

FUTUR

Vision Innovation Realization

International Research and Development



Lightweight Components for Large Jets

Metal Additive Manufacturing at Embraer

An ENRICHing Experience

How a Global Network Drives Innovation

Content

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Editorial

Dear Readers, Fraunhofer IPK might be based in Berlin, yet our research is advancing industrial production across the world. Our institute's many partnerships connect us to present and future key areas of science and industry – granting us access to internationally available knowledge and opening up new markets for production technology know-how made in Germany. This enables us to export application-driven research and development to some of the world's fastest growing economies, including Brazil and China. Some of the projects with international customers and partners now generating a considerable proportion of our revenue are presented in this issue of FUTUR.

Our key activities abroad focus on research, development and consulting in the domain of Industrie 4.0 as well as on setting up national and regional innovation systems. An essential asset of our international collaborations is their added scientific value not only for our institute, but for our partner countries as well. A perfect example of this approach is our Fraunhofer Project Center for Advanced Manufacturing @ ITA, which was officially opened in March 2018 in São José dos Campos, Brazil. The center, also known as FPC@ITA, is considered the official seal on a strategic cooperation between our German research institution and one of the top engineering schools in Brazil. At FPC@ITA, Fraunhofer IPK and ITA now join forces to develop production technology solutions for the benefit of Brazil's industrial sector, including German and European companies producing there. Among them is Embraer, the fourth largest aircraft manufacturer in the world, on whose behalf we are developing additive manufacturing technologies for lightweight aircraft components.



Prof. Dr. h. c. Dr.-Ing. Eckart Uhlmann

Our R&D commitment in Brazil dates back to an educational cooperation: for the past five years, the German-Brazilian university exchange program »Science without Borders« has led numerous Brazilian students to Fraunhofer IPK. Many of these now support our research activities in their home country and form the backbone of a growing network of experts who shape Brazil's innovation system.

How we at Fraunhofer IPK work together with a range of partners to optimize innovation systems abroad is also illustrated by ENRICH, the European Network of Research & Innovation Centres and Hubs. ENRICH fosters cooperation in research, technology and entrepreneurship between Europe, Brazil, China, and the USA by offering on-the-spot services to companies, universities, research organizations, funding agencies, and not-for-profit organizations. A very rewarding mission for our experts, as we know from experience that it is not a single actor's know-how, but the interaction of all that is at the heart of a successful innovation performance.

Yours sincerely,

Eckart Uhlmann

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International R&D

Advanced Manufacturing

Fraunhofer Project Center in São José dos Campos

In March 2018, Fraunhofer IPK opened the Fraunhofer Project Center for Advanced Manufacturing @ ITA in São José dos Campos, Brazil. Abbreviated as FPC@ITA, this joint venture is considered the official seal on a strategic cooperation between the German research institution and one of the top engineering schools in Brazil. Based within the facilities of the Technological Institute of Aeronautics (ITA), the center aims at the joint acquisition and implementation of industrial and publicly funded research and development projects, pooling the resources and expertise of both Fraunhofer IPK and ITA.

ITA offers research and education in distinct engineering fields, including aerospace, aeronautical, civil, mechanical, computer and electronics engineering. It is located inside the Department of Aerospace Science & Technology (DCTA) which is considered one of the biggest research centers in Latin America. ITA has been responsible for some major achievements in Brazil over the last 60 years, including the foundation of the Brazilian Aeronautical Industry (Embraer), the development of the Automotive Ethanol Program, and the enhancement of the Telecommunications Industry (Telebrás). In the future, Fraunhofer IPK and the Competence Center for Manufacturing (CCM) at ITA will jointly develop production technology solutions for the benefit of industry in Brazil, including German and European companies producing there. The region hosts 70 percent of all German enterprises with branches in Brazil. Many of these German companies have expressed an interest in cooperating with FPC@ITA; several cooperations have already started. In total, projects amounting to about 11 million euros are currently running or were recently finished by Fraunhofer IPK in Brazil, many of them already in close collaboration with ITA and CCM.

► Service Portfolio

Partners and customers of FPC@ITA benefit from a high-quality product and service portfolio comprising of both similar and com-



São José dos Campos hosts about 50 percent of Brazilian industrial enterprises and 70 percent of all German enterprises that run Brazilian branches. (© ITA)

plementary services offered by Fraunhofer IPK in Berlin and by CCM-ITA in São José dos Campos. Based on the process chain in industrial companies, the project center develops and implements complex system solutions for digitally integrated production

(dip). On a management level this includes methods and tools for the planning, control and execution of business processes down to the shop floor as well as efficient and interdisciplinary future-oriented quality methods. Engineering solutions for digital



FPC@ITA offers R&D solutions for corporate management, product development, production systems as well as manufacturing and automation.

products and product manufacturing are followed by application-specific detail and system solutions for component manufacturing and highly flexible automation of machines, plants and processes.

Across this product and service portfolio FPC@ITA provides assistance to the Brazilian industry, offering comprehensive consulting for the development of innovation projects. It provides not only the scientific expertise required to assist clients in achieving their goals, but also gives international access to those technologies needed to complete such development work. The specific mission of FPC@ITA is to promote the competitiveness of the Brazilian, German and European industries by means of applied research and innovation as well as knowledge transfer. The strategic objectives of FPC@ITA are oriented towards promoting and supporting the national and international innovation system with operational excellence, strong capabilities in research and development of innovative technological solutions and pro-

cesses, as well as close collaboration with clients, partners and the scientific community. One highlight at FPC@ITA in 2018 was the first Board of Trustees meeting on October 4, 2018 at ITA in São José dos Campos. The Board of Trustees of FPC@ITA is composed of 15 high-ranking executives from industry, government and public institutions, with the majority of members coming from the industry, and it meets on an annual basis. The Board of Trustees advises the directors and the steering committee of FPC@ITA on its RD&I strategy and business results, reviews progress in implementation and operation and helps with best practices to improve the operation of FPC@ITA.

Another major event in the first year of operation was the International Workshop on Industrie 4.0 conducted on November 22, 2017 at Vitória-ES in cooperation with the Industry Federation of Espírito Santo (FINDES). New incoming projects were on innovation benchmarking for Ciser, a manu-

facturer of fixing solutions, and turning analyses with prototype-based niobium carbide tools for the mining company CBMM (Araxá-MG). Both projects are presented in detail in this magazine. ■

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International R&D

Lightweight Components for Large Jets

Metal Additive Manufacturing at Embraer

In the aerospace industry, additive manufacturing of metal parts shows huge potential yet also poses a major challenge. A relatively low level of technological readiness for critical applications, fragmented technology approaches and lack of full standardization are all factors that restrict the extensive use of metal additive manufacturing in the aerospace industry. Against this backdrop, Fraunhofer IPK and Embraer, the world's third largest jet manufacturer, have set out to acquire significant knowledge to understand and clarify key-points regarding selective laser melting (SLM), an additive manufacturing method specially developed for 3D printing of metal alloys. The partners aim to assess the SLM process status specifically for titanium-based alloys, including post-processing characteristics, mechanical tests and properties, design for additive manufacturing, manufacturing decision-making, and certification.



Embraer 190-2 belongs to the manufacturer's under 150 seat aircraft fleet. © Embraer

The history of aviation has been marked by an enduring discussion about who invented the first powered airplane. Much controversy has surrounded this question. It is widely held today that the Wright brothers in 1903 were the first to fly successfully. However, the plane of the Wright brothers only managed to fly with the aid of a ramp and a catapult. On October 23, 1906, in Paris, the Brazilian Santos Dumont, an experienced airship builder, took off on board his

14-Bis airplane, built of wood, covered in tissue paper and powered by a 50 hp engine without resorting to any system of catapult. For the first time a plane went airborne gaining speed in its takeoff run. Dumont flew almost 70 meters at a speed of 30 km/h up to two meters off the ground. Brazil regards Santos Dumont as the first successful aviator because the Wright brothers' flyer took off from a rail and used a catapult.

This is certainly a tendentious discussion. The only certainty is that since the time of Santos Dumont Brazil has become a nation with a great tradition in the construction of airplanes. The Brazilian General Command for Aerospace Technology (CTA) and its Aeronautics Institute of Technology (ITA) have been setting milestones that extend this Brazilian tradition. ITA is an institution of higher education and advanced research maintained by the Brazilian Federal Government with a focus on aerospace science and technology. On a strategic initiative of the Brazilian government, the Empresa Brasileira de Aeronáutica S.A. (Embraer) was founded in 1969 at São José dos Campos, within the premises of ITA. ITA engineers made a critical contribution to the development of its first Embraer aircraft called Bandeirante. Nowadays, Embraer is a holding company responsible for manufacturing military, commercial, executive and agricultural aircraft. It was listed as the world's third largest jet manufacturer. This year Boeing and Embraer announced a joint venture for Embraer's airliners.

► Additive manufacturing of titanium alloy for aircraft components

Embraer forecasts a need for more than 5,000 new jets in the 30- to 120-seat capacity segment over the next 15 years, with an estimated total market value of up to US\$ 200 billion. In addition, the aviation programs ACARE 2020 (Advisory Council for Aviation Research and Innovation in the EU) and Flightpath 2050 both call for a reduction of aircraft fuel consumption together with CO₂ and NO_x emissions over the course of the coming years.

Such framework conditions represent a challenge for the producers of structural parts and engines for aircrafts. To meet current



SLM-structural prototypes for airplanes produced at Fraunhofer IPK for Embraer

and future requirements, the aircraft industry will have to undergo considerable technological development in terms of innovative materials and design techniques as well as new fabrication processes. To satisfy upcoming requirements for the aerospace industry, innovative material and manufacturing technologies are urgently needed.

Additive Manufacturing opens new opportunities for engineers to design lightweight and topological optimized parts for aircrafts. One interesting additive manufacturing technology for the fabrication of components with innovative designs but also topologically optimized geometries is selective laser melting (SLM). SLM enables layer-by-layer production of complex components directly out of metal powder, based on CAD data. One outstanding advantage of SLM is the possibility it offers to manufacture complex lightweight structures that cannot be produced using conventional processes. Lightweight structures can contribute to the increase of efficiency and to the reduction of fuel consumption and emission levels of pollutant gases by aircrafts. However, more knowledge regarding the SLM process and the resultant material properties of the produced parts is essential. Over the past five years, Embraer has been working in cooperation with Fraunhofer IPK to investigate the process characteristics and mechanical properties of titanium parts produced by selective laser melting for a structural aerospace application.

