Weber, Prof.Dr. Andreas Reuter (Managing Director, Nordwest, Fraunhofer Institute for Wind Energy and Energy System Technology IWES), Dr. Leena Srivastava (Vice Chancellor, TERI University and Hony. Executive Director, The Energy & Resources Institute TERI) and Dr. Ajay Mathur (Director, Bureau of Energy Efficiency BEE) were the key panellists who shared their valuable insights on Global Energy Trends, Industry's view on Energy situation in India etc. and the discussion was moderated by Ms. Anandi Iyer, Director, Fraunhofer Office India.

# "Fraunhofer culture in India needed"

Delivering the Keynote Address on 22nd November 2014, Dr. Anil Kakodkar (DAE Homi Bhabha Chair Professor, Baba Atomic Research Centre BARC and Member, Atomic Energy Commission AEC) said India had to bring in 'Fraunhofer culture' if it had to translate Research efforts into outcomes that positively impacted society at large. He added that, "There was a need for graded partnership between Academia and Industry. For competitive Product Development, India needs to look at the model of Indian Academia-Indian Industry-labs abroad wherein Institutes such as Fraunhofer could be capable mentors." He also reiterated the importance of both Nuclear and Solar for future Energy Security in the World. Dr. Kakodkar played a key role in Nuclear Tests in 1974 & 1998 at Pokhran. His sterling leadership led to a significant boost to India's Nuclear Power Programme notwithstanding the Uranium supply constraints. As a result, India's Nuclear



generation capacity is set to reach 10,000 MW with the completion of projects already underway. India under his leadership has earned a distinctive status as a country with Advanced Nuclear Technology.

The Guests of Honour were Mrs. Andrea Christ, Deputy Consul General, German Consulate, Bangalore and Shri. G.V.Balaram, Managing Director, Karnataka Renewable Energy Development Limited KREDL. In her address, Mrs. Andrea Christ said that the partnership in the Energy sector between India and Germany would be further strengthened in the near future and that the Indo-German Energy Forum was looking at enhancing cooperation in areas such as Energy Efficiency, Reliability, Investments etc. Mrs. Christ mentioned Germany's *Energiewende* (Energy Transition) programme which had set goals of using less Energy and the right Energy, in its bid to cut Carbon Dioxide Emissions by 80 to 95 per cent by 2050. *Energiewende*, she said, has an ambitious goal of using 80 per cent of Energy from Renewable sources by 2050 and to ensure that by 2022, the last switch off of a Nuclear power plant takes place. Shri.G.V.Balaram shared how the Government is becoming more proactive and bringing major changes in its policies for the growth of Renewable Energy. He outlined the statistics of the Development achieved so far and welcomed Fraunhofer's initiative to support such a Development and be a catalyst for growth.

# **Blueprints for Photovoltaic scalability**

Prof. Dr. Eicke Weber, Director, Fraunhofer ISE and the Chairman for this year's FIT Platform, underscored the benefits, besides environmental, of Wind and Solar Energy compared to Nuclear power plants. He said, "The cost of Power from a Nuclear plant, as per a recent Study in the United Kingdom, was 10 cents per kilowatt hour, while Wind and Solar energy was around six to seven cents per kwhr. The Photovoltaic Industry which is presently at 40 gigabit would expand to 100 gigabit by 2020 and 300 gigabit by 2035. We are right at the beginning of the Development. We need gigabit scale of Photovoltaic Industries." Prof. Dr. Weber has a broad international experience in Research, R&D management and also holds a Professor of Physics/Solar Energy position at the University of Freiburg. He was recently elected as EUREC's President for the term 2015-2017, the leading Association of European Research Centres and University Departments active in the area of Renewable Energy. In January 2014, he received the 'Zayed Future Energy Prize', endowed with 1.5 million US dollars, from the Crown Prince of Abu Dhabi on behalf of Fraunhofer ISE.

Dr. Leena Srivastava, Co-Chairperson, FIT Platform said with 60 per cent of coal and oil being imported, it was time to accelerate Renewable Energy sources to meet Energy demand. She also stated, "In the last 10 years, India had added 75,000 MW of

# Experts Speak:

"India needs to double its generation capacity in a 'clean way'. India's requirements are varied, from urban to rural pockets, and that 'mini-grids' would be practical and feasible considering geography, demographics etc."

Dr. Gopichand Katragadda

"There is a huge spread of technologies in India on a wide spectrum of efficiencies – from highly efficient to highly inefficient and there needs to be standardisation. The potential to bring about efficiencies along the value chain is high and they can be realised through incentivisation." *Dr. Leena Srivastava* 

3: Dr. Kakodkar delivering the Keynote Address at the Inaugural session on 22nd November 2014

4: FIT Platform participants interacting with the Experts

5: Prof.Dr. Eicke Weber giving his Context Setting speech during the Inaugural session on 22nd November

6: One of the four Technical sessions in progress





# Experts Speak:

"We are very well on track to achieve the 2025 milestone of 35 per cent of Energy coming from Renewable Sources. In 2012, the share of Nuclear Energy was 20 per cent, while Renewable Energy had gone up to 25 per cent. Wind and Solar Energies would become price competitive in about 10 years. The more renewable you use, the more competitive it becomes."

