

*FAMOSflexible* –  
**AUTOMATED MICROREACTION  
SYSTEM FOR R&D LABORATORIES**



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# MICROREACTION TECHNOLOGY – CHEMICAL PROCESSES AT MICRO SCALE

The application of micro-structured reactors in chemical process technology is an innovative technique which makes use of both the significant miniaturisation and the resulting increase in the surface-to-volume ratio to ensure high mass and heat transfer. Highly exothermic processes can be carried out quasi-isothermally with precise dosing and thorough mixing of the reactants. This leads to high process safety and accurate thermal management of the chemical reactions, which can often lead to improved product yield and selectivity. Continuous process control allows microreaction technology to be used with precisely adjustable residence times, to achieve high space/time yields.

## *“FAMOSflexible”* – A HIGH-PERFORMANCE MICROREACTION SYSTEM FOR R&D LABORATORIES

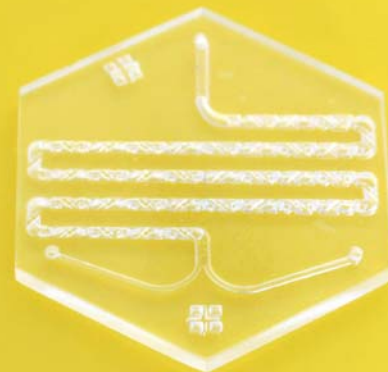
*“FAMOSflexible”* is the next generation of an automated microreaction system developed at the Fraunhofer ICT, which combines the advantages of microreaction technology with a high-performance modular laboratory system. Based on over 10 years' practical experience with microreaction processes, the system has been specially developed for chemical synthesis and process optimisation in the R&D field. *“FAMOSflexible”* therefore offers the necessary flexibility to meet diverse and varying requirements in research and development.

With *“FAMOSflexible”* almost any microfluidic processes for liquid, liquid/liquid and gas/liquid reactions can be quickly set up and reconfigured. For this purpose, a broad selection of microstructured reactors is available. Non-system microreactors can also be built easily into the laboratory system. The regulation of the microreaction system enables fully automated realisation and recording of individually designed experiments. Systematic parameter screenings and the generation of sample databases for subsequent investigations are therefore possible. In addition, the use of micro-effects allows the investigation of reaction regimes which conventional processes are unable to handle. *“FAMOSflexible”* is also equipped with interfaces for online and offline analysis, integrated safety features and an optional remote control and observation system for potentially hazardous reactions. The stable setup and continual process monitoring mean that *“FAMOSflexible”* can also be used for small-scale series production in the laboratory.

*“FAMOSflexible”*: the automated microreaction system created by the Fraunhofer ICT.



1



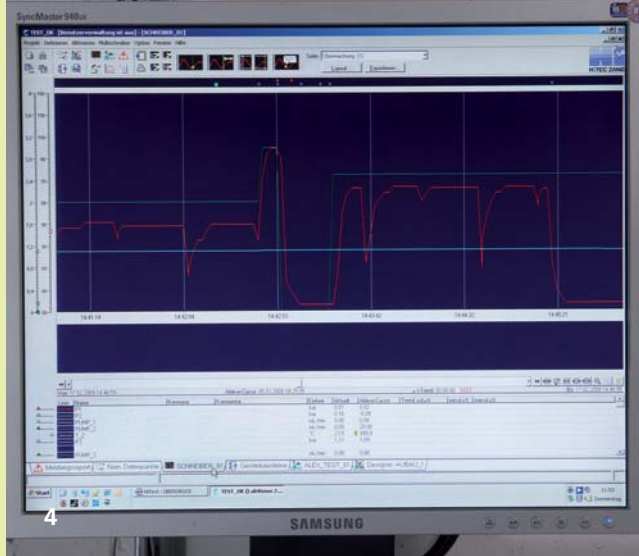
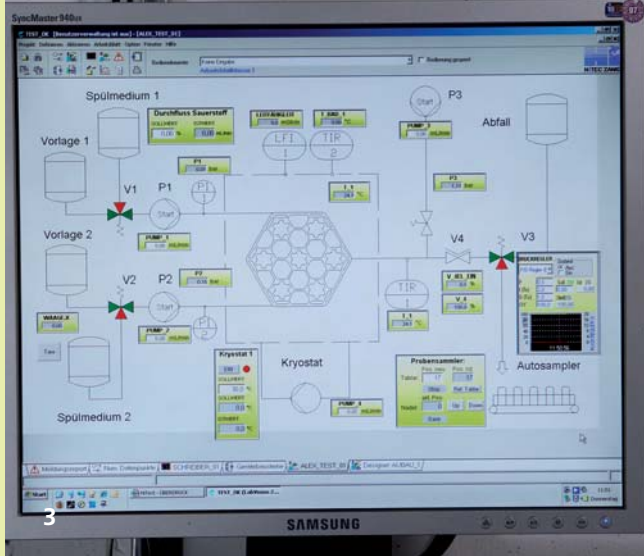
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## THE MICROFLUIDIC PROCESS