► From process design to finished prototypes

Several projects involving the development of a complete manufacturing chain for the fabrication of components via SLM in a holistic way have been carried out both in Berlin and São José dos Campos. The first projects between Embraer and Fraunhofer IPK developed material qualifications for SLM and post-processing technologies. To analyze the potential of SLM additive manufacturing technology for the production of structural parts for airplanes, a wide range of tests were carried out in these projects. Characterization of raw titanium powder, development of SLM process parameters, and application of different surface finishing and heat treatment processes formed a key plank of the research approach. It was demonstrated that titanium alloy specimens and workpieces produced by an optimized SLM process can present mechanical properties similar to those of parts manufactured using conventional processes. Design for manufacturing and SLM part orientation trials provided the know-how needed for the optimization of support structures and reduction of manufacturing time and warping mitigation. Furthermore, economic aspects related to the SLM manufacturing process costs were analyzed and compared with costs associated with conventional manufacturing technologies.

With SLM technology, a new era of innovative component design has been launched.



Generated test specimens for mechanical characterization of titanium alloy parts produced by SLM

Application of this technology now opens the way to the fabrication of aeronautic parts with optimized geometry and topology that seeks a reduction in weight while retaining good mechanical properties. The qualification of the materials used by Embraer in concert with AM topological optimization, has enabled the production of real prototypes for the aeronautical industry. Certainly, the way ahead is still long before SLM structural parts will be flying in commercial aircrafts in conformity with all the necessary safety standards of the aerospace industry. However, the technologies of additive manufacturing have developed rapidly over the last years and expectations are high for the application of this technology in new products. ■

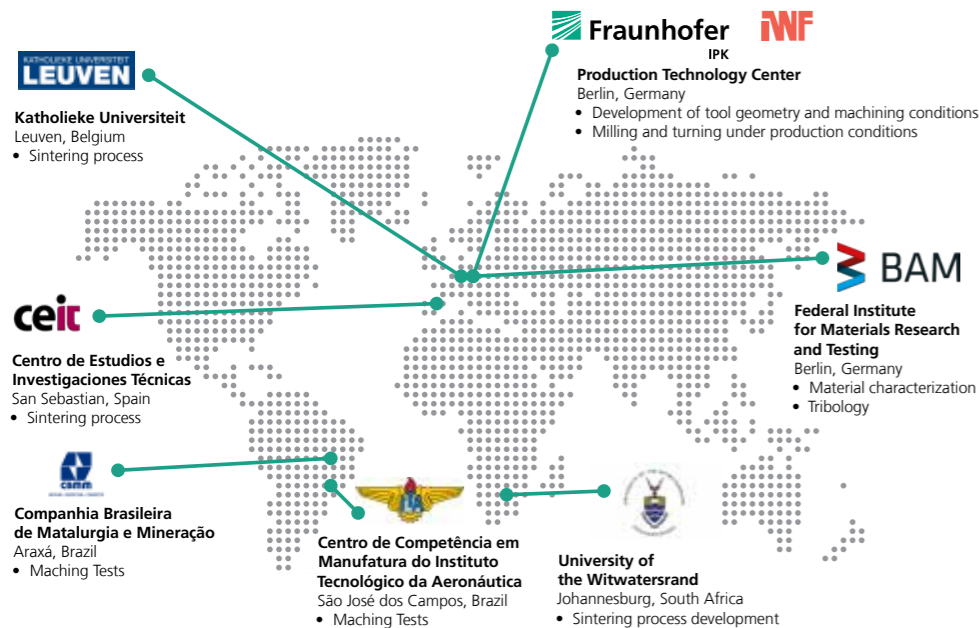
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A Promising Alternative Niobium Carbide as Cutting Tool Material

Niobium carbide (NbC) shows promising results as an alternative cutting tool material to industrially used tungsten carbide (WC) for the machining of iron-based materials. In order to investigate a possible substitution of the conventional cutting tool material WC, the IWF of the Technische Universität Berlin and Fraunhofer IPK collaborate internationally in investigating the suitability of NbC for use as a cutting tool in dry cylindrical longitudinal turning processes. Unlike WC tools, NbC substrates show constant material removal at increased cutting speeds combined with higher process reliability for the specific experimental setup and the chosen iron-based workpiece materials.



International collaboration for the development of NbC cutting tools

► A Critical Resource

With a market share of approximately 53 percent of distributed cutting materials, WC now dominates the commercial use of hard metal tools. In combination with a wear resistant tool coating, WC is applied to different machining operations such as turning, milling and drilling for a variety of workpiece materials. With regard to this industrial standard, NbC inherits a series of beneficial properties for machining operations such as comparable hardness, toughness, as well as heat and wear resistance. Although WC tools currently provide efficient and reliable industrial

manufacturing processes, the recent quest for an alternative cutting material is focused on NbC-based cutting tools. By substituting the WC hard metal phase in its spectrum of technical applications, the continuous optimization of NbC cutting tool material aims to adapt to increasingly complex machining operations in, for instance, high speed cutting (HSC) or high performance cutting (HPC) conditions.

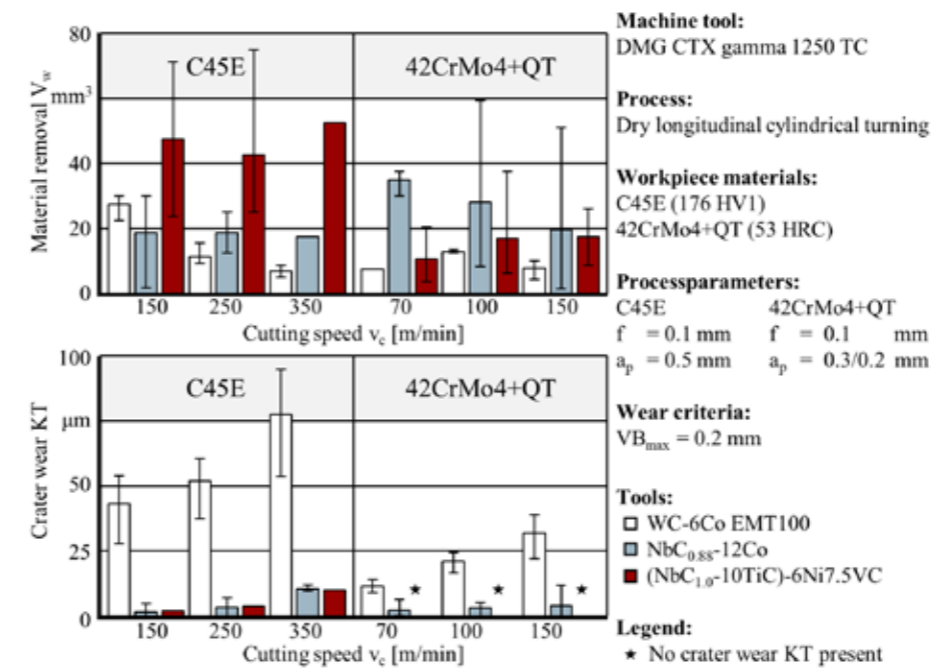
Since 80 percent of raw tungsten is located in China, a guaranteed supply for global consumption is subject to Chinese economic

International R&D

policies. Thus, WC is classified as a critical resource. The latest basic research has identified the cutting tool market as a possible new technological field of application for NbC, alongside its current uses in the aerospace, electronics and medical industries and its use as a grain growth inhibitor and micro-alloying element for increased strength and ductility. The long term objective to establish NbC as a reliable cutting tool material offers beneficial economic impacts in terms of price stability and material supply for manufacturing industries. Along the entire tool manufacturing process chain, the international collaboration network covers the mining and processing of NbC bulk material in Brazil by the Companhia Brasileira de Metalurgia e Mineração (CBMM), powder metallurgical manufacturing and material characterization by KU Leuven, Belgium, and the German Federal Institute for Materials Research and Testing (BAM), as well as its application as a cutting tool by the Instituto Tecnológico de Aeronáutica (ITA), Brazil, the University of Witwatersrand, South Africa and the IWF in association with Fraunhofer IPK, Germany.

► Cutting Materials in the Test

Based on the lower solubility of binderless NbC in solid chrome, nickel, cobalt and iron as compared to WC, reduced chemical wear on the rake face of the cutting tool has been



Material removal V_w and crater wear KT when machining C45E and 42CrMo4+QT in dependence on cutting tool material and cutting speed v_c

certified. Due to the higher melting point of NbC at 3520 °C linked with its lower solubility in alloys, a reduction of adhesion with the workpiece during machining has also been attested. The tribological profile of NbC displays the properties required for machining iron-based workpiece materials based on a lower wear rate caused by friction at elevated speeds combined with a higher hot hardness as of 800 °C.

In order to underline the promising tribological behavior of different NbC substrate materials that differ in binder composition and thus in mechanical properties, dry cylindrical turning trials were performed at Fraunhofer IPK. The experimental NbC tool compositions used in this wear investigation are

defined as substoichiometric $NbC_{0.88-12Co}$ and stoichiometric $(NbC_{1.0-TiC})-6Ni7.5VC$, and are manufactured by the Catholic University of Leuven, Belgium. Commercially available WC tools with a 6 percent cobalt binder manufactured by EXTRAMET AG, Plaffeien, Switzerland, denominated as WC-6Co (submicron grain), serve as the industrial reference commonly used in production.