Mrs. Andrea Christ

"India is a huge market for Wind Energy and that efficiencies are improving with larger turbines and rotors. Though transporting huge blades in India is a challenge, which can be overcome through improved Technologies."

Prof. Dr. Andreas Reuter

"One of the answers to India's Energy generation woes is to look at centralised and decentralised generation. Technological Innovations are essential to make Solar and Wind Energy systems not only cost competitive but also reach out to larger sections of the society." *Dr. Ajay Mathur*  Conventional Energy and the scale of expansion had been accelerated by the Prime Minister Shri. Narendra Modi to generate 100,000 MW of Solar Energy in the next five to six years."

#### Fraunhofer involved in over 100 project proposals in India

In her Welcome Address on 22nd November 2014, Ms. Anandi Iyer, Director, Fraunhofer Office India, outlined the Fraunhofer's footprint in India. She said that Fraunhofer is going at a very fast pace in India, is involved in over 100 project proposals and already has the top 30 Indian companies as its clients. Giving a few examples, she mentioned the Association with a large Indian Original Equipment Manufacturer towards 'Light Weighting' programmes and the submission of a Techno Economic Feasibility Report (TEFR) for Bharat Heavy Electricals Limited BHEL on setting up a 500 MW Solar Energy plant through backward integration. She stated that the Research and Innovation were keys to Technological developments and Fraunhofer was at the forefront and one indicator was that every working day, two patents are registered. Dr. Raoul Klingner, Director, International Business Development, Fraunhofer HQ, Munich, said with the new Government in place in India, the opportunities to expand bilateral relations in Research, Energy and other sectors with Germany had opened up further. The Inaugural session was followed by four break-away parallel Technical sessions on the sub-thematic areas of Energy Efficiency, Wind Energy, Solar Energy and Energy for Smart Cities. Chaired by Fraunhofer experts, each session featured acclaimed personalities from India and Germany. These sessions set the pace for understanding the issues and challenges faced and showcased few Fraunhofer Technology solutions and models for India. Mr. Gerhard Stryi-Hipp (Coordinator Smart Energy Cities, Fraunhofer ISE) who was the Chair of one of the sessions said, "Smart Cities are going to be Engines of Growth and that India should adopt a low Energy path, aiming high GDP at low Energy demand. Dr. Raoul Klingner steered the concluding session with the four session chairs, Prof.Dr. Eicke Weber, Prof. Dr. Andreas Hornung, Prof. Dr. Andreas Reuter and Mr. Gerhard Stryi-Hipp and presented the main outcomes of the deliberations of the two days and the way forward. On the sidelines of the FIT Platform, several business meetings and workshop were also organised for the Fraunhofer Experts to explore possible collaborations.

Overall the FIT event served as a great platform for Fraunhofer Delegates and the participants to exchange new ideas and take it to the next level of establishing business and Research relations. It provided an insight into latest Research and Development in the Energy sector, coupled with Fraunhofer Technological offerings to the Indian Industry in particular.



# "Working with Fraunhofer will yield rich dividends for us, in realizing our R&D vision"

Dr. Surinder Kapur is a pioneer in the Indian Automobile Components manufacturing industry. He is the Founder Chairman of The Sona Group, a USD 750 million multi-national. He was Awarded the CII President's Award for contribution in Mission for "Innovation in Manufacturing" for the year 2006-2007, he was a Member of the CII International Council for Japan. Excerpts from an interview with Dr. Kapur.

# What is your vision for R&D at Sona Group? How is Sona Group fast-tracking its R&D efforts in India?

Sona Group's excellent growth in the past has been mainly due to the excellent Technology partnerships with overseas companies, mainly Japanese. Going forward, Sona Group has a Global Advisory Board for R&D, which is advising the Management of R&D priorities. This Advisory Group has now set up a target for Sona Group to become technologically independent by 2020.

To achieve this objective, the R&D Organization is being strengthened internally with extraordinary people, best in class processes, and great workplace environment. At the same time, we are creating strong partnerships with R&D Institutes like Fraunhofer in Germany and Council of Scientific & Industrial Research CSIR in India.

# What are the latest trends that you see in the Indian automotive sector?

Indian Automotive Sector will follow the Global Technological trends to create Safe and Smart Automobiles. Like elsewhere in the world, the emphasis in India will also be on Safety, Comfort, and Environment.

