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IMM

FRAUNHOFER INSTITUTE FOR MICROENGINEERING AND MICROSYSTEMS IMM

GET TO KNOW US INSIDE OUT

PRECISION, ACCURACY, COMPACTNESS

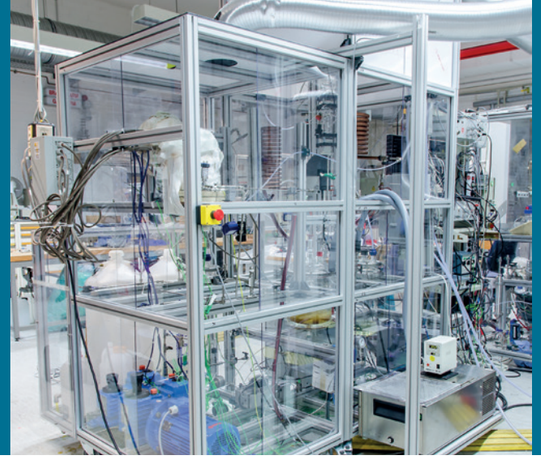
PROVIDING PRECISE, ACCURATE AND COMPACT SYSTEM SOLUTIONS …

… that is exactly what all our employees strive for. Working in the fields of energy and chemical technology as well as analysis systems and sensors we perform the transfer from the scientific idea towards innovation. Using microtechnology and microfluidics we create specific system solutions to be applied in energy technology, heterogeneous catalysis, chemical process engineering, functional materials, nanotechnologies, technical and (bio) chemical analytics, medical diagnostics as well as sensor technology.

We improve the reliability and efficiency of compact substance and energy conversion systems as well as of decentralized mobile energy supply units. We increase process safety and availability of materials, measuring data and information for questions related to products, production and analysis. We improve the reliability of automated, continuous process analysis and process control as well as the robustness of sensor solutions. Our system solutions comprise lab and pilot scale set-ups and can be scaled-up to production, straightforwardly and consistently.

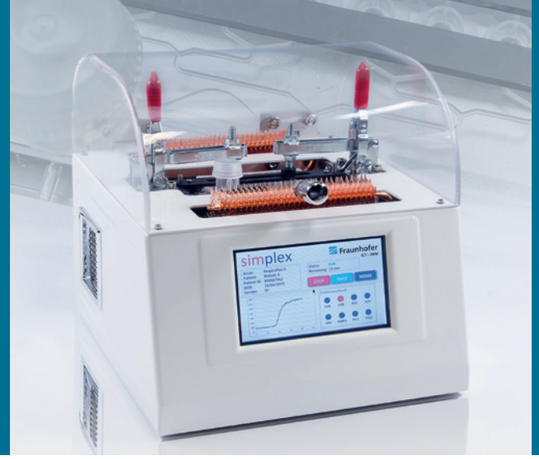
Our ambition is to act in a professional, quality conscious, economic and sustainable manner based on our competencies. We are your competent and valued partner for turning groundbreaking ideas into robust processes and hardware.

EXPERTISES & TECHNOLOGIES



Pilot plant for the production of biodiesel under supercritical conditions

Lab-on-a-chip technology platform for POCT diagnostics



PLANT DEVELOPMENT

Microreactors and -devices allow to increase the economic efficiency and to intensify continuous chemical and thermal processes. Furthermore, they permit an improved control over exothermic reaction or process conditions, respectively. Interconnecting microreactors and -devices in process systems allows very compact plants which are predestinated for decentralized applications in chemical and energy technology. Our services in plant development comprise in general the whole chain from simulation, CAD design via method and process development, basic engineering and detailed engineering up to the provision of components, assembly and initial operation. Besides the actual process equipment including tooling and auxiliary stock, we are able to develop the entire measuring, control and regulating technology (BoP – Balance of Plant). We develop plants for gaseous, liquid as well as supercritical fluids and mixtures. Reaction conditions from cryogenic to high temperature at pressures of up to 400 bar are feasible. Our developments are preferably used in the sectors exhaust gas treatment, air conditioning (mobile and decentralized stationary applications), automotive industry, aerospace, chemical, petrochemical and pharmaceutical industry, energy supply and plant engineering. Typical questions include as well the decentralized fuel synthesis based on renewable feedstock, chemical and electrochemical storage for renewable energy, synthesis of fine and special chemicals as well as pharmaceutical ingredients, synthesis of reactive intermediates, nanoparticle synthesis, photochemistry and heterogeneously catalyzed organic reactions.

ASSAY DEVELOPMENT, ASSAY MODIFICATION AND SYSTEM INTEGRATION

Core part of any molecular biological detection method is the so-called assay, a standardized reaction process to evidence a substance. Once the application setting changes, usually the biochemical processes have to be adapted. A mere adjustment of the automation hardware is, however, not sufficient. Some steps of the assay need to be modified as well. Our expertise as well as the comprehensive and, at the same time, profound understanding of the assay development in combination with our experience in the field of systems engineering comprise: nucleic acid based tests and their integration into microfluidic cartridges (including sample preparation and extraction, amplification and lyophilization of reagents), cell-specific immunomagnetic separation, cost-efficient plasmid DNA isolation out of one liter of bacterial culture, development and integration of ELISA based assays as well as the enrichment and analysis of proteins and cells/bacteria from a large volume (without chromatographic methods and centrifugation).

ELECTRONIC AND SOFTWARE ENGINEERING

Integrated software and microelectronics are integral parts of modern analysis and control systems. We accompany our customers during the entire development process, starting from the conception phase via layout and design up to the integration and fabrication of individual systems. Doing so, we offer different hardware solutions independently if we are dealing with control or analysis systems being connected to a personal computer via USB or with stand-alone systems comprising an integrated user interface. Depending on the range of functions we use either so called bare-metal micro controller systems or integrated Linux systems. Typical application areas are the development of integrated control systems for lab-, analysis-, and measuring instruments, development of partial circuits or, respectively, subcomponents for existing systems, transfer of electronic circuits into 3D models for an implementation into the mechanical construction, lab automation of existing systems, also in combination with new developments, assembly of printed circuit boards of prototypes and smallest batch series, software development for embedded systems, lab automation and for evaluation systems in cooperation with our simulation team.

CATALYST DEVELOPMENT

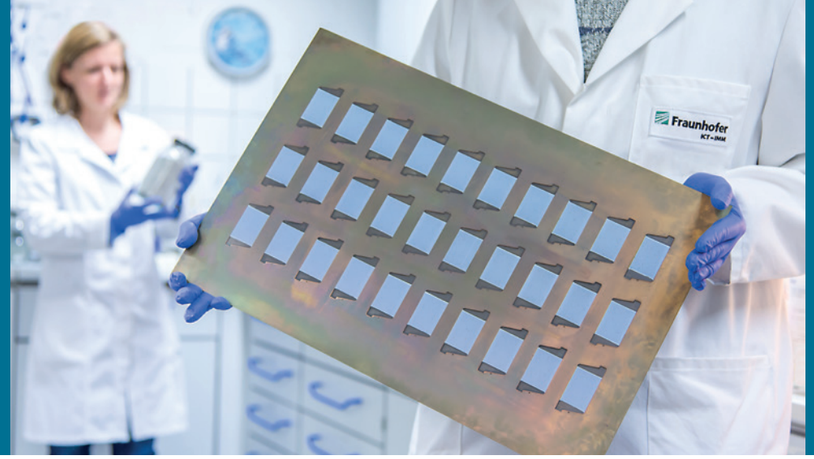
We develop catalysts and catalyst coatings ideally suited for use in microstructures being optimally adapted to reactor type and scale of your process. Catalysts can, for instance, be tested as powder in a fixed-bed reactor or as a layer onto monolithic or microstructured substrates. The small channel dimensions in microstructured reactors allow faster heat and mass transfer and offer a significantly larger inner surface area in relation to the inner volume compared to conventional reactors. Our existing portfolio of long-time stable catalyst formulations allows to carry out various heterogeneously catalyzed gas phase reactions. Our portfolio comprises, among others, the hydrogen generation via reforming reactions using hydrocarbons (methane, biogas, propane, butane, diesel) and alcohols (methanol, ethanol, polyalcohols), hydrogen generation via partial oxidation of propane and biogas, hydrogen purification, the catalytic combustion of VOC containing exhaust gas and purification of exhaust streams containing carbon monoxide or hydrogen, catalytic combustion for the internal heating of plate heat exchangers as well as the conversion of carbon monoxide into methane (power to gas).