For the microfluidic process setup, various glass modules with special microfluidic structures are available for mixing, emulsification, reaction, residence time supply etc. These modules have characteristic features (e. g. mixing performance, mixing principle, residence time, channel dimension, pressure drop etc.) and can thus be selected for different applications. The simple and rapid fluidic coupling of the microfluidic modules is carried out on a mounting plate. The modules have a standardised hexagonal form and are each equipped with up to six fluid connectors, which ensure a high level of flexibility in carrying out diverse and often complex microfluidic processes.

The microfluidic setup is submerged in a closed bath, which is connected to a cryostat. The special construction of the mounting plate means that the high thermal conductivity of microfluidic systems can be utilised. The system allows multi-step synthesis processes to be carried out at a range of different temperatures (-30 °C to +180 °C).

For all components in direct contact with the medium, resistant materials such as glass, Teflon and titanium are used, which means that "FAMOSflexible" can also be used for reactions involving highly aggressive or corrosive media. Depending on the microfluidic modules applied, process pressures of up to 18 bar can be generated, for example to process liquid-phase reactions above the boiling point of the solvent. Reactions can be terminated using either a thermal or a chemical quench. All liquid media such as reaction, rinsing and cleaning solutions are pumped by continuous syringe pumps (volume flow range 0-40 ml/min).



## SOFTWARE AND AUTOMATION

The regulation of the microreaction system means that all commercially available and controllable process components such as pumps, cryostats, valves, pressure and flow controllers can be connected over standardised interfaces. Additional or already existing laboratory devices can therefore easily be applied. Fully automated registration, control and recording of relevant process parameters such as pressure, temperature, flow rate etc. can be carried out with the respective software.

The microreaction system can be operated manually by remote control, but is also capable of carrying out individually-designed experimental plans completely automatically. Parameter screenings are possible with variations of temperature, pressure, stoichiometry, residence time etc. When operated manually, the system is controlled using a spreadsheet: all process components can be visualised and parameterised. Different spreadsheets can be used for different experimental setups, and can be easily modified and adjusted by the users.

For automatic operation, the software offers both classic programming and ready-made modules which already contain the necessary programming for a particular processing step. It is consequently possible for users without programming knowledge to set up and carry out an experiment simply by connecting individual programme modules together.