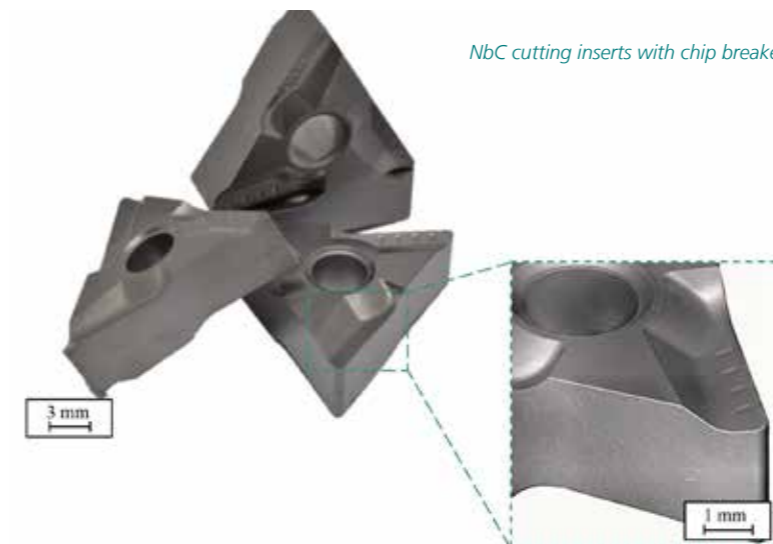
► The Experimental Setup

The turning tests were performed on a DMG MORI AG, Bielefeld, Germany machining center CTX gamma 1250 TC. Assessment of the cutting materials was carried out via dry longitudinal cylindrical turning. In compliance with ISO 3685, a maximum wear width

of 0.2 mm and crater wear depth are used for quantitative wear evaluation. A variation in cutting speed was performed for the two different workpiece materials carbon steel C45E (SAE 1050) as well as quenched and tempered tensile steel 42CrMo4+QT (AISI 4140). In each case, three machining trials for all combinations of cutting material, workpiece material and cutting speed were performed.

► Excellent Results

Machining trials with carbon steel C45E and hardened, quenched and tempered tensile steel 42CrMo4+QT show the potential of NbC as a capable cutting material substitute for WC. The promising material properties of NbC that profile its competitive mechanical characteristics vis-à-vis conventionally used WC have focused interest on NbC as a powerful cutting tool material. Based on present dry turning operations, the following conclusions for the NbC compositions investigated and future scientific work may be drawn: First, NbC-based cutting materials achieve a higher average material removal rate than WC-6Co with regard to the iron-based alloys C45E and 42CrMo4+QT. Improvement of process reliability at higher cutting speeds in the $(NbC_{1.0-TiC})-6Ni7.5VC$ substrate is based on the above mentioned lower wear rate at elevated speeds. Secondly, the lower diffusion wear, i.e. crater wear, of NbC substrates compared to the reference WC-6Co cutting tool materials is based on the lower solubility of iron-based workpiece materials in NbC substrates. Further investigations will include the optimization of cutting tool geometry for best possible engagement conditions, adaptation of a tool coating to increase wear resistance as well as extension towards varying machining processes such as milling. ■



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Road to Success

Innovation Benchmarking for Ciser

On behalf of one of the largest manufacturers of fasteners in Latin America, the experts of Fraunhofer IPK together with the SENAI Innovation Institute for Manufacturing Systems in Joinville have conducted an innovation benchmarking study in Europe and North America. This study identified current trends in new materials, production technology, products, services and business models in both markets and used their findings as the basis for an innovation roadmap that will shape their clients' long-term strategic planning.

Company Profile

Ciser is the largest manufacturer of fasteners in Latin America. It has a production capacity of 6,000 tons/month and 27,000 products grouped into 436 lines to supply 20,000 customers in over 20 countries. The company has approximately 1400 employees spread between Ciser, Joinville (SC), and Ciser Auto-

employees, clients and suppliers through technical courses and academic training.

Ciser Innovation Benchmarking

The company target is to be the reference in Latin America for innovative solutions, a target which acknowledges how vital it is to be fully aware of actual market condi-

for, and implementation of, innovative solutions that contribute to their competitive and sustainable development. The project was divided into two phases: a first analysis and benchmarking phase involved elaboration of strategic mapping of existing products, definition of the market position, analysis of strengths and weaknesses, as well as identification of global innovation leaders through the screening of patents and trade fairs, followed by a thorough analysis of innovation mechanisms. A joint innovation workshop to define the innovation strategy for Ciser was at the heart of the second phase.

The accomplishment of these phases corroborate the achievement of the project sub-goals which are to provide an actual product portfolio and service portfolio map of Ciser and to analyze the competition in Europe, USA and Mexico. Further objectives of the project were to provide an innovation benchmarking report that focused on the new trends identified by Fraunhofer IPK and ISI-MS together with a technology roadmap for innovative ideas based on the innovation benchmarking realized. The outcome was an action roadmap for implementation of the ideas thus generated.

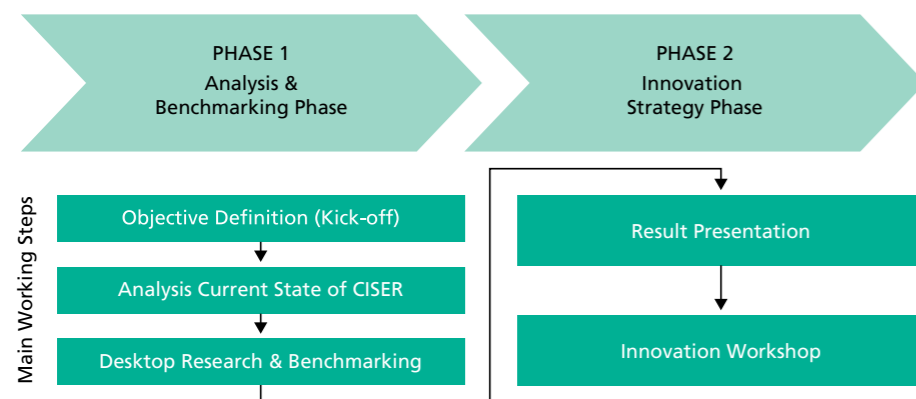
Execution

Phase one kicked off with a questionnaire for gathering internal data for benchmarking, followed by a two-day workshop at the Ciser factory in Joinville /SC that detailed the project objectives and analyzed Ciser's

tions and current developments in the fastener sector. In line with this perspective, Ciser together with Fraunhofer IPK and the SENAI Innovation Institute for Manufacturing Systems (ISI-MS) has developed an innovation benchmarking project. This project shall guide and support the company in the search and application of innovative solutions of fixation with a focus on products and services.

Methodology

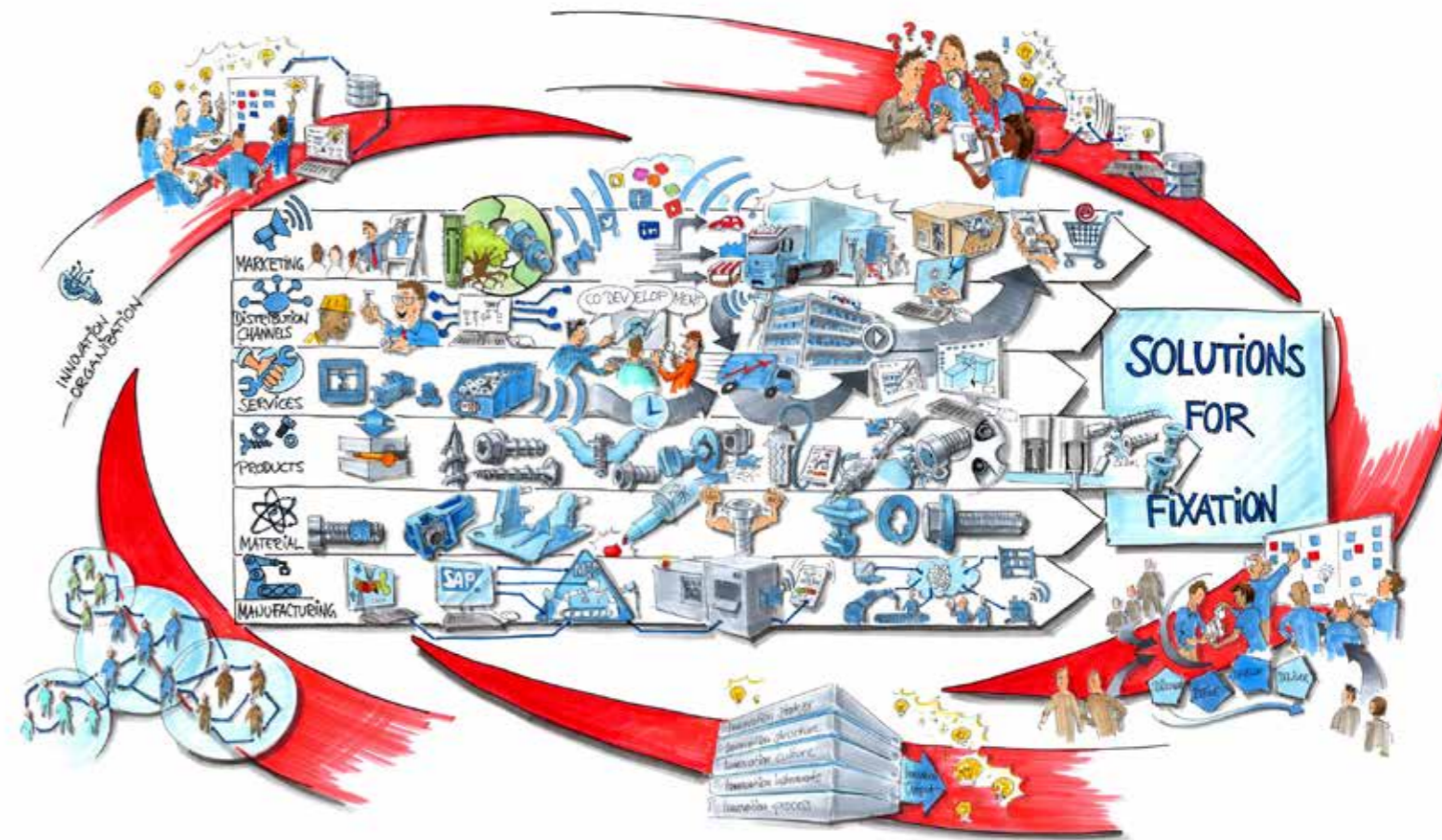
The main goal of the project was to develop a process for innovation benchmarking which shall guide the company in the search



Innovation Benchmarking for Ciser

motive in Sarzedo (MG). With its broad range of products, the company provides solutions for the metal-mechanical, electrical-hardware, agribusiness, automotive, white and brown goods, oil and gas industries, as well as the electronics, rail, furniture, retail and wholesale sectors. Founded in 1959, the company invests in technological innovation and carries out environmental responsibility initiatives. Ciser's distribution center in Joinville with its significant storage capacity for finished products ensures timely delivery to customers in different regions of Brazil. It has its own Technical Training Centre which aims to provide qualifications for

and analyzed Ciser's



Roadmap

status quo. This workshop generated the input required for elaboration of the Ciser product portfolio map, the service portfolio and the SWOT analysis. The next step was the innovation benchmarking and competitor analysis, which were realized separately by Fraunhofer IPK for Europe and ISI-MS for the USA and Mexico.