LASER MICROMACHINING

Our long-time experience in laser micromachining is the basis from which we elaborate individual solutions in the course of our cooperation with project partners. The contactless processing without transmission of force as well as the high accuracy and speed are only some of the features that make the use of a laser attractive to microtechnological applications. With suitable methods even structures in the nanometer range can be achieved. These methods include two-photon-absorption or interference lithography. We offer to conduct technological feasibility studies, the realization of functional models as well as the fabrication of pilot series. If desired, we arrange a technology transfer or build up systems which are tailor-made to meet the requirements of our customers. Typical application examples of laser micromachining are laser welding of reformers and microreactors, polymer welding used for applying a cover foil to polymer chips, micro drilling of polymers, metals and ceramics, 3D nanostructuring as well as the ablation for the realization of microfluidic structures, to name a few.

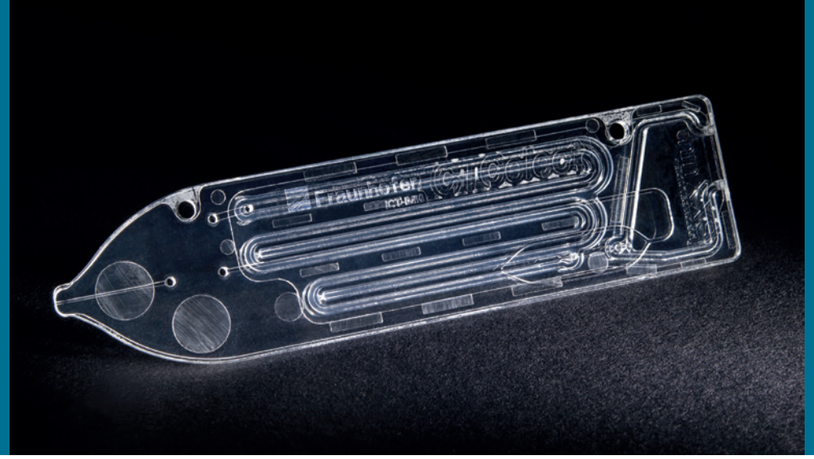
MICROFLUIDICS

The use of microfluidics and the related system technology for the handling of liquid quantities from the micro- to picoliter range, the so called lab-on-a-chip technology, resulted in significant progress with respect to the development of efficient analysis methods and, thus, has revolutionized lab technology. The combination of high sensitivity and resolution combined with shorter analysis times and high throughput makes lab-on-a-chip technology interesting for the user. As a pioneer in this field, we are developing microfluidic systems as well as novel sensing methods for chemical analytics and life science applications for more than 20 years. In doing so, we use innovative physicochemical methods and implement automated and optimized workflows. We understand a fully integrated analysis system as a combination of mass producible microfluidic components (often injection molded cartridges) and the related operating device enabling miniaturized and portable system solutions for novel laboratory or on-site applications. Our microfluidic systems are applied in automated laboratory measurement instrumentation, process and quality control for industrial production processes, life science applications, medical diagnostics, food safety, environmental monitoring and the protection against biological hazards.



Panel with coated catalyst platelets

Microfluidic cartridge for single cell dispensing



NANOPARTICLE SYNTHESIS AND CHARACTERIZATION

Nanoparticles made from inorganic and organic/polymer materials have unique properties, which have already been demonstrated in various applications in material sciences and life sciences. This comprises coatings, adhesives, polymers, catalysis, paper, assembly and packaging technology, textiles, food, cosmetic and pharmaceutical products. When synthesizing nanoparticles, one of the major goals is a high reproducibility. While the reproducibility is one of the biggest challenges in conventional batch synthesis, continuous synthesis can eliminate this problem making use of a series of inherent advantages. This allows access to high quality uniform particles. We are developing modular reactors for different nanoparticle systems to be used with continuous synthesis routes such as liquid phase reactions with rapid mixing and, if required, high temperatures up to for instance 400 °C. Central parts of the setup are our microfluidic mixers in combination with temperature-controlled reaction zones. Integrated on-line process analysis provides valuable information about critical product parameters and, thus, permits a real-time quality control.
We give your particles the desired properties, whether fluorescence, magnetism, catalytic activity, fouling inhibition, durability (for instance against temperature, humidity, heat, light), antimicrobial surfaces, protein repelling, biocompatibility or ion and gas selectivity, respectively. We encapsulate active components for in-situ release and functionalize particles for improving specificity and effectivity in the release of active substances at the target site. Specific particle systems we are working on are for instance fluorescent quantum dots, single core iron oxide nanoparticles as well as polymer particles and capsules.

OPTICAL SPECTROSCOPY

Methods of optical spectroscopy are perfectly suited to determine certain material properties such as bond energy, chemical composition, structure or optical density. A sensory detection as done in preliminary on-line analysis of chemical solutions or the creation of a calibration curve requires spectroscopic analyses being performed with mature lab equipment. We carry out spectroscopic measurements in the course of technological feasibility studies evaluating the data gained correspondingly. This is the basis for the design of miniaturized optical sensor systems which are tailored to the requirements of customers dealing with chemical, industrial and biological analysis. Thus, the water content, the level of oxidation and the total base number (TBN) can be determined as well as the hydrogen peroxide and the sulphuric acid content in DSP solutions. We can measure the glucose concentration in blood, detect poisonous gases and chemical compounds in catalyst layers as well as fluorescence light for cell counting or PCR conversion control.

POLYMER PROCESSING

Polymer materials are an indispensable part of, in particular, microfluidic and optical analysis applications. We have long-time practical experience with the realization of micro-structured polymer parts, for instance microfluidic chips, polymer waveguides or micro lenses. We guide you through the entire process from the idea generation via molding techniques, assembly and packaging technologies and surface treatment up to small series. The process portfolio we have at our disposal comprises cutting precision engineering, laser material processing, 3D and screen printing processes, plasma treatment, spotting, hot embossing and injection molding.
We have extensive experience in assembly and packaging technologies for the realization of (hybrid) complete systems. This includes the covering of multilayer polymer channels, the integration of lithographically structured silicon and glass components, applying metal layers/electrodes or the incorporation of membranes and filters as well as surface modification procedures.

REACTOR DESIGN AND DEVELOPMENT

We use our extensive hardware portfolio as well as our long-time experience to develop individually adapted reactors in a modular and scalable design meeting the requirements of the process to be optimized. At the same time we make use of cost-effective fabrication processes. Thanks to their properties, micro- and millistructured reactors or devices are ideally suited to solve the issues described, especially when continuous synthesis processes are applied in the special and fine chemical field as well as in the synthesis of active pharmaceutical ingredients. Even larger quantities are not a problem. Meanwhile, we have a wide portfolio of very often highly integrated solutions for single-phase or multi-phase processes as well as for non-catalytic, heterogeneously and homogeneously catalyzed reactions. Controlled processing and a significantly reduced reaction volume compared to a conventional reaction apparatus allow to increase process safety. Applying novel fabrication technologies we have manufactured and successfully tested special reactors for the decentralized energy production based on fuel processor technology for hydrogen and fuel cells in large quantities. Highly exothermic processes, the production and work-up of hydrogen containing gases for fuel cells, the decentralized production of critical (dangerous) chemicals, different processes in the bio refinery field as well as gas/liquid contacting are typical questions we are dealing with.

CLEANROOM AND SILICON TECHNOLOGY

Focus of our research and development work in the field of silicon and thin film technology is on the realization of innovative sensors, system components and product applications according to our customers coming from the fields of industrial metrology and analytics, medicine and aerospace. Our service portfolio comprises design and simulation, process development, realization of demonstrators for the verification of feasibility, pilot series in documented quality for further validation by the customer in product use. Examples for application developments performed on direct customer's order or in the course of research partnerships are 3D force sensors for pressure and shear forces, flow rate sensors for gases and liquids, density sensors for liquids, helium and hydrogen detection via highly selective thin film membranes, bolometer sensors for fusion research with high radiation and temperature resistance, flexible and rigid multichannel micro electrode probes for neuroscience research and neuroprosthetics as well as micro electrode structures for electrochemical analysis.

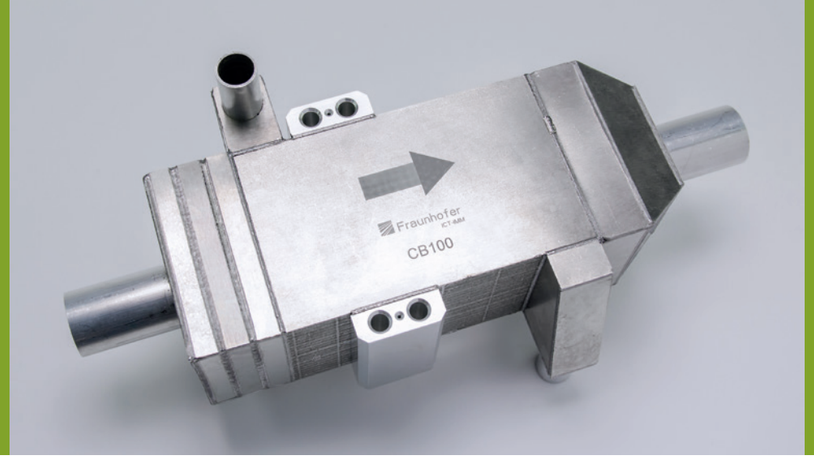
SIMULATION

Numerical simulation and mathematical modelling are an integral part of our research and development projects and important tools to speed up and optimize product development. This starts with problem analysis, continues with the selection of the appropriate simulation environment, the optimization of components, systems and processes and ends with data interpretation. The interplay between simulation and experimental development work allows us to address various questions, such as fluid dynamics, heat transfer, mixing and chemical reactions, the interaction with electric and magnetic fields, multi-phase systems and the propagation of optical beams. At the same time we work on developing and improving simulation tools being optimized for the use with microsystems.

