Fraunhofer
IMM

FRAUNHOFER INSTITUTE FOR MICROENGINEERING AND MICROSYSTEMS IMM

2017/18

ANNUAL REPORT

2017/18

ANNUAL REPORT

CONTENTS


"Hit the ground running
and make further
big things happen"
PROF. DR. MICHAEL MASKOS

DEAR READERS

During the past months all of our skills were demanded to create an excellent starting point for acting as Fraunhofer Institute for Microengineering and Microsystems IMM from the beginning of 2018. I am very proud of all my coworkers. Crucially thanks to their enthusiasm and commitment we were able to master all challenges during the last years.

But it is of course as well the perfect time to say "thank you" to all those helping hands that extended to us such a warm welcome to Fraunhofer right from the beginning, in particular all the collegues from Fraunhofer ICT, accompanying us during the integration phase. And it is even more the right time to set our sights on the future now, to hit the ground running and make further big things happen.

One such big thing literally could be the so-called "ISO-Container Forty-feet Equivalent Units" which serve us as ideal approach to establish flexible, efficient and economical production processes on-site, still retaining the advantages of a microstructure based operating principle. Aiming at a self-sufficient, modular and flexible chemical plant this container will comprise all plant periphery and control as well as a modular, multi-purpose microreactor based equipment for the production process. Possible applications range from the synthesis of fine and specialty chemicals, the in situ generation of intermediates to energy carriers as well as energy conversion processes (including biofuels) based on a heterogeneously catalyzed approach (gasoline synthesis, power-to-gas).

The ground has been paved by a series of large European cooperation projects. So we put on our "seven-league boots", remove the remaining obstacles and bring this successfully to the start. In this spirit, enjoy reading our latest annual report designed to present an attractive composition of already completed "runs" and their relevance to actual and future endeavors while having always in mind that "a rolling stone gathers no moss".

PROF. DR. MICHAEL MASKOS
DIRECTOR FRAUNHOFER IMM

PROFILE

FRAUNHOFER INSTITUTE FOR MICROENGINEERING AND MICROSYSTEMS IMM

As Fraunhofer IMM, we work in the two fields of Energy and Chemical Technology (processes, reactors, plants) as well as Analysis Systems and Sensors (methods, components, systems). We organize our competencies in these two pillars according to the priorities Energy, Chemistry and Raw Material, Safety, Health and Nutrition, Mobility and Transport and Industrie 4.0. Our developments are used in the business fields Energy and Environment, Chemistry, Process Engineering and Aerospace, Biomedical Analysis and Diagnosis, Safety as well as Industrial Analysis. With our system and technology oriented innovations we contribute to the competitiveness of our customers and partners. In doing so, we stand for responsible handling of new technologies and for sustainable development to benefit private and public enterprise as well as society.

The division **Energy and Chemical Technology** comprises the product areas **Energy Technology, Chemical Technology** and **Nanoparticle Technology**.

In the product area **Energy Technology**, we deal with current and future issues concerning mobile and decentralized provision and storage of electrical energy, with thermal management in the automotive industry and with the production of synthetic (bio)fuels. We improve the reliability and efficiency of compact material and energy conversion systems as well as of decentralized, mobile power supply units.

In the product area **Chemical Technology**, we focus on the intensification of chemical production using methods and devices of chemical micro process engineering. Based on a well-scalable, modularly designed reactor family or by means of specific, often highly integrated designs, we develop, design and manufacture milli- and microstructured flow reactors from laboratory to industrial scale, which are optimally adapted to the respective process or application. We intensify chemical production processes and increase the availability of materials, data and information for product and production issues.

We intensify chemical production processes and increase the availability of materials, data and information for product and production issues.

In the product area **Nanoparticle Technologies** we deal with the production and characterization of nano- and microparticles with different properties and their applications in pharmaceutical, chemical, agricultural and consumer goods industry. Our research is focused on different material classes such as metals (e.g. Cu, Pt, Pd), metal oxides (e.g. ZnO, SiO_2, Fe_xO_y, Al_2O_3) and semiconductor nanoparticles (quantum dots), as well as polymeric particles and capsules up to several micrometers. We improve the quality of nanoparticles, enhance the productivity of syntheses and increase both, the efficiency and the availability of agents at the target site.

The division **Analysis Systems and Sensors** comprises the product areas **Microfluidic Analysis Systems, Sensor Technology** and **Equipment Engineering**.

As one of the pioneers of microfluidics, we have been developing fully integrated and automated **Microfluidic Analysis Systems** for over 20 years. Based on a "microfluidic construction kit" with comprehensive coverage of the required functional elements, we are able to develop an application idea to the proof of function and build fully functional demonstrators up to pilot production within short time. We accelerate and automate reliable analysis systems, increase the compactness of established processes and bring them to the place of action.

In the product area **Sensor Technology** we deal with the development of customer-specific optical, electrochemical and MEMS sensor technology. Comprehensive competencies in the design of microstructured components and their system integration associated with a wide spectrum of micro manufacturing processes such as mechanical precision machining, laser material processing, silicon and thin-film technology are our unique selling points. We increase the robustness of our customers' sensor technology and thereby minimize the effort in process monitoring.

In the framework of "Systems Engineering" our production portfolio ranges from numerous individual manufacturing processes up to **Equipment Engineering**. By this, we understand the integration of microfluidic cartridges or e.g. silicon-based sensors in mechanical constructions in functional connection with the necessary optics, actuators as well as with other electronic functional elements (heaters, motors, pumps, etc.). We combine and integrate fluidic elements and sensors in intelligent systems, thus, creating new fields of application.

Our product areas are complemented technologically by our long-standing know-how in mechanical precision machining processes, spark erosion, laser material processing as well as by a series of clean room based chemical and physical structuring processes.

QUALITY POLICY

As contract research organization a reproducibly high quality of our research and development services is the basis for a successful business activity and customer loyalty in the long term. Quality means for us to understand the partially complex customer requirements, whether expressed or unspoken, to transfer them into workable and customer-friendly solutions and to meet or exceed our customers' expectations. The quality of our work is crucial for customers to place an order and to successfully exploit the results.

We are not only developing solutions with and for industry, we as well strive for a project-oriented continued development of our capabilities. We are working together with industry, research organizations and universities in projects being co-financed by the federal government, the federal state or the European Commission in order to tackle important issues for the future. Fraunhofer IMM is a reliable partner and cultivates fair relationships to customers and suppliers. Without doing so the provision of our services would not be possible. To openly communicating with all stakeholders is the absolute precondition for any constructive collaboration.

Our employees are the backbone of our institute. Their skills, willingness and subjective well-being determine our target achievement. Our employees feel fully committed to our standards of quality and are being encouraged to further expand our high standards in project work and quality of service by continuous training. Essential prerequisites for professional operation such as adequate communication structures, training and qualification opportunities as well as a positive and productive working environment are created.

Quality-determining process flows are clearly defined, documented and are continuously adapted to changing requirements and improved. Novel quality-determining processes are documented immediately. All related documents are clearly guided and controlled in order to guarantee a sustainable quality in all areas. Our quality awareness and understanding as well as the attitude of all employees towards quality are essential to achieving the project objectives and, by this, the satisfaction of our customers.

Our management stipulates the quality policy and ensures a consequent implementation of the quality management system. We strive for a continued certification according to DIN EN ISO 9001:2015 and review the effectiveness of our quality management system by regular internal audits and quality meetings.

FRAUNHOFER IMM IN NUMBERS (2017)

12,7
MILLION EURO
CONTRACT RESEARCH

> 59 %
INDUSTRY AND PUBLICLY FINANCED RESEARCH PROJECTS

< 41 %
CONTRIBUTED BY THE GERMAN FEDERAL AND STATE GOVERNMENTS

103
PROJECTS

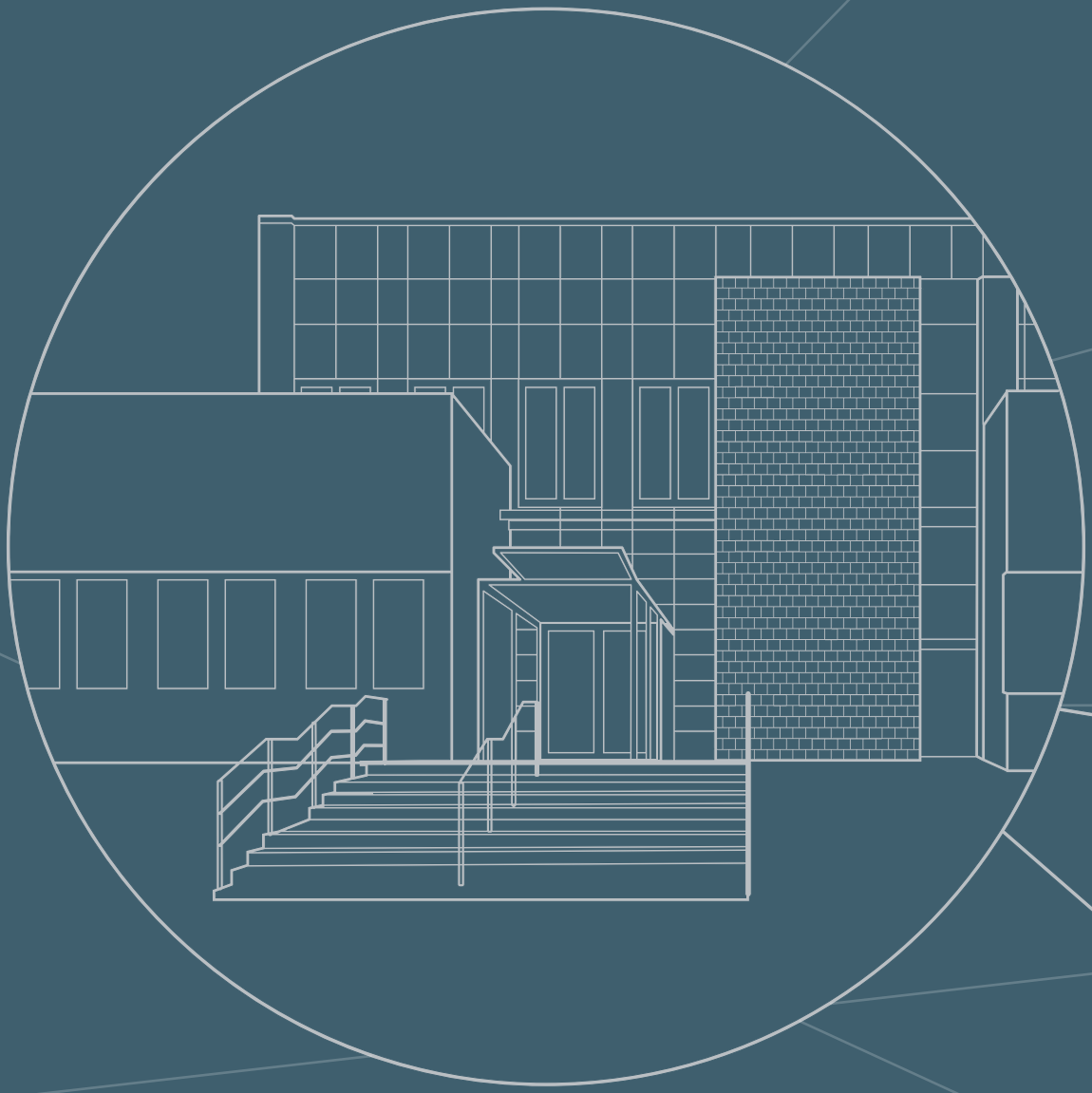
> 77 %
INDUSTRIAL

< 23 %
PUBLIC

138
STAFF (AVERAGE)

76 %
TECHNICAL STAFF

24 %
OTHER



FRAUNHOFER IMM NETWORK

In order to secure our competitiveness and scientific excellence a close cooperation with research institutes and multipliers is of particular importance to us.
Our scientists and engineers therefore cooperate with universities, institutes and companies both nationally and internationally in development projects with a short-term and long-term focus. Close connections to partners in the region are of special relevance in this process.

STUDENT RESEARCH PROJECTS AND DISSERTATIONS

UNIVERSITY OF MAINZ // UNIVERSITY OF APPLIED SCIENCES MAINZ // TU DARMSTADT // TU KAISERSLAUTERN // RHEINMAIN UNIVERSITY OF APPLIED SCIENCES // FRANKFURT UNIVERSITY OF APPLIED SCIENCES // KAISERSLAUTERN UNIVERSITY OF APPLIED SCIENCES // BINGEN UNIVERSITY OF APPLIED SCIENCES // UNIVERITY OF STUTTGART // UNIVERSITY OF DUISBURG-ESSEN

COOPERATIONS AND STAFF EXCHANGE

UNIVERSITY OF MAINZ // MAX PLANCK INSTITUTE FOR POLYMER RESEARCH MAINZ

NETWORKS

CENTER OF SMART INTERFACES // DUAL CAREER NETWORK RHEINMAIN // MAINZ RESEARCH ALLIANCE E.V.// CLUSTER INDIVIDUALIZED IMMUNEINTERVENTION (CI3) E.V.

REGIONAL NETWORK

RESEARCH NETWORK

BMBF PROJECT PARTNERS // TU EINDHOVEN // EUROPEAN TECHNOLOGY PLATFORMS // EU PROJECT PARTNERS // BAM BUNDESANSTALT FUER MATERIALFORSCHUNG UND -PRUEFUNG // DECHEMA // PROCESS-NET

1

FRAUNHOFER INSTITUTE FOR CHEMICAL TECHNOLOGY ICT

The Fraunhofer Institute for Chemical Technology ICT focuses on process scalability and on the transfer of research results from laboratory to pilot scale, or even pilot-level applications. In 2017, 540 employees were working at Fraunhofer ICT's site in Pfinztal (close to Karlsruhe) and 25 in the Project Group for New Drive Systems at the east campus of the Karlsruhe Institute of Technology KIT.

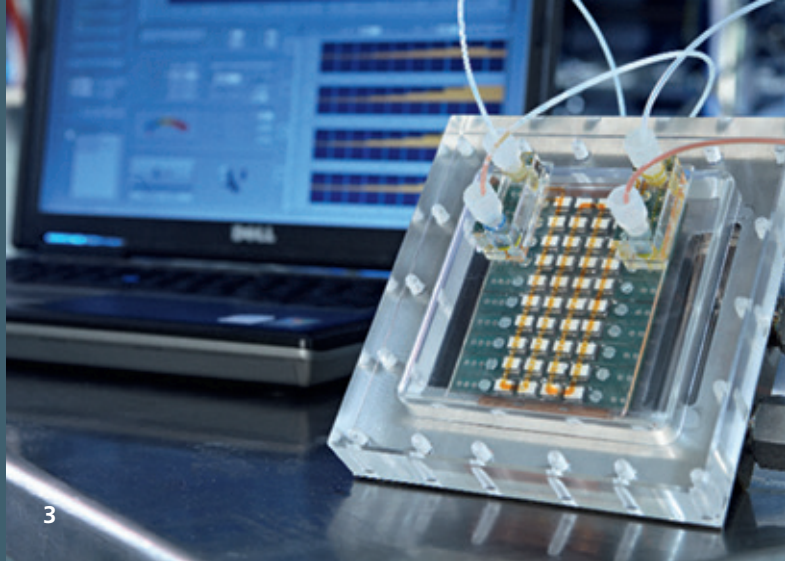
Our customers and project partners include companies concerned with chemicals and chemical process engineering, vehicle manufacturers and their suppliers, the plastics processing industry, manufacturers of materials, recycling companies, companies in the field of energy and environment, customers concerned with safety-related issues, and the construction and aviation industries. In addition, we are the only explosives research institute in Germany to cover the entire development chain for explosives, from the laboratory through to the pilot plant and system.

We are the only explosives research institute in Germany to cover the entire development chain for explosives

Our core competences

The core competence **Chemical and Environmental Engineering** is concerned with the design and implementation of novel, resource-efficient chemical processes, from the laboratory to the technical scale. This core competence spans the entire processing chain - from raw material processing, chemical engineering and downstream processing through to subsequent processes such as the refinement and shaping of products.

In the core competence **Polymer Engineering** we successfully conduct application-related research on polymer synthesis and material technology, plastics processing, component development and manufacture and the recycling of plastics and their applications.



Important research topics include sustainable and affordable energy supply and efficient energy management. In the core competence **Energy Systems** we are concerned with energy storage devices for mobile and stationary systems, fuel cells, heat storage devices and material energy storage. The institute's electrochemical and chemical know-how has been accumulated over more than 30 years, laying the foundations for the development of efficient and cost-effective storage devices and converters.

Based on long-standing experience, and as the only German research institution in the field of **Explosive Technology**, we assist the German Federal Ministry of Defence, the defence industry and the public sector with current challenges in the field of domestic and international security. Fraunhofer ICT covers the whole system development chain, from the raw product through to the prototype of an explosive.

→ **From January 2014 until December 2017 Fraunhofer IMM has been a branch of Fraunhofer ICT. Since January 2018 we act as Fraunhofer IMM.**

1 *Fraunhofer ICT Campus*
2 *Recycling of wind turbine rotor-blades.*
3 *Reaction calorimetry for real-time measurement of heat flows in microreactors.*

Kontakt

Prof. Dr. Peter Elsner
Phone +49 721 4640-401
peter.elsner@ict.fraunhofer.de
www.ict.fraunhofer.de

FRAUNHOFER-GESELLSCHAFT IN NUMBERS (2017)

72

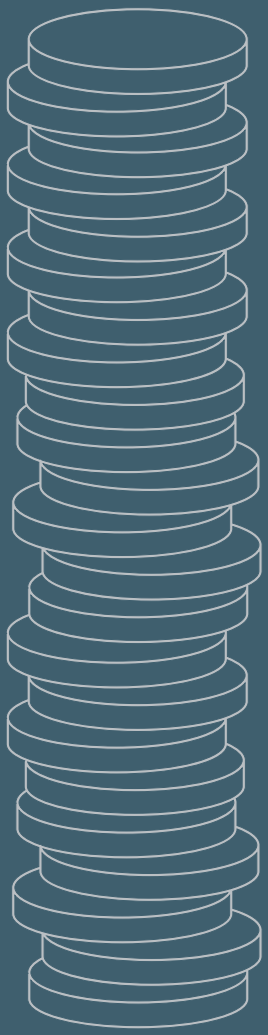
INSTITUTES AND RESEARCH UNITS IN GERMANY

25.000

STAFF

2,3

BILLION EURO RESEARCH BUDGET



>2

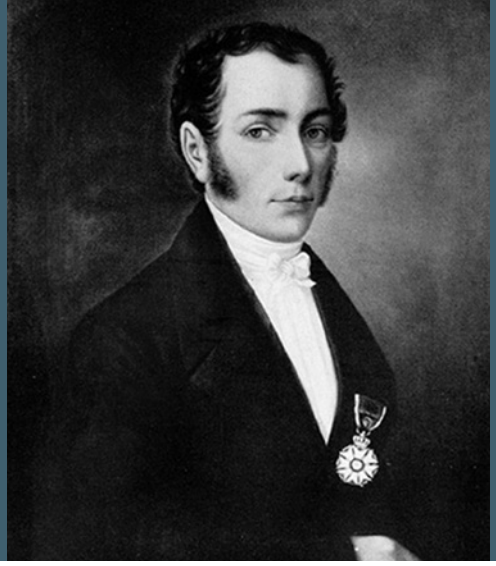
BILLION EURO CONTRACT RESEARCH

>70 %

INDUSTRY AND PUBLICLY FINANCED RESEARCH PROJECTS

<30 %

CONTRIBUTED BY THE GERMAN FEDERAL AND STATE GOVERNMENTS



Joseph von Fraunhofer

FRAUNHOFER-GESELLSCHAFT

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

At present, the Fraunhofer-Gesellschaft maintains 72 institutes and research units. The majority of the more than 25 000 staff are qualified scientists and engineers, who work with an annual research budget of 2.3 billion euros. Of this sum, almost 2 billion euros is generated through contract research. Around 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Around 30 percent is contributed by the German federal and state governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

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

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

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

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

CORE COMPETENCIES

The core competencies and related core topics are the basis for the specialized focus as well as positioning of Fraunhofer IMM within the research and development landscape. Via the core services, based on the core competencies and core topics, Fraunhofer IMM meets the demands from the market-oriented business fields and applications.