Phase two took place in a four-day workshop at Fraunhofer IPK in Berlin. The first steps considered the presentation of results and Industrie 4.0 immersion at the facilities of the Production Technology Center (PTZ). Step two, the innovation workshop, was based on data generated during the initial workshop, the remote analysis (innovation benchmarking and competitor analysis) and the presentation of results. The workshop was supported by an idea drawer who visualized the ideas in first prototype drawings.

Results

The innovation benchmarking realized by Fraunhofer IPK and ISI-MS identified several trends in the categories marketing, services,

business models, products, materials, and manufacturing systems. The workshop team discussed the importance of the new trends identified and the readiness of Ciser to embrace each of them. This information was summarized in a technology and action roadmap that shall drive Ciser to become the largest manufacturer of fasteners in Latin America. This masterplan shall support the company in its innovation path, covering actions for strengthening Ciser and enhancing its market competitiveness. ■

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Customer Feedback

Carlos Rodolfo Schneider is head of Ciser Porcas e Parafusos and the man who commissioned the innovation benchmarking project conducted by Fraunhofer IPK and SENAI Innovation Institute for Manufacturing Systems in Joinville. FUTUR talked to him about the importance of innovation for his family-owned company and collaboration with Fraunhofer in the project.

FUTUR: What role does innovation play in your business?

Ciser: In a world where change occurs at increasing speed, the business environment becomes much more challenging. The key issue then is how to follow this revolution, be part of it, and if possible, be a protagonist.

And the main tool for achieving this is innovation in processes, in products, in materials, in business models. It therefore follows that innovation will necessarily dictate the future strategies of our business.

FUTUR: As a family owned business, how do you shape up in the global competitive environment?

Ciser: The 137 years history of the H. Carlos Schneider group and the 59 years of Ciser testify to the company's concern with its perpetuity. Based on our strong values, we always seek to prepare and direct future generations of the family to add their own chapters to this history. The skills needed to do so point more and more towards resilience as a key factor in preserving competitiveness in an increasingly global environment, despite political resistance that we believe to be transitory.

FUTUR: You have German roots and recently conducted a project with Fraunhofer IPK. What is it like working with Germans as compared to working with Brazilians?

Ciser: The company was founded in 1881 by a German immigrant and ever since then has sustained its trajectory with values inherited from the previous three generations, values which include ethics, austerity, financial solidity and the commitment of each generation to deliver to the next more than it received from the previous one. Preservation of these values established by the founder no doubt facilitates interaction with German



organizations, which are usually guided by similar concepts. Fraunhofer IPK, an organization recognized worldwide for its competence and its work on the frontier of knowledge, was undoubtedly the right choice for this project, through which we are committed to understanding the future of our business.

FUTUR: What were the most valuable results from the project and how will you implement them?

Ciser: The work allowed us to become conversant with the business models of the most innovative companies in our industry, from a very broad point of view, and the trends that have been set by them. From there we will be rethinking our plans and strategies and developing the means that allow us to follow the trends and – who knows – even to dictate some of them. The interaction with Fraunhofer IPK may be just the beginning.

FUTUR: What advice would you give other Brazilian companies to become more innovative?

Ciser: It is important for companies to be clear about the fact that innovation can no longer be accessory, can no longer be at the periphery of business plans. The potential impact of changes in strategies and results requires constant attention to the last step taken by industry-leading companies and the next one they may be taking. Support by organizations such as Fraunhofer IPK certainly facilitates this work. ■

Role Model

Industrie 4.0 Application Center in China

Fraunhofer IPK not only plays a key role in Germany's rollout of Industrie 4.0, it is also one of the five German-based specialist organizations engaged by the Chinese government under its »Made in China 2025« initiative. In Nanjing, IPK experts support the implementation of SGIMRI – the Sino-German Intelligent Manufacturing Research Institute – which pursues an integrated training, demonstration and application approach in the field of intelligent production for both Chinese and foreign companies.

The privately organized Sino-German Intelligent Manufacturing Research Institute (SGIMRI) integrates training, demonstration and application-oriented research to create a comprehensive and modular package for industry located in Jiangsu Province. Fraunhofer IPK is supporting this institute along a five year planning and implementation process from a strategic, technical and organizational perspective. Fraunhofer experts have already developed comprehensive curricula for the specific application of Industrie 4.0 in China and conducted their first training programs to develop expertise. Key factors in this context are the integration of specific ancillary conditions and the enterprise culture in the Chinese business environment.

Through this project, Fraunhofer IPK seeks to establish an increasingly strong network with thriving Chinese companies. To achieve this goal, IPK experts cooperate closely with SGIMRI colleagues to develop new solutions for the local market. In the process, SGIMRI combines German engineering with the proverbial Chinese speed to turn innovative business models into innovative solutions. The benefit for the German economy is twofold. First, German machines and equipment will have a market in China, thus increasing German exports. Second, offerings of SGIMRI will help German companies in China to optimize their processes and technologies according to the needs of local Chinese markets.

Several technology-oriented innovation projects have already been realized within the first two years. One is the development of a novel factory concept for the production of control devices for electrical energy distribution for the NARI group, a subsidiary of China State Grid. This integrates modular production systems consisting of manufacturing facilities and shop floor IT with intelligent intra-logistics materials flow solutions. After implementation, the system is expected to shorten processing times by up to 60 percent, among other benefits.

A key success factor for this and other projects is the perfect orchestration of an intercultural and inter-disciplinary team. Moreover, five other Fraunhofer Institutes have already been involved in projects and joint activities. This integrated IPK approach has created a remarkable national perception. The Chinese state-run channel CCTV was just one of the channels to broadcast a half-hour special program about SGIMRI and its achievements. In 2019, joint developments with German companies in Jiangsu province and with a Chinese company for planning a new lead factory are foreseen. ■



Carlos Rodolfo Schneider

... earned a Bachelor and Masters at the São Paulo School of Business Administration of the Fundação Getúlio Vargas – FGV, and is head of the H. Carlos Schneider Group. He was CEO of Centrais Elétricas de Santa Catarina S.A. – Celesc and chairman of the Board of Directors at Celesc, two-term president of the Associação Empresarial de Joinville – ACIJ (Joinville Entrepreneurs Association) as well as honorary consul of Colombia for Santa Catarina. He received the Joinville Meritorious Citizen award from the City Council and the Order of Industrial Merit of Santa Catarina from the Industry Federation of Santa Catarina – FIESC. Schneider is also founder and national coordinator of the Movimento Brasil Eficiente (Efficient Brazil Movement) which seeks to increase public management efficiency, reduce the burden of taxes and simplify the tax system.

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An ENRICHing experience

How a global network drives innovation

ENRICH, the European Network of Research & Innovation Centres and Hubs, facilitates cooperation in research, technology and entrepreneurship between Europe and Brazil, China and the USA by supporting and empowering research and innovation actors.

► ENRICH Initiative

ENRICH is a global network of centers and hubs that promotes the internationalization of European science, technology and innovation (STI). Supported by the European Commission through Horizon 2020, the ENRICH network currently offers services to connect European research, technology and business organizations with three global frontrunner innovation markets: China, Brazil and the USA.

This mutually beneficial network provides standardized and tailor-made internationalization support services to European researchers and innovators to accelerate access to global markets. The service portfolio targets researchers and entrepreneurs and includes webinars, training, research connection symposia, business matchmaking opportunities, working visits and innovation tours. The goal is to facilitate research and technology partnerships and business development opportunities. With the inauguration of a European focal point office in April 2018 in Brussels, the ENRICH initiative is prepared for the future demand and requirements of STI actors aiming for internationalization.

► ENRICH in Brazil

Funded by the European Commission's Research and Innovation Programme H2020 as a CEBRABIC project, ENRICH in Brazil was inaugurated in November 2017 in Brasilia as one of the pilot centers of the European Network of Research and Innovation Centres and Hubs. With partners from Brazil and eight European countries, the consortium's

goal is strengthening cooperation in research, innovation, and business between Brazil and Europe by exchanging innovative practices, experience, and knowledge between all partners involved. The diverse project consortium will work together until the end of 2020 and is coordinated by Fraunhofer IPK.

To connect European researchers and entrepreneurs in the Brazilian market, ENRICH in Brazil offers a broad range of services to its community of actors along the innovation value chain including companies, universities, research and innovation organizations, funding agencies, and not-for-profit organizations. Throughout 2018, ENRICH in Brazil has offered various training programs to European and Brazilian STI actors, including acquisition of H2020 funds, and boot camp preparation trainings, as well as vari-

ous webinars focused on specific technology areas and cultural differences. As building bridges between Europe and Brazil is one of its main targets, matchmaking activities and individual partner and funding searches were also offered.

Whereas all services thus far have been offered on a free-of-charge basis, ENRICH in Brazil will intensify paid services in 2019 in an effort to meet the challenge of becoming self-sustainable within the two remaining years of the project. With a consolidated innovation hub in Brazil in 2020 and an established network consisting of innovation actors on both sides of the Atlantic, ENRICH will be prepared to tackle the challenges of a world where creation of knowledge increasingly happens on a global scale and at an accelerating pace.