INNOVATION FIELDS

Test plant for cryogenic fuels (in an external container)

Reactor for exhaust gas purification



HYDROGEN TECHNOLOGY – USE OF MICROSTRUCTURED COMPONENTS INCREASES SYSTEM EFFICIENCY

We develop complete fuel processors based on microstructured plate heat exchanger technology. Our skills comprise the conception and integration of system components including process control, testing up to the pilot scale and – depending on the task – even the development of stable catalysts for the individual steps of the fuel processor. Additionally, we care for all aspects of production technology for the components. Thereby, we use all conventional and regenerative fuels such as natural gas, methanol, ethanol, liquid gas, gasoline and diesel, but also polyalcohols which occur as by-products in biodiesel production or which are used as cooling agents in applications such as aerospace. We cover a performance range of 100 W up to 100 kW+ and a temperature range of -250 to 950 °C. Project-related we already worked on solutions for the hybrid transport of cryogenic fuels, electric current and data in an innovative, thermally super-insulated umbilical cable. The high energy density of liquid hydrogen generally comes along with very small cross sections and limited flow rates. For the system components and the assembly of decentralized energy infrastructure systems this suggests the application and further development of microstructured components.

FUEL PROCESSORS – MICROTECHNOLOGY ENABLES THE DEVELOPMENT OF COMPACT AND EFFICIENT SYSTEMS

In the context of fuel cell systems hydrogen is tested and applied in the automotive and marine sector but also for portable power supply solutions for applications such as electronic devices and camping as well as for small power stations. Fuel processors are required for the production of hydrogen out of fossil and regenerative fuels. The integration of the single components into a completely thermally integrated fuel processor is a critical step on the road to a marketable product. Compactness, maximum efficiency and short start-up times are important goals during the development process. In the field of fuel preparation and synthesis we develop complete solutions from the lab to pilot scale and even further to production scale. Our expertise comprises the modelling of the process, the optimization of heat integration, the design of the reactors and peripheral components (such as evaporators, heat exchangers, condensers), the layout or selection of the reactors and components (such as evaporators, heat exchangers, condensers, pumps, blowers, valves), the construction of the reactors and components, the manufacturing of the prototypes or pilot series respectively as well as the integration of the complete system. Tests on single components, the development of the system control and tests on the entire system up to pilot scale complete the competencies. We complement and support this work with our expertise in catalyst development and a manufacturing technology which is suitable for series production.

CATALYSIS – INCREASING THE CONVERSION AND SELECTIVITY IN CHEMICAL REACTIONS

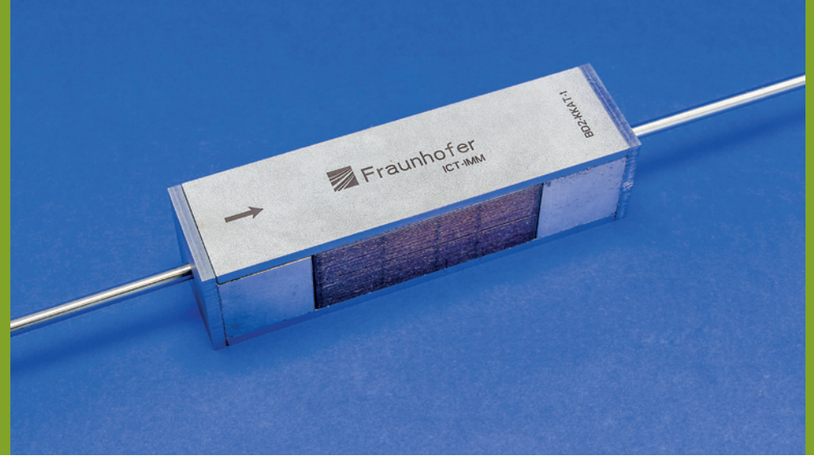
In addition to the development of new catalysts, the optimization of existing catalyst formulations with regard to selectivity and activity is as much part of our services as the stabilization of the catalysts for robust use in a real process environment. This includes the optimal adaptation to the type of reactor and the scaling of your process. For the heterogeneous gas-phase catalysis, our current focus is on the generation of hydrogen by reforming hydrocarbons (such as methane, biogas propane, butane, diesel, kerosene) and alcohols (such as methanol, ethanol, polyalcohol), the production of hydrogen by partial oxidation of propane and biogas, hydrogen purification which means depletion of carbon monoxide using the water-gas shift reaction and the selective oxidation of carbon monoxide, the catalytic combustion of volatile organic compounds (VOC) in exhaust gases and purification of exhaust gas streams containing hydrocarbons, carbon monoxide or hydrogen, the catalytic combustion for the internal heating of plate heat exchangers, the methanol synthesis from synthesis gas, the conversion of methanol to gasoline (methanol-to-gasoline, MTG), the conversion of synthesis gas to synthetic fuels (Fischer-Tropsch synthesis) as well as the conversion of carbon dioxide to methane (power-to-gas). Examples of heterogeneous liquid phase catalysis and multiphase catalysis are the single-phase production of biodiesel, the single-phase or two-phase Suzuki-coupling reactions, the selective hydrogenation of carbon-carbon triple bonds (gas/liquid) and the hydrogenation of nitro groups (gas/liquid). Amongst others, we have already investigated the following homogeneously catalyzed reaction systems: oxidation reactions, esterification, enzymatic oxidation of glucose and photo catalysis.

HEATING AND COOLING MANAGEMENT – HIGHLY EFFICIENT HEAT TRANSFER THANKS TO MICROSTRUCTURED COMPONENTS

Microstructured components enable a highly efficient heat transfer at a low pressure drop. The portfolio of laser welded and brazed heat exchangers we developed for the heat transfer between gas flows as well as for evaporation and condensation processes allows for very high operating temperatures and pressures. We have the experience in and the technology for heating / evaporation of gases and liquids by means of electrical energy. In our test and pilot plants we use electric heating components being developed in-house. Depending on the application, we can realize heat exchanger components for operating temperatures between -250 °C and 950 °C. The maximum gas flow rate depends on the specified pressure drop and can be up to several 100 m^3 per hour. Typical parameters are heat-transfer capacities up to 100 kW and specific heat exchange surfaces up to 2400 m^2 / m^3.

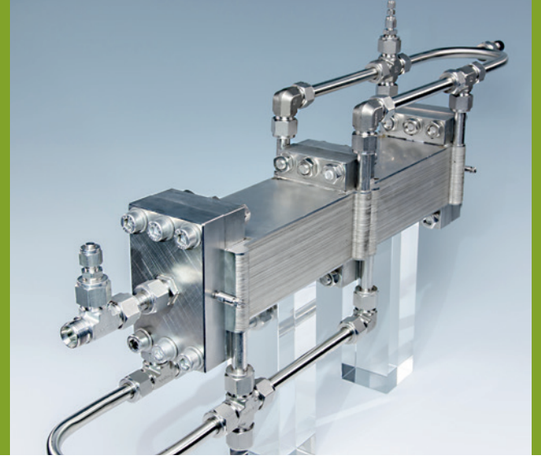
EXHAUST GAS PURIFICATION – MODULAR AND STATIONARY EXHAUST GAS PURIFICATION, CATALYTIC COMBUSTION

In order to clean exhaust gases from industrial processes as well as from individual emissions, many different processes are implemented. The goal of all purification processes is the decontamination of exhaust gases from polluting and unhealthy substances, and hence, keeping our breathing air clean. Catalytic exhaust gas purification is used for example in every modern car. The comparatively low energy requirement for the chemical reactions of these exhaust gas purification processes is a huge advantage. At the same time, the sensibility of the catalyst to contaminations and so-called catalyst poisons must be taken into account. We have considerable knowledge of robust, long-term stable catalyst technology and have extensive know-how and experience when it comes to reactor design (also on the kW scale) and the integration of the reactors into complete fuel processors. We meet tasks concerning exhaust gas purification by individually customized solutions. We count on catalytic processes that include integrated cooling functions and highly efficient, tailored heat exchangers to control exothermic processes. This allows to improve the heat management of the dynamic operation of automotive exhaust gas purification systems. In the field of fuel processing technology we have particular expertise in eliminating carbon monoxide out of the reformate flow via water-gas shift, preferential (selective) oxidation of carbon monoxide, selective methanation, as well as in the elimination of critical (toxic) substances out of exhaust gas flow by catalytic combustion.