The applied microstructure technology and microfluidics, as it is practiced by IMM within the Fraunhofer-Gesellschaft, is aimed at the design, construction and testing of chemical and analytical processes using microstructured or microfluidic components and functional units made from various materials, coupled with nanostructured elements and surfaces. In combination with the appropriate sensors and actuators this results in integrated systems with a broad application potential in energy technological, chemical and biological processes as well as for resolving questions in analytics and sensor technology.

In this way we drive forward specific system solutions in the fields of energy technology, heterogeneous catalysis, chemical (process) engineering, functional materials, nanotechnologies, technical and (bio)chemical analysis as well as sensor technology. Microstructure technology and microfluidics, as developed by IMM, are characterized by a consistent relevance to application, the bridge building from available basic knowledge up to required implementations and the claim of scientific excellence. It does not focus on single industries or segments. In fact, our ability to realize microstructures in a variety of materials and to understand how liquids and gases as well as the microstructures themselves react fluidically, mechanically, thermally and (bio)chemically leads to an enormous spectrum of applications. These applications are reflected in the portfolios of our customers, business fields and core topics, though they are based upon the same, defined core competencies.

1

MICROSTRUCTURE-BASED ANALYTICS AND SENSOR TECHNOLOGY

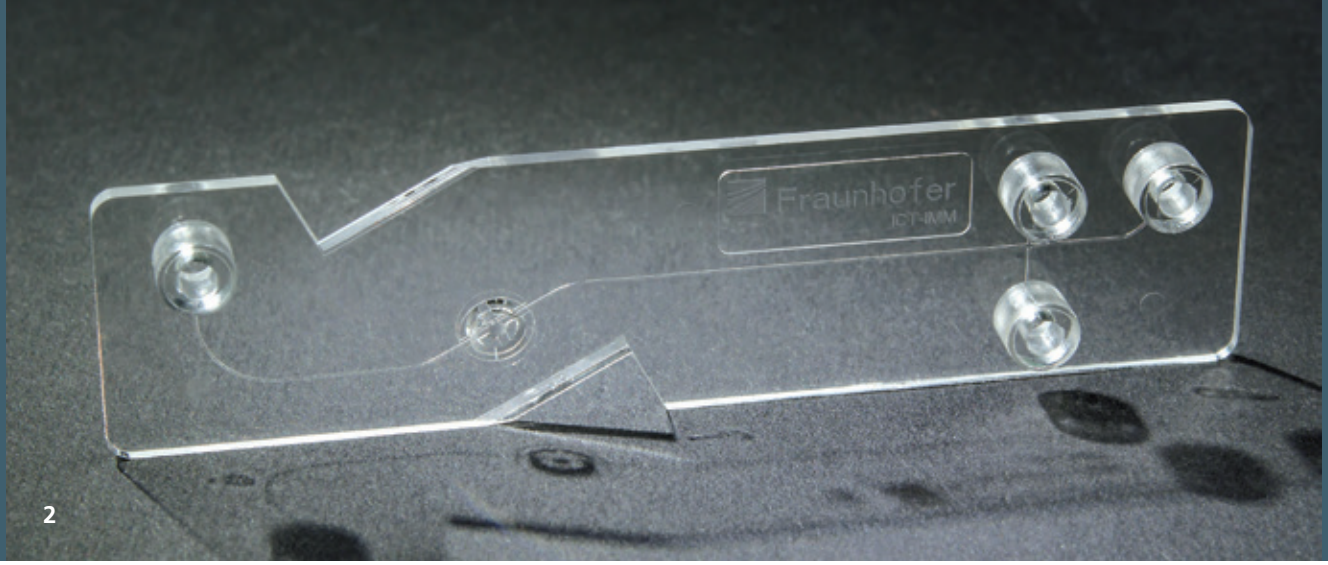
The core services of Fraunhofer IMM within the core competency »Microstructure-based Analytics and Sensor Technology« are aimed at a significant improvement of the availability of information and data at the point of need by using microstructure technologies.

The core competency is characterized by the ability to rethink sensor solutions as well as (bio) chemical analysis processes and processes based on microstructure technologies, to interpret them in a completely new way by considering microfluidic principles and by using micro fabrication technologies. In doing this, we open up solutions for the on-site generation of data and information which are not accessible in traditional approaches and offer them to the market.

Within the core competency our scientists perform work on the core topics:

Analysis Methods & Microfluidics: portable micro analysis systems for chemical- and bioanalysis for the process control in electroplating-, energy- and biotechnology, semiconductor industry and medical technology; microfluidic cartridges for sample preparation and cell handling; protocols and processes for quality- and process control in food- and semiconductor industry, in safety technology, liquid biopsy and personalized healthcare

Sensor Design & Micro Structuring: Multichannel micro electrode probes for neural signal recording and neurostimulation; foil-based sensors for the application in on-line process analytics and process control; development of dead volume free membrane valves; acceleration



2

of micro drilling processes due to the development of a high-precision vibration rotation spindle for electrical discharge machining; development of gas-selective separation membranes for the fabrication of highly sensitive gas sensor chips for the detection of helium or hydrogen

Assembly Units & System Engineering: Design and implementation of a fully automated ion analysis unit with self-sufficient, maintenance-free operation for laboratory applications; development of a highly automated POCT-system for the subtyping of influenza viruses with integrated sample preparation and multiplex proof RTqPCR detection; development and realization of a non-dispersive multiparameter on-line sensor for the quality control of lubricating oil; development and realization of a compact module for the measurement of the size distribution of nanoparticles in continuous flow; development and realization of a compact cytometry module for fluorescence based cell counting; a fully automated system for the isolation of circulating tumor cells directly from a high-volume blood sample for the application in liquid biopsy

Hence, we cover the entire value chain beginning with the design and processing of microstructured components, the sample preparation for analytics, the conception, testing and optimization of methods for sample handling, the sample concentration and marking, the adaption or optimization of necessary protocols and required reagents up to the detection of elements marked in the process and their automated evaluation.

1 *Device for continuous µ-titration*
2 *Injection mulded microfluidic cartridge with flow cytometry optics*

MICROSTRUCTURE-BASED PROCESS ENGINEERING AND CATALYSIS

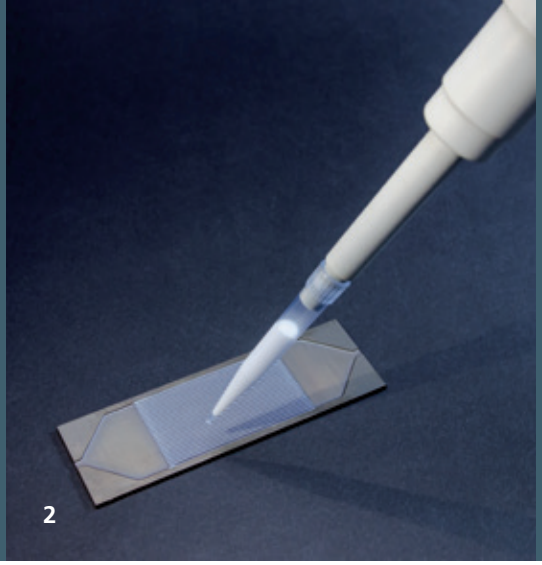
The core services of Fraunhofer IMM within the core competency »Microstructure-based Process Engineering and Catalysis« are aimed at a significant improvement of the availability of chemicals, energy and materials by using microstructure technologies. These improvements affect, amongst others, the yield and selectivities in chemical processes, the dynamics and compactness of systems developed for the decentralized energy generation and the accuracy and consistent quality of customized material properties of nanoparticles and encapsulations.

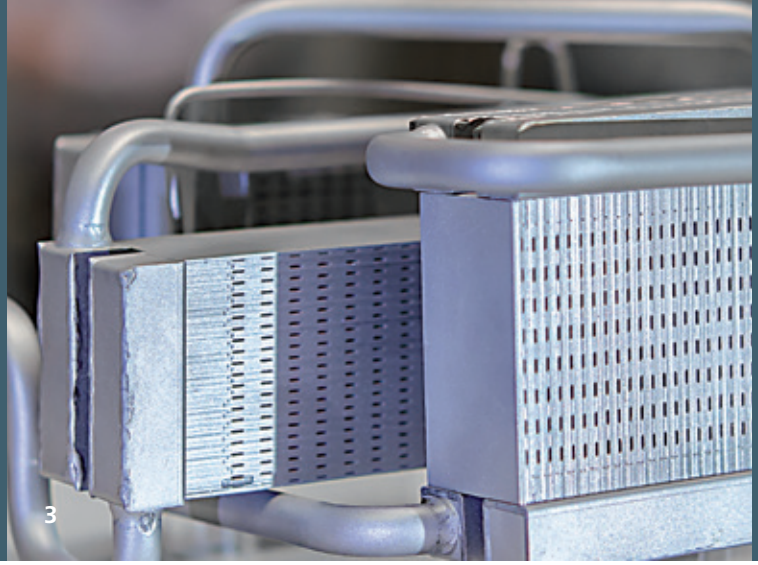
On the basis of the inherent operating principle "microstructuring" the core competency »Microstructure-based Process Engineering and Catalysis« is characterized by the ability to rethink whole classes of chemical process controls, which are particularly performed in fine and specialty chemical industry as well as in pharmaceutical industry in the liquid phase or gas/liquid phase in batch processes, thus discontinuous and with often severely alternating product quality. To interpret these processes in a completely new way by applying continuous flow principles and microstructured mixers and reactors is one of our strengths. In many cases, we hereby make entirely new process routes accessible which are not feasible in a traditional batch process.

In many cases, we hereby make entirely new process routes accessible

Within the core competency our scientists perform work on the core topics:

Catalysis: development of long-term stable catalyst formulations for the combustion of toxic gases; long-term stable catalysts for the reforming process of liquid gas, propylene glycol, ethanol and methanol, for water-gas-shift reactions, for the preferential oxidation of carbon





monoxide and for a variety of other reactions; performance of catalyst analyses on behalf of large industrial companies and public organizations

Microstructured Reactors and Flow Chemistry: automated solid handling in additively manufactured reactors for the continuous processing of intermediates like Grignard reagents; development of a new generation of reactors for photocatalysis and of catalytic combustion reactors made from aluminum for aeronautical applications

Encapsulation and Nanoparticle Synthesis: continuous encapsulation in a polymer matrix; customized capsules made from renewable raw materials for the encapsulation of fragrances with different polarity; encapsulation of isocyanates and their controlled release; development and design of continuous processes for the synthesis of biodegradable and biocompatible nano capsules for the transport and controlled release of active ingredients; continuous synthesis of quantum dots as well as activities in medical diagnostics with quantum dots as fluorescent marker

Hence, we cover the entire process chain beginning with the reactant preparation for the processing, including conception, testing and optimization of the process control, the development or optimization of catalysts potentially needed and the coordination of process control, reactor design, the experimental optimization of the overall process up to downstream processing (for instance separation and cleaning technologies).

1 *Miniaturized tube bundle heat exchanger*
2 *Catalyst preparation: impregnation of a wash coat*
3 *250 W fuel processor for LPG (Liquefied Petroleum Gas)*

FUNCTIONAL MATERIALS

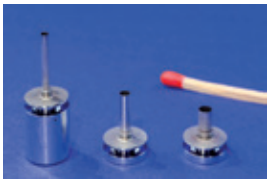
The business field "Functional Materials" is dealing with the production and characterization of nano- and microparticles with different properties and their applications in pharmaceutical, chemical, agricultural, and consumer goods industries. Our research is focused on different material classes such as metals (e.g. Cu, Pt, Pd), metal oxides (e.g. ZnO, SiO_2, Fe_xO_y, Al_2O_3) and semiconductor nanoparticles (quantum dots), as well as polymeric particles and capsules up to several micrometers.

For the encapsulation of active ingredients we have established different technologies for the effective loading with hydrophilic and lipophilic liquids, and solid materials. The physicochemical properties of the particles such as chemical composition, shape, morphology and surface functionalization are designed according to the specific requirements. The use of modular reactors in the continuous synthesis process increases both reproducibility and control of particle size, size distribution and composition. A simple adjustment of flow rate and temperature allows for a precise control of the desired product properties. Together with integrated on-line process control, quality control can be realized in real time.

FROM CONTINUOUS AND REPRODUCIBLE PRODUCTION STRATEGIES TO TAILOR-MADE PARTICLE PROPERTIES

2014

Coaxial micromixer (disassembled & assembled)



Development of a novel coaxial mixer with separation layers for the continuous synthesis of silica nanoparticles.

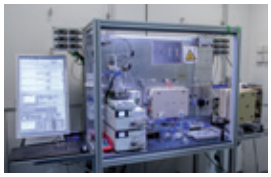
2015

Coated fracture implant / ROTOCOAT system prototype

3D plasma treatment and coating of microscopic objects.

2016

System for the continuous synthesis of quantum dots with integrated high-temperature reactors



High-temperature reactor for the continuous synthesis of nanomaterials with in-line process analytics, e.g. for fluorescent quantum dots.

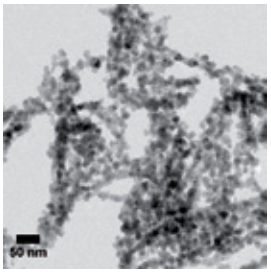
2016

Setup for the continuous formation of polymer-based particles

Continuous synthesis of polymeric nano- and microparticles with customized functionalities.

2017

Setup with integrated PEEK caterpillar mixer / TEM image of catalyst particles



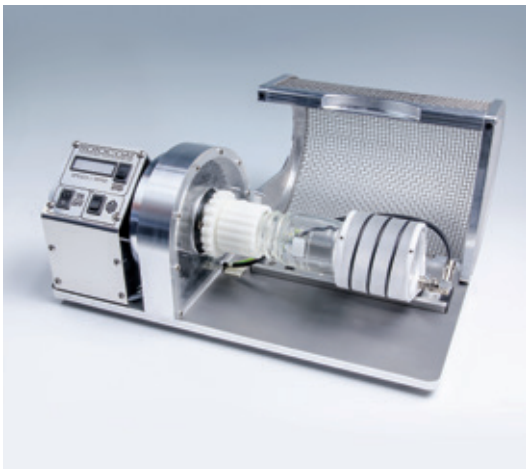
Development of a continuous process to synthesize CuO/ZnO nanoparticles as catalyst for syngas conversion.

2017

Setup for the continuous synthesis of nanocapsules

Encapsulation of hydrophilic active agents in PLGA nanocapsules in continuous flow.

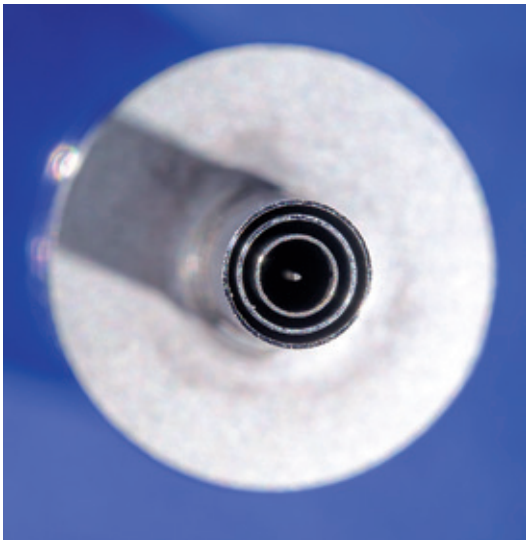
MILESTONES



3D PLASMA TREATMENT AND COATING OF MICROSCOPIC OBJECTS

(Project ANTIOBTI, 4/2012 to 3/2015)
Milestone in "surface modification of microstructured objects"

Plasma treatment is the first choice for engineering surface properties in an all dry process. Tailored surface properties can be realized for small parts and components without affecting bulk properties. Microstructured objects with complex shapes and geometries are treated homogeneously providing full surface coverage and thus maximum product efficacy and safety. 3D plasma treatment is suitable for medical devices, 3D printed components and rapid prototyping. The ROTOCOAT system, developed at Fraunhofer IMM, is a versatile and easy-to-use tool for coating small parts with complex shapes. It can be used for the modification of polymeric, metallic or ceramic parts, hence bringing new and multiple functionalities to the surface.



DEVELOPMENT OF A NOVEL COAXIAL MIXER WITH SEPARATION LAYERS FOR THE CONTINUOUS SYNTHESIS OF SILICA NANOPARTICLES

(Project M4N-EFRE, 4/2012 to 3/2015)
Milestone in "nanoparticle fabrication process"

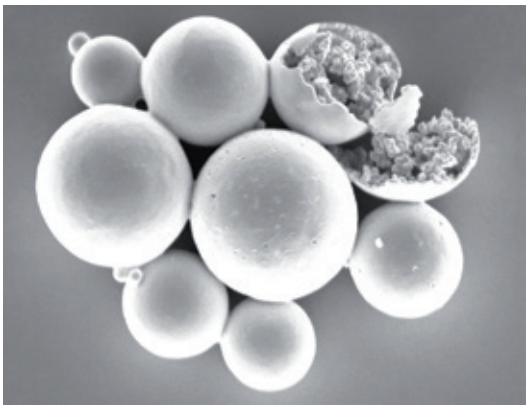
For precipitation reactions with fast kinetics, that are prone to clog the reactor system, a novel type of coaxial mixer has been developed featuring multiple layers of a separation fluid, that prevents mixing of the chemical precursors close to the nozzle where fouling is most critical. This new mixer has successfully been applied to the synthesis of silica nanoparticles using economical precursors that had previously been prohibitive for the above reasons.