International R&D

► ENRICH in China

China is a leading player in the global economy. It is also increasingly relevant in the global science, technology and innovation (STI) domain. Launched in October 2017 with the support of the European Commission, ENRICH in China offers unique services for European research, technology and business organizations looking for a competitive presence in the Chinese market. ENRICH in China has a total of 13 implementing partners, eight European organizations and five Chinese partners. The main objective of the initiative is to reinforce Europe's STI leadership in China and foster cooperation between both regions.

The service portfolio of ENRICH in China seeks to be comprehensive and diverse, aiming at addressing the needs and interests of its European clients in the Chinese market and maximizing the benefits of their activities and presence in China. With headquarters in Beijing and a regional branch in Chengdu, ENRICH in China provides customized services on soft landing, consultancy, business and research intelligence, training and events.

Development of tailor-made sector reports, feasibility and market studies are also available through the RDI intelligence service.

ENRICH in China regularly organizes targeted training, workshops on open innovation management, knowledge and technology transfer, co-creation of products and user-driven innovation, through its open innovation training service. Matchmaking sessions, roadshows, business visits, scientific exchanges, seminars and conferences that build trust and drive the exploitation of research, innovation and business collaborative opportunities are organized through the cooperation enabling events service. Soft landing and co-working spaces in the various certified soft landing zones in China are also provided. Any stakeholder interested in knowing more about China and the center's activities, can also follow all the latest updates in research and innovation through regular RDI briefings.

► The European Innovation House

The ENRICH initiative believes that higher social welfare can be achieved through innovative measures on several fronts, from industrial and academic research to public policies and business management. In addition to Brazil and China, partnerships with institutions from other ENRICH centers are foreseen as part of a greater community, exponentially increasing the number of potential customers on a global level. As the core of a European innovation house, ENRICH

profits from its highly skilled community and offers solutions to challenges in a synergetic way, strengthened by the establishment of partnerships between beneficiaries from distinct backgrounds and with different roles as service providers, soft landing hubs, or ENRICH ambassadors. The growing ENRICH community will highly profit from this dynamic and innovative business model, drawing the project closer to its goal of becoming a central intermediary between innovative businesses worldwide – the ultimate key to its success. ■



The ENRICH initiative offers similar services on all three pilot markets, always adapting the needs to the local market conditions. (© IASP)



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New Case for the e-puzzler

Reconstruction of the Archive Material of the Instituto Judío de Investigaciones (IWO)

On 18 July 1994, the Asociación Mutual Israelita Argentina (AIMA) building in Buenos Aires, the centre of the Jewish community in Argentina, was destroyed in a bombing. The building, which housed numerous Jewish organisations and associations, was completely destroyed. 85 people were killed and 300 injured, and over 400 nearby homes and businesses were destroyed or damaged. To this day, it remains unclear who was responsible for the attack. The bombing also affected the archives and library of the Fundación IWO, Idisher Visnshaftlejer Institut – Instituto Judío de Investigaciones. Starting in fall 2018 with funding from the Cultural Preservation Programme of the Federal Foreign Office, Fraunhofer IPK will investigate whether the damaged IWO material can be restored by means of automated virtual reconstruction.



After the attack, 800 young volunteers gathered to help recover the cultural heritage of Fundación IWO. (© Fundación IWO)

The research institution IWO aims to enhance knowledge of the history of Jewish life, with a particular focus on the history and culture of Eastern European Jews. The organisation's archives and library are among the world's most important resources for research into Jewish life and Jewish history in Europe, the Yiddish language, literature and folklore, the various aspects of the Holocaust and the history of Jewish migration to America.

The attack affected a unique collection of documents and books in Yiddish, as well

as historical documents relating to Jewish history in Argentina and many publications, documents and other Jewish cultural artefacts rescued from the National Socialists and removed from Europe. The unbelievable effort to rescue this unique library, in which up to 800 young people took part, began even as the rescue services were searching for survivors and freeing the injured. Countless documents, recordings and objects and over 70,000 books were brought to safety. This was the second time many of these artefacts had been saved: first they were

removed from the Nazis' grasp, and now, fifty years later, they were pulled out of the rubble that was all that remained of the archives.

While some of the archive material was made accessible again in AMIA's new building and at IWO's new location in 2012, a large number of the damaged documents are still awaiting reconstruction and (re)formation. Since the terror attack on 18 July 1994, the challenge for IWO has been to organise millions of fragments back into



The bombing had a dramatic effect on the IWO collections: Millions of newspaper pages, documents, photographs and books were scattered in the rubble. (© Fundación IWO)

their original form. The sheer number of fragments, never mind the degree of damage, makes manual reconstruction an impossibility.

This is where Fraunhofer IPK in Berlin comes into the picture: its methods for the automated virtual reconstruction of destroyed or damaged documents, which were originally developed to make the shredded files of the German Democratic Republic State Security Service legible once more, are widely sought-after worldwide. Outstanding instances of their application include the restoration of documents damaged when the City of Cologne's historical archives collapsed in 2009 and the reconstruction of the mediaeval prayer book of St Gregory of Narek in Yerevan, Armenia. At the heart of this unique virtual reconstruction method is the ePuzzler software developed at IPK which can join scanned paper fragments of any type up to make complete pages without any template, thanks to completely new

image processing and pattern recognition algorithms.

Starting in fall 2018 with funding from the Cultural Preservation Programme of the Federal Foreign Office, experts from the IPK will run a test and concept phase to investigate whether and how the damaged IWO material can in the first instance be properly digitised and secured to allow reconstruction. Then they will consider the extent to which existing virtual reconstruction methods can be used to restore the damaged material. The investigations will also include estimates of how much work the digitisation and virtual reconstruction of the IWO material will involve. The results of the study will be presented to IWO in a final workshop. ■

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International Innovation

Brazil has the largest industrial park of German companies outside of Germany, featuring more than 800 German industries responsible for 250,000 direct jobs – in just one of 27 states. For José Henrique Videira Menezes, this is an obvious natural incentive to stimulate cooperation between the two countries. And a good reason for the federal career civil servant at the Brazilian Ministry of Economy to come to Berlin and study the German innovation system and its policies. FUTUR spoke to him about how to foster innovation on an international scale.

FUTUR: What are your main responsibilities at the Brazilian Ministry of Economy and how are they connected to your long-term visit to Germany and to Berlin in particular?

Menezes: As a federal career civil servant at the Brazilian Ministry of Economy, I am part of a unit that is responsible for innovation policy. The aim of my visit here as a visiting researcher is to gain a better understanding of policies for innovation both in Brazil itself and in cooperation with Germany. I have spent three months here at Fraunhofer IPK as a visiting researcher to this end.

FUTUR: Did you look into other research organizations here in Germany or did you focus exclusively on Fraunhofer?

Menezes: My main focus was to understand the Fraunhofer model and Fraunhofer IPK, but also the German innovation system and some of its main policies. Within this context I had the opportunity of conducting several meetings with different organizations based in Berlin, be they government organizations, research organizations, or other Fraunhofer institutes like HHI and FOKUS, together with other partners of the Fraunhofer Gesellschaft's network here in Berlin.

FUTUR: Can you briefly sum up what impressed you most?

Menezes: What has impressed me most is the complexity of the German innovation

system. I mean complexity in a positive sense, in other words there are so many different types of support available for businesses to innovate, as an incentive to innovate and to lower the risks and costs of doing research and development. When companies have institutions as big and as powerful as Fraunhofer IPK as a support mechanism, that makes it easier for them to foster innovation. And that is the greatest asset of the German innovation system.

There is a professor at the University of São Paulo who studies innovation in depth, and he uses the term »Innovation Metabolism«. I believe that the German innovation metabolism is increased by the combination and harmonization of all of those organizations that support research for private companies. In fact, this year Germany was rated in the World Economic Forum's global competitiveness ranking as the world's best country in terms of innovation capacity. This completely justifies my time spent here studying, and it only proves what I was able to see here in practice: that the German innovation ecosystem is extremely lively and competitive.

FUTUR: What was your impression of Fraunhofer IPK's international cooperations?

Menezes: I had the pleasure of dining with Professor Uhlmann on the same day that Fraunhofer IPK hosted both the Armenian President and the Prime Minister of Thailand. I felt like a pop star [laughs]. One of the things that Professor Uhlmann told me

is that on average, Fraunhofer IPK receives about 1000 people a year. In the three months I have been here, I have seen many, many delegations and companies being trained. So I do not doubt this number.

FUTUR: How did you first get to know of our international activities in Brazil?

Menezes: I have been interacting with Fraunhofer IPK via Dr. David Domingos for about seven years. We were involved in different projects when I was still at the Brazilian Council of Scientific and Technological Research and Development, which would be the equivalent of the DFG in Germany. In the last five years that I have been with the Ministry of Economy, we have cooperated in different projects with Fraunhofer IPK at the Fraunhofer Project Center for Advanced Manufacturing at the Aeronautics Technological Institute in Brazil, or FPC@ITA for short.

FUTUR: What opportunities do you see for FPC@ITA? Which kind of projects or topics should be covered in the scope of this new cooperation?

Menezes: I believe that FPC@ITA is a great path for increasing the competitiveness of Brazilian firms, and upgrading Brazil's industries technologically. The cooperation spans technological advancements and new materials, new business models and methods, as well as joint R&D projects. Foreign partnerships are also very important. The process

of innovation has become more and more complex, and no single organization – even if it is the largest corporate name you can imagine – no single company, university, or research organization is able to do innovation by itself. It needs to cooperate with universities, other countries, research centers, etc. FPC@ITA is a fast channel for Brazilian companies and industries in an open innovation model, which is most likely the future of how to innovate in a fast, low-cost and much more effective manner.

Along with the industry-oriented FPC@ITA, there is also the research platform ENRICH Brazil. In my opinion, the Fraunhofer Project Center is the best channel for competitiveness and increased innovation for companies. But ENRICH Brazil is a project that is excellent for strengthening academic ties between Brazil and Germany.

FUTUR: When you return to Brazil, what will be your focus? Will you stay in touch with these topics?