Laser-welded microreactor for the biodiesel production

Modular microreactor



BIOFUELS – ROBUST PRODUCTION OF BIOFUELS THANKS TO MICROREACTORS AND SUPERCRITICAL PROCESS CONDITIONS

In diesel fuel the formerly used sulfur compounds which worked also as lubricants are replaced by biofuel. This reduces the CO_2 emission of the replaced fossil diesel by 70 %. The production of biodiesel from vegetable oils in the conventional homogeneously catalyzed process however has a number of disadvantages. We are able to realize a robust production of biodiesel even from waste material such as used cooking oil and also in the presence of free fatty acids. This gets feasible by using microstructured reactors in a heterogeneously catalyzed process conducted under supercritical conditions. Simultaneously, the generation of waste water as well as the energy consumption is minimized compared to the conventional process and reactor dimensions can be decreased. Fields of application are decentralized plants which produce biodiesel from waste materials, flexibly and on-site, and without long transport routes. In the scope of the development of integrated bio refinery concepts we research novel routes for the generation of basic chemicals such as methanol and higher alcohols as well as for the production of fuels from regenerative energy sources via the methanol-to-gasoline processes. In the latter case, methanol and ultimately gasoline components are synthesized out of pyrolysis oil and biogas. Our plate heat exchanger technology allows for process intensification and the improvement of heat integration of the envisaged decentralized plant technology.

SYNTHESIS OF BIOFUELS – REACTORS WITH INTEGRATED HEAT EXCHANGER ALLOW FOR PRECISE PROCESS CONTROL

Biodiesel is a first generation biofuel and is gained in a conventional process by transesterification of vegetable oil with methanol at standard pressure and temperatures between 55 and 80 °C. This process is comparatively slow and the reaction times usually take up to four hours. Key technology of the alternative process we have developed is the catalyst which is applied in solid form as a layer on a metallic carrier. Thus, the catalyst does not have to be separated later in the process and, additionally, reaction time can be shortened to a time demand between half a minute and five minutes. Synthesis gas, a mixture consisting of hydrogen and carbon monoxide, serves as starting point for the value chain of a substantial part of second generation biofuels. For this purpose, the biomass initially is split up into solid, liquid and gaseous fractions in a pyrolysis process. Especially from the liquid, organic fraction the required synthesis gas can be produced via reforming reactions. In the scope of a project dealing with the realization of integrated bio refinery concepts, we are currently developing a process for the production of synthesis gas from pyrolysis oil and biogas via autothermal reforming. Our objective is the demonstration of feasibility as well as the further conversion of the synthesis gas with the help of a miniplant being built-up in a mobile container environment. For the production of hydrogen we develop highly active and efficient catalysts for water-gas-shift and selective oxidation of carbon monoxide. The required catalysts are preferably deposited into plate heat exchanger reactors. The configuration of specific temperature profiles allows us to intensify the aforementioned reactions and simultaneously improve the heat integration primarily of decentralized plants. For the gasoline synthesis we convert methanol into a mixture of hydrocarbons of the gasoline fraction, preferentially in presence of zeolitic catalysts. The very exothermic reaction process is putting high demands on the heat management. Due to our reactor technology with integrated heat exchanging functions the precise control of the reaction temperature becomes possible.

ENERGY STORAGE – CONVERSION OF RENEWABLE ENERGY INTO METHANE, FUELS AND CHEMICALS

Renewable energy sources such as photovoltaics and wind power increasingly generate considerable surpluses of electrical energy which may exceed the capacity of the power grid. A surplus of electrical energy can be used for electrolysis of water to produce hydrogen. The conversion of hydrogen with carbon dioxide into methane is a promising alternative to the chemical storage of excess renewable energy. Carbon dioxide is a by-product in many industrial processes but as such can also come from regenerative sources. Normally it has to be released into the atmosphere. To convert this greenhouse gas into methane provides a smart way to defuse its impact on the environment. Our reactor technology allows for the improvement of the thermal management for this methanation reaction. We also work on alternative reactor concepts for the chemical storage of electrical energy based on electrochemical reactions.

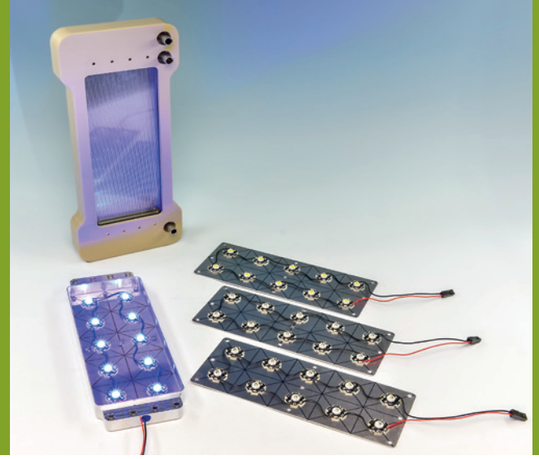
FLOW CHEMISTRY – ACCESS TO INTENSIFIED CONTINUOUS SYNTHESES

Microreactors or, more generally, flow reactors enable a precise control of chemical processes. This fact and the conversion of chemical processes from batch to continuous processes correlated with the use of flow reactors allow an intensification of the processes as well as the improvement of their efficiency. Often, the use of flow reactors serves to overcome mass or heat transport limitations in chemical reactions. Additionally, flow reactors allow opening up novel process windows by a better control of extreme reaction and process conditions. We carry out customized, experimental process development in a lab environment which is focused on continuous processes. The use of micro- and flow reactors respectively leads to advantages such as a higher product selectivity and yield in many organic reactions by minimizing side reactions, the production of materials with tailored properties (for instance particle size, morphology) by precise control of process conditions as well as a quick adaptation to changing process parameters. An efficient, sustainable and cost-effective production is getting possible due to a reduced use of raw materials and energy. The development of new chemical processes can be accelerated and optimized. Ozonolysis, halogenation reactions, the synthesis of ionic liquids, nitration, hydrogenation, epoxidation and ethoxylation reactions as well as polymerizations are classic examples that benefit from being processed in flow reactors. We currently also deal with photochemistry, heterogeneously catalyzed organic reactions, the synthesis of reactive intermediates (such as Grignard reagents) and nanoparticle syntheses.

REACTIVE INTERMEDIATES – IN-SITU PRODUCTION OF GRIGNARD REAGENTS WITH CONTINUOUS PROCESS CONTROL

The synthesis of Grignard reagents and their conversion with a variety of organic molecules such as ketones and aldehydes has been one of the most effective methods of C-C bond formation. The actual Grignard reagent formation here represents a reaction that can immensely benefit from a continuous process. This enables the use of a large magnesium excess to suppress unwanted side reactions such as Wurtz coupling, the improved heat transfer prevents a runaway of the reaction. Other outstanding aspects are the continuous supply of magnesium, an integrated magnesium activation and process control as well as an in-line analysis via IR measurements. It is the ultimate objective of our work to produce reactive intermediates like Grignard reagents in a continuous process in-situ. We are able to detect them in-line, check their quality and, in a second step, we can convert them directly into the desired product. In our first pilot reactor throughputs depending on the Grignard reagent of 5 – 50 ml/min in a temperature range of 10 – 60 ° C are possible.

Grignard reactor (lab-scale)



Falling film microreator with LED illumination devices for photo chemistry

ELECTROCHEMICAL SYNTHESIS – AN EFFICIENT AND ENVIRONMENTALLY FRIENDLY PROCESS FOR INDUSTRIAL USE

Because of the large oxidative and reductive potential range being directly accessible by electrochemical methods, they are in particular of great interest for industry for the production of organic compounds. Electrochemical synthesis methods have the outstanding advantage to allow reactions without "substantive" reagents, which otherwise would have to be separated in their used form from the reaction products. For nearly 20 years, we have been building and investigating electrochemical (micro)reactors for diverse applications within the framework of internal, national and European projects as well as in direct contract research for industry. Thereby, electro-organic synthesis is one of the most important areas e-reactors were designed and constructed for. Our electrochemical reactors are based on the thin-layer cell or thin-gap cell concept. The resulting advantages are, compared to the conventional type of construction, primarily due to the small electrode spacing (in the range ≤100 µm). These include low ohmic resistances, low energy losses, short diffusion paths, effective heat control, homogeneous mass and power distribution, greatly reduced need for conducting salt as well as shorter residence times. Overall, we are able to significantly increase conversion and selectivity of your reactions.