## Could you please outline Sona Group's growth strategy for the next five years?

Sona Group intends to benefit from the growth that will take place in the local market. We will continue to be strong market leaders in the Indian market. In addition to this, we have a strategy to be a Global player in some niche markets and some niche Technologies. The Sona Group was founded in 1987 to manufacture Components for the Automotive industry. Today it is a USD 800 million multinational - with over 16 plants across India, 3 in Germany and 1 in the USA. The Group also has a Strategic position in Fuji Autotec, Europe - which has subsidiaries in Brazil, France, Sweden and the Czech Republic. Starting out as a "Manufacture to Print" organisation, the Group today boasts having created its own IPR, particularly in the areas of Power Steering for off highway applications and Precision forging. The Sona Group has engineering capabilities in the areas of Machining and assembly, Precision forging, Cold & hot forging and Heat treatment. The Group's range of products primarily consists of steering and driveline components for the automotive OEM segment namely passenger cars, utility vehicles, commercial vehicles and specialty vehicles. It also boasts the World's largest precision forging enterprise, India's largest steering systems manufacturer – recognized in 1997, by the World Economic Forum as a top-performing Global Growth Company; a recipient of the prestigious Deming Award in 2003, it received the TPM Excellence award in 2007. The Group has been actively engaging with Fraunhofer by looking at many R&D projects in India and Germany.

Your views on the Government's "Make in India" initiative and its importance for the Automotive Industry.

'Make In India' program initiated by the Government of India has the three main objectives:

- 1) Increasing the domestic value addition and Technological depth in Manufacturing,
- 2) Enhancing the Global competitiveness of the Indian Manufacturing sector, and
- 3) Ensuring sustainability of growth, particularly with regard to environment.

This major new national program is designed to facilitate Investment, foster Innovation, enhance Skill development, protect Intellectual Property, and build best in class Manufacturing Infrastructure.

I believe that these measures will benefit the Automotive Industry a great deal since this Industry is already leading the Manufacturing Industry by its competitiveness and reach. Indian Automotive Industry, thanks to the push of 'Make-In-India' by the Government can soon become a hub for exporting Automotive systems and Components to all the major Global markets.

# Can you please share your experience of working with Fraunhofer and how do you view its role in India?

We have just begun to work with Fraunhofer. We see a great amount of talent, experience, and infrastructure available collectively at the Fraunhofer Institutes. We are very confident that working with Fraunhofer will yield rich dividends for us, in realizing our vision of R&D. We are surely looking forward to a fruitful partnership with Fraunhofer.

# **PROFILE: FRAUNHOFER**

## Fraunhofer-Gesellschaft

Fraunhofer has been active in India since the past several years, bringing Innovative Technologies and Research competence to India. Fraunhofer offers applied R&D services in various fields such as Technology, Textiles and New Materials, Aviation, Aerospace and ICT. The India Office of Fraunhofer in Bangalore, was inaugurated on October 30, 2012 which houses an Experience Theatre showcasing some of the latest Technologies and the Fraunhofer Innovation and Technology (FIT) Academy which conducts workshops, bringing Fraunhofer Experts from various Institutes to connect with our clients and partners in India. Ms. Anandi Iyer is presently the Director of India office and based on her network within Fraunhofer, she makes Innovative Technologies accessible to Indian clients and establishes strategic partnerships with Indian Industry and Research organisations. 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.

### **Editorial notes**

Editorial Team Ms. Anandi Iyer Ms. Prathyusha Josyula

### Cover Page Credit:

Researcher Joseph von Fraunhofer, born in 1787, brought us closer to the stars. Counted as one of the founders of Modern Optics, he succeeded in manufacturing Telescopes in a quality that had never been seen before. In 1814, he made his most significant discovery, which was then named after him – Fraunhofer lines. These make it possible for us to get a closer look at space and to understand how stars are born.

## Acknowledgements:

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Sources of "Solutions for Future Food Logistics": "Feeding a Billion: Role of the Food Processing Industry", AT Kearney 2013; Länderbericht Indien, BMEL 2014; Bottlenecks in Indian food processing industry, 2010; Food wastage in India-causes and consequences, Indian streams research journal ISSN no 2230-7850; The food wastage & cold storage developing realistic solutions infrastructure relationship in India, Emerson Climate Technologies 2014

# Fraunhofer partners in India Advisory Board

The Fraunhofer Advisory Council in India consists of Indian and German industry leaders, who are practitioners in Innovation and Research. This pool of experts meets at least two times a year and guide, mentor and catalyze Fraunhofer activities in India.

- Dr. Homi Bhedwar, Regional Technology Director, Dupont
- Mr. Jayant Davar,
  Co-Chairman & Managing Director,
  Sandhar Technologies Ltd.
- Dr. Gautam Chatterjee, Jt. Executive President, Aditya Birla Science and Technology Company Ltd.
- Dr. Leena Srivastava, Vice Chancellor, TERI University and Hony. Executive Director, The Energy & Resources Institute TERI
- Shri. Shyam Chetty, Director, National Aerospace Laboratories (NAL)
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