Menezes: My personal intent is to continue to contribute to policymaking within the innovation area. But we just had a presidential election, so starting January 1, there will be a new government in place. I serve at the Minister's will, the minister who is in power at any given time, so we will see. But I intend to continue to contribute within the science, technology and innovation arena in the country.

FUTUR: Are you planning to maintain dialogue between your ministry and Fraunhofer IPK?

Menezes: It all depends on the intentions of the new administration. But I believe that this cooperation is very rich and most likely will intensify in the coming years. I personally understand and believe that Brazilian researchers should come more often to spend time here, and vice versa. Brazilian companies should engage with German companies. Brazil actually has the largest industrial park of German companies outside of Germany. A report by the Deutsches Wissenschafts- und Innovationshaus (DWIH) in Brazil says that there are more than 800 German industries responsible for 250,000 direct jobs in the state of São Paulo alone, and Brazil has 27 states. This to me is a natural incentive and a leverage to stimulate a cooperation between the two countries. ■



José Henrique Videira Menezes

José Menezes holds a Bachelor's degree in Economics from Mackenzie University, a political science diploma from the University of Brasília and a Development Studies Master's degree from the University of Sussex, United Kingdom. He has worked for IBM, the National Council for Scientific and Technological Development of Brazil (CNPq) and the Brazil-US Chamber of Commerce. Since 2014 he has been a federal civil servant at the Brazilian Ministry of Economy (MDIC) where he served as New Technologies Director.

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3D Metal Print

Economical and Quick

With the introduction of 3DMP®, GEFERTEC GmbH has set a new industry standard for the manufacture of metal parts. This new additive manufacturing method offers unprecedented opportunities and enables low-cost, yet rapid manufacturing of near-net-shape blank parts from metal. 3DMP® is based on the technically mature and highly reliable arc welding technology and thus uses wire as its feedstock, which means that a workpiece is printed welding bead by welding bead.



GEFERTEC arc operates with the innovative additive manufacturing technology 3DMP®. (© GEFERTEC GmbH)

This new manufacturing technology offers a host of advantages over conventional 3D printing methods which use metal powder as their feedstock. There is no more need for time-consuming handling of the

powder whilst most standard materials are already available in wire form at significantly lower costs. Yet, the major advantage is its extremely high build rate which can be up to 600 cm³ per hour, depending on the material used.

► State-of-the-art Production Machines

With its machines of the arc series based on the patented 3DMP® technology, GEFERTEC offers the way forward for rapid and affordable manufacturing of much larger workpieces up to 3 m³ of steel, nickel-based

alloys, titanium or aluminium. GEFERTEC arc machines operate like traditional machining tools with CNC automated control. Specially developed 3DMP®-CAM-software generates data with which CNC control can precisely position the welding head from the CAD data of the workpiece. Machining of the near-net-shape component is fully automatic, while the final milling of the workpiece is done using conventional CNC milling technology. Compared to other manufacturing solutions, the 3DMP® method makes optimal use of the feedstock material which leads to considerable cost benefits, especially with expensive materials like titanium: manufacturing costs can be cut by as much as 60 percent, depending on the specific application.

► Part of a Strong Group of Companies

GEFERTEC GmbH, the company which developed the 3DMP® method, was founded in 2015. The young company successfully launched its arc-machine series at the 2017 EMO. The GEFERTEC arc now ships in four different variants and customers worldwide are using the new technology in their manufacturing. With the entry of the EMAG Group – starting off as strategic partner, later as investor – 3DMP® has been firmly established as the new industry standard. GEFERTEC is part of the medium-sized BERLIN.INDUSTRIAL.GROUP headquartered in Berlin. With some 320 employees, the group has an annual turnover of around 45 million euros.

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Additive Manufacturing Technologies

From Design to Quality Assurance

The Additive Manufacturing Technologies laboratory at Fraunhofer IPK, with its selective laser melting (SLM), laser cladding, and selective laser sintering (SLS) methods, offers a range of forward-looking technologies that can reliably process a broad spectrum of metallic alloys and plastics. The lab covers fields of application from individual manufacturing to batch production. Our experts research new approaches in design, construction and manufacture of additive parts and, working together with customers and partners, develop individually specified process chains from product design and process development to integration of additive technologies in the target company.

► Technical Facilities

Selective Laser Melting (SLM)

SLM250 HL

- 400 W YLR laser
- Zero-point clamping system for post-processing
- Qualification of metallic materials
- Manufacture of small batches

Laser Cladding (LPA)

TruLaser Cell 7020

- 2000 W disk laser
- Tilt and turn table for flexible positioning of parts
- Repair and coating of components

Selective Laser Sintering (SLS)

DTM Sinterstation 2000

- 100 W CO₂ laser
- Production of prototypes
- Geometric and concept models made of plastic

3D Printer

HP Designjet 3D, MakerBot Replicator 2X Dual Extruder, Ultimaker Original, Ultimaker 2

- Development of recyclable materials
- Production of design models

CAD-CAM-Software

Ansys Workbench, Solid Works, Magics, Siemens NX

- Simulation, construction and HMI programming

Powder Analysis

HAVER & Böcker Analytical Screening Machine, EDX System

- Characterization of powder materials
- EDX analysis for analysis of chemical substances
- Hall Flowmeter for determining flowability

Material Testing

Zwick & Roell Z150, REM Jeol JCM-5000, Neoscope

- Testing of density
- Determination of tensile strength and hardness
- Structural examination

Optical and Tactile Measurement

Alicona InfiniteFocus, GOM ATOS 3, Jenoptik nanoscan 855, Zeiss F25, Zeiss LSM 5, Zeiss Metrotom 800, Zeiss O-Inspect

- Testing of geometry, roughness, contours and topography



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► Fraunhofer Project Center in Brazil

Official Opening of FPC@ITA with an Industrie 4.0 Conference

March 6, 2018 marked the official inauguration of the Fraunhofer Project Center for Advanced Manufacturing @ ITA, or FPC@ITA for short, in São José dos Campos. In honor of the occasion, some 280 senior figures from government, industry and science accepted the invitation to the first joint Fraunhofer and ITA Conference on Industrie 4.0. The exceptionally comprehensive spectrum of talks included 20 presentations by representatives of the universities and research institutes, Brazilian ministries and industry associations linked to FPC@ITA as well as local enterprise. Talks and presentations dealt with current trends in research, development and industrial application in the fields of automobile construction, aviation and the petrochemical and metal processing industries. The highpoint of the conference was the nomination of the Board of Trustees of the new Project Center whose 14 members include executives and managers from such companies as General Motors, Siemens, and ThyssenKrupp as well as from SENAI, Brazil's National Service for Industrial Training, and the Brazilian development bank BNDES.

Industrie 4.0, the central topic of the conference, is also the R&D focus of FPC@ITA. »In future Fraunhofer IPK and ITA will jointly offer technologies for digitally integrated production«, says FPC@ITA managing director Dr. David Carlos Domingos. These will include sustainable solutions for the fields of corporate management, product development, production systems, and manufacturing and automation technologies. Fraunhofer IPK and ITA began cooperating in 2009 and have successfully pooled their expertise and services for the acquisition and execution of industrial research projects in Brazil. Partners and customers of the Project Center can now benefit from an even wider-ranging product and services portfolio, specially tailored to the Brazilian market and local industry and including German and European companies with subsidiaries in Brazil.

FPC@ITA was officially inaugurated with a conference on Industrie 4.0. The highpoint of the conference was the nomination of the members of the Board of Trustees (m.). (© ITA / Beatriz Grassi)

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► Memorandum of Understanding

A New Agreement to Strengthen Cooperation with Brazil

On March 9, 2018 a Memorandum of Understanding was signed between the Berlin Center for Digital Transformation and the Instituto de Pesquisas Tecnológicas (IPT) in São Paulo, Brazil. On behalf of the Berlin Center, the signatories were its speaker, Professor Manfred Hauswirth, Professor Eckart Uhlmann, executive director of Fraunhofer IPK, together with Nikolai Schmeißer and Dr. Christina Treeger as representatives of the Fraunhofer-Gesellschaft. The signatories for IPT were its managing director, Fernando José Gomes Landgraf and manager Mário Boccalini Júnior. The Memorandum agreed on the promotion and facilitation of technical cooperation between the partner institutes for a period of five years with the aim of creating beneficial synergies for both parties in the fields of research and development. LZDV and IPT agreed on a future exchange in research and development as well as the initiation of joint projects services and other activities particularly in the fields of Industrie 4.0, smart cities and sustainable cities.



(from the left): IPT managing director Fernando José Gomes Landgraf, Professor Eckart Uhlmann, director of Fraunhofer IPK, Alessandro Santiago dos Santos, R&D manager at IPT, Dr. David Carlos Domingos, managing director of FPC@ITA at Fraunhofer IPK. (© IPT).

With twelve technology centers, IPT is one of Brazil's largest research institutes, offering solutions and services both for the public and private sector in a wide range of fields that include urban infrastructure, transport and security.

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► Successful Conference

I-ESA'18 at Fraunhofer IPK

From March 19 to 23, 2018 Fraunhofer IPK played host to the International Conference on Interoperability for Enterprise Systems and Applications – I-ESA. This conference brings together global leaders in the research and use of enterprise interoperability and its associated fields, including interoperability aspects of enterprise systems and applications. Over 150 guests from Israel, Japan, the USA and European countries participated in a program of international keynote addresses, presentations of current research projects and a symposium for doctoral candidates. In particular, conferences slots dealing with the internet of things, blockchain and communication security offered the opportunity for a lively exchange of views and experiences between scientists, service providers, companies and industry interest groups and lead to a strengthening of international contact between research and industry. In the run-up to the conference, ten interactive workshops were held in which 51 papers discussed such themes as industrial big data and cloud platforms for the provision of smart services in the context of Industrie 4.0, digital transformation, and the smart factory.



The interactive pre-conference workshops were well attended.

