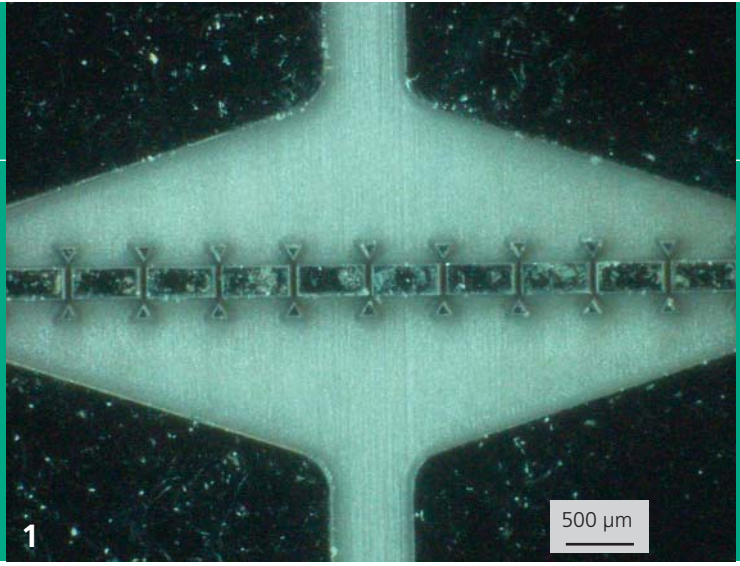

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DYNAMIC MICROREACTOR PLATFORM WITH INTEGRATED MICROPUMPS AND MICROSTRUCTURES

THE TASK

