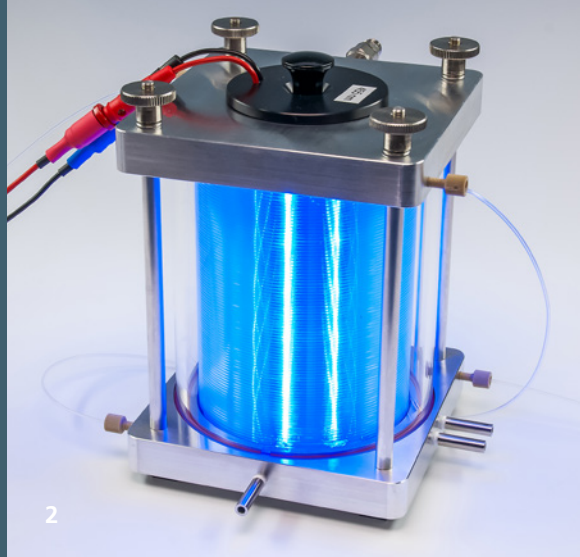
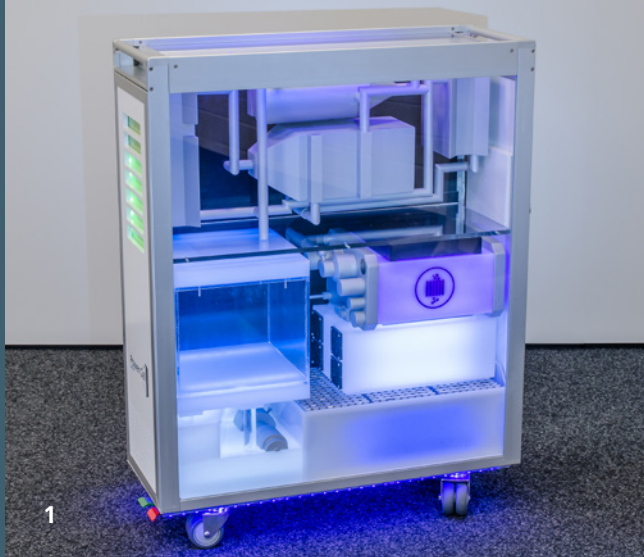


# MICROSTRUCTURE-BASED PROCESS ENGINEERING AND CATALYSIS





## APPLICATION PORTFOLIO

### Fine chemistry

We design chemical processes from lab to pilot scale in a safe, efficient and flexible way: using micro- and milli structured flow reactors to achieve higher product selectivity and yield by minimizing side reactions, accelerating the development and optimization of new chemical processes and adapting quickly to changing process parameters.

### Cosmetics

We ensure reproducible quality for customized products: applying continuous synthesis processes allowing access to high quality uniform particles in the required size range, ensuring precise control of process conditions and encapsulating ingredients for in-situ release.

### Active ingredients

We increase efficiency and availability of active ingredients: adapting and realizing continuous processes for the formulation of polymer-based particles and capsules and the synthesis of reactive intermediates such as Grignard, adjusting chemical composition, particle size, morphology and surface functionalization according to the requirements..

### Mobile energy supply

We enhance the efficiency of compact fuel cell/fuel processor systems: using fuels such as (bio)-ethanol, methanol, propylene glycol, kerosene, diesel, natural gas and LPG, covering the whole chain from design, construction, prototyping, system integration, control and testing, cost optimization - towards robust solutions.

### Sustainable fuels

We transform biological waste into valuable biofuels: developing novel integrated bio refinery concepts and routes for the generation of basic chemicals as well as for the production of fuels from regenerative energy sources, implementing process intensification and improving heat integration by plate heat exchanger technology.

### Energy conversion

We optimize material and energy conversion systems: integrating single components into a completely thermally integrated fuel cell or power-to-gas system, aiming for compactness, maximum efficiency and short start-up times, realizing set-ups from laboratory to pilot scale and further up to production stage.

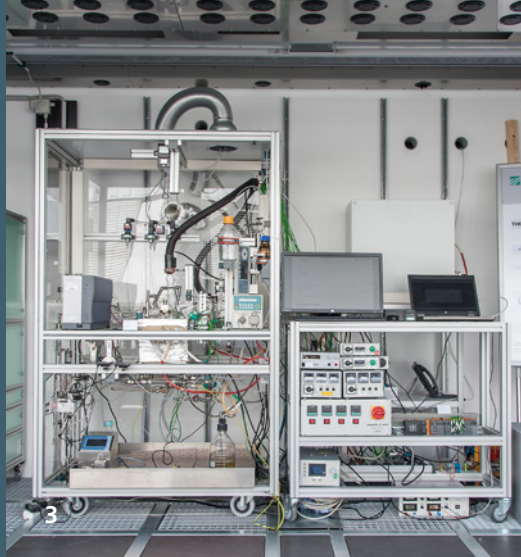
### Photochemistry

We increase process efficiency for complex photochemical applications: allowing a precise control of the irradiation period due to exactly defined volumes in channels/capillaries, preventing by-product formation and decomposition of reaction components.