CURRENT PROJECTS

SYSTEM FOR THE CONTINUOUS SYNTHESIS OF QUANTUM DOTS, BASED ON AN INTEGRATED REACTOR CONCEPT FOR HIGH-TEMPERATURE SYNTHESIS OF NANOMATERIALS

(Projects M4N-EFRE / KONTIDOT, 4/2012 to 12/2016)
Milestone in "production of functional materials"

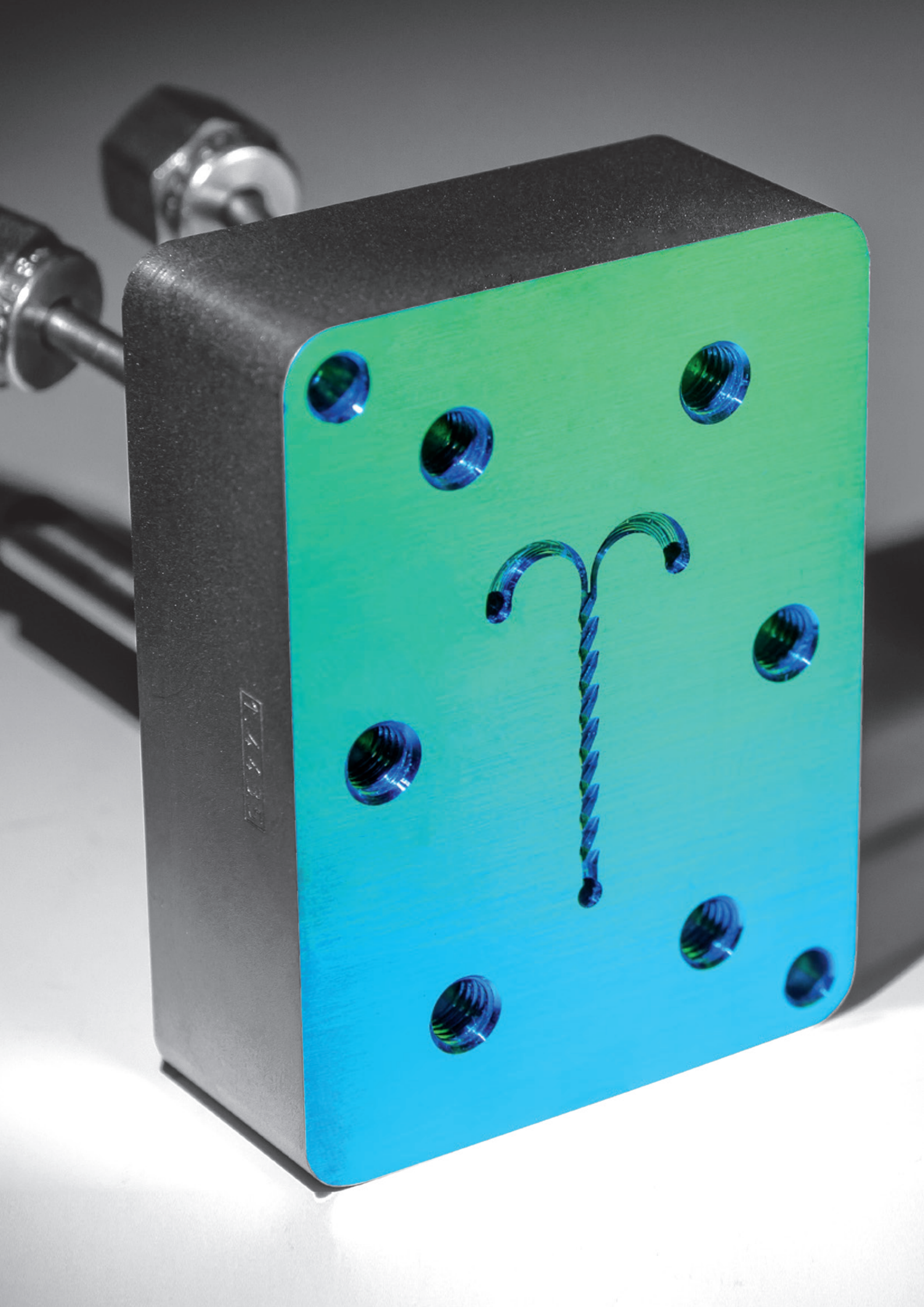
The reactor with integrated heating (up to 400 °C), mixing and optical detection cells is designed for the continuous and reproducible synthesis of nanomaterials at high temperatures and allows the transfer of common hot-injection protocols from batch to continuous. The setup features precursor delivery, pumps, mass-flow controllers, additional temperature zones, fraction collection and process analytics by optical spectroscopy. Due to its modular layout, the system can be flexibly reconfigured to suit a specific material system or synthesis protocol, respectively. Optical absorbance and fluorescence spectra are recorded in-line at multiple detection points and provide information about product quality and process stability in real time.



PROCESS DEVELOPMENT FOR CONTINUOUS SYNTHESIS OF MULTIFUNCTIONAL POLYMERIC NANOPARTICLES AND NANOCAPSULES LOADED WITH HYDROPHILIC AND HYDROPHOBIC COMPOUNDS

(Project CONTICAPS, 1/2016 to 12/2016)
Milestone in "tailoring particle properties"

Advances in nanotechnology offer immense potential towards the development and production of innovative materials with improved, customized properties. To match the application requirements, the physical and chemical properties of the end-product can be adjusted by the effective combination of properly chosen materials. The encapsulation of active ingredients in polymeric particles protects them against environmental conditions, prolonging the lifetime and reactivity of the end-product. Our main focus is the development of energy-/cost-efficient and high-throughput synthetic strategies for the preparation of polymeric particles and capsules in batch and in continuous flow, specializing in particles that react to external stimuli.



CHEMISTRY

The business field "Chemistry" is mainly dealing with the intensification of chemical production applying methods and devices of chemical micro-process engineering. Following a well-scalable, modularly designed reactor family concept or by means of specific, often highly integrated solutions, we develop, design and manufacture milli- and microstructured flow reactors from laboratory to industrial scale, which are optimally adapted to the respective process or application. We develop chemical processes mainly in the field of organic chemistry covering both, single and multiphase processes as well as non-catalytic and heterogeneously and homogeneously catalyzed reactions. Our research priorities comprise photochemistry, electrochemistry and the synthesis of reactive intermediates.
By linking with new plant concepts, such as the chemical plant infrastructure in container format, we open up decentralized and mobile production approaches. The integrated approach of development, modularization and process automation builds a bridge to the chemical Industrie 4.0.

FROM SINGLE PROCESS ENGINEERING COMPONENTS TO NOVEL REACTOR AND PLANT CONCEPTS FOR SUSTAINABLE MODULAR AND DECENTRALIZED CHEMICAL PRODUCTION

earlier than

1996

Slit interdigital micromixer

Establishing the first unit operation for process engineering at lab scale.

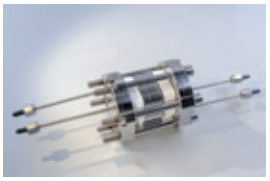
1999

Caterpillar micromixer and star laminator

Significantly increasing reaction throughput.

2000

Gas phase microreactor



First gas phase micro-reactor based on a stack of microstuctured catalyst coated plates.

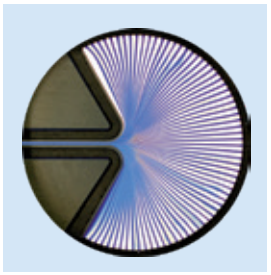
2001

Falling film microreactor

Establishing gas-liquid contacting device for fast and highly exothermic reactions.

2003

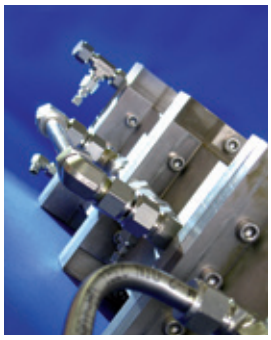
SuperFocus interdigital micromixer



Ultra-fast multi-lamination mixer for laboratory and pilot production range.

2009

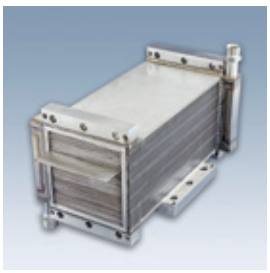
Scalable microreactor for pilot plant production



Microchemical process engineering for process intensification in chemical production.

2011

Large scale microreactor with removable plates



Novel reactor concepts for modular and decentralized chemical production.

2013

Pilot plants in a container

Integration of a small-scale multi purpose plant for continuous processes in a container infrastructure.

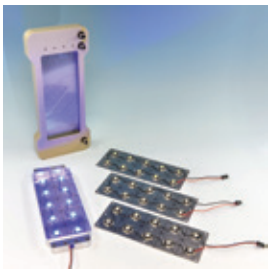
2016

Grignard pilot reactor

In situ production of reactive intermediates (e.g. Grignard reagents) involving continuous solids handling (e.g. Mg turnings).

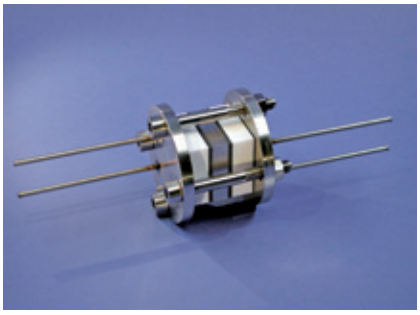
2017

Falling film microreactor for photochemistry



Carbon dioxide as a raw material source for photocatalytic conversion into basic chemicals.

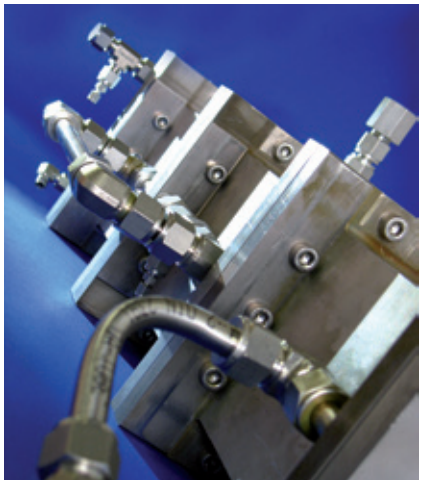
MILESTONES



PERIODIC PROCESSING IN MICROREACTORS

(Project PERIMI, 11/1998 to 10/2001)
Milestone in "modular reactor technology"

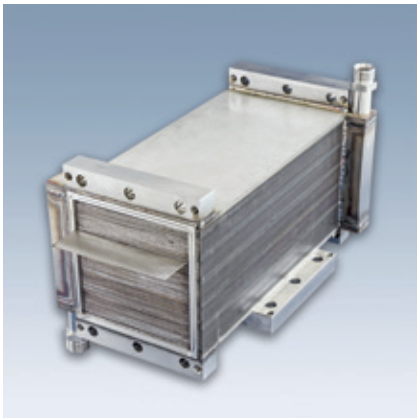
The developed microreactor was the first modular, reaction plate based system which could be customized to a certain extent and, thus, adapted to process requirements. The plates could be coated with catalyst, so that the assembled device can function as gas-phase reactor, either with or without internal heat transfer. For coating at this stage of development wash coating, coprecipitation and sol-gel techniques were applied. The device could also be used as liquid-phase micro heat exchanger. For the first time temperature modulation with short response times was realized allowing periodic processing with respect to concentration and temperature.



INTEGRATED MULTISCALE PROCESS UNITS WITH LOCALLY STRUCTURED ELEMENTS

(Project IMPULSE, 2/2005 to 1/2009)
Milestone in "plant development"

IMPULSE was an EU-FP6 flagship project targeting the utilization of (micro) structured equipment as a key for the development of innovative chemical plants of tomorrow. The former IMM was responsible for the development and manufacture of microstructured reactors as well as involved in process development for various application areas and establishing pilot installations. The main focus was lying on the application areas of ionic liquids synthesis, emulsification, electrochemistry, and micro encapsulation.



COMBINING PROCESS INTENSIFICATION-DRIVEN MANUFACTURE OF MICROSTRUCTURED REACTORS AND PROCESS DESIGN REGARDING TO INDUSTRIAL DIMENSIONS AND ENVIRONMENT

(Project CoPIRIDE, 1/2009 to 8/2013)
Milestone in "flexible and scalable production, even under harsh process conditions"

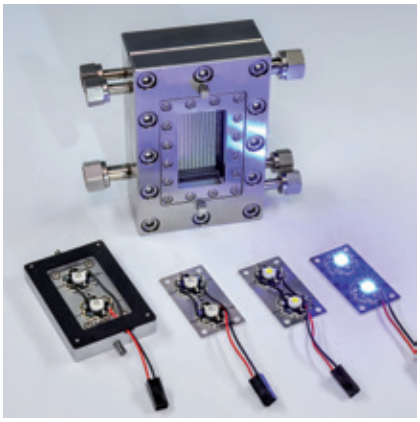
Within the EU-FP7 project CoPIRIDE the consortium followed the approach of modular production and plant concepts for intensified processes in order to achieve a flexible and scalable production taking into account sustainability and economic efficiency. One core element thereby was the development and use of a mobile, container-like plant infrastructure. Another one was the advancement of modular and, thus, scalable microreactors for industrial production relying on manufacturing technologies being suitable for series production. Achieved successes comprise: a high product quality in anionic polymerization, an increased space-time yield in the epoxidation of soybean oil, supercritical biodiesel production using lower value raw material.

CURRENT PROJECTS

MODERN POLYMER-BASED CATALYSTS AND MICRO-FLOW CONDITIONS AS KEY ELEMENTS OF INNO-VATIONS IN FINE CHEMICAL SYNTHESIS

(Project POLYCAT, 1/2010 to 3/2014)
Milestone in "selectivity and efficiency of industry relevant reactions"

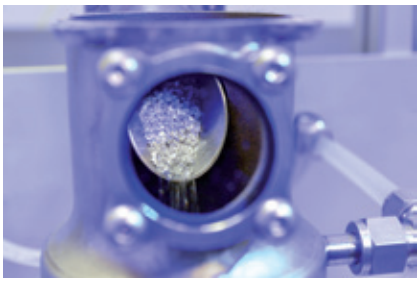
The EU-FP7 funded project POLYCAT has developed novel, polymer-supported catalysts to improve, based on highly reactive nanoparticles, the selectivity and efficiency of industry relevant reactions. The combination of these novel catalyst systems with microprocess technology allowed the precise adjustment of ideal process conditions. Furthermore, a multifunctional, compact plant installed in a container-like infrastructure was established allowing the industrial partners the application of a novel and improved production method for the synthesis of pharmaceutical active ingredients.



PHOTOCHEMICAL CO_2 ASSIMILATION WITH VISIBLE LIGHT ON MICROSTRUCUTRED DIAMOND SURFACES IN CONTINUOUSLY OPERATED MICROREACTORS

(Project CarbonCat, 1/2016 to 8/2019)
expected milestone in "CO_2 utilization"

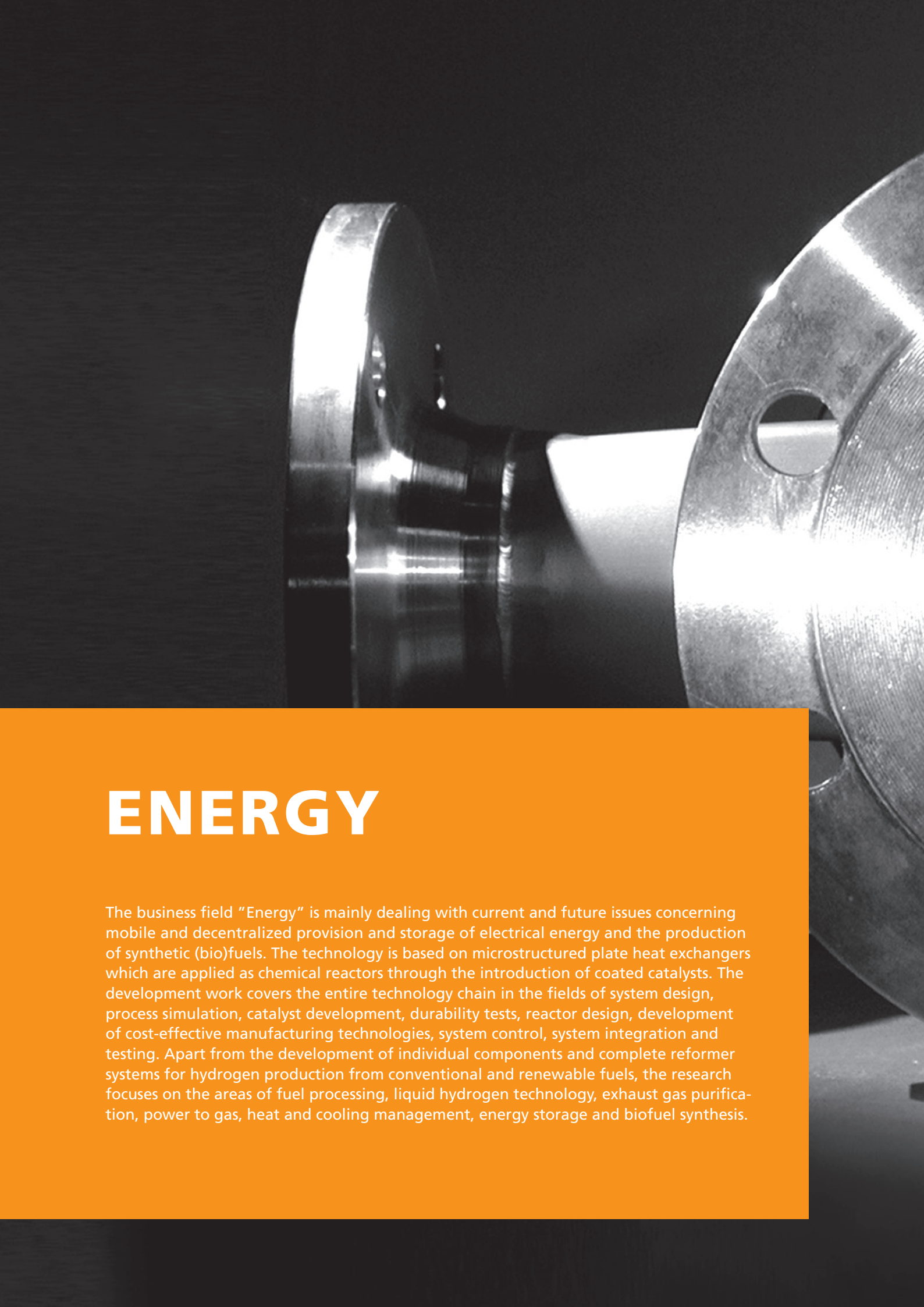
The CarbonCat project aims for the pioneering development of a microreactor system for the evaluation of the potential of novel catalyst materials aiming at the innovative utilization of CO_2, coming as close as possible to nature inspired photosynthesis while exclusively using sunlight. Instead of plant cells we will use a newly developed microreactor containing a diamond photocatalyst as photoactive center. Ultimate goal of the CarbonCat project is the development and provision of a demonstration plant which converts CO_2 into valuable chemical C1 components.