SUSTAINABLE DRUG SYNTHESIS – FROM BATCH TO FLOW PROCESSING

High selectivities and yields play a particularly important role in the individual synthesis steps of the mostly multi-stage synthesis of active pharmaceutical ingredients. Similarly, waste prevention, the efficient use of raw materials and the minimization of energy use as well as the implementation of a real-time process monitoring is essential. Our starting points for the targeted innovations are based upon the transfer of batch processes into continuous processing, the use of microreactors and flow chemistry approaches in synthesis and the integration of in-line sensors as a basis for effective process control. Thanks to a precise control of the reaction by effective mass and heat transfer we can achieve higher product selectivities and yields in many organic chemical reactions. Synthesis routes are simplified since reactive intermediates can be produced in-situ and can directly be processed. Catalysts which are immobilized in flow reactors additionally reduce downstream processing efforts. Photochemical reactions are being processed under milder reaction conditions and do not require toxic reagents, the residues of which have to be separated at a later stage.

PHOTOCHEMISTRY – MICROSTRUCTURED FLOW REACTORS INCREASE PROCESS EFFICIENCY

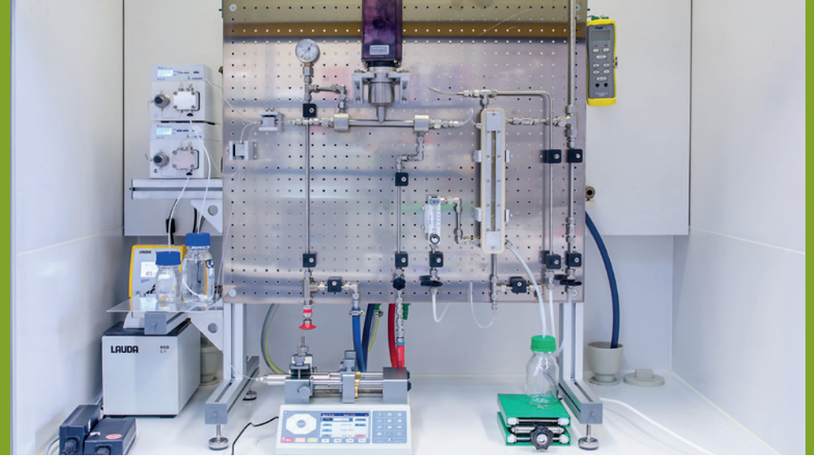
Microstructured flow reactors are perfectly suited for performing photochemical syntheses. The formation of very thin liquid films in microchannels or capillaries allows full irradiation of the reaction solution and thus an optimum utilization of the incident light. A precise control over the irradiation period results from the exactly defined volume in the channels and capillaries. Therewith, we can prevent both, the by-product formation and the decomposition of the reaction components caused by excessive radiation. Concerning the light input we count on energy-efficient LEDs which allow a very selective excitation of the photocatalyst or of the reaction substrate due to their quasi-monochromatic light emission. Besides the efficient light irradiation into the reaction solution, efficient contacting of the liquid or gas phase with heterogeneous photocatalysts in the microchannels is realized. The combination of efficient light input and material bonding forms an excellent basis for the reactor and process development for complex photochemical applications. Various falling film microreactors and capillary photoreactors are at our disposal for this kind of work. For our photocatalysts we use organic sensitizers, organometallic complexes, heterogeneous metal oxides and immobilized inorganic photocatalysts that are modified or doped with organic sensitizers. The photochemical applications include the in-situ generation of singlet oxygen for photo-oxigenations, photo-oxidations, photo-hydrogenations, cis-trans isomerizations, fluorinations and nanoparticle manufacturing.

ENCAPSULATION OF ACTIVE INGREDIENTS – EFFECTIVE PRODUCTION PROCESS FOR POLYMER-BASED PARTICLES

The encapsulation of active ingredients is essential for many applications. It prevents incompatibility between different materials or protects an active ingredient by the complete separation from the environment. Encapsulation improves the handling of adhesive materials, preserves reactive agents or permits the selective control of the release of an active ingredient or perfume. Depending on the requirements of the application, we can realize homogeneous particles as well as capsules with a "core-shell"– or a "multi-core" morphology in a continuous process. The material selection based on many years of experience combined with effective production processes is part of the expertise that allows us to develop polymer-based particles or capsules with customized properties. We adapt chemical composition, particle size, morphology and surface functionalization according to customer requirements. We use different formulation processes for preparing particles and capsules, such as emulsion / dispersion polymerization, self-assembly of amphiphiles, surface polymerization / polyaddition / polycondensation and emulsification / solvent evaporation process. Materials used for particle and capsule shells are, for instance, polyacrylates, polysiloxanes, polyurethanes, polyalkylcyanoacrylates, polylactides and their copolymers, polysaccharides, phospholipids and non-ionic surfactants, block copolymers and waxes.

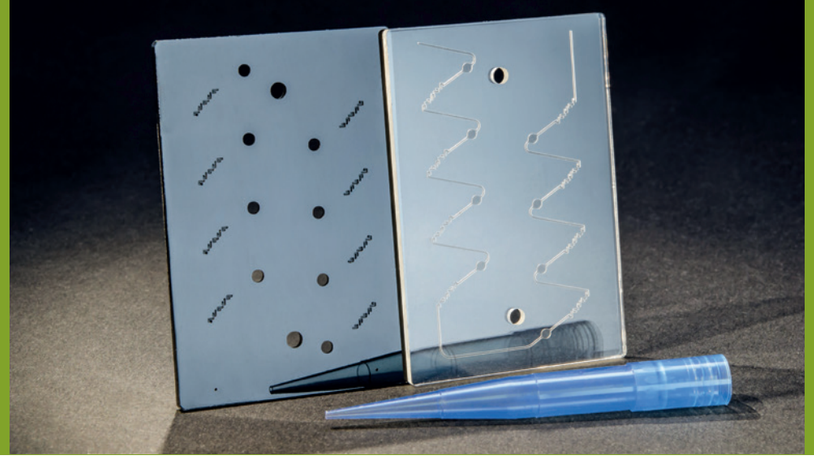
NANOPARTICLES – SMALL PARTICLES ALLOW THE OPENING UP OF COMPLEX APPLICATION SCENARIOS

The more complex application scenarios are, the more urgent the demand for tailor-made and, above all, consistent product quality is getting when dealing with nanoparticles. We master efficient and effective continuous synthesis processes as well as state-of-the-art analytics which, in the interplay with knowledge in microbiology and surface- and boundary-layer technique, also allow an adequate risk assessment. Due to our long-time experience in the field of chemical micro process engineering as well as in the design and realization of continuous chemical processes in flow chemistry we are capable to confer the desired properties to your particles in a reproducible quality. We are scaling processes while exactly controlling process parameters like flow rate and temperature as well as adjusting particle size and shape. Particles can be functionalized accordingly to improve specificity and effectivity. We have capabilities for the encapsulation of active components, the characterization of nanoparticles in liquid and solid media, the measurement of particle size and concentration of nanoparticles and to realize close-to-reality systems for the examination of the interaction between nanoparticles and biological material. Our expertise in continuous synthesis comprises the use of modular reactors (for instance in liquid phase reactions), rapid mixing, the realization of high temperatures (for instance wet chemical synthesis at up to 400 °C) and temperature-controlled reaction zones as well as integrated on-line process analytics. Our existing portfolio of analytical procedures consists of electron microscopy (REM, TEM, cryo-TEM), dynamic and static light scattering, analytical centrifugation, optical spectroscopy (transmission, absorption, UV-VIS, fluorescence, FTIR, on-line measurement) and the measurement of the streaming- or zeta potential.



Lab-scale plant for the encapsulation of active ingredients or flavoring agents

Microfluidic chip for on-line titration



PROCESS MONITORING – OPTIMIZATION OF PROCESS PARAMETERS VIA ON-SITE MEDIA ANALYSIS

The monitoring of chemical, process-relevant parameters in industrial production in addition to the control of the physical parameters is decisive for a safe process management. Intelligent analysis systems are able to constantly monitor these parameters either in-line or on-line, i.e. in bypass mode. By the timely provision of the analysis results, these simplify the automated monitoring, the control and regulation of the processes and, beyond that, depending on the configuration, even their optimization. Our systems are particularly suited for applications based on process parameters with short or medium half-lives. Thereby, one or more parameters can be determined simultaneously and various methods of analysis (chemical, optical and optical-spectroscopic) can be combined, such as direct measurement (pH value, redox potential, conductivity, potentiometry with ion-selective electrodes, refractive index, density, viscosity), on-line titration, photomery / spectroscopy, voltammetry. Typical fields of application for these monitoring technologies are electroplating technology, chemical process technology, water analysis, biotechnology and food technology.