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► Endoscopic Cleaning of Turbine Blades

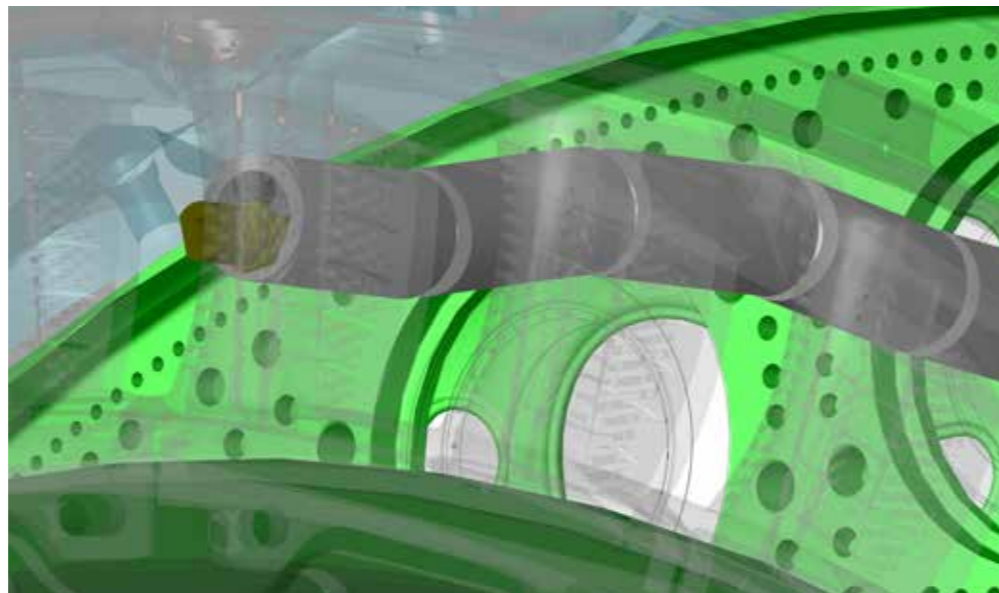
Project of Rolls-Royce in Cooperation with SCHÖLLY FIBEROPTIC and Fraunhofer IPK Wins German Aviation Innovation Award 2018

Rolls-Royce Deutschland, in partnership with SCHÖLLY FIBEROPTIC and Fraunhofer IPK has won the German Aviation Innovation Award in the category of »Cross Innovation«. The award-winning project »Longevity for Turbine Blades through Endoscopic Cleaning« successfully applies methods from medical technology to complex highly stressed parts of modern jet engines, thus increasing their longevity whilst also reducing maintenance costs.

Modern high-pressure turbine blades are operated at temperatures far above the melting point of the materials used. In order to be able to withstand this reliably over millions of flight hours, they are cooled by air flowing out through ducts. This creates an air film around the blades which prevents direct contact with the hot combustion gases. If the cooling holes are blocked with impurities in the air stream, the blades can lose performance. Regular inspection and cleaning of the cooling ducts of turbine blades on installed engines lowers maintenance costs, improves fuel efficiency and also helps avoid unplanned engine changes.

The winning team of experts from the three companies developed a tool that cleans difficult to access turbine blades in the engine with a high pressure water jet. This newly developed, heavily miniaturized and flexible instrument can be endoscopically inserted directly through the existing fuel injection entrances into the engine where it is precisely directed by a control unit similar to those used in medical interventions. Unwanted contact with engine parts is thus avoided. The special cleaning head delivers a water jet at a pressure of up to 500 bar – approximately four times the pressure of a conventional high pressure cleaner – onto the turbine blades whilst precisely maintaining the selected position. Due to precise holding of its position, depending on the particular construction, several blades or some 360 cooling holes, can be cleaned at the same time.

The theoretical groundwork for the new method was laid in an early concept phase of the project as part of the LuFo (Luftfahrtforschungsprogramm) aeronautical research program. In a further phase, under the leadership of Rolls-Royce working together with



A virtual reality visualization showing insertion of the newly developed tool through the openings of the fuel jet (© SCHÖLLY FIBEROPTIC GMBH)

research partners Fraunhofer IPK and SCHÖLLY FIBREOPTIC, the tool was brought to maturity.

The German Aviation Innovation Award took place on April 25 at the ILA (Innovation and Leadership in Aerospace) 2018 air show in Berlin. Award-winners in the four categories Emissions Reduction, Customer Journey, Industrie 4.0 and Cross Innovation were selected by an expert jury chaired by Professor Rolf Henke, executive director of Aeronautics at the German Aerospace Center (DLR). The jury used a multi-stage selection procedure to determine the winners from a broad field of candidates. Innovation power and implementability of the concept were important criteria in their decision-making.

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► International Guests

H. E. Jean Graff, Ambassador of the Grand Duchy of Luxembourg

On April 13, 2018, Professor Jörg Krüger, head of the Automation Technology division (l.), and Dr. Bertram Nickolay, head of the Machine Vision department (r.) welcomed some high-ranking visitors to Fraunhofer IPK. H. E. Jean Graff, ambassador of the Grand Duchy of Luxembourg (2nd from left) accompanied by the deputy head of the Department of Economics and Trade, Julie Jacobs, came to inform himself about automation and reconstruction technologies, and expressed great interest in strengthening cooperation with the city of Berlin and Fraunhofer IPK. It might be little known in Germany, but Luxembourg has a very strong manufacturing sector. This is why the Ambassador sees great potential in new projects on flexible production and Industrie 4.0.



H. E. Dr. Peter Huber, Ambassador of the Republic of Austria

H. E. Dr. Peter Huber, ambassador of the Republic of Austria (2nd from left) and Viktoria Wagner, director of the Austrian Cultural Forum in Berlin were guests of Fraunhofer IPK on April 18, 2018. Prof. Eckart Uhlmann, executive director of Fraunhofer IPK (r.) and Dr. Bertram Nickolay (l.) presented the concept of the Fraunhofer-Gesellschaft as well as current collaborative projects between Fraunhofer IPK and the TU Berlin with Austria. The four of them discussed solutions and projects concerned with Industrie 4.0 und digitally integrated production. Viktoria Wagner showed keen interest in cooperation in the field of virtual reconstruction for the conservation of cultural assets. In the central testing area, ambassador Huber was fascinated by a new gesture-based programming method for robots.



Cameron Dick MP, Australia

On April 20 the Honorable Cameron Dick MP, Minister for State Development, Manufacturing, Infrastructure and Planning in Queensland, Australia visited Fraunhofer IPK. He was received by Prof. Holger Kohl, head of the Corporate Management division and Prof. Frank Wagner of Fraunhofer IAO who reported on Fraunhofer activities in Australia. Cameron Dick inquired about the Fraunhofer model in Germany, and was particularly impressed by the innovation systems and R&D activities of Fraunhofer IPK in the field of digitally integrated production and its associated value chain and business models. At the end of his visit, during a tour of the central testing area, he showed great enthusiasm for a cooperative robotics solution for the automobile industry.



► Robotics Live at automatica

Fraunhofer IPK Showcases Automation Solutions

From June 19 to 22 at this year's automatica trade show in Munich, Fraunhofer IPK gave the first live presentation of two technology solutions from the field of robotics. The lightweight robot CATCH for the automated harvesting of cucumbers is being developed in a collaborative project between Fraunhofer IPK, the Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB) and the CSIC-UPM Centre for Automation and Robotics in Spain. The CATCH robot gave its first public performance at automatica where in a plastic garden it recognized plastic cucumbers among the green leaves and accurately plucked them.

The soft robotics orthosis CareJack is a wearable-robotics system for the upper body that has been developed in cooperation with CBT – customized bionic technology – and Fraunhofer IZM for improved ergonomics and movement support for people working in manufacturing, logistics and the service sector. In its latest iteration, CareJack features a passive hip bracket that supports the posture of the upper body and thus offers intuitive power assistance. The energy needed for this is generated from the wearer's movements.



CATCH (top) and CareJack (right) in action.



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► A Visitor from Colombia

Honorary Consul Alejandro José Tieck Gaviria

On July 9, 2018 Prof. Rainer Stark, head of the Virtual Product Creation division, welcomed the German honorary consul in Medellin, Alejandro José Tieck Gaviria to Fraunhofer IPK, accompanied by the presidents of eight Colombian universities. Their visit was part of a tour of research establishments in Germany the delegation was making with stopovers in Bonn, Cologne and Berlin. During his visit to Fraunhofer IPK, the honorary consul inquired about the Fraunhofer model in Germany and the institute's PDM/PLM Competence Center. The presidents expressed particular interest in research in the field of digital twins and additive manufacturing.

During a tour of the central testing area, the visitors were given live demonstrations of the application-oriented technologies developed by Fraunhofer IPK. The highlight was a use case from agrobotics showing the harvester robot CATCH in action.



The honorary consul (6th from right) and the delegation of presidents of Colombian universities visit the central testing area at Fraunhofer IPK.

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► A Distinguished Visitor from China

Research Minister Wang Zhigang

On July 10, 2018 Professor Eckart Uhlmann, executive director of Fraunhofer IPK, and Professor Holger Kohl, head of the Corporate Management division, welcomed China's Research Minister Wang Zhigang to Fraunhofer IPK. As part of the delegation of the Chinese Premier Li Keqiang, the minister had come to Germany to take part in talks with chancellor Angela Merkel in the 5th Sino-German Government Consultations held on July 9 at the Federal Chancellery. On the same day Zhigang visited Federal Research Minister Anja Karliczek at the Federal Ministry of Education and Research. The two parties agreed to strengthen their cooperation on climate research and to work together in the fields of Industrie 4.0, vocational training, the humanities and social sciences.

During his visit to Fraunhofer IPK, Industrie 4.0 was also one of Wang Zhigang's key topics of interest: in March 2018 he was appointed as the Minister of the Ministry of Science and Technology (MOST) of the People's Republic of China. He was particularly

interested in the close interlocking of basic and applied research at Fraunhofer IPK, and was impressed by the manufacturing intelligence of digital twins which he saw in action during his tour of the central testing area. He himself tested a demonstrator for smart production environments from the Berlin Center for Digital Transformation, and was gratified by the personalized present specially produced for him by the digital twin of a smart factory cell.