IN SITU PRODUCTION OF GRIGNARD REAGENTS WITH CONTINUOUS PROCESS CONTROL

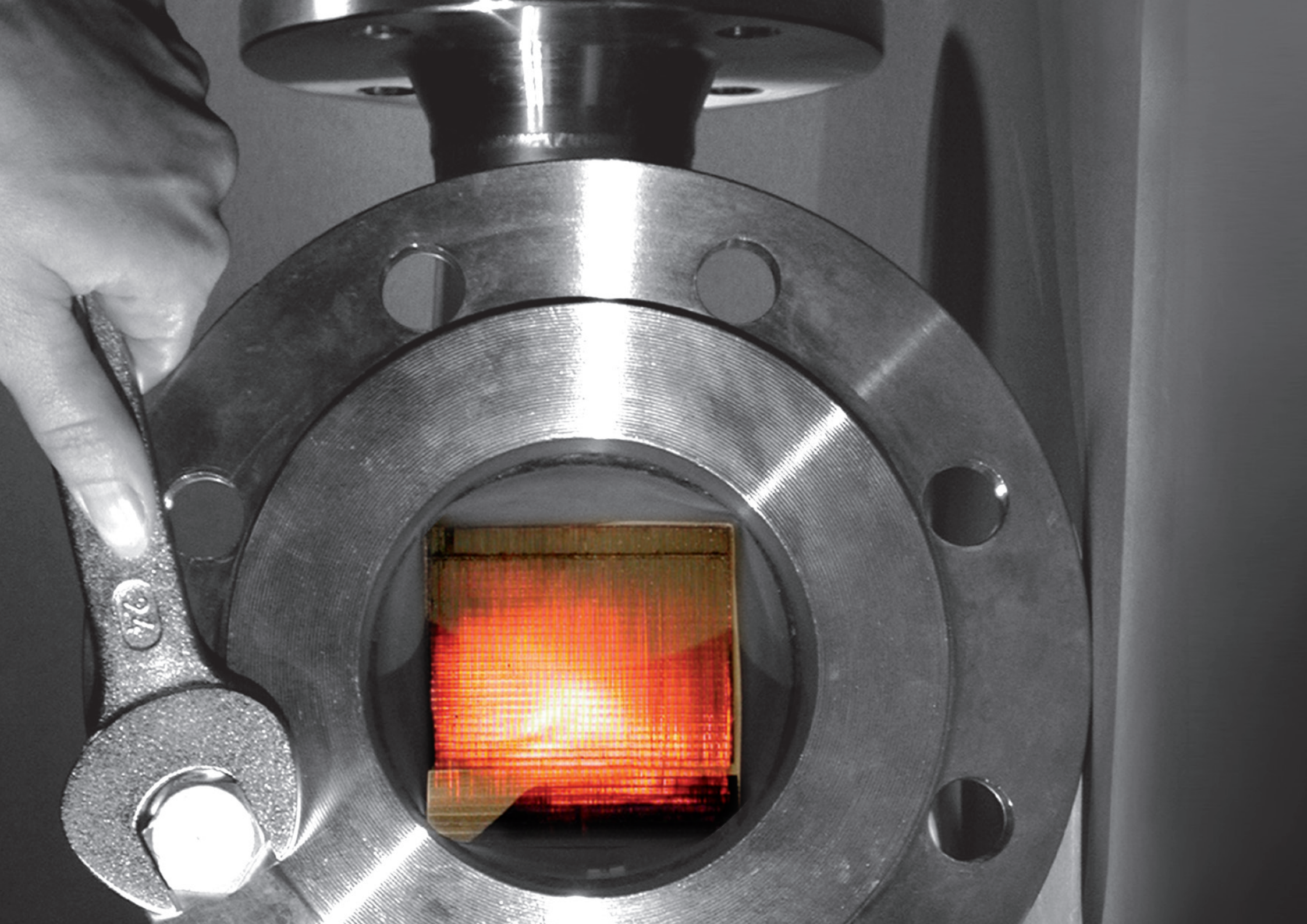
(Internal project, 2017)
Milestone in "in situ production of reactive intermediates and solid handling"

The synthesis of Grignard reagents and their conversion with a variety of organic molecules such as ketones and aldehydes is one of the most effective methods of C-C bond formation. Continuous processing enables a large magnesium excess to suppress unwanted side reactions and improves heat transfer to avoid runaway of the reaction. Our novel reactor system allows a continuous supply of magnesium, integrated magnesium activation, integrated process control as well as in-line analytics via IR measurements.



ENERGY

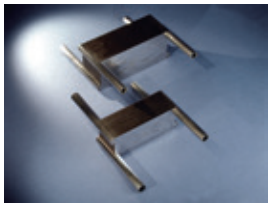
The business field "Energy" is mainly dealing with current and future issues concerning mobile and decentralized provision and storage of electrical energy and the production of synthetic (bio)fuels. The technology is based on microstructured plate heat exchangers which are applied as chemical reactors through the introduction of coated catalysts. The development work covers the entire technology chain in the fields of system design, process simulation, catalyst development, durability tests, reactor design, development of cost-effective manufacturing technologies, system control, system integration and testing. Apart from the development of individual components and complete reformer systems for hydrogen production from conventional and renewable fuels, the research focuses on the areas of fuel processing, liquid hydrogen technology, exhaust gas purification, power to gas, heat and cooling management, energy storage and biofuel synthesis.

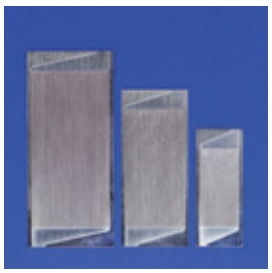


FROM HEAT MANAGEMENT TO COMPLEX UNITS FOR MOBILE ENERGY GENERATION; FROM POWER TO GAS AND CHEMICALS

2000

Heat exchangers of different size

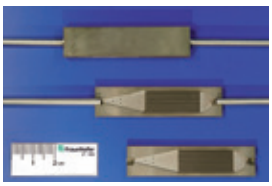


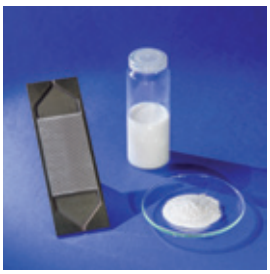


Heat exchangers based on stacks of microstructured plates.

2000

Sandwich reactor for methanol fuel processing / catalyst development





First microreactor for methanol fuel processing with catalyst developed at IMM.

2004

Evaporator based on microstructured plates

First evaporator designed at IMM for use in fuel processor applications.

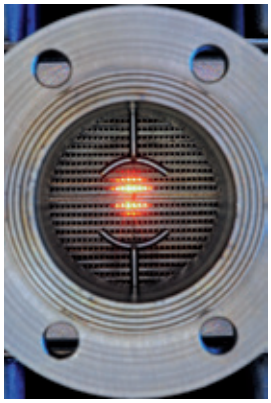
2005

Pre-heater for air

Electrical gas pre-heater for use in fuel processor applications.

2006

Diesel fuel processor



Development of a (5 kW PEM) fuel cell system including a diesel based fuel processor for Auxiliary Power Unit (APU) applications for trucks.

2010

Cryogenic test plant in container

Development of a system for the transportation of cryogenic liquid hydrogen for local energy supply.

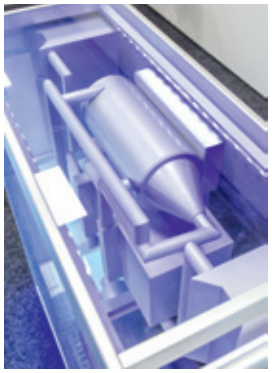
2013

Microreactor for biodiesel production

Development of micro-reactors for economic processing of biofuels from biomass.

2014

Fuel processor system for propylene glycol



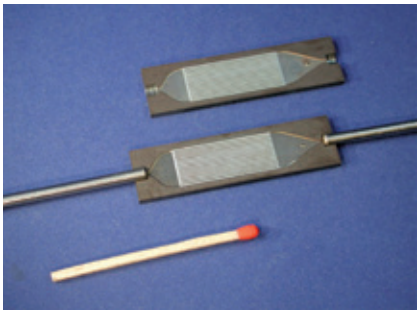
Development of a mobile power supply for aircraft galleys based on a propylene glycol fuel processor.

2017

Heat exchanger for use in fuel processor system

Development of a fuel processor system for the conversion of methanol into natural gas.

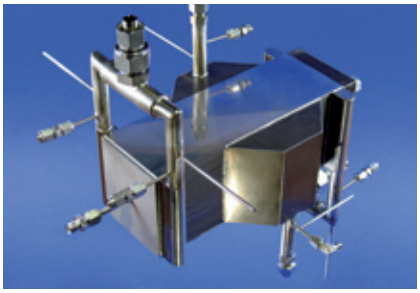
MILESTONES



REALIZATION OF A MINIATURIZED REFORMER FOR MOBILE HYDROGEN GENERATION

(Project METAFORM, 6/2000 to 8/2002)
Milestone in "hydrogen generation and catalyst preparation"

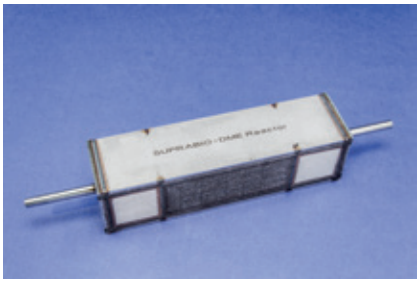
The project METAFORM has paved the ground for the still ongoing successful development of mobile hydrogen generators. Systematic research work with respect to compact reformers, catalyst development for LPG (propane/butane) steam reforming, partial oxidation and autothermal reformation, the further development of these catalysts towards long term stability and robustness formed a sound basis for our projects.



HYDROGEN AND FUEL CELL TECHNOLOGIES FOR ROAD TRANSPORT

(Project HYTRAN, 1/2004 to 3/2012)
Milestone in "APU development"

The reliable and environmentally friendly energy supply of trucks during stop-times is highly required especially in the US, where drivers need electric power for air conditioning, communication and entertainment when not driving. Instead of relying on a diesel generator the use of a reformer/fuel cell system (auxiliary power unit, APU) to transform diesel into hydrogen and finally into electricity is the more eco-friendly option. Within the EU-FP7 project HyTRAN a fuel processor composed of a diesel reformer, a watergas shift reactor, a preferential oxidation reactor as well as microstructured plate heat exchangers was developed as part of a 5 kW APU. A dedicated test rig allowed for testing each component individually as well as the entire system.



SUSTAINABLE PRODUCTS FROM ECONOMIC PROCESSING OF BIOMASS IN HIGHLY INTEGRATED BIOREFINERIES

(Project SUPRA-BIO, 2/2010 to 7/2014)
Milestone in "biomass utilization"

In order to ensure the competitiveness and sustainability of the processes to produce fuel and chemicals from biomass, critical technologies had to be developed. The main objective of the EU-FP7 project "Sustainable products from economic processing of biomass in highly integrated biorefineries" SUPRABIO was to research, develop and demonstrate novel intensified unit operations which can be integrated into economic and sustainable biorefineries for the production of second generation biofuels, intermediates and high value products, together with assessment of the outcomes to enable sustainable implementation. Thereby, negative cost aspects associated with smaller scale production of microreactors had to be overcome. The focus of IMM was mainly on syngas conversion technologies.

CURRENT PROJECTS

CATALYTIC PARTIAL OXIDATION OF BIOGAS AND REFORMING OF PYROLYSIS OIL (BIO-OIL) FOR AN AUTOTHERMAL SYNTHESIS GAS PRODUCTION AND CONVERSION INTO FUELS

(Project BioGO, 12/2013 to 11/2017)
Milestone in "developing decentralized plants"

In the scope of the large scale EU-FP7 project BIO-GO-For-Production which was co-ordinated by Fraunhofer IMM, a decentralized plant concept was developed for the conversion of pyrolysis oil and biogas into synthetic gasoline.
The process chain involves the reforming of pyrolysis oil and biogas to synthesis gas, its conversion to methanol and finally the Methanol-to-Gasoline (MtG) step. Fraunhofer IMM researched and developed advanced nano-catalysts, which were allied with advanced reactor concepts to realize modular, highly efficient, integrated processes for the sustainable production of fuels from renewable sources.
Reactors with integrated heat removal were designed for the methanol synthesis and gasoline synthesis processes. The 4-year project culminated in the integration of the entire process chain at mini-plant scale starting from bio-oil and biogas feedstocks in a containerized environment.

DEVELOPMENT OF A DECENTRALIZED SYSTEM FOR THE CONVERSION OF RENEWABLE ENERGY SOURCES INTO NATURAL GAS

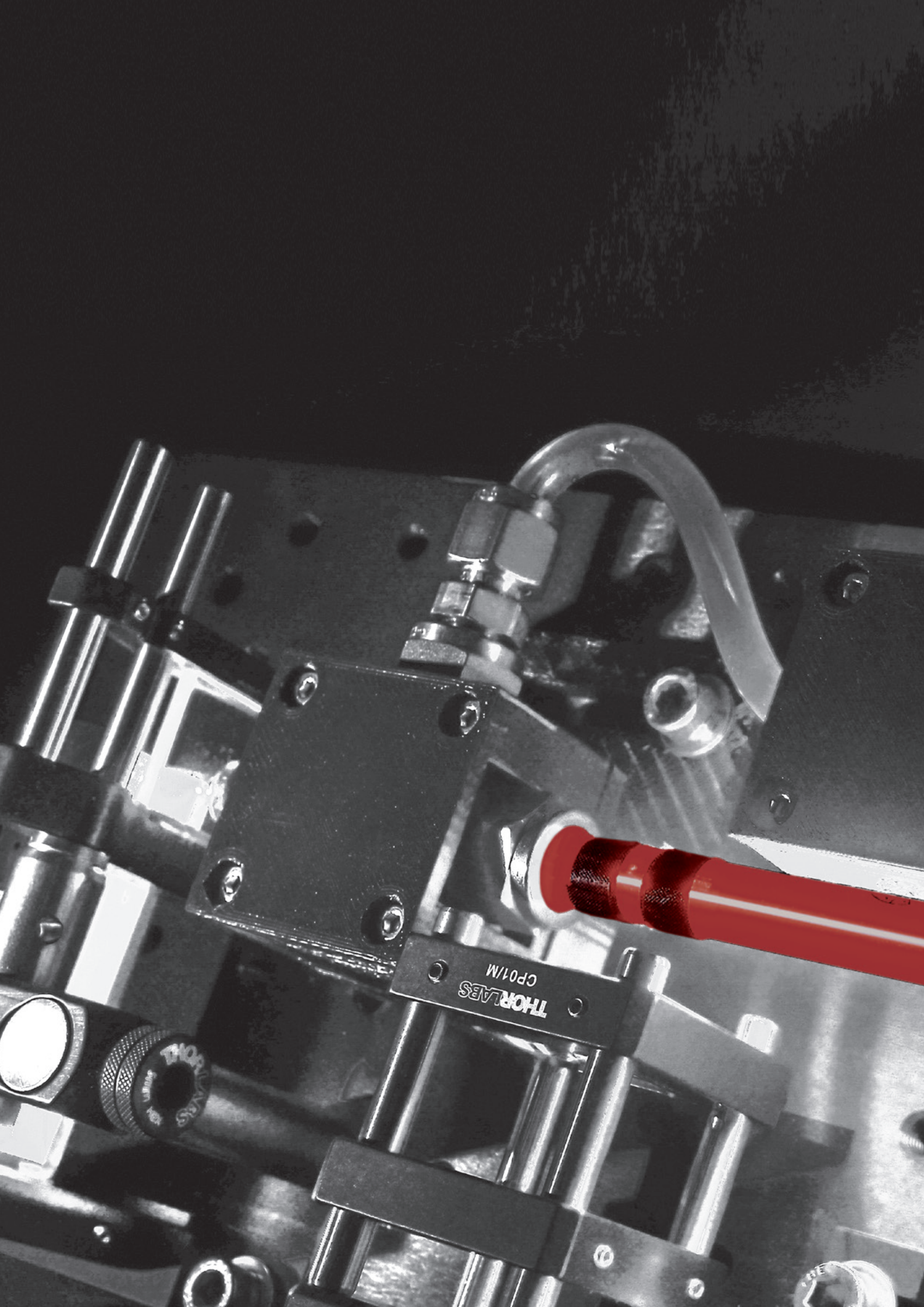
(Project MethGas, 10/2015 to 10/2017)
Milestone in "resource efficiency"

Natural gas supply is either based on connection to a natural gas grid or the use of liquefied natural gas (LNG). Whenever the consumption rate is sufficiently high the so-called "boil-off" is not a significant problem for LNG. But there are numerous scenarios when the LNG losses make the operation of a LNG tank unattractive. Aim of the project was the development of catalysts and of a decentralized plant concept for providing synthetic natural gas from renewable resources such as alcohols which can be stored as long as desired. The use of microstructured reactors allows increasing the compactness of such a plant.

DEVELOPMENT OF A COMPLETE REFORMER FOR PROPYLENE GLYCOL / INVESTIGATION OF ALTERNATIVE FUELS AND REFORMING PROCESSES

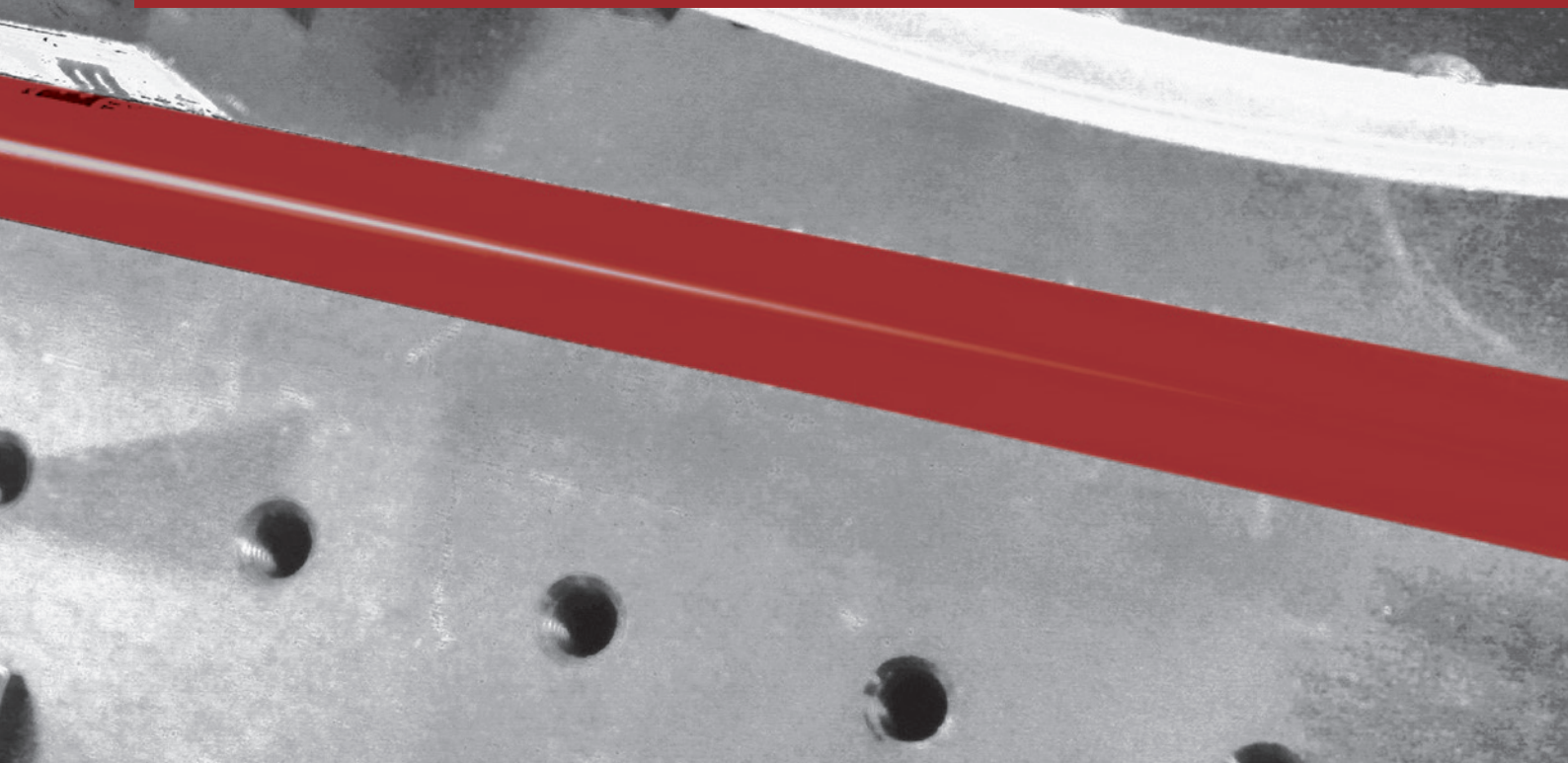
(Projects PROGLENA (Diana) / GetPower, 4/2012 to 12/2015 / 1/2016 to 9/2019)
Milestone in "reforming technology"

The increasing power demand of aircrafts will create problems in future for the power supply through the main turbine or the auxiliary power unit (APU). IMM develops under the lead of Diehl Aerospace GmbH and together with the German Aerospace Center an independent power supply unit, which can be introduced into passenger planes several times, e.g. into the kitchen (galley) and which is shaped into a regular trolley.
The galleys are one of the main power consumers in passenger aircrafts. The system is based upon fuel cell technology and propylene glycol was chosen as fuel owing to its non-toxic nature and non-flammability. The hydrogen for the fuel cell is extracted from this fuel in our fuel processor.