WATER ANALYSIS – CHIP-BASED MICRO-ANALYSIS ALLOWS FOR THE SIMULTANEOUS DETERMINATION OF SEVERAL PARAMETERS

With their integrated data evaluation and transfer microfluidic analysis systems become a more and more powerful tool for modern environment analysis. Additionally, they reduce the consumption of chemicals to a minimum and allow for previously unaccessible measurements on-site or in-line. Our fully integrated microfluidic analysis systems based on the lab-on-a-chip concept offer a fast, reliable and cost-saving way for this purpose. Within these portable system solutions, we combine many individual steps required for analysis carried out in a laboratory or on-site, to an automated and optimized integrated process. It starts with sample collection and ends with output of the result. Possible applications are quality assurance of production processes in industrial companies and monitoring of guidelines and recommended limit values, e.g. in surface water, fish farming water, public swimming baths or private households. The control of the pathogen number and the cell counting in public baths certainly are particularly relevant application examples. Our existing portfolio includes fully automated ion analysis, on-line micro titration for process control, measurement of turbidity and conductivity as well as automated preparation of complex samples.

LAB-ON-A-CHIP FOR POINT-OF-CARE TESTING – HOW MINIATURIZATION SPEEDS UP DIAGNOSES

The trend towards miniaturization has become well established in medical diagnostics and will be further continued, in particular by use of the lab-on-a-chip technology which enables rapid tests in disposable plastic chips. Therefore, innovative physicochemical methods are miniaturized and automated. The key challenge of on-site analysis (point-of-care testing) is to downsize the measurement systems to compact and, thus, portable devices. The spectrum of analytes ranges from ions, biomarkers and DNA to living cells or pathogens (bacteria and viruses) which can directly be isolated and detected from a blood, saliva or swab sample. The development of advanced sample preparation methods (one example among others is the so called “liquid biopsy”) combined with sensitive measurement technologies (e.g. nucleic-acid or immunodiagnostic based) allows for a complete, automated sample analysis (sample in – answer out). Due to the unique, broad coverage of all necessary core technologies (integration of bioassays, chip design and manufacturing, systems engineering, prototype and apparatus engineering, optics and sensor technology, electronics and software) we are able to rapidly develop an application idea to a fully functional demonstrator. We adjust your assay to an automated microfluidic environment and develop customized detection assays and total systems for point-of-care testing or patient monitoring. Thereby, the processes and the production costs are optimized with regard to the commercialization of the systems.

CBRN DETECTION – RAPID IDENTIFICATION OF THREATENING SUBSTANCES IN THE AIR

The release of biochemical substances in the context of a terrorist attack is a scenario which unfortunately is no longer unthinkable. A rapid detection of biological pathogens or toxins, thus, may prevent dangers in the event of such a crisis and save human lives. The development of innovative technologies at Fraunhofer IMM includes the required sample preparation of unknown biological substances. Especially for the analysis of high-volume air samples, a pathogen concentration as well as the removal of inhibitors is necessary. The use of microfluidic, contamination-safe disposable cartridges in combination with robust analytical methods, such as sensitive and ultrafast qPCR, enables the realization of automated systems with high multiplexing functionality. By eliminating manual steps, the reliability of the analysis increases and risks for the users are significantly reduced by avoiding potentially dangerous handling errors. We develop and optimize customized detection assays as well as overall systems for monitoring critical facilities and critical infrastructures as well as for the analysis of environmental or food samples.

OIL SENSOR TECHNOLOGY – COMPACT AND ROBUST SENSORS FOR CONDITION MONITORING

In many areas, such as in ship’s engines, wind turbines or landfill gas engines, real-time monitoring of the lubricant or gear oil is essential to control the condition of the oil and the operating status of the machine. Doing so, engine or transmission failure can be prevented, downtimes can be minimized and, thereby, operating expenses can also be reduced. For this purpose and based on various spectroscopic, chemical and physical processes, we develop miniaturized on-line sensors, which are characterized by a high degree of integration, high robustness and low cost. We support our partners from the idea via simulation, through the implementation of functional models, up to pilot series production or technology transfer. In addition, we realize laboratory equipment for special measurement tasks. Besides the monitoring of high-quality lubricating oils, we have experience in the on-site analysis of crude oils with regard to asphaltene content, TAN value, thiophen content, viscosity and density. For these measurements, we have developed laboratory solutions as well as total analysis systems which allow a fast, simultaneous measurement with a disposable microfluidic chip in portable devices. Our range of services includes reference measurements with laboratory spectrometers (UV-VIS, FTIR, Raman, refractometry), the design of optical cells and flow cells, electronics and data processing including data transmission, miniaturized spectral and MEMS-based sensors, prototype and pilot production as well as technology transfer to industrial partners.

APPLICATIONS

Cooler used in the production of biodiesel

BIODIESEL PRODUCTION

Biodiesel from vegetable oils is the best known biofuel in Germany. With around 1.8 million tons it accounts for approximately two-thirds of the German biofuel sales volume, mostly as an additive to diesel fuel. Compared to mineral oil-based diesel, biodiesel has lower emissions. It is produced from renewable raw materials, is biodegradable and has good lubricating properties, which is advantageous for the use of low-sulfur diesel fuel.

Objective

Within the framework of the project, a small laboratory plant shall be developed and tested, which can produce biodiesel from different vegetable oils and used cooking oils in a supercritical process at significantly higher reaction rates and with other expected benefits. “Supercritical“ defines the thermodynamic state of substances at and beyond of a specific constellation of temperature and pressure, in which the properties of liquids and gases merge without phase separation.

Features

Biodiesel production as a supercritical process with heterogeneous catalysts has been investigated for the first time in a continuously operated complete plant. Due to the supercritical process management the reaction time is reduced. At the same time, several process steps such as the recovery of the homogeneous catalyst become redundant. The transesterification of vegetable oil, which is quite common in biodiesel production, is carried out with supercritical methanol. Instead of the homogeneous catalysts used otherwise, we rely on innovative heterogeneous catalysts that are applied as a coating in microscale reactors. Thanks to the new concept, transesterification rates are being increased, while the reactor size as well as water consumption are reduced. The sensitivity of the process against traces of water in the raw material decreases. Besides this, the lower demand of methanol, the higher purity of the by-product glycerin and the long-term stability of the catalyst are expected advantages. When replacing methanol by ethanol, the already improved environmental compatibility can be increased even further. Although the process takes place at high pressures and temperatures, process optimization ensures a total energy consumption which is significantly lower compared to conventional methods. We were responsible for the development of the plant, the process and the novel catalyst technology. We also carried out tests with various vegetable oils and, for instance, used cooking oils as well.

Our research & development services

Together with our customers, we are engaged in developing decentralized plants which produce biodiesel from waste materials on-site without long transportation routes, depending on the application. We are also developing concepts for the production of basic chemicals such as methanol and higher alcohols as well as for the production of fuels from renewable energy sources.

Funded by: Federal Ministry of Food and Agriculture, following a decision of the German Bundestag and supported by the Energy and Climate Fund of the Federal Government through the Agency for Renewable Resources. (FNR, reference number: 22 400111).

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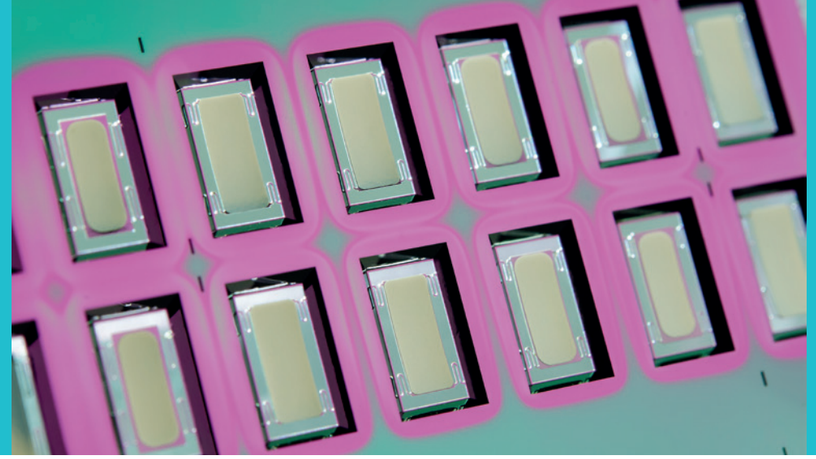

Bolometer chips on a wafer

RADIATION MONITORING

By means of nuclear fusion, i.e. the fusion of two light atomic nuclei, a considerable amount of energy can be gained from only very small quantities of “combustion material“ such as deuterium and tritium. However, the nuclear fusion reaction demands considerable technical effort to generate an extremely hot, magnetically confined fusion plasma as well as precise monitoring and control of the respective processes. This includes for instance the determination of the plasma radiated power at different points of the containment. For this purpose, special radiation sensors known as bolometers are used. In many of the fusion research plants operated around the world these radiation sensors nowadays come from us.