### Process analysis technology

We upgrade your on-line analytics for industry 4.0 applications: offering customer-specific development of monitoring systems and sensors for the automated on-site monitoring of process media, combining chemical, optical and optical-spectroscopic analysis methods to determine various parameters simultaneously.

- 1 Fuel processor/fuel cell system for use in an aircraft
- 2 Capillary photoreactor
- 3 Pilot plant for bio diesel synthesis
- 4 Pilot plant for drug synthesis
- 5 Laser welding & cutting machines



## OUR LEADING EDGE

### STAFF

- pioneers in micro process engineering
- multiple discipline experts
- active partner network

### TECHNOLOGY

- highly developed, fabrication processes suited for mass production
- extensive portfolio of test equipment and analysis instruments
- easily scalable and modular development basis

### SOLUTIONS

- customer specific and often highly integrated design
- accelerated development and optimization times from lab to pilot scale
- performance range 100 W to 100 kW+, temperature range -250 to 950 °C

### KNOW-HOW

- intensifying continuous chemical and thermal processes
- using conventional/regenerative fuels for fuel preparation/synthesis
- giving particles the right size and the desired properties
- providing robust, long-term stable catalyst technology

### CUSTOMERS

- direct contract research or publicly funded cooperation projects
- saving excess energy and reducing waste in your processes
- open up new business fields

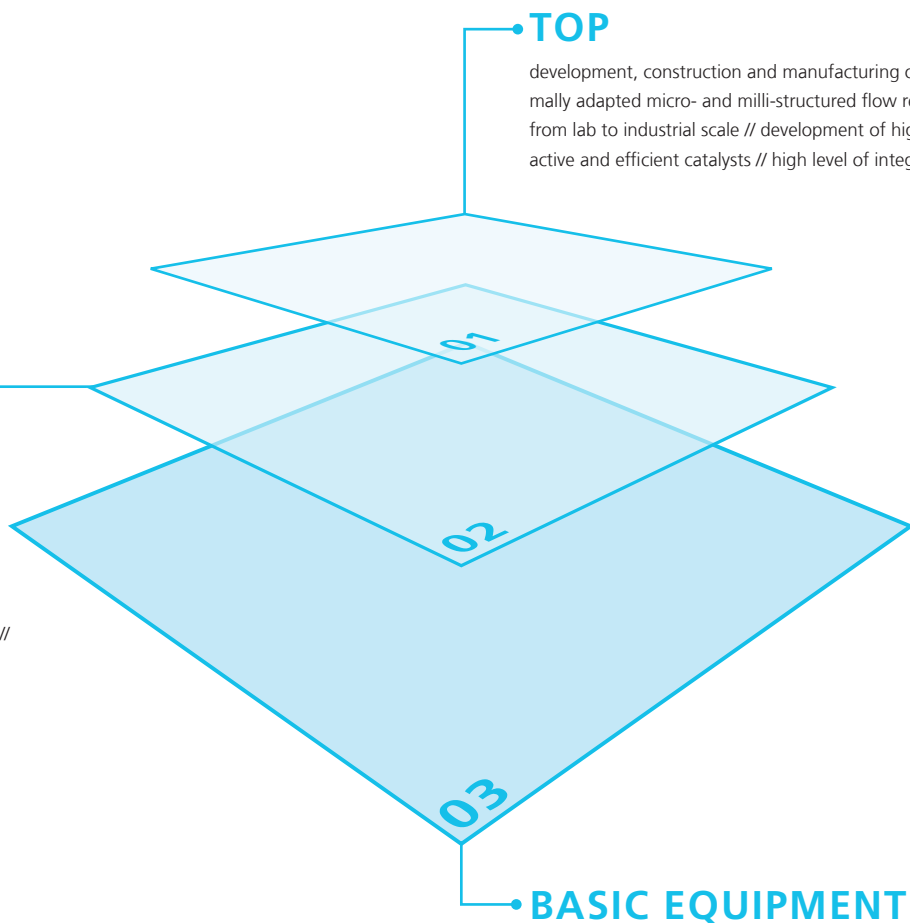
We guide our customers from the initial idea via simulation, the realization of a functional model, optimization up to the fabrication of pilot series or technology transfer. In a holistic approach we thereby consider all influencing factors such as suitable catalysts as well as process equipment and plants up to intensified process conditions.