THORLABS
CP01/M

INTELLIGENT SENSORS/ANALYSIS SYSTEMS FOR INDUSTRIE 4.0

The business field "Intelligent Sensors/Analysis Systems for Industrie 4.0" is mainly dealing with the development of sensors and analytical systems to monitor parameters of intermediates and products in process industries (process analytical technology) and the properties of fluids utilized in plants or machines. One target is the optimization of fabrication processes to avoid waste and reduce shutdown periods. The other target is the minimization of maintenance and service costs for machines by enabling truly predictive maintenance. Our technological capabilities address chemical, physical and biological parameters of fluids such as compound concentration, dynamic viscosity or bacterial contamination and many more. Target applications range from continuous or batch production in food or industrial chemistry to lubricants in engines, generators, gears, drives or other process media in industrial fabrication. Besides optimization those sensors and systems in particular support monitoring of equipment which is not easy to access like in off-shore windfarms. From early on our component and system development is designed to identify and optimize cost-effective solutions which are compatible with standard manufacturing methods. Our research focusses on miniaturization of sensor concepts and analytical procedures and the seamless integration of the resulting microsystems in a macroscopic environment. To realize such sensors and systems we combine the expertise of natural and engineering sciences and utilize a broad range of microfabrication technologies.



FROM SINGLE SENSORS TO FULLY AUTOMATED PROCESS ANALYTICAL AND CONTROL TECHNOLOGY

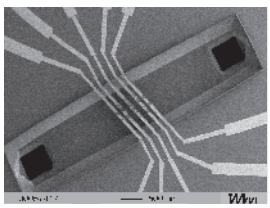
1996

Hand-held spectrometer prototype

Low-cost VIS spectrometer made from injection molded parts.

2000

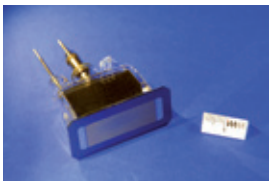
Self-supporting Si_3N_4 micro-bridges with Pt-resistors



Gas massflow sensor for use in a micro-analytical system.

2006

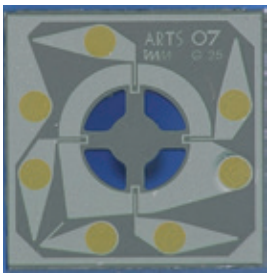
Helium detector of the Inficon Protec P3000

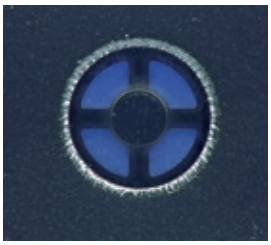


Market launch of the Inficon Protec P3000 leakage detector using the innovative membrane-based He sensor jointly developed by Inficon and IMM.

2010

Sensor backside with piezo resistors and bond pads/ Piezo-resistive three-axial force transducer

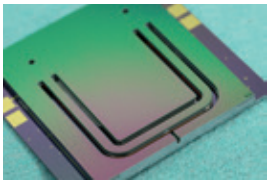




Tactile force sensor for use in neuroprosthetics and robotics.

2010

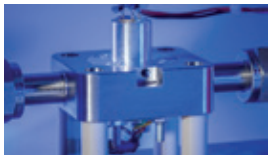
MEMS U-tube resonator

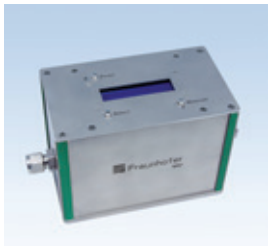


Miniaturized, electrostatically actuated U-tube resonator chip for density measurement of liquid media.

2014

Multi-parameter oil sensor

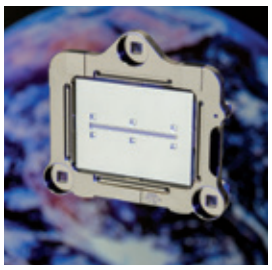




Optical sensor for on-line oil condition monitoring in landfill gas engines and wind turbines.

2015

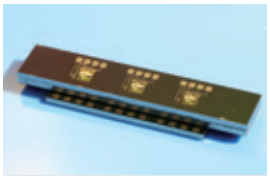
Monolithic silicon double-slit



Precision entrance double slit assembly for the EnMAP hyperspectral satellite mission.

2016

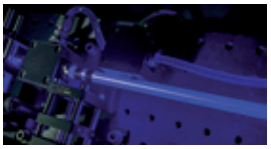
Opto-fluidic chip



First demonstrator of miniaturized opto-fluidic chip device for monitoring of engine oils.

2017

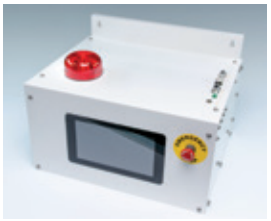
Laser sensor/ prototype device



On-line device for determination of the size distribution in nanoparticle suspensions.

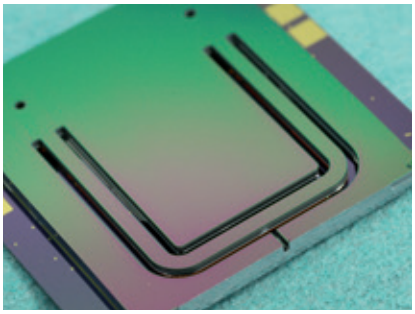
2017

Graphical user interface/ system prototype



On-line system for condition monitoring of Dilute Sulfuric Peroxide Solutions (DSP).

MILESTONES



FLOW-THROUGH DEVICE FOR THE DENSITY MEASUREMENT IN CRUDE OIL ANALYSIS

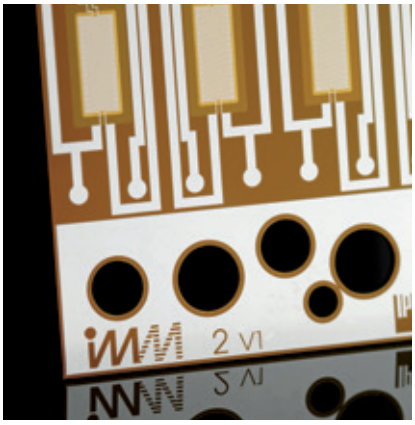
(Project SEVEN, 12/2006 to 10/2008)
Milestone in "precise components for in-line quality control"

The measurement of density using off-line lab analysis devices and in-line procedures is a widely used method for monitoring and quality control of media, processes and products in many fields of industrial production. Applications with limited space or sample volume, however, require miniaturized solutions. The measurement principle of this device is based on a miniaturized, silicon-based vibrating U-tube resonator perfused with the specimen. A change in density will result in a changed overall mass of the resonating feature, thus shifting its resonance frequency.

MODULAR SENSOR PLATFORM FOR CIVIL SECURITY IN PUBLIC TRANSPORT SYSTEMS

(Project ORGAMIR, 2/2008 to 3/2011)
Milestone in "sensor platform technology"

The goal of the research project was the development of a tool that allows to determine the existing and developing contamination of the air by volatile hazardous agents in subway systems. For this purpose, a modular analysis platform for the detection of volatile compounds has been developed and integrated into the forecast system to continuously provide passengers, rescue services, and operators of the public transportation with purpose and goal-directed instructions. The universal applicability of the concept is supposed to provide important contributions to the design of interfaces in marketable microstructure-based analysis systems.



DEVELOPMENT AND ADAPTATION OF A CRUCIAL SUBPROCESS OF A THIN FILM BOLOMETER WITH LARGE ABSORBER HEIGHT

(Project CALORI, 2/2008 to present)
Milestone in "sensor technology for harsh environments"

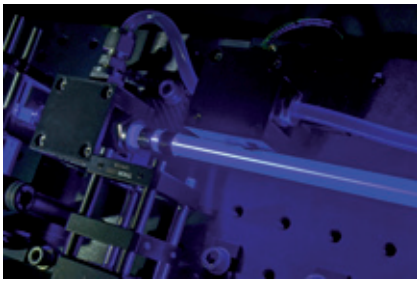
As fossil energy sources are of finite nature novel processes for generating energy have to be developed. The ITER project, dedicated to gain all relevant knowledge for operating a fusion power plant, is one prominent approach. IMM is working on the bolometer sensors which are needed to monitor the plasma confinement in the reaction chamber. These chips are measuring the photon spectrum emitted by the plasma ranging from infrared to x-ray. The material needs to be highly radiation resistant and needs to withstand the impact of fusion neutrons as well as high temperatures up to 450 °C.

CURRENT PROJECTS

DEVELOPMENT AND MANUFACTURING OF A MULTI PARAMETER SENSOR DEMONSTRATOR FOR GENERATOR OIL

(Project MULSENG, 5/2013 to 6/2014)
Milestone in "compact, integrated and cost-efficient on-line measurement"

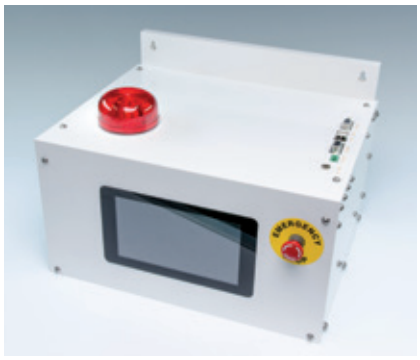
High quality lubricating oils are required for a functional operation in many applications. Quality control usually either leads to time consuming lab analysis or just a preventive change of oil. In order to gain a specific number of condition parameters via on-line analysis infrared measurements are the method of choice. By means of non-dispersive, filter-based spectroscopy the realization of a compact on-line sensing device is possible. Although the accuracy of a profound lab analysis cannot yet be met completely, the advantages of decreasing down-times as well as reducing costs speak for themselves. Key for the market success will be the availability of cost-efficient MEMS based fabrication technologies.



CONTROLLED CONTINUOUS SYNTHESIS OF NANO-PHOSPHATES BY ON-LINE PROCESS ANALYSIS BASED ON LIGHT SCATTERING

(Project NANOSTREAM/NANOPHAT, 4/2016 to 12/2016)
Milestone in "particle measuring technology"

Dynamic Light Scattering (DLS) is a very powerful and well-established method for the characterization of particles in dispersion as well as for polymers in solution. As the method is not relying on special properties of the analyte it is applicable on a wide spectrum of materials and solvents. Although the correct data analysis is not trivial in DLS, the measurement itself is simple and modern instruments are easy to use. The technology we have developed for measuring DLS continuously and in flow meets the need for fast and cost effective in-line/on-line particle sizing easy-to-use devices.



DEVELOPMENT, DESIGN AND REALIZATION OF A DEMONSTRATOR FOR THE QUANTIFICATION OF H_2SO_4 AND H_2O_2 IN DILUTE SULFURIC PEROXIDE (DSP) SOLUTION BY LED-BASED OPTICAL ABSORPTION SPECTROSCOPY

(Project DSPOAS, 7/2006 to 3/2018)
Milestone in "on-line process control"

IMM, in cooperation with ATI Korea, has developed a measuring device for the on-line monitoring of (Dilute Sulfuric Peroxide) DSP solutions which are frequently used in cleanroom environments of semiconductor industries for wafer cleaning. To ensure a stable process performance the composition of the DSP solution has to be monitored carefully. For that purpose IMM has developed a fast, simple and robust dispersionless optical measuring technology which correlates optical transmission in selected wavelength bands with corresponding concentrations of the DSP constituents. The device with integrated flow-through cell allows for an independent and simultaneous measurement of the DSP constituents' concentration with an accuracy of $\Delta c/c = 0.02$.

SENSORS AND ANALYTICS FOR PEOPLE

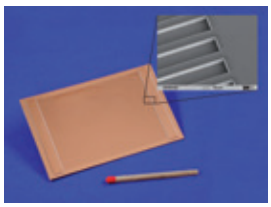
The business field "Sensors and Analytics for People" is mainly dealing with analytical and diagnostic systems for personalized healthcare and patient monitoring (liquid biopsy, point-of-care systems, glucose monitoring) as well as with environmental analysis, particularly in form of pathogen detection, water analysis and nanotoxicology. Main target is the miniaturization and automation of complex laboratory procedures and equipment to give access to a wide range of biological data of a specimen (genes, cells, enzymes, …) very fast and directly on-site for example in a doctor´s office or at the water pipe. Our research concentrates on challenging microtechnological key components particularly in precision microfluidics (lab-on-chip) for the handling, analyzing and detection of cells or for fully automated and ultrafast ELISA and PCR technologies. From early on our component and system development is focused on optimized protocols which are cost-effective and compatible with microfluidic technologies. To realize such fully automated analytical systems we combine the expertise of natural and engineering sciences and utilize a broad range of microfabrication technologies.


Fraunhofer
ICT-IMM
Status: RUN
Remaining: 12 min
RespiraPlex 2
Welzel, K.
000567362
11/15/1972
M
HRV
NMPV

FROM CREDIT CARD SIZED POLYMER-BASED LABS TO AUTOMATED FAST, RELIABLE, AND SIMPLE ON-DEMAND ANALYSIS SYSTEMS

2000

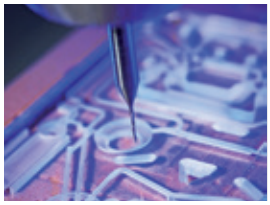
Injection molding tool

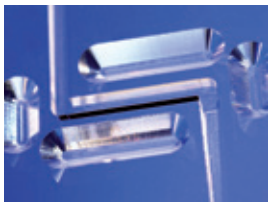


2D electrophoresis chips for protein analysis made by injection molding with LIGA-based tool.

2001

Milling of a chip / bonding / reflecting surfaces / fluidic filters

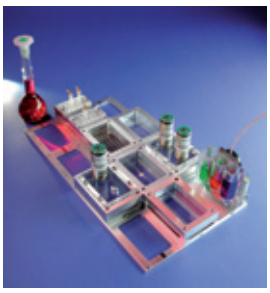




First prototype chips (made by high precision milling) with integrated photoelectric sensors and fluidic filters (structure covering by manual bonding).

2002

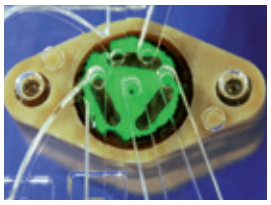
Setup of different lab-on-a-chip components



Modular lab based on microstructured lab-on-a-chip components, first use of a standard chip size.

2003

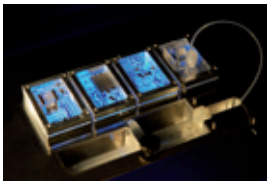
Different types of valves



Use of in-house developed valves integrated on a chip.

2004

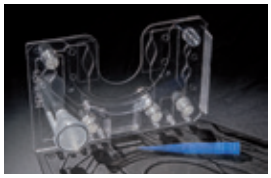
Test setup with different types of chips

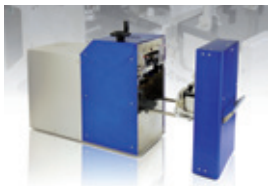


Development of a system for the determination of gluten concentrations in food.

2006

Injection molded chip / complete prototype device

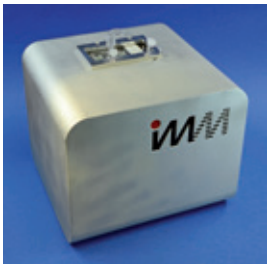


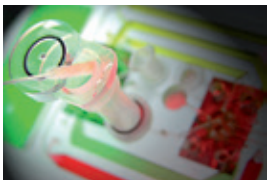


Development of a miniaturized fully automated system for integrated nucleic acid analysis of sputum.

2008

Prototype / microfluidic chip





Early diagnosis and treatment of lower respiratory tract infections by pathogen screening and analysis of antibiotic resistance.

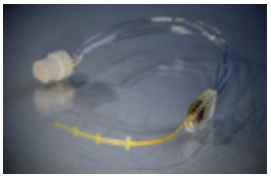
2010

Complete device / microfluidic chip

Development of a lab-on-a-chip system for mycotoxin detection in animal feed.

2013

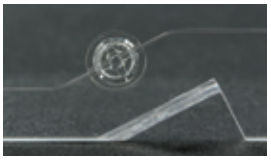
Microelectrode probe



Neuroprosthetic interface systems for restoring motor functions.

2016

Part of microfluidic chip / device prototype



Automated instrument for fast, reliable, and simple on-site detection of Legionella contaminations.

MILESTONES

MICROFABRICATION OF POLYMERIC LAB-ON-A-CHIP WITH INTEGRATED OPTICAL DETECTION

(Project MICROFLUID, 6/2008 to 10/2011)
Milestone in "integrated sample preparation"

Mycotoxins are health hazardous metabolites (carcinogenic, genotoxic or targeting kidney and liver) of some mold fungi species growing on foodstuffs or animal feed that can neither be destroyed by heat treatment or by freezing processes. Therefore, it is of vital importance to have sensitive, accurate and affordable rapid tests for the detection and quantification of mycotoxins. One important step in this direction is a fully automated device performing an ELISA test with subsequent optical detection that was developed at IMM within this project. This system with integrated shredder allows to process raw material such as maize, seeds or pellets directly.

INTEGRATED PLATFORM ENABLING THERANOSTIC APPLICATIONS AT THE POINT OF PRIMARY CARE

(Project THERAEDGE, 3/2008 to 8/2012)
Milestone in "chip-based analytical platform technology"

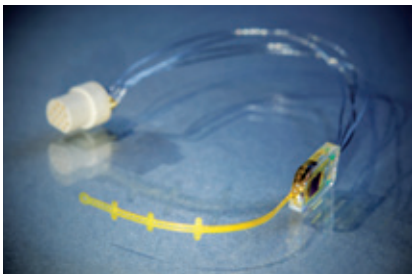
By simultaneous testing for different pathogens and their antibiotic resistance the project aimed for a more effective and timely diagnosis of community-acquired lower respiratory tract infections. The core component of the TheraEDGE platform is a chip-based analytical platform that supports screening for multiple pathogens applying amplification-free detection technologies. Starting from swab samples, the system implements a full sample preparation protocol that does not require any manual user operation except from sample insertion and starting the analysis. After fragmentation of the extracted nucleic acids and pathogen-sequence specific fluorescence labelling in a hybridization step, an optical characterization of the sample material is performed.

DEVELOPMENT AND REALIZATION OF THE PREPARATION OF HIGHLY VISCOUS SAMPLES COMBINED WITH A MOLECULAR DIAGNOSTIC LATERAL FLOW DETECTION

(Project NALF, 10/2009 to 9/2012)
Milestone in "fully automated device operation"

Many products in chemical industry need to be tested for possible contaminations with microorganisms. Typically, cultivation techniques are applied and the products need to be stored until the negative result is confirmed. Within the project a molecular lateral flow chip for rapid on-site quality control has been developed as robust platform which allows to perform all steps required for molecular diagnostics (such as pipetting and signal detection) integrating established lateral flow dipstick technologies with microfluidic chip technologies. The preparation is performed fully automatic and the operator does not need to have any molecular diagnostic knowledge.