Before leaving, the minister reaffirmed his interest in future cooperation with Fraunhofer IPK and extended an invitation for further talks in China. Just how Chinese research institutes and universities could achieve a stronger orientation to applied research following the Fraunhofer model could well be one of the talking points of such discussions, according to Wang Zhigang.

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(clockwise): Professor Eckart Uhlmann, director of Fraunhofer IPK, welcomes the Chinese Research Minister Wang Zhigang. The minister put the digital twin through a ViP test. Wang Zhigang was also given a vivid illustration of what we mean when speaking about human-centric robotics in a live demonstration of a robot. He was also impressed by the sheer complexity of the parts that additive technology can manufacture.



► Digital Twin Meets Plug & Produce

Fraunhofer IPK at the International Manufacturing Technology Show (IMTS) in Chicago

The Hannover Messe made its first sortie into the USA – and Fraunhofer IPK joined in with a trendsetting exhibit. At the booth of the Fraunhofer-Gesellschaft at the »Hannover Messe USA« at IMTS, the Berlin institute showcased Modular Shop Floor IT, a flexible control unit for smart factories. This IPC solution enables the simple, quick, flexible and cross-system development, implementation and maintenance of shop floor IT. Its aim is to »Plug & Produce« whereby the control unit of every newly acquired machine is connected up to an existing production network and should smoothly function within it from the very first moment. To this end, the modular shop floor IT connects an upstream adapter to the proprietary machine control unit to ensure interoperability with higher job control systems. At the Hannover Messe we demonstrated how, with the help of a digital twin via a head-mounted display, production data could be placed within the field of vision of workers such as line managers. This has multiple benefits from facilitating early machine adjustments for the manufacture of newly developed products through to ensuring the flow of an error-free production stream.



The interplay between modular shop floor IT and the machine twin enables context-sensitive delivery of current relevant machine and process data to workers.

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► Well Informed

A British Minister of State Visits the PTZ

Sam Gyimah, the United Kingdom's Minister for Universities, Research, Science and Innovation visited the Production Technology Center (PTZ) on November 7, 2018. The Technische Universität Berlin and Fraunhofer IPK were two of the stopovers on the minister's two-day tour of Berlin. The visit aimed to strengthen the United Kingdom's international relations in the fields of research and development. At the PTZ, Mr. Gyimah learnt more about Industrie 4.0 and the Fraunhofer model of applied research. In the following guided tour he expressed particular interest in the demonstration of gesture-based robotic control in combination with a digital twin. And when he held in his hand a 20 micron thin copper-coated steel wire, he had a very tangible impression of the dimensions our researchers at the Application Center for Microproduction Technology work with. In the evening Mr. Gyimah spoke in Berlin's Red Town Hall as guest of honor at the Berlin Science Award 2018. He was invited by the Governing Mayor of Berlin, Michael Müller who gives the traditional address on science in Berlin at the award ceremony.



Almost invisible: Sam Gyimah holds a 20 micron thin steel wire in his hands, of the sort used by researchers at Fraunhofer IPK's Application Center for Microproduction Technology.

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► Conserving Jewish Cultural Assets

II. Berlin-Visegrád Conference in the Red Town Hall

From October 18 to 19, 2018, the Berlin Senate Chancellery, Fraunhofer IPK and the Moses Mendelssohn Foundation held the II. Berlin-Visegrad Conference in Berlin's Red Town Hall. Dedicated to »Conserving Jewish Cultural Assets. The Opportunities of New Digitization and Reconstruction Technologies«, this international conference of experts presented state-of-the-art technologies for the digitization and reconstruction of Jewish cultural assets and discussed potential fields of application in the four states of the Visegrad Group, Poland, the Czech Republic, Slovakia, and Hungary. With their key geographic position in the heart of Europe, the Visegrad states harbor countless treasures of a multicultural past which are now damaged by the passage of time, environmental influences or war. The Jewish cultural heritage is particularly important in this context as an integral part of culture of Central and Eastern Europe. Just how digitization and reconstruction methods could be used to save valuable assets of Jewish history, conserve them on a long term basis and open them up to coming generations was the subject of a lively exchange of views between the some 70 guests from Germany and abroad.

The experts of Fraunhofer IPK presented their globally unique reconstruction technology, and illustrated its potential applications by reference to on-going projects such as restoration of the archives of the Instituto Judío de Investigaciones (IWO) in Buenos Aires, reconstruction of destroyed documents in the Historical Archive of the City of Cologne, and reconstruction of the fragmented Leibniz manuscripts. Joint discussions with representatives of cultural establishments, museums, memorial sites, libraries, archives, universities and public administration in the Visegrad Group aired new solutions for quickening the pace of the digitization and reconstruction of cultural assets in the respective countries. At the same time, the conference itself aimed to raise esteem of those actors already committed to the Jewish culture of remembrance and to act as a spur for the initiation of joint project initiatives.

Berlin is partnered with the cities of Warsaw, Prague and Budapest through long-standing sister city partnerships. This conference is the second of its kind to be held and should lead to an intensification of exchange of experience and the opening of new fields of cooperation.

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Cloud solutions, Leibniz manuscripts and Klezmer music were just three of the topics at the Berlin-Visegrad Conference in Berlin's Red Town Hall. The photo shows (from left to right): Prof. Jörg Krüger, Fraunhofer IPK, Prof. Dr. Julius H. Schoeps, Moses Mendelssohn Foundation, and Thomas Pröpstl, Head of Protocol of the State of Berlin.



»It is not just the way we exchange information that has changed, but the way we do our research and the questions we ask, too«, Dr. Miriam Bistovic of the Leo Baeck Institute in Berlin.



Day two of the Berlin-Visegrad Conference was opened by Rabbi Prof. Dr. Andreas Nachama, executive director of the Topography of Terror Foundation.

► Top-Ranking Diplomatic Guests

Thailand and Armenia Express Interest in Cooperation

November 28, 2018 marked the visit of no less than two top-ranking guests of Fraunhofer IPK. Both the president of Armenia, Dr. Armen Sarkissian, and the prime minister of Thailand, H. E. Prayut Chan-o-cha, had a guided tour of Fraunhofer IPK on the agenda of their Berlin program.

The globally unique Fraunhofer model of applied research has a particular impact on Germany's innovation capability and is a beacon whose light radiates across the world. Small wonder then that the two heads of government came to question Fraunhofer IPK director Professor Eckart Uhlmann about applied research and the associated transfer of science to industry.

Fraunhofer IPK scientists also gave demonstrations of a range of research projects. Dr. Sarkissian was already conversant with the work of Fraunhofer IPK through its project for the virtual reconstruction of the Narek prayer book, one of the cultural treasures

of the Matenadaran Institute for Ancient Manuscripts in Armenia. Armenia is a country well advanced in computer science and Dr. Sarkissian expressed particular interest in project drafts for automation technology and artificial intelligence.

Prime minister Prayut was accompanied by a large delegation which included several of Thailand's ministers. At the central testing area of the Production Technology Center the group inspected various Industrie 4.0 demonstrators. Before taking leave, H.E. Prayut inquired how Thailand might position itself on the Fraunhofer world research map. Both parties agreed to hold further talks to discuss possible forms of cooperation.

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Armenia's president Dr. Armen Sarkissian visited Fraunhofer IPK on the morning of November 28, 2018.



H. E. Prayut Chan-o-cha, prime minister of Thailand came to the institute in the afternoon, together with several of his ministers.



► Save the Date

PTK 2019: Digitally Integrated Production – Solutions from Berlin/Brandenburg

Digitalization has now arrived in production. What used to be, just a short time ago, a theoretical concept and a vision is now increasingly shaping the manufacturing of products and transforming the associated internal and external value chain. Yet in implementing Industrie 4.0, German know-how in manufacturing and development must increasingly struggle to hold its ground in international competition – both against the furious pace of digitalization in the production sector in China, relentlessly driven by the »Made in China 2025« strategy, and against the disruptive transformation of production in the USA where Internet of Things and artificial intelligence are delivering the groundwork for »Manufacturing as a Service«.

You can learn about which innovative technologies, methods and business models you need for rapid, low-cost and successful digital transformation at our Production Technology Conference. Manufacturers, developers, users and researchers will be presenting the latest digitalization solutions for engineering, manufacturing and assembly. We will show you how manufacturing techniques – and above all additive technologies – can support end-to-end digitization of whole process chains. Also, we offer best practice illustrations of the use of AI methods, digital twins, cloud control, and adaptive shop floor IT. We invite you to discuss with experts from other corporations, SMEs and start-ups about how they integrate augmented, mixed and virtual reality in their manufacturing processes and what data analytics tools they use as the basis for their intelligent data management. And you will learn about the sheer potential packed by Berlin/Brandenburg as the new hot spot for digitalization and join us in taking a look at the world of Learning and Work 4.0

Agenda Topics

- How will digitalization change tomorrow's production?
- Digital networking in automation and product creation
- Digitization of complex assembly processes
- Tomorrow's manufacturing – technology-driven and digitally integrated
- Artificial intelligence and data analysis
- Management of digitalization – best practice solutions

Further information and registration:

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XVI. INTERNATIONAL
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PTK 2019

**DIGITALLY INTEGRATED
PRODUCTION
SOLUTIONS FROM
BERLIN / BRANDENBURG**

**SAVE THE DATE
12. – 13.09.2019**

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Profile

Production Technology Center PTZ Berlin

The Production Technology Center PTZ Berlin comprises of the Institute for Machine Tools and Factory Management IWF of the Technische Universität Berlin and the Fraunhofer Institute for Production Systems and Design Technology IPK. The PTZ develops methods and technologies for management, product development, production processes, and design of industrial manufacturing plants. Furthermore, we also leverage our proven expertise to engineer novel applications in emerging fields such as security, transport and medical technology.

The PTZ is equally committed to making its own contributions to application-oriented basic research and to developing new technologies in close collaboration with industry. The PTZ works together with its industry partners to transform basic innovations born in research projects into fully functional applications.

With the methods and techniques we develop or improve, we offer our partners comprehensive end-to-end support from product development and fabrication through to product recycling. This also includes the conception of means of production and its integration in complex production facilities, and innovation of all corporate planning and controlling processes.



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