Functionalities

Bolometers usually rely on a gold or platinum absorber with a thickness of up to some 10 microns depending on the maximum radiation energy to be detected. Precise measurement of the temperature increase resulting from the radiation absorption is provided by a temperature-dependent, precision platinum resistor located on the back side of the absorber.

Challenges for use at ITER

At the world's largest fusion experiment “ITER“, which is currently under construction, very harsh environmental conditions will prevail. In particular, changing thermal loads up to 450 °C together with high radiation levels represent substantial challenges. Therefore, existing bolometers can be used only to a limited extent. In cooperation with the Max-Planck Institute for Plasma Physics in Garching, we have made significant steps towards a new generation of more reliable bolometer sensors able to match the extreme operation conditions at ITER. By using alternative materials and a new concept for mechanical fixation of the sensor structure by flexure hinges, a temperature stability of up to 450 °C could be verified in preliminary tests.

Application areas

Further current application developments for silicon-based components are:

- Microfluidic density measurement for liquids,
- flow rate sensors,
- 3D tactile force sensors,
- silicon micromachined precision components,
- micro electrode structures.

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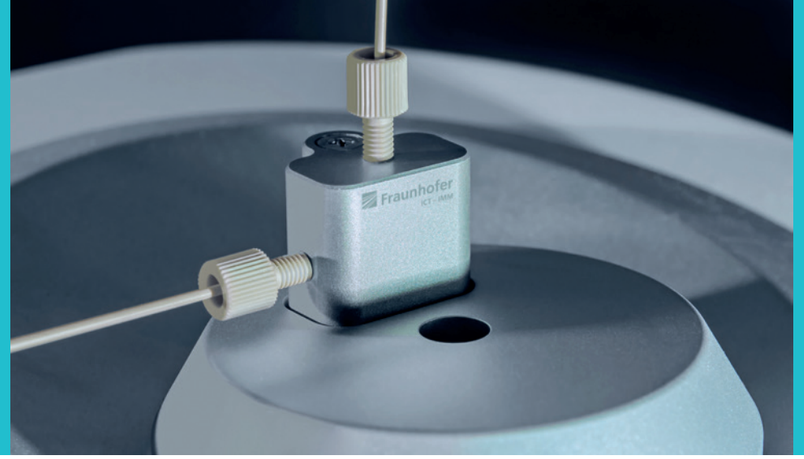
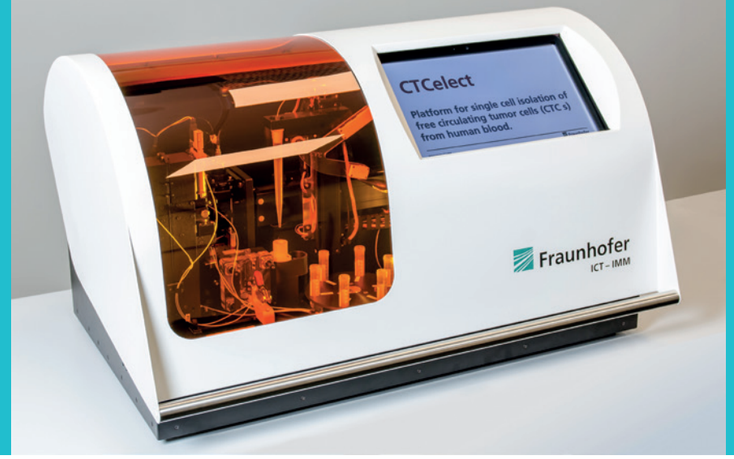


Flow cell installed in benchtop NMR spectrometer

Device for the isolation of circulating tumor cells



ON-LINE PROCESS MONITORING

Pharmaceutical products often contain fluorine fine chemicals as essential components. Their fluorine groups are responsible for the enhanced activity of the substances. The composition of the drug, its purity and, of course, its consistent quality are of utmost importance. Here the use of NMR spectroscopy, one of the most relevant methods for the structural determination of chemical compounds, is helpful. We have taken a first step towards a method that combines the advantages of continuous synthesis with integrated on-line NMR analysis together with our partners Hansa Fine Chemicals and Nanalysis Corporation.

Functionalities

In the course of the project we have developed and built a laboratory unit for the continuous synthesis of four fluorine compounds. All necessary reagents are provided by an integrated cartridge system. We use the compact benchtop NMR spectrometer NMReadyTM 60 as analytical platform. The required flow cells have been developed and adapted to the NMR spectrometer by ourselves. They are integrated into a control system that enables, based on magnetic valves, the continuous filling of the flow cell with reaction solution (continuous measurement) or the bypassing of the solution at the spectrometer to achieve a longer measurement during the process development (stopped-flow-measurement).

Features

The production of chemicals in small reactor volumes in combination with a contactless analysis method, such as NMR spectroscopy, allows a safe handling and, thus, reduces the risk potential of the active ingredients for the laboratory staff. The chosen design opens up the realization of several different routes for the synthesis of fluorine chemicals, or phosphorous compounds as well. From the signals in the NMR measurement we derive information such as level of conversion and, associated therewith, quality of the solution and structure.

Our research & development services

We offer to our customers the development, construction and manufacturing of milli- and microstructured flow reactors which are perfectly adapted to the respective process. This covers reactors suited for lab scale up to the production process. We as well integrate NMR spectroscopy into the system in terms of an on-line process control

Application areas

Production and analysis of agrochemical products.

Funded by: AiF Arbeitsgemeinschaft industrieller Forschungsvereinigungen, reference number KF2104409NT4

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ISOLATION OF CIRCULATING TUMOR CELLS

The course of a cancerous disease is difficult to predict and, thus, the prognosis for the patient often is uncertain. Although it is known that each patient responds differently to one and the same therapy in clinical practice diagnostic and therapeutic options are still not sufficient to allow for a treatment taking into account the patient's individual tumor characteristics. For a more efficient investigation of individual courses of disease we have developed a fully automated system for the "liquid biopsy" in order to isolate single tumor cells (CTCs) from patient blood. The system is designed to enable cancer researchers to obtain CTCs from individual patients and, on the basis of them, to study tumor characteristics and develop therapeutic approaches. This would be a further step towards the so-called personalized healthcare by means of which a therapy could be tailored to each single patient with so far unmet precision.

Functionalities

At first, tumor cells are coupled with magnetic particles, using the specific characteristic of the cell surface, and are extracted from the blood sample using magnetic fields. Subsequently, the extract is transferred into a microfluidic cartridge in which the tumor cells are detected by flow cytometry in order to remove the unspecific cell background. By means of hydrodynamic focusing of the sample in the cartridge a nearly ideal isolation of cells can be achieved. After the detection of a tumor cell in the microchannel the single cells are dispensed directly into cavities of a microtiter plate by pressure pulse. Each isolated tumor cell then can be examined for its genetic and molecular biological characteristics.

Features

Right from the start of the development we were eager to use affordable components in the system design to optimally position such a system on the market. Thus, the optical components of the system have been integrated with cost-effective injection molded polymer cartridges. Fluorescence excitation and detection are made possible by an easy to integrate, self-adjusting optical access to the polymer cartridge. This allows for a simple exchange of the contaminated parts prior to each analysis. As a result, time-consuming and cost-intensive calibration and cleaning steps no longer apply. The compact and cost-effective OEM design enables the development of a new generation of pipetting heads for the growing market of cell experiments as well as the integration into devices for a fast on-site analysis.

Application areas

Water analysis, diagnostic and life science applications, routine tests in hematology, infectiology and immunology.

Funded by: 7th Framework Programme of the European Commission, project reference 258604; Federal Ministry of Education and Research, reference numbers 131A020B, 03VP01061.

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Fuel processor system for the reforming of propylene glycol

LENA system with flow chamber

ENERGY SUPPLY FOR AIRCRAFT

In the framework of the project DIANA, we develop a mobile power supply for passenger aircraft together with the lead company Diehl Aerospace GmbH and the German Society of Aerospace e.V. (DLR). The increased energy consumption in an aircraft cannot completely be covered by the conventional power generators main turbine and the auxiliary power unit (APU). Therefore, and because the galleys are one of the main consumers of electricity in the aircraft, a trolley was chosen as a mobile unit, which can be docked to the galley and in this way ensures its energy supply.

Functionalities

A core component of the innovative trolley is our fuel processor consisting of a reformer, a catalytic start-up burner, reactors for the water-gas shift reaction and the selective oxidation as well as heat exchangers and an evaporator. From the energy source propylene glycol, which is already accredited for the aviation sector, purified hydrogen will be generated via a series of catalytic processes. Besides the storage tank for propylene glycol, the trolley contains a fuel cell, in which the produced hydrogen is converted into electric power through a reaction with oxygen. Harmless water and heat are the waste products of this energy conversion.