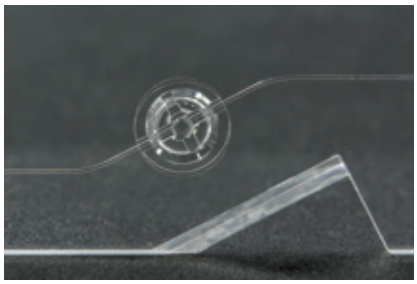
CURRENT PROJECTS



NEUROPROSTHETIC INTERFACE SYSTEMS FOR RESTORING MOTOR FUNCTIONS

(Project NEUWALK, 6/2010 to 11/2014)
Milestone in "neuro recording and stimulation techniques"

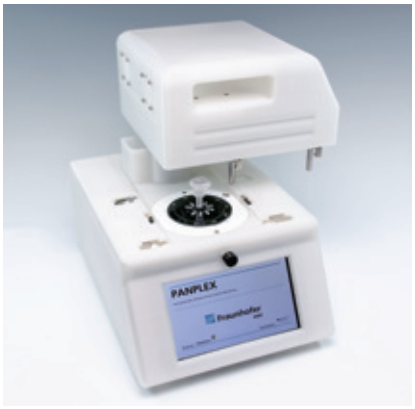
In the course of the EU-FP7 NEUWalk project a new therapy approach was developed which can prospectively allow restoration of motor functions after severe spinal cord injury. The procedure is based on electrical stimulation of the neural pathways in the spinal cord beneath the impaired section. IMM has realized specific mulitchannel micro-electrode arrays that are epidurally implanted in the lumbar region on the spinal cord. Positioning of the micro-electrodes is done close to the roots of the nerve cords which are responsible for activation of those muscles involved in locomotion. Walking motor functions can be triggered by feeding in pulse patterns in a certain time and spatial sequence and thereby be modeled in their flow.



AUTOMATED INSTRUMENT FOR FAST, RELIABLE, AND SIMPLE ON-SITE DETECTION OF LEGIONELLA CONTAMINATIONS

(Project LEGIOTECTION, 1/2015 to 6/2017)
Milestone in "fast on-site testing"

Within the Project a fully automated instrument capable of reliably detecting and counting bacteria such as Legionella in drinking water within one hour has been developed. This will reduce the time-to-result by two orders of magnitude compared to standard plating techniques available today and will pave the way for a mobile, fast and reliable on-site test. Moreover, a distinction between living and dead cells will be possible. The instrument works with a consumable microfluidic cartridge on which the sample handling, separation, purification, and counting is performed. The system is expandable to detect other pathogens.



FAST MULTIPLEX BASED POINT OF CARE DETECTION OF PATHOGENS WITH PANDEMIC POTENTIAL

(Projects PANPLEX / SIMPLEX, 11/2015 to 10/2018)
Expected milestone in "sample multiplexing"

The project work aims at the development of a mobile, autonomously working platform for near patient diagnostics of influenza allowing to determine the infection status of the patient as well as the subtype of the influenza virus. This information yield will help to rapidly control the spread of the disease. The working principle of the detection system is a PCR-based nucleic acid amplification. The patient material is collected with a swab and initially put into a sample container. After lysis the buffer solution is transferred into several reaction chambers in which the multiplex detection reactions take place. The fluorescence that occurs during the assay is recorded via detectors included in the system and then finally is analyzed.

EXTENSION BUILDING

Our construction project is literally getting more tangible. The bare brickwork gradually reveals the implementation of the planning. Ambling through the freshly stripped walls you can already imagine the great potential of this extended infrastructure to move things forward. For us as future users everything cannot happen fast enough.

The current construction schedule however forces us to practice patience until the end of 2019 when the usage is supposed to begin. Up to this date the additional space provided in external containers will fulfill its intended purpose. And we currently focus on thoroughly planning the laboratory equipment for the new building so that we get to work immediately once the handover has taken place. With the opening of the extension building 2000 additional square meters of main usable area will be available comprising offices, labs, technical facilities and, thus, offering the opportunity to realize a selective increase of capabilities as required by our customers.

2000 additional square meters of main usable area will be available

The concept of the extension building closely follows the concept of optimum functionality, ensuring a high safety standard for experiments, high economic efficiency, innovation and sustainability in a combined lab and technology center concept, direct connection to the existing building as well as functional and representative entrance area. The project is primarily focused on an infrastructural enhancement of Fraunhofer IMM's areas of competence, on a significant extension of existing competencies by establishing infrastructure and on building new capacities. The extension building will be characterized by newly created, high-grade lab and technical facilities. This is supposed to be the appropriate way to answer all currently evident customer inquiries meeting our portfolio in a future-oriented way and to develop our core competencies further. This refers in particular to demonstrating technical and process engineering solutions as well as to showcasing complete process and procedure chains as tool and motor for further innovation impulses in cooperation especially with industry. The creation and strengthening of a working environment for well-equipped working groups guarantees a strong and competitive position for the coming years. The realization of a research and development infrastructure for the investigation and adaptation of pilot plants and large-scale chemical process engineering reactors will significantly improve Fraunhofer IMM's technology position in energy and chemical technology as well as the position of the entire Fraunhofer-Gesellschaft. This will be especially true for the demonstration and preparation for implementing innovations in cooperation with project partners and customers.

Furthermore, the potential of the research landscape in Rhineland-Palatinate will be sustainably strengthened in the sense of Rhineland-Palatinate's innovation strategy and an important regional impetus will be set. The extension building is a technology intensive research infrastructure with a high number and physical density of laboratory fume hoods in a safe environment allowing to work with various technical gases, chemicals as well as bio materials. A comprehensive technical equipment for the building primarily related to gas supply, ventilation, cooling technology and air conditioning guarantees high-grade working possibilities for cutting-edge research in energy, chemistry, functional materials as well as in analytic and sensor solutions for people and Industrie 4.0.

This construction project is funded by the Federal Ministry of Education and Research, the Ministry of Science, Education and Culture Rhineland-Palatinate and the European Regional Development Fund.

View of the construction site (facing east)

APPENDIX

FAIRS & EVENTS 2017/2018

Fraunhofer IMM supports the process of acquisition through an intense presence at fairs and exhibitions, organizing an average of 15 appearances per year. The focus lies on activities in Germany with a share of more than 50% while the rest of the activities is almost equally distributed between Europe, North America and Asia.

Industry branch events of central importance are, for instance, the Hannover Messe, Sensor + Test, analytica and ACHEMA. In discussions with our scientists we regularly identify new exhibition opportunities which are offering an appropriate framework for our innovations.

Fair/event	when	where
SLAS2017	February 4 - 8, 2017	USA / Washington DC
Flow Chemistry Europe	February 7 - 8, 2017	UK / Cambridge
FC EXPO	March 1 - 3, 2017	Japan / Tokyo
OPRD Organic Process Research and Development	March 6 - 8, 2017	USA / Pasadena
PITTCON	March 5 - 9, 2017	USA / Chicago
microTEC Südwest Clusterkonferenz 2017	March 27 - 28, 2017	Germany / Freiburg
Open House "Flow Chemistry Demonstration Workshop"	May 11, 2017	Germany / IMM

Fair/event	when	where
HANNOVER MESSE	April 24 - 28, 2017	Germany / Hanover
SENSOR + TEST	May 30 - June 6, 2017	Germany / Nuremberg
Mainzer Wissenschaftsmarkt	September 9 - 10, 2017	Germany / Mainz
10th World Congress of Chemical Engineering	October 1 - 5, 2017	Spain / Barcelona
Open House "On-line Process Analytics"	October 10, 2017	Germany / IMM
COMPAMED	November 13 - 16, 2017	Germany / Düsseldorf
Flow Chemistry Europe	February 6 - 7, 2018	UK / Cambridge
MD&M West	February 6 - 8, 2018	USA / Anaheim
PITTCON	February 26 - March 1, 2018	USA / Orlando
FC EXPO	February 28 - March 2, 2018	Japan / Tokyo
JEC World 2018	March 6 - 8, 2018	France / Paris
Anuga FoodTec	March 20 - 23, 2018	Germany / Cologne
analytica	10. - 13.4.2018	Germany / Munich
HANNOVER MESSE	23. - 27.4.2018	Germany / Hanover

CONFERENCES 2017/2018

Fraunhofer IMM regularly presents results from its innovation fields and from current research projects to a specialist audience. Our scientists are well-received guest speakers at international conferences. We as well regularly invite external scientists from industry and research to join our in-house colloquia. This intensive exchange of experiences and knowledge between industry and research serves not least to initiate international cooperations.

Conference	when	where
Flow Chemistry Europe 2017	February 7 - 8, 2017	England / Cambridge
37th Organic Process Research and Development - Conference and Exhibition	March 6 - 8, 2017	USA / Pasadena
NCCC 2017	March 6 - 8, 2017	The Netherlands / Noordwijkerhout
Processnet-Jahrestreffen Mikroverfahrenstechnik und Hochdruck-verfahrenstechnik	March 8 - 10, 2017	Germany / Frankfurt
50. Jahrestreffen Deutscher Katalytiker	March 15 - 17, 2017	Germany / Weimar
Transferinitiative RLP - Workshop Additive Manufacturing	March 16, 2017	Germany / Ludwigshafen
5th Annual Conference of AnalytiX 2017	March 22 - 24, 2017	Japan / Fukuoka
PharmaForum	March 23, 2017	Germany / Mainz
microTEC Südwest Clusterkonferenz	March 27 - 28, 2017	Germany / Freiburg
1. Statuskonferenz CO_2Net+	April 17, 2017	Germany / Berlin
International Workshop on Magnetic Particle Imaging	April 23 - 24, 2017	Czech Republic / Prague

Conference	when	where
COMPAMED Frühjahrsforum	May 3, 2017	Germany / Frankfurt
2nd Green & Sustainable Chemistry Conference	May 14 - 17, 2017	Germany / Berlin
International Symposium on Mixing in Industrial Processes IX	June 25 - 28, 2017	England / Birmingham
XXXVI Biennial Meeting of the Spanish Royal Society of Chemistry (RSEQ): Flow Chemistry Symposium 2017	June 25 - 29, 2017	Spain / Sitges
HYPOTHESIS XII	June 28 - 30, 2017	Italy / Syrakus
CTRS 4 Conference - CATALYSIS FOR RENEWABLE SOURCES: FUEL, ENERGY, CHEMICALS	September 4 - 8, 2017	Italy / Gabicce Mare
Organic Process Research and Development	September 27 - 29, 2017	Sweden / Stockholm
10th WCCE/11th ECCE 2017	October 1 - 5, 2017	Spain / Barcelona
CATSA 2017 - 28th annual conference of the Catalysis Society of South Africa	November 19 - 22, 2017	South Africa / Pilanesberg
Flow Chemistry Europe 2018	February 6 - 7, 2018	England / Cambridge
2nd International Conference on Catalysis and Chemical Engineering	February 19 - 21, 2018	France / Paris
µFlu´18 NEGF18 µFluidics and Non-Equilibrium Gas Flows 2018 Conference	February 28 - March 2, 2018	France / Strasbourg
51. Jahrestreffen Deutscher Katalytiker	March 14 - 16, 2018	Germany / Weimar
Fachtagung Klebetechnik in der Fahrzeug-Produktion	March 20, 2018	Germany / Pirmasens
microTec Südwest Clusterkonferenz	April 16 - 17, 2018	Germany / Freiburg
Polymer Forum Aschaffenburg	April 17, 2018	Germany / Aschaffenburg

PUBLICATIONS 2017/2018

PUBLICATIONS IN REFEREED JOURNALS

01| Heiland, J.J.; Lotter, C.; Stein, V.; Mauritz, L.; Belder, D.:
TEMPERATURE GRADIENT ELUTION AND SUPERHEATED ELUENTS IN CHIP-HPLC
In: Analytical Chemistry 89 (2017) 6, 3266-3271

02| Sanchez, J.L.A.; Joda, H.; Henry, O.Y.F.; Solnestam, B.W.; Kvastad, L.; Akan, P.S.; Lundeberg, J.; Laddach, N.; Ramakrishnan, D.; Riley, I.; Schwind, C.; Latta, D.; O'Sullivan, C.K.:
ELECTROCHEMICAL GENETIC PROFILING OF SINGLE CANCER CELLS
In: Analytical Chemistry 89 (2017) 6, 3378-3385

03| Shanmugam, V.; Zapf, R.; Neuberg, S.; Hessel, V.; Kolb, G.:
EFFECT OF CERIA AND ZIRCONIA PROMOTERS ON Ni/SBA-15 CATALYSTS FOR COKING AND SINTERING RESISTANT STEAM REFORMING OF PROPYLENE GLYCOL IN MICROREACTORS
In: Applied Catalysis B 203 (2017), 859-869

04| Shanmugam, V.; Zapf, R.; Hessel, V.; Pennemann, H.; Kolb, G.:
NANO-ARCHITECTURED CeO2 SUPPORTED RH WITH REMARKABLY ENHANCED CATALYTIC ACTIVITY FOR PROPYLENE GLYCOL REFORMING REACTION IN MICROREACTORS
In: Applied Catalysis B 226 (2018), 403-411

05| Haliburton, J.R.; Kim, S.C.; Clark, I.C.; Sperling, R.A.; Weitz, D.A.; Abate, A.R.:
EFFICIENT EXTRACTION OF OIL FROM DROPLET MICROFLUIDIC EMULSIONS
In: Biomicrofluidics 11 (2017) 3, 034111

06| Reisbeck, M.; Richter, L.; Helou, M.J.; Arlinghaus, S.; Anton, B.; van Dommelen, I.; Nitzsche, M.; Baßler, M.; Kappes, B.; Friedrich, O.; Hayden, O.:
HYBRID INTEGRATION OF SCALABLE MECHANICAL AND MAGNETOPHORETIC FOCUSING FOR MAGNETIC FLOW CYTOMETRY
In: Biosensors and Bioelectronics 109 (2018), 98-108

07| Alebrand, S.; Freese, C.; Schunck, T.; Baßler, M.:
ZIRKULIERENDE TUMORZELLEN – VOLL AUTOMATISIERTE VEREINZELUNG AUS BLUT
In: Biospektrum 23 (2017) 7, 766-768

08| Wu, Z.; Calcio Gaudino, E.; Manzoli, M.; Martina, K.; Drobot, M.; Krtschil, U.; Cravotto, G.:
SELECTIVE HYDROGENATION OF ALKYNES OVER PPM-LEVEL Pd/BOEHMITE/Al_2O_3 BEADS IN A CONTINUOUS-FLOW REACTOR
In: Catalysis Science and Technology 7 (2017) 20, 4780-4791

09| Karl, D.; Börner, P.; Misuk, V.; Löwe, H.:
OPENING OF NEW SYNTHETIC ROUTES USING SEGMENTED MICRO FLOW IN MULTISTEP SYNTHESES
In: Chemical Engineering and Technology 40 (2017) 6, 1124-1131

10| Izquierdo, U.; Neuberg, S.; Pecov, S.; Pennemann, H.; Zapf, R.; Wichert, M.; Barrio, V.L.; Cambra, J.F.; Kolb, G.:
HYDROGEN PRODUCTION WITH A MICROCHANNEL HEAT-EXCHANGER REACTOR BY SINGLE STAGE WATER-GAS SHIFT; CATALYST DEVELOPMENT
In: Chemical Engineering Journal 313 (2017), 1494-1508

11| Rehm, T.H.; Reinhard, D.; Kost, H.-J.; Hofmann, C.; Zapf, R.; Löb, P.; Laribi, Y.; Perrichon, P.D.; Berguerand, C.; Kiwi-Minsker, L.; Sulman, E.; Szirbik, G.; Richert, H.; Lang, J.; Gottfried, M.; Roggan, S.:
CHEMOSELECTIVE THREE-PHASE HYDROGENATION OF AN OMBRABULIN NITRO-STILBENE INTERMEDIATE IN A CONTINUOUS-FLOW MOBILE PLATFORM
In: Chemical Engineering Journal 316 (2017), 1069-1077

12| Hermann, P.; Timmermann, J.; Hoffmann, M.; Schlüter, M.; Hofmann, C.; Löb, P.; Ziegenbalg, D.:
OPTIMIZATION OF A SPLIT AND RECOMBINE MICROMIXER BY IMPROVED EXPLOITATION OF SECONDARY FLOWS
In: Chemical Engineering Journal 334 (2018), 1996-2003

13| Ortega, C.; Rezaei, M.; Hessel, V.; Kolb, G.:
METHANOL TO DIMETHYL ETHER CONVERSION OVER A ZSM-5 CATALYST: INTRINSIC KINETIC STUDY ON AN EXTERNAL RECYCLE REACTOR
In: Chemical Engineering Journal 347 (2018), 741-753

14| Samaryk, V.; Varvarenko, S.; Nosova, N.; Fihurka, N.; Musyanovych, A.; Landfester, K.; Popadyuk, N.; Voronov, S.:
OPTICAL PROPERTIES OF HYDROGELS FILLED WITH DISPERSED NANOPARTICLES
In: Chemistry and Chemical Technology 11 (2017) 4, 449-453

15| Fabry, D.; Ho, Y.A.; Zapf, R.; Tremel, W.; Panthöfer, M.; Rueping, M.; Rehm, T.H.:
BLUE LIGHT MEDIATED C-H ARYLATION OF HETEROARENES USING TiO_2 AS IMMOBILIZED PHOTOCATALYST IN A CONTINUOUS-FLOW MICROREACTOR
In: Green Chemistry 19 (2017) 8, 1911-1918

16| Bomhard, S.v.; Schelhaas, K.-P.; Alebrand, S.; Musyanovych, A.; Maskos, M.; Drese, K.S.:
SELECTIVE SOLVENT EVAPORATION FROM BINARY MIXTURES OF WATER AND TETRAHYDROFURAN USING A FALLING FILM MICROREACTOR
In: Green Processing and Synthesis 6 (2017) 4, 403-411

17| Sundaram, S.; Kolb, G.; Hessel, V.; Wang, Q.:
ENERGY-EFFICIENT ROUTES FOR THE PRODUCTION OF GASOLINE FROM BIOGAS AND PYROLYSIS OIL-PROCESS DESIGN AND LIFE-CYCLE ASSESSMENT
In: Industrial and Engineering Chemistry Research 56 (2017) 12, 3373-3387

18| Baki, A.; Löwa, N.; Thiermann, R.; Bantz, C.; Maskos, M.; Wiekhorst, F.; Bleul, R.:
CONTINUOUS SYNTHESIS OF SINGLE CORE IRON OXIDE NANOPARTICLES FOR MPI TRACER DEVELOPMENT
In: International Journal on Magnetic Particle Imaging 3 (2017) 1, 1703004

19| Karl, D.; Löwe, H.:
ENHANCED [4+2] CYCLOADDITIONS BY SOLVOPHOBIC EFFECTS AND GRAVITY-INDUCED MIXING IN CORE-SHELL DROPLETS
In: Journal of Flow Chemistry 7 (2017) 1, 9-12

20| Hentrich, D.; Tabaache, S.; Brezesinski, G.; Lange, N.; Unger, W.; Kübel, C.; Bertin, A.; Taubert, A.:
A DENDRITIC AMPHIPHILE FOR EFFICIENT CONTROL OF BIOMIMETIC CALCIUM PHOSPHATE MINERALIZATION
In: Macromolecular Bioscience 17 (2017) 8, 1600524

21| Thiermann, R.; Bleul, R.; Maskos, M.:
KINETIC CONTROL OF BLOCK COPOLYMER SELF-ASSEMBLY IN A MICROMIXING DEVICE – MECHANISTICAL INSIGHT INTO VESICLE FORMATION PROCESS
In: Macromolecular Chemistry and Physics 218 (2017) 2, 1600347

22| Quint, S.; Wittek, J.; Spang, P.; Levanon, N.; Walther, T.; Baßler, M.:
IMPROVED SIGNAL RECOVERY FOR FLOW CYTOMETRY BASED ON ‚SPATIALLY MODULATED EMISSION'
In: Methods and Applications in Fluorescence 5 (2017) 3, 035002

23| Augel, L.; Berkmann, F.; Latta, D.; Fischer, I.; Bechler, S.; Elogail, Y.; Kostecki, K.; Potje-Kamloth, K.; Schulze, J.:
OPTOFLUIDIC SENSOR SYSTEM WITH Ge PIN PHOTODETECTOR FOR CMOS-COMPATIBLE SENSING
In: Microfluidics and Nanofluidics 21 (2017) 11, 169