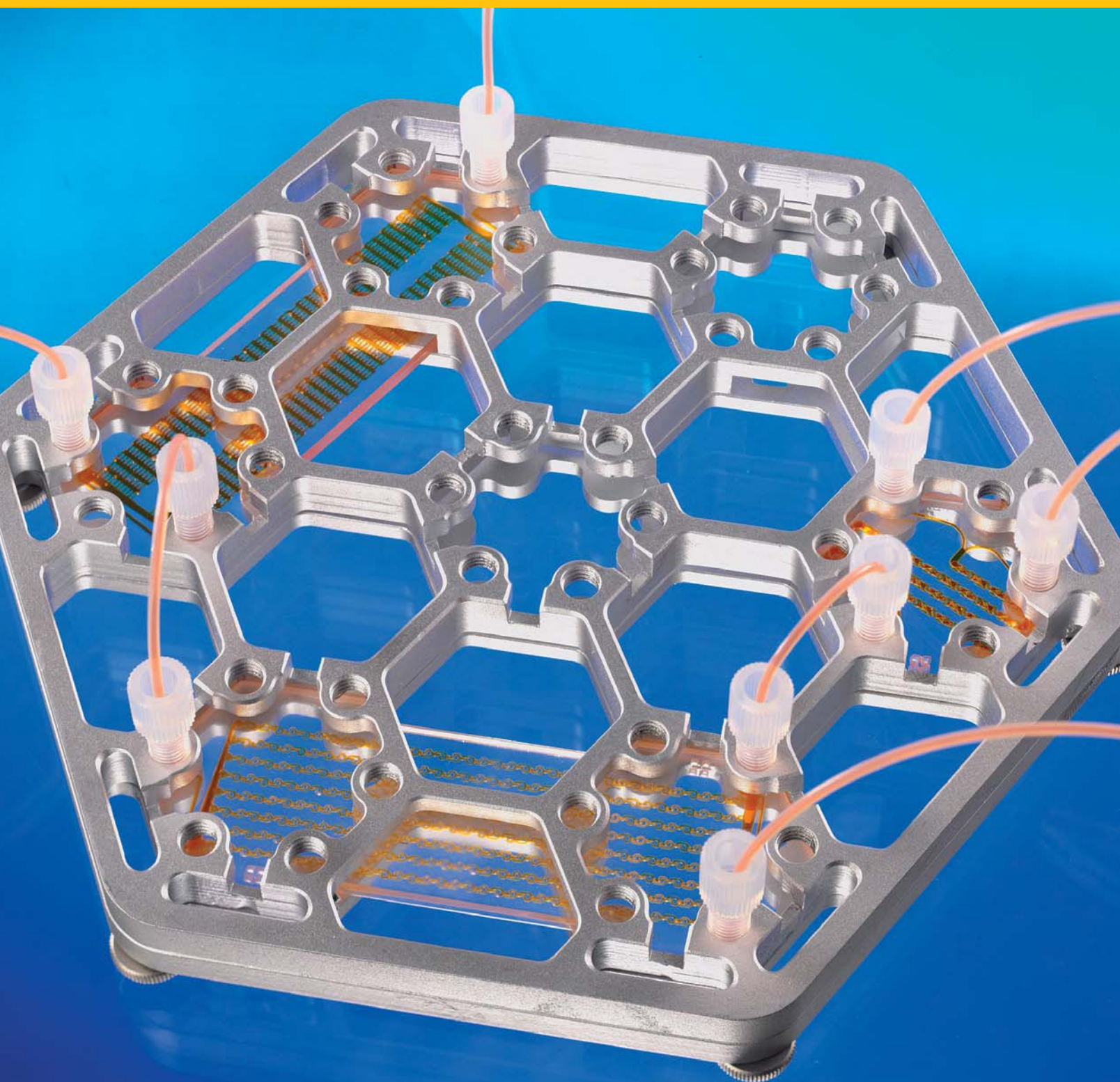
Safety shut-downs are also incorporated for both manual and automatic operation. They ensure that the process is automatically shut down in case of defects or leakages, maintaining safe operating conditions.

1 and 2 Exemplary modules of the "FAMOSflexible" system: microreactors made of glass with special mixing structures.

3 Interactive flow chart of the microreaction process.

4 Realtime recording of process parameters by the process control software.

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## ONLINE AND OFFLINE ANALYSIS

For offline analysis (for example using GC or HPLC) a sampling device is integrated. Using a time and event-controlled sampling carousel, samples can be obtained and prepared for subsequent analysis, for example according to changes in the processing conditions. There is also the option of monitoring the reaction mixture using online or inline analysis. For this purpose, special flow cells for different spectroscopic analysis methods (UV/VIS, NIR, IR, Raman) can be integrated into the system setup. The spectroscopy software can be incorporated into the controlling and recording of the microreaction system, allowing the entire process to be controlled and regulated.

## OUR OFFER

We offer our project partners and customers tailored microreaction systems based on "FAMOSflexible". The systems are equipped with process components according to customer requirements. To enable rapid implementation of the system, process sequences, synthesis recipes and where necessary safety devices can be pre-programmed and installed. We offer advanced instruction courses for the individual operation, reconfiguration and programming of the microreaction system.

We also offer R&D projects employing "FAMOSflexible" as a modern laboratory tool. Commissioned by our customers, we carry out experimental investigations into chemical synthesis and process optimisation using microreaction technology. Experimental feasibility studies, rapid parameter screenings and targeted analyses of individual processing steps form a part of our offer.

*Mounting plate of the  
microreaction system with  
connected microfluidic  
glass modules.*

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For more information on microreaction  
technology at the Fraunhofer ICT,  
please visit:

[www.microreaction-technology.info](http://www.microreaction-technology.info)