Features

The limited space available in the trolley posed the highest demands especially on the fuel processor in terms of compactness. We have managed to integrate the gas purification unit into one single component, whereas in conventional equipment it normally consists of five components. Only this allowed us to cope with the limited space available. Our service included the development of a new catalyst formulation for the reforming of propylene glycol, the development of a suitable reactor design for the reformer system, the development of a new catalytic start-up burner and new evaporation concepts.

Our research & development services

Our services in the field of aerospace range from detailed design and manufacture of individual reactors and components via testing up to the integration of complete fuel processors for a power range of 50 kW and more. Compactness, maximum efficiency and highly dynamic behavior are system properties our customers can benefit from.

Developed in the framework of collaboration with Diehl Aerospace within the projects DIANA and GETPOWER, funded by the aviation research program of the Federal Ministry for Economic Affairs and Energy.

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LASER GENERATED NANOPARTICLES FOR HIGH-PERFORMANCE POINT-OF-CARE APPLICATIONS

Rapid tests in medical diagnostics are often based on the lateral flow platform technology. They usually work with chemically produced nanoparticle bioconjugates for detecting substances. If it is possible to increase the sensitivity and selectivity of the detection component this will open up the chance to achieve more reliable diagnostic results but as well to establish completely new rapid tests.

Objective

Our goal in the project LENA is, together with our partners from the University of Duisburg-Essen, the Microcoat Biotechnologie GmbH and the Particular GmbH, to develop new rapid tests for Staphylococcus aureus and for MRSA strains, which are currently not available due to a lack of sensitivity.

The basic principle

In order to be able to develop a particular product for point-of-care diagnostics the project aims at a substitution of the common, chemically produced nanoparticles by laser generated alloy nanoparticle conjugates. As a result, improved optical properties as well as higher functional densities at the surface of the particles shall achieve increased sensitivities and selectivities in detection. For this purpose we strive for a transfer of particle synthesis to a continuous process in a microstructured flow-through chamber. The development and realization of this flow-through chamber allows to generate nanoparticles by laser ablation of a metal target and is our main task in the project. With this continuous process as an innovation we finally aim at a robust series production of particles with improved product properties and reduced resource consumption. This will allow for competitive prices of the resulting products.

Our research & development services

We have substantial experience in the continuous synthesis of nanoparticles and, thus, improve quality as well as quantity of available nanoparticles. From numerous projects we have learned how to make near-patient testing more simple, fast, safe and cost-efficient by using microstructured elements or microfluidic basic operations.

Application areas

- Fluorescent quantum dots for the consumer goods sector,
- iron oxide nanoparticles for separation processes and targeted drug release.

Funded by: Federal Ministry of Education and Research, reference number 13N12978.

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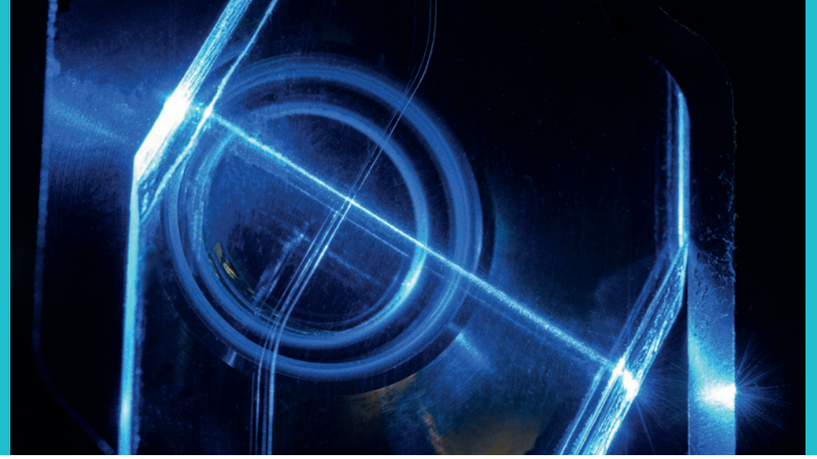

Microfluidic chip for particle size analysis via light scattering

Point-of-care testing device

IN VITRO TEST SYSTEMS

During the past years enormous progress could be achieved in materials sciences and nanotechnology. Due to the excellent controllability of synthesis processes we can nowadays realize nanoscale particles with tailor-made properties. As questions with respect to environmental dangers and health risks for people are still unaccounted for, we meet the existing demand by novel in vitro test systems allowing examining the interaction with biological material. Being able to reflect the real conditions as close as possible (for instance in a blood vessel or at the blood brain barrier) is of high importance.

Functionalities

Using a high precision pump we can expose the test substances in microfluidic chips against sample material in a controlled manner, applying close to reality conditions (such as in flow), even at very short time scales. Moreover, we have a long-term expertise in examining the interaction of particles with cells. If required and requested, we complement microfluidic exposure studies with a comprehensive sample analysis which is available in-house.

Properties and application areas

Our systems can be used for:

- A controlled exposition of particles (size: 50 nm up to 10 µm) against biological samples (such as blood plasma, saliva, lymph),
- the assay development to achieve the functionalization of nano and micro particles with bio molecules in a microfluidic channel (including washing steps),
- the analysis of the behavior of particles in an artificial blood vessel (where appropriate with patient material → personalized medicine),
- the passage of particles across a blood brain barrier model,
- the analysis of the absorption and toxicity of the particles in different cell models.

Our research & development services

We accompany our partners from the basic idea via exploratory work, exposure/incorporation and viability analysis up to the realization of test systems and functional models. This includes:

- Exposure studies – (nano)based active ingredients against bio fluids and cell/organ models,
- analytics (for instance flow cytometry, fluorescence microscopy, analytical disc centrifugation),
- co-staining of cellular compartments (for instance cell nucleus, membrane, mitochondria, lysosomes, determination of cell viability, intracellular localization of particles),
- prototype construction,
- technology transfer to industrial partners.

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FIGHTING THE PANDEMIC

In the course of a joint research project we have developed a mobile, autonomously working platform for near patient diagnostics of influenza together with R-Biopharm GmbH. With the help of this platform the infection status of the patient as well as the subtype of the influenza virus can be determined. This information yield will help to rapidly control the spread of the disease.

Functionalities

The working principle of the detection system is the PCR-based nucleic acid amplification. The patient material is collected with a swab and initially put into a sample container. Subsequently, it is transferred into the buffer solution comprised. After lysis the buffer 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. The result allows drawing conclusions with respect to the bare existence of influenza viruses as well as to their subtypes.

Properties and application areas

The overall design of the detection system we have developed is characterized by the following properties:

- Very compact, light and robust design in the size of a shoebox,
- all process steps including sample collection and preparation as well as amplification of the target DNA are automated,
- integrated detection and analysis of the optical signal,
- stable long-term storage of all reagents in the cartridge.

Our research & development services

The basic principle of the fully automated detection system is designed as a platform technology. By modifying the detection reaction and the temperature profile we can easily adapt the system to your application specific requirements.

Application areas

Further possible application areas for example would be the determination of the health status by means of near patient testing or the analysis of food and feed contamination.

Developed in a framework of cooperation with R-Biopharm GmbH

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Pilot plant for drug synthesis (in a container)

INNOVATIONS IN FINE CHEMICAL SYNTHESIS

The chemical industry in Europe is on the one hand under enormous cost pressure, on the other hand expectations with respect to the ecological sustainability of processes increase. This is due to the additional production capacities in low-wage countries, raw materials getting more expensive, increasing energy costs as well as grown requirements concerning product quality, environmental awareness and safety. The key lies in providing novel and sustainable technologies allowing to reduce the impact on environment and to save exhaustible resources.

The basic principle

The EU funded project POLYCAT joined the expertise of 19 industrial and academic partners in order to develop novel, polymer-supported catalysts which were intended to improve, based on highly reactive nanoparticles, the selectivity and efficiency of industry relevant reactions. Furthermore, the combination of these novel catalyst systems with micro process technology was expected to allow improved production processes in chemical industry in which the precise adjustment of ideal process conditions is possible.

Objective

The development efforts within the project aimed at the realization of a multifunctional, compact plant installed in a container-like infrastructure allowing the industrial partners the use of the novel and improved production method for the synthesis of pharmaceutical active ingredients. Accompanying these technical developments the preparation and maintaining of life cycle assessments and cost analyses took place in order to ensure sustainability and competitiveness of the POLYCAT based processes.

Our research & development services

We show you a way to design your chemical processes in a safe, efficient and flexible way. In a holistic approach we thereby consider all influencing factors such as suitable catalysts as well as process equipment and plants up to intensified process conditions.

Application areas

- Fine and special chemistry,
- production and processing of gases containing hydrogen from different conventional and renewable fuels, used for fuel cells,
- various biorefinery processes,
- photochemical processes.

Funded by: 7th Framework Programme of the European Commission, project reference 246095.

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