24| Kessler, S.; Drese, K.S.; Schmid, F.:
SIMULATING COPOLYMERIC NANOPARTICLE ASSEMBLY IN THE CO-SOLVENT METHOD: HOW MIXING RATES CONTROL FINAL PARTICLE SIZES AND MORPHOLOGIES
In: Polymer 126 (2017), 9-18

25| Tabaache, S.; Bertin, A.:
VESICLES FROM AMPHIPHILIC DUMBBELLS AND JANUS DENDRIMERS: BIOINSPIRED SELF-ASSEMBLED STRUCTURES FOR BIOMEDICAL APPLICATIONS
In: Polymers 9 (2017) 7, 280

26| Steinmacher, F.R.; Baier, G.; Musyanovych, A.; Landfester, K.; Araújo, P.H.H.; Sayer, C.:
DESIGN OF CROSS-LINKED STARCH NANOCAPSULES FOR ENZYME-TRIGGERED RELEASE OF HYDROPHILIC COMPOUNDS
In: Processes 5 (2017) 2, 25

27| Rehm, T.H.; Hofmann, C.; Reinhard, D.; Kost, H.-J.; Löb, P.; Besold, M.; Welzel, K.; Barten, J.; Didenko, A.; Sevenard, D.V.; Lix, B.; Hillson, A.R.; Riegel, S.D.:
CONTINUOUS-FLOW SYNTHESIS OF FLUORINE-CONTAINING FINE CHEMICALS WITH INTEGRATED BENCHTOP NMR ANALYSIS
In: Reaction Chemistry & Engineering 2 (2017) 3, 315-323

28| Pala, L.P.R.; Wang, Q.; Kolb, G.; Hessel, V.:
STEAM GASIFICATION OF BIOMASS WITH SUBSEQUENT SYNGAS ADJUSTMENT USING SHIFT REACTION FOR SYNGAS PRODUCTION: AN ASPEN PLUS MODEL
In: Renewable Energy 101 (2017) , 484-492

29| Landgraf, L.; Nordmeyer, D.; Schmiel, P.; Gao, Q.; Ritz, S.; Gebauer, J.S.; Graß, S.; Diabaté, S.; Treuel, L.; Graf, C.; Rühl, E.; Landfester, K.; Mailänder, V.; Weiss, C.; Zellner, R.; Hilger, I.:
VALIDATION OF WEAK BIOLOGICAL EFFECTS BY ROUND ROBIN EXPERIMENTS: CYTOTOXICITY/BIOCOMPATIBILITY OF SiO_2 AND POLYMER NANOPARTICLES IN HepG2 CELLS
In: Scientific Reports 7 (2017), 4341

30| Sperling, R.A.; García-Fernández, L.; Ojea-Jiménez, I.; Piella, J.; Bastús, N.G.; Puntes, V.:
ONE-POT SYNTHESIS OF CATIONIC GOLD NANOPARTICLES BY DIFFERENTIAL REDUCTION
In: Zeitschrift für Physikalische Chemie 231 (2017) 1, 7-18

PUBLICATIONS IN OTHER JOURNALS

31| Klotzbücher, T.:
SCHMIERÖLZUSTANDSÜBERWACHUNG MITTELS NICHT-DISPERSIVER SPEKTROSKOPISCHER ONLINE-SENSOREN
In: Analytik News (2017), 1-4

32| Löb, P.:
CHANCEN UND GRENZEN DER SMALL-SCALE-CHEMIE. ABSCHIED VOM HOHEN SCHORNSTEIN
In: CAV 50 (2017) 6, 116-118

33| Löb, P.:
PRODUKTIONSKONZEPTE FÜR INTENSIVIERTE PROZESSE IM CONTAINER. POTENZIAL NOCH LANGE NICHT AUSGESCHÖPFT
In: CAV 50 (2017) 6, 120-121

34| Ziogas, A.; Lenz, M.; Kolb, G.:
AUFBAU EINES MULTIDIMENSIONALEN PROZESS-GC-MS
In: Nachrichten aus der Chemie 65 (2017) 9, 897-902

BOOKS

35| Koltzenburg, S.; Maskos, M.; Nuyken, O.:
POLYMER CHEMISTRY :
English translation of the successful German textbook "Polymere", winner of the Chemical Industry in Germany's 2015 literature prize: Springer-Verlag Berlin Heidelberg, 2017
ISBN: 9783662492772

CONTRIBUTIONS TO BOOKS

36| Maskos, M.; Stauber, R.H.:
3.21; CHARACTERIZATION OF NANOPARTICLES IN BIOLOGICAL ENVIRONMENTS
In: Comprehensive Biomaterials II, Volume 3; Ducheyne, P.; Grainger, D.W.; Healy, K.E.; Hutmacher, D.; Kirkpatrick, C.J. (Ed.): Elsevier, 2017, 467-481
ISBN: 9780128035818

37| Drese, K.S.; Maskos, M.; Musyanovych, A.:
NANOPARTIKELHERSTELLUNG MITTELS FLOW CHEMISTRY
In: Angewandte Nanotechnologie; Haas, K.-H.; Tovar, G. (Ed.)
Stuttgart: Fraunhofer IRB-Verlag, 2018, 153-167
ISBN: 9783839609187

38| Kolb, G.:
I**NNOVATIVE DESIGN OF MICROSTRUCTURED PLATE-AND-FRAME HEAT EXCHANGERS**
In: Innovative Heat Exchangers; Bart, H.-J.; Scholl, S. (Ed.): Springer Science+Business Media LLC, 2018, 117-134
ISBN: 9783319716398

CONTRIBUTIONS TO CONFERENCE TRANSCRIPTS

39| Kretzschmar, T.; Baßler, M.; Drese, K.S.:
SYSTEMATIC CLASSIFICATION OF MICROMIXERS
In: 3rd Conference on MicroFluidic Handling Systems MFHS, October 4–6 2017 - Enschede, NL, 2017, 118 – 121

40| Leube, F.; Drese, K.S.; Stephan, P.:
DYNAMIC MODEL FOR INVESTIGATION OF INSTABILITIES IN MICROCHANNEL EVAPORATORS
In: 3rd Conference on MicroFluidic Handling Systems MFHS, October 4–6 2017 - Enschede, NL, 2017, 148 - 151

41| Alebrand, S.; Spang, P.; Welzel, K.; Wittek, J.; Tracksdorf, M.; Dethling, D.; Schwind, C.; Oster, C.; Baßler, M.:
MIKROFLUIDISCHES ZELLZÄHLMODUL ZUR DETEKTION VON PATHOGENEN IN FLÜSSIGKEITEN: AUTOMATISIERT, INTERGRIERBAR UND ROBUST; MICROFLUIDIC CELL COUNTING MODULE FOR DETECTION OF PATHOGENS IN FLUIDS: AUTOMATED, INTEGRATABLE AND ROBUST
In: MikroSystemTechnik Kongress 2017 - München: VDE-Verlag, 2017, 297 - 300
ISBN: 9783800744916

SCIENTIFIC LECTURES

42| Menges-Flanagan, G.; Deitmann, E.; Hofmann, C.; Löb, P.:
ENTWICKLUNG UND VALIDIERUNG EINES SKALIERBAREN KONTINUIERLICHEN PROZESSES ZUR GRIGNARD REAGENZ HERSTELLUNG
In: ProcessNet Jahrestreffen der Fachgruppen Hochdruckverfahrenstechnik, Mikroverfahrenstechnik, Molekulare Modellierung und Simulation
March 8–10, 2017 - Frankfurt am Main

43| Löb, P.; Hofmann, C.; Krtschil, U.; Menges-Flanagan, G.:
NUTZUNG ADDITIVER FERTIGUNGSVERFAHREN FÜR DIE REALISIERUNG METALLISCHER MIKRO-/MILLI-STRUKTURIERTER REAKTOREN
In: ProcessNet Jahrestreffen der Fachgruppen Hochdruckverfahrenstechnik, Mikroverfahrenstechnik, Molekulare Modellierung und Simulation
March 8–10, 2017 - Frankfurt am Main

44| Löb, P.; Hofmann, C.; Krtschil, U.; Menges-Flanagan, G.:
NUTZUNG ADDITIVER FERTIGUNGSVERFAHREN ZUR REALISIERUNG STRUKTURIERTER CHEMISCHER REAKTOREN
In: Transferinitiative RLP "Additive Fertigung: Chancen und Herausforderungen durch 3D Druck"
March 16, 2017 – Ludwigshafen

45| Ziogas, A.; Kolb, G.:
PROCESS ANALYTICAL TECHNOLOGY: DEVELOPMENT AND CONFIGURATION OF A PROCESS GC-MS
In: BIT Annual Conference of AnalytiX-2017, 5
March 22–24, 2017 - Fukuoka, Japan

46| Baßler, M.:
CTCelect - MIKROFLUIDISCHES SYSTEM ZUR VOLLAUTOMATISCHEN ISOLATION ZIRKULIERENDER TUMORZELLEN MIT INTEGRIERTEM EINZELZELLDISPENSER
In: PharmaForum "Pharma trifft Medizintechnik": Ministerium für Wirtschaft, Verkehr, Landwirtschaft und Weinbau Rheinland-Pfalz
March 23, 2017 - Mainz

47| Maskos, M.:
BUILDING THE BRIDGE TO INDUSTRIAL MICRO- AND NANO-APPLICATIONS
In: Opening Sino-German Micro- & Nano Manufacturing Innovation Center and Shenzhen Intelligent Offshore Manufacturing Innovation Center
April 28, 2017 - Shenzhen, China

48| Baßler, M.:
MICROFLUIDIC SYSTEM FOR FLUORESCENCE ACTIVATED SINGLE CELL DISPENSING DEMONSTRATED FOR CIRCULATING TUMOR CELLS
In: COMPAMED Frühjahrsforum, 11
May 3, 2017 - Frankfurt am Main

49| Alebrand, S.:
ALS PHYSIKERIN AM FRAUNHOFER ICT-IMM: DIE FASZINATION INTERDISZIPLINÄRER, ANGEWANDTER FORSCHUNG
In: DPG Veranstaltung "PhysikerInnen im Beruf"
May 5–7, 2017 - Bad Honnef

50| Kretzschmar, T.:
EVALUATION OF MICROMIXER PERFORMANCE
In: ISMIP-9 - The International Symposium on Mixing in Industrial Processes IX
June 25–28, 2017 - Birmingham, UK

51| Löb, P.; Rehm, T.H.; Menges-Flanagan, G.; Illg, T.; Hofmann, C.; Schütt, C.:
NEW MICROREACTOR CONCEPTS FOR ORGANIC SYNTHESIS
In: XXXVI Biennial Meeting of the Spanish Royal Society of Chemistry (RSEQ): Flow Chemistry Symposium
June 25–29, 2017 - Sitges (Barcelona), Spain

52| Leube, F.:
DYNAMIC MODEL FOR INVESTIGATING INSTABILITIES IN MICRO-CHANNEL EVAPORATORS
In: Institutsseminar im Institut für Strömungsmechanik (ISTM) am KIT
June 26, 2017 - Karlsruhe

53| Neuberg, S.; Pennemann, H.; Wichert, M.; Schürer, J.; Kolb, G.:
HYDROGEN PRODUCTION FROM METHANOL, ETHANOL AND POLYALCOHOLS FOR DE-CENTRALISED FUEL CELL APPLICATIONS
In: Hypothesis XII - Hydrogen power theoretical and engineering solutions international symposium
June 28–30, 2017 - Sirakusa, Italy

54| Feldhaus, M.:
MESSUNGEN IN DER INFRAROTSPEKTROMETRIE. KONSTRUKTION EINES PHOTOVOLTAISCHEN INFRAROT-QUADSENSORS
In: Hochschule RheinMain
June 29, 2017 - Wiesbaden; Rüsselsheim

55| Kolb, G.; Pennemann, H.; Schürer, J.:
CONVERSION OF PYROLYSIS OIL TO SYNTHESIS GAS THROUGH AUTOTHERMAL REFORMING OPERATED IN A MINIPLANT IN AN MODULAR CONTAINERISED ENVIRONMENT
In: CRS - Catalysis for renewable sources: Fuel, Energy, Chemicals, 4
September 4–8, 2017 - Gabicce Mare, Italy

56| Schramm, J.:
CONTINUOUS SYNTHESIS AND MODIFICATION OF NANOPARTICLES
In: Young scientist workshop ICT-IMM, 11
September 27, 2017 – Mainz

57| Schindler, C.:
DEVELOPMENT OF A CONTINUOUS SYNTHESIS OF NANOPARTICLES FOR CATALYTIC APPLICATIONS
In: Young scientist workshop ICT-IMM, 11
September 27, 2017 - Mainz

58| Ayhan, R.:
CHARACTERIZATION OF LATERAL MIGRATION OF PARTICLES IN MICROFLUIDIC FLOWS DEPENDING ON THE PARTICLE SIZE AND VELOCITY
In: Young scientist workshop ICT-IMM, 11
September 27, 2017 - Mainz

59| Teichmann, T.:
ESTABLISHMENT AND OPTIMIZATION OF A METHOD FOR IMMUNOMAGNETIC ENRICHMENT AND FLUORESCENCE LABELING OF MELANOMA AND CARCINOMA CELLS
In: Young scientist workshop ICT-IMM, 11
September 27, 2017 - Mainz

60| Bacher, L.:
CONTINUOUS FLOW ENCAPSULATION BY MICROFLUIDIC DEVICES
In: Young scientist workshop ICT-IMM, 11
September 27, 2017 - Mainz

61| Baki, A.:
CONTINUOUS SYNTHESIS OF SINGLE-CORE IRON OXIDE NANOPARTICLES FOR BIOMEDICAL APPLICATIONS
In: Young scientist workshop ICT-IMM, 11
September 27, 2017 - Mainz

62| Onyema, H.:
ESTABLISHING A 3D MODEL OF A BRAIN VESSEL TO IDENTIFY RELEVANT NANOPARTICLE CHARACTERISTICS FOR CROSSING THE BLOOD-BRAIN BARRIER
In: Young scientist workshop ICT-IMM, 11
September 27, 2017 - Mainz

63| Heinß, N.:
EQUILIBRIUM VELOCITY AND BIOLOGICAL CELLS IN MICRO FLOWS
In: Young scientist workshop ICT-IMM, 11
September 27, 2017 - Mainz

64| Darouich, D.:
D**EVELOPMENT OF AN ISOLATION PROCESS FOR MICROVESICLE**
In: Young scientist workshop ICT-IMM, 11
September 27, 2017 - Mainz

65| Kretzschmar, T.:
DETERMINATION OF MICROMIXER EFFICIENCY
In: Young scientist workshop ICT-IMM, 11
September 27, 2017 - Mainz

66| Leube, F.:
MICROCHANNEL EVAPORATORS FOR SMALL SCALE VAPOR GENERATION. INTRODUCING AN ANALYTICAL ANNULAR FLOW MODEL TO SIMULATE MICROCHANNEL EVAPORATORS
In: Young scientist workshop ICT-IMM, 11
September 27, 2017 - Mainz

67| Menges-Flanagan, G.:
SCALABLE CONTINUOUS PROCESS FOR THE PRODUCTION OF GRIGNARD REAGENTS
In: OPRD - Organic Process Research and Development
September 27–29, 2017 - Stockholm, Sweden

68| Löb, P.; Hofmann, C.; Krtschil, U.; Menges-Flanagan, G.:
EXPLOITATION OF ADDITIVE MANUFACTURING FOR THE REALISATION OF METALLIC MICRO/MILLI-STRUCTURED REACTORS
In: WCCE - World Congress of Chemical Engineering, 10
October 1–5, 2017 - Barcelona, Spain

69| Alebrand, S.; Spang, P.; Welzel, K.; Wittek, J.; Tracksdorf, M.; Dethling, D.; Schwind, C.; Oster, C.; Baßler, M.:
MIKROFLUIDISCHES ZELLZÄHLMODUL ZUR DETEKTION VON PATHOGENEN IN FLÜSSIGKEITEN: AUTOMATISIERT, INTERGRIERBAR UND ROBUST
In: MST - Mikrosystemtechnik Kongress, 7
October 23–25, 2017 - München, Unterschleißheim

70| Neuberg, S.; Pennemann, H.; Shanmugam, V.; Wichert, M.; Schürer, J.; Kolb, G.:
MICROSTRUCTURED REACTORS FOR DISTRIBUTED POWER GENERATION, POWER STORAGE AND FUEL SYNTHESIS
In: CATSA - Catalysis Society of South Africa
November 19–22, 2017 - Pilanesberg, South Africa

71| Rehm, T.H.:
(**PHOTO)CHEMICAL CONVERSION OF DIAZONIUM SALTS IN FLOW INCLUDING ONLINE NMR ANALYSIS**
In: FCS - Flow Chemistry Europe , 8
February 6–7, 2018 - Cambridge, UK

72| Shanmugam, V.; Kolb, G.:
REMARKABLE SUPPORT EFFECT ON THE REACTIVITY OF Pt BASED CATALYSTS FOR STEAM REFORMING OF METHANOL IN MICRORE-ACTORS
In: CCE - International Conference on Catalysis and Chemical Engineering, 2
February 19–21, 2018 - Paris, France

73| Rehm, T.H.; Krüger, A.; Sahlmann, B.:
PHOTOCHEMISCHE CO2-ASSIMILIERUNG MIT SICHTBAREM LICHT AUF MIKROSTRUKTURIERTEN DIAMANTOBERFLÄCHEN IN KONTINUIERLICH BETRIEBENEN MIKROREAKTOREN
In: Statuskonferenz zur BMBF Fördermaßnahme CO2Plus, 1
April 17–18, 2018 - Berlin

SCIENTIFIC POSTERS

74| Rehm, T.H.; Gros, S.; Renken, A.; Fabry, D.; Rueping, M.:
HOMOGENEOUS AND HETEROGENEOUS PHOTOCATALYSIS IN A FALLING FILM MICROREACTOR
In: FCS - Flow Chemistry Europe, 7
February 07–08, 2017 - Cambridge, UK

75| Menges-Flanagan, G.; Deitmann, E.; Hofmann, C.; Löb, P.:
SCALABLE CONTINUOUS PROCESS FOR THE PRODUCTION OF GRIGNARD REAGENTS
In: FCS - Flow Chemistry Europe, 7
February 07–08, 2017 - Cambridge, UK

76| Leube, F.; Drese, K.S.; Stephan, P.:
DYNAMISCHES MODELL ZUR SIMULATION VON INSTABILITÄTEN IN MIKROVERDAMPFERN
In: ProcessNet Jahrestreffen der Fachgruppe Wärme und Stoffübertragung
February 13–17, 2017. – Bruchsal

77| Menges-Flanagan, G.; Deitmann, E.; Hofmann, C.; Löb, P.:
SCALABLE CONTINUOUS PROCESS FOR THE PRODUCTION OF GRIGNARD REAGENTS
In: Organic Process Research and Development; International Conference and Exhibition, 37
March 6–8, 2017 - Pasadena, USA

78| Schürl, S.; Wittek, J.; Roth, K.; Nikiforov, O.; Walther, T.:
FPGA BASED DETECTION SYSTEM FOR QKA
In: DPG-Frühjahrstagung
March 6–10, 2017 - Mainz

79| Rehm, T.H.; Gros, S.; Renken, A.; Fabry, D.; Rueping, M.:
HOMOGENEOUS AND HETEROGENEOUS PHOTOCATALYSIS IN A FALLING FILM MICROREACTOR
In: ProcessNet Jahrestreffen Deutscher Katalytiker, 50
March 15–17, 2017 - Weimar