## FROM BOTTOM TO TOP

### HIGH LEVEL PROCESSES

catalyst coating, laser welding of components // laser drilling // precision engineering // detection of chemical compounds in catalyst layers via Raman spectroscopy // continuous encapsulation // process intensification // transformation batch to continuous // light scattering measurement



### TOP

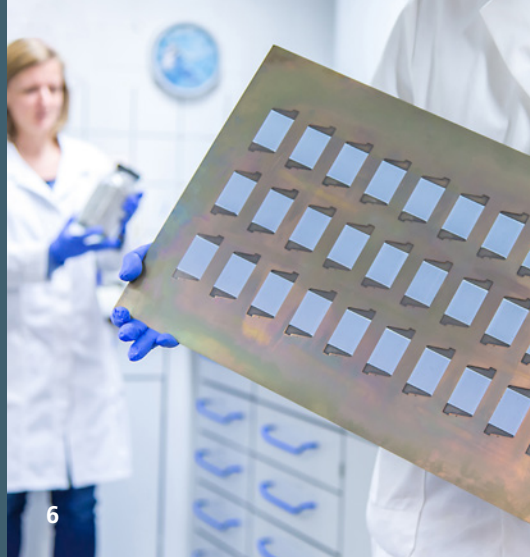
development, construction and manufacturing of optimally adapted micro- and milli-structured flow reactors from lab to industrial scale // development of highly active and efficient catalysts // high level of integration

### BASIC EQUIPMENT

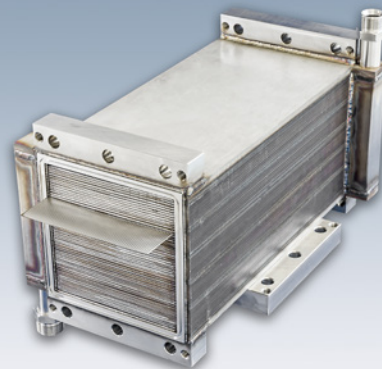
screen printing machine // catalyst characterization via BET, SEM, TEM and TGA // laser systems (excimer, Nd:YAG, CO<sub>2</sub>, HeCd, Ti:Sapphire) // electro discharge machining (wire, bulk) // milling machines // CNC machines // on-line measurement technology (GC, μ-GC, MS, GC-MS, FTIR) // optical spectrometers // HPLC // electron microscope (REM, TEM, Cryo-TEM) // light scattering // test rigs (performance, stability) // simulation

6 Stainless steel sheet with an array of 30 reaction plates coated with catalyst layer

7 Laser-welded large micro-reactor with exchangeable reaction plates



6



7

## PERFORMANCE CAPABILITIES

### CORE TOPICS

#### ENCAPSULATION AND NANOPARTICLE SYNTHESIS

dispersion polymerization // self assembly of amphiphiles // surface polymerization // polyaddition // polycondensation // emulsification // solvent evaporation // phase separation // internal gelation

rapid mixing // modular reactors for liquid phase reactions // wet chemical synthesis up to 400 °C // temperature-controlled reaction zones // integrated on-line process analytics

continuous encapsulation of active ingredients // formulation of polymer-based particles and capsules // investigation of the interaction between nano-particles and biological material // functionalization of particles

#### MICROSTRUCTURED REACTORS AND FLOW CHEMISTRY

reactive intermediates // halogenation reactions // ozonolysis // ionic liquids // nitration // Grignard // Suzuki // hydrogenation // epoxidation // ethoxylation // polymerization // photochemistry // nanoparticle synthesis // heterogeneous and homogeneous catalysis // pharmaceuticals

continuous flow mixers // heat exchangers // flow reactors // capillary photoreactors // falling film microreactors // modular reactors // highly exothermic processes // gas/liquid contacting // photochemistry // electrochemistry

epoxidation of soy bean oil // in-situ production of Grignard reagents // anionic polymerization // benchtop on-line NMR analysis // 20' to 40' container periphery // all-in-one systems // miniplant to pilot scale // cryogenic to high temperature

#### CATALYSIS

reforming of hydrocarbons // partial oxidation // hydrogen generation, purification // catalytic combustion // internal heating // synthesis gas to methanol // methanol to gasoline // synthesis gas to synthetic fuels // carbon dioxide to methane // catalyst development // chemical storage of electrical energy

watergas shift // preferential oxidation // heat exchanger components (laser-welded, brazed) // evaporators // condensers // selective methanation // balance of plant components // catalytic start-up burner // fuel processor

production of biodiesel // Suzuki-coupling // selective hydrogenation of carbon-carbon triple bonds (gas/liquid) // hydrogenation of nitro groups (gas/liquid) // oxidation reactions // esterification // enzymatic oxidation of glucose // photocatalysis // auxiliary power units // energy conversion systems

#### FUNCTIONAL MATERIALS

#### CHEMISTRY

#### ENERGY

### BUSINESS FIELDS

PROCESSES

REACTORS

PLANTS/SYSTEMS

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