80| Baki, A.; Löwa, N.; Thiermann, R.; Bantz, C.; Maskos, M.; Wiekhorst, F.; Bleul, R.:
CONTINUOUS SYNTHESIS OF SINGLE CORE IRON OXIDE NANO-PARTICLES FOR MPI TRACER DEVELOPMENT
In: IWMPI - International Workshop on Magnetic Particle Imaging, 7
March 23–24, 2017 - Prague, Czech Republic

81| Onyema, H.; Wilhelmi, S.; Musyanovych, A.; Freese, C.; Schunck, T.:
ESTABLISHING A 3D MODEL OF A BRAIN VESSEL TO IDENTIFY RELEVANT NANOPARTICLE CHARACTERISTICS FOR CROSSING THE BLOOD-BRAIN-BARRIER
In: Transporter- und Barrierentreffen, 19
May 15–17, 2017 - Bad Herrenalb

82| Onyema, H.; Musyanovych, A.; Schunck, T.; Freese, C.:
AN IN VITRO MODEL OF THE BLOOD-BRAIN-BARRIER ON A MICROFLUIDIC CHIP
In: Transporter- und Barrierentreffen, 19
May 15–17, 2017 - Bad Herrenalb

83| Feldhaus, M.:
MESSUNGEN IN DER INFRAROTSPEKTROMETRIE. KONSTRUKTION EINES PHOTOVOLTAISCHEN INFRAROTSENSORS
In: Hochschule RheinMain
June 29, 2017 - Wiesbaden; Rüsselsheim

84| Durieux, S.; Rehm, T.H.; Renken, A.:
CHARACTERISATION OF A CAPILLARY PHOTOREACTOR FOR PARALLEL AND CONSECUTIVE PHOTOCHEMICAL PROCESSING
In: Postervorstellung an der Ecole Polytechnique Fédérale de Lausanne
September 1, 2017 - Lausanne

85| Menges-Flanagan, G.; Deitmann, E.; Hofmann, C.; Löb, P.:
SCALABLE CONTINUOUS PROCESS FOR THE PRODUCTION OF GRIGNARD REAGENTS
In: WCCE - World Congress of Chemical Engineering, 10
October 1–5, 2017 - Barcelona, Spain

86| Soylu, M.:
CHARACTERIZATION OF A MICROFLUIDIC CHIP USING µ-FREE-FLOW ELECTROPHORESUS (µ-FFE)
In: CE- and FFE-Forum, Fraunhofer ICT, 1
October 5–6, 2017 - Karlsruhe, Berghausen

87| Rehm, T.H.; Gros, S.; Renken, A.; Fabry, D.; Rueping, M.:
HOMOGENEOUS AND HETEROGENEOUS PHOTOCATALYSIS IN A FALLING FILM MICROREACTOR
In: SolChem - International Symposium on Solar-Driven Chemistry, 1
October 8–10, 2017 - Ulm

88| Zapf, R.; Neuberg, S.; Pennemann, H.; Shanmugam, V.; Ziogas, A.; Kolb, G.:
DEVELOPMENT OF RHODIUM-BASED CATALYSTS FOR STEAM REFORMING OF METHANE IN MICROCHANNELS
In: Jahrestreffen Deutscher Katalytiker, 51
March 14–16, 2018 – Weimar

RESEARCH REPORTS

89| Löb, P.; Illg, T.; Kost, H.-J.:
DURCHFLUSSKAMMERN FÜR DIE SYNTHESE BIOKONJUGIERTER LEGIERUNGS-NANOPARTIKEL.
KMU-innovativ: Nanotechnologie – Verbundprojekt: Hochleistungs-Point-of-Care-Testing mittels biokonjugierter Legierungs-Nanopartikel-Detektion am Beispiel von Lateral-Flow-Testsystemen (LENA).
Laufzeit: July 1, 2014 – December 31, 2016
Förderkennzeichen: 13N12978 – Zuwendungsgeber: BMBF
Projektträger: VDI Technologiezentrum GmbH. – Mainz, 2017

90| Bantz, C.; Frese, I.; Schramm, J.; Sperling, R.A.:
NanoPhat - KONTROLLIERTE KONTINUIERLICHE SYNTHESE VON NANOPHOSPHATEN DURCH LICHTSTREU-BASIERTE ONLINE-PROZESSANALYTIK
Laufzeit: September 1, 2016 – 01.09.2016 - December 31, 2016
Zuwendungsgeber: Ministerium für Wissenschaft, Weiterbildung und Kultur Rheinland-Pfalz – Wissen schafft Zukunft – Mainz, 2017

91| Löb, P.; Bomhard, S.v.; Schramm, J.; Höbel, P.; Krtschil, U.:
NanoStream – FEEDBACK-GESTEUERTE, EIGENSCHAFTS-OPTIMIERTE AUFARBEITUNG NANOPARTIKULÄRER MATERIALIEN IM KONTINUIERLICHEN VERFAHREN.
Laufzeit: April 1, 2016 - December 31, 2016
Zuwendungsgeber: Ministerium für Wissenschaft, Weiterbildung und Kultur Rheinland-Pfalz – Wissen schafft Zukunft – Mainz, 2017

DISSERTATIONS

92| Kessler, S.:
MODELING SIZE-CONTROLLED ASSEMBLY OF POLYMERIC NANOPARTICLES IN INTERDIGITAL MICROMIXERS
Zur Erlangung des Grades "Doktor der Naturwissenschaften"
am Fachbereich Physik, Mathematik und Informatik der
Johannes Gutenberg-Universität, 2017

BACHELOR THESES

93| Teichmann, T.:
ETABLIERUNG UND OPTIMIERUNG EINER METHODE ZUR IMMUNO-MAGNETISCHEN ANREICHERUNG UND FLUORESZENZ-MARKIERUNG VON MELANOM- UND KARZINOMZELLEN
Bachelorarbeit. Im Studiengang Bachelor Biosciences, Fachbereich Chemie & Biologie der Hochschule Fresenius Idstein. Durchgeführt im Fraunhofer ICT-IMM, 2017

94| Feldhaus, M.:
ENTWICKLUNG EINES PHOTOVOLTAISCHEN MIR-SENSORS ZUR QUALITÄTSÜBERWACHUNG DER ABGASAUFREINIGUNG
Bachelorbeit. Im Studiengang Umwelttechnik, Fachbereich Ingenieurwissenschaften, Hochschule RheinMain. Durchgeführt im Fraunhofer ICT-IMM, 2017

95| Wieltsch, A.:
SIMULATION DES STRAHLENGANGS DER BELEUCHTUNGSEINRICHTUNG EINES FALLFILM-MIKROREAKTORS MIT COMSOL MULTIPHYSICS
Bachelorarbeit. Im Studiengang Physikalische Technik, Fachbereich Ingenieurwissenschaften, Hochschule RheinMain. Durchgeführt im Fraunhofer ICT-IMM, 2017

96| Darouich, D.:
ENTWICKLUNG EINES ISOLATIONSPROTOKOLLS FÜR MIKROVESIKEL
Bachelorarbeit. Im Studiengang Biotechnik, Fachbereich Life Sciences and Engineering, TH Bingen, University of Applied Sciences. Durchgeführt im Fraunhofer ICT-IMM, 2017

97| Sedita, C.:
VERFAHRENSTECHNISCHE CHARAKTERISIERUNG DER CO_2-ABSORPTION IN EINER MINIPLANT-ANLAGE ZUR HERSTELLUNG VON SYNTHETISCHEN TREIBSTOFF AUS PYROLYSEÖL UND BIOGAS
Bachelorarbeit. Im Studiengang Bioverfahrenstechnik, Frankfurt University of Applied Sciences. Durchgeführt im Fraunhofer ICT–IMM, 2018

98| Münch, J.:
MODELLIERUNG DES [MIKRO]-TRÖPFCHENTRANSFERS ZWISCHEN EINEM MIKROTRÖPFCHENDISPENSER UND EINEM PLASMAMASSENSPEKTROMETER
Bachelorarbeit. Maschinenbau, Hochschule RheinMain. Durchgeführt im Fraunhofer IMM, 2018

MASTER THESES

99| Strauch, A.:
EXPERIMENTELLE UNTERSUCHUNG VON MIKROKANAL-VERDAMPFERN
Masterarbeit. Verfahrenstechnik; Beuth Hochschule für Technik Berlin. Durchgeführt im Fraunhofer ICT-IMM, 2017

100| Durieux, S.:
CHARACTERIZATION OF A CAPILLARY PHOTOREACTOR FOR PARALLEL AND CONSECUTIVE PHOTOCHEMICAL PROCESSING
Masterarbeit. Chemical Engineering and Biotechnology, Ecole Polytechnique Federale de Lausanne. Durchgeführt im Fraunhofer ICT-IMM, 2017

101| Thomas, T.:
DESIGN OF BANDPASS FILTERS FOR HIGHLY INTEGRATED MICRO-OPTICAL SENSORS FOR ONLINE FLUID CHARACTERIZATION
Masterarbeit. Dept. Sensor Systems Technology, Hochschule Karlsruhe. Durchgeführt im Fraunhofer ICT-IMM, 2017

102| Bächler, P.:
EVALUATION OF PHOTOCATALYTIC CO2 REDUCTION IN A FALLING FILM MICROREACTOR AND DEVELOPMENT OF AN IMPROVED PHOTOREACTOR
Masterarbeit. Im Studiengang Process Engineering and Energy Technology der Hochschule Bremerhaven. Duchgeführt im Fraunhofer IMM, 2018

103| Soylu, M.:
CHARAKTERISIERUNG UND ENTWICKLUNG EINES KONTINUIERLICHEN MIKROFLUIDISCHEN POLYMER-CHIPS MITTELS FREE-FLOW-ELEKTROPHORESE
Masterarbeit. Im Studiengang Chemie- und Biotechnologie, Fachbereich Chemie- und Biotechnologie der Hochschule Darmstadt. Durchgeführt im Fraunhofer IMM, 2018

PATENTS

104| Höbel, P.; Maskos, M.:
VERFAHREN ZUR BESTIMMUNG DER MITTLEREN PARTIKELGRÖSSE VON PARTIKELN, DIE IN EINEM FLÜSSIGEN UND FLIESSENDEN MEDIUM SUSPENDIERT SIND, ÜBER DYNAMISCHE LICHTSTREUUNG UND VORRICHTUNG HIERZU
Patentnummer: DE 10 2016 212 164 B3 – Prioritätsdatum: July 4, 2016
Erteilungsdatum: September 21, 2017

105 | Hofmann, C.; Krtschil, U.:
MIKROSTRUKTURBAUTEIL UND VERFAHREN ZU DESSEN HERSTELLUNG
Patentnummer: JP 6174058 B2 – Prioritätsdatum: March 15, 2013
Erteilungsdatum: July 14, 2017

106 | Baßler, M.; Drese, K.S.; Latta, D.:
FLUIDIC SYSTEM, USE, AND METHOD FOR OPERATING THE SAME
Patentnummer: US 9,726,302 B2 – Prioritätsdatum: March 27, 2013
Erteilungsdatum: August 8, 2017

107 | Baßler, M.; Quint, S.:
METHOD FOR DETECTING PARTICLES
Patentnummer: US 9,891,158 B2 – Prioritätsdatum: June 7, 2013
Erteilungsdatum: February 13, 2018

PATENT APPLICATIONS

108 | Frese, I.; Klotzbücher, T.:
GLUKOSESENSOR
Offenlegungsschrift: CN 107072601 A1 – Prioritätsdatum: June 2, 2015
Veröffentlichungsdatum: August 18, 2017

109 | Bleul, R.; Thiermann, R.:
VERFAHREN ZUR HERSTELLUNG VON STABIL DISPERGIERBAREN MAGNETISCHEN EISENOXID-EINKERN-NANOPARTIKEL, STABIL DISPERGIERBARE MAGNETISCHE EISENOXID-EINKERN-NANOPARTIKEL UND VERWENDUNGEN HIERVON
Offenlegungsschrift: DE 10 2015 215 736 A1
Prioritätsdatum: August 18, 2015 – Veröffentlichungsdatum: 23.03.2017

110 | Wink, M.; Baßler, M.:
ISOLATION UND ANREICHERUNG MAGNETISCH MARKIERTER ZELLEN IM DURCHFLUSS
Offenlegungsschrift: DE 10 2015 218 177 A1
Prioritätsdatum: September 22, 2015 – Veröffentlichungsdatum: March 23, 2017

111 | Kolb, G.; Henninger, S.; Kummer, H.; Jeremias, F.; Munz, G.:
WÄRMETAUSCHER UND VERFAHREN ZU DESSEN VERWENDUNG
Offenlegungsschrift: DE 10 2015 224 660 A1
Prioritätsdatum: December 9, 2015 – Veröffentlichungsdatum: June 14, 2017

112 | Bleul, R.; Thiermann, R.; Maskos, M.:
KONTINUIERLICHES VERFAHREN ZUR HERSTELLUNG VON VESIKULÄREN ODER SCHEIBENFÖRMIGEN, SUPRAMOLEKULAREN NANOPARTIKELN, UND VERWENDUNGEN HIERVON
Offenlegungsschrift: DE 10 2015 226 018 A1
Prioritätsdatum: December 18, 2015 – Veröffentlichungsdatum: June 22, 2017

113 | Gransee, R.:
VERFAHREN ZUR HERSTELLUNG EINER VORRICHTUNG MIT ZUEINANDER BEWEGLICHEN, IM MIKROMETERBEREICH BEABSTANDETEN BAUTEILEN, BEREITGESTELLTE VORRICHTUNG UND VERWENDUNGEN HIERVON
Offenlegungsschrift: DE 10 2016 210 010 A1
Prioritätsdatum: June 7, 2016 – Veröffentlichungsdatum: December 7, 2017

114 | Hoffmann, A.; Baßler, M.; Potje-Kamloth, K.; Welzel, K.; Besold, M.:
SENSOR ZUM ERFASSEN EINER FLÜSSIGKEIT IN EINEM FLUIDKANAL
Offenlegungsschrift: EP 3 169 991 A1
Prioritätsdatum: July 18, 2014 – Veröffentlichungsdatum: May 25, 2017

115 | Frese, I.; Klotzbücher, T.:
GLUCOSE SENSOR
Offenlegungsschrift: US 2017/0086716 A1
Prioritätsdatum: June 3, 2014 – Veröffentlichungsdatum: March 30, 2017

116 | Baßler, M.; Besold, M.; Hoffmann, A.; Potje-Kamloth, K.; Welzel, K.:
SENSOR FOR DETECTING A LIQUID IN A FLUID CHANNEL
Offenlegungsschrift: US 2017/0205369 A1
Prioritätsdatum: July 16, 2015 – Veröffentlichungsdatum: July 20, 2017

117 | Bleul, R.; Thiermann, R.:
VERFAHREN ZUR HERSTELLUNG VON STABIL DISPERGIERBAREN MAGNETISCHEN EISENOXID-EINKERN-NANOPARTIKEL, STABIL DISPERGIERBARE MAGNETISCHE EISENOXID-EINKERN-NANOPARTIKEL UND VERWENDUNGEN HIERVON
Offenlegungsschrift: WO 2017/029130 A1
Prioritätsdatum: August 18, 2015 – Veröffentlichungsdatum: February 23, 2017

118 | Frese, I.:
VERFAHREN ZUR BESTIMMUNG DES MITTLEREN TRÄGHEITSRADIUS VON PARTIKELN MIT EINER GRÖSSE VON KLEINERGLEICH 1µM IN EINER SUSPENSION UND VORRICHTUNG ZUR DURCHFÜHRUNG DES VERFAHRENS
Offenlegungsschrift: WO 2017/046337 A1
Prioritätsdatum: September 16, 2015 – Veröffentlichungsdatum: March 23, 2017

119 | Wink, M.; Baßler, M.:
ISOLATION UND ANREICHERUNG MAGNETISCH MARKIERTER ZELLEN IM DURCHFLUSS
Offenlegungsschrift: WO 2017/050649 A1
Prioritätsdatum: September 22, 2015 – Veröffentlichungsdatum: March 30, 2017

120 | Kolb, G.; Henninger, S.; Kummer, H.; Jeremias, F.; Munz, G.:
WÄRMETAUSCHER UND VERFAHREN ZU DESSEN VERWENDUNG
Offenlegungsschrift: WO 2017/097892 A1
Prioritätsdatum: December 9, 2015 – Veröffentlichungsdatum: June 15, 2017

121 | Bleul, R.; Thiermann, R.; Maskos, M.:
KONTINUIERLICHES VERFAHREN ZUR HERSTELLUNG VON VESIKULÄREN ODER SCHEIBENFÖRMIGEN, SUPRAMOLEKULAREN NANOPARTIKELN, UND VERWENDUNGEN HIERVON
Offenlegungsschrift: WO 2017/103268 A1
Prioritätsdatum: December 18, 2015 – Veröffentlichungsdatum: June 22, 2017

122 | Hofmann, C.; Menges-Flanagan, G.:
KONTINUIERLICHES VERFAHREN ZUR HERSTELLUNG VON GRIGNARD-ADDUKTEN UND VORRICHTUNG ZU DESSEN DURCHFÜHRUNG
Offenlegungsschrift: WO 2017/178230 A1
Prioritätsdatum: March 29, 2017 – Veröffentlichungsdatum: October 19, 2017

123 | Gransee, R.:
VERFAHREN ZUR HERSTELLUNG EINER VORRICHTUNG MIT ZUEINANDER BEWEGLICHEN, IM MIKROMETERBEREICH BEABSTANDETEN BAUTEILEN, BEREITGESTELLTE VORRICHTUNG UND VERWENDUNGEN HIERVON
Offenlegungsschrift: WO 2017/211844 A1
Prioritätsdatum: June 6, 2017 – Veröffentlichungsdatum: December 14, 2017

124 | Höbel, P.; Maskos, M.:
VERFAHREN ZUR BESTIMMUNG DER MITTLEREN PARTIKELGRÖSSE VON PARTIKELN, DIE IN EINEM FLÜSSIGEN UND FLIESSENDEN MEDIUM SUSPENDIERT SIND, ÜBER DYNAMISCHE LICHTSTREUUNG UND VORRICHTUNG HIERZU
Offenlegungsschrift: WO 2018/007328 A1
Prioritätsdatum: July 4, 2016 – Veröffentlichungsdatum: January 11, 2018

IMPRINT

EDITORIAL TEAM
Dr. Stefan Kiesewalter
Antonia Winkler

LAYOUT AND DESIGN CONCEPT
2m Advertising GmbH
www.2m-advertising.de

PRODUCTION
H. Kunze GmbH und Partner KG
www.kunze-und-partner.de

EDITORIAL DEADLINE
4/2018

Information on fields of research and detailed contacts are available on both the German and English versions of the Fraunhofer IMM website:
www.imm.fraunhofer.de

PICTURE SOURCES
Titel: istock/Alija
Seite 11: Wikipedia (Wikimedia Commons)
Seite 12, 13: Fraunhofer ICT
Seiten 6, 15, 16, 22 – 55, 57, 65, 67, 68:
Tobias Hang, Fraunhofer IMM
Seite 56, 57: plan|4 architekten GmbH
S. 61 iStock/rclassenlayouts
S. 63 iStock/RapidEye
S. 71 iStock/PeopleImages
S. 72 iStock/Warchi

EDITORIAL ADDRESS
Fraunhofer Institute for Microengineering and Microsystems IMM

Carl-Zeiss-Strasse 18-20
55129 Mainz | Germany

Phone +49 6131 990-0
Fax +49 6131 990-205

info@imm.fraunhofer.de
www.imm.fraunhofer.de

Interested in further information?
www.imm.fraunhofer.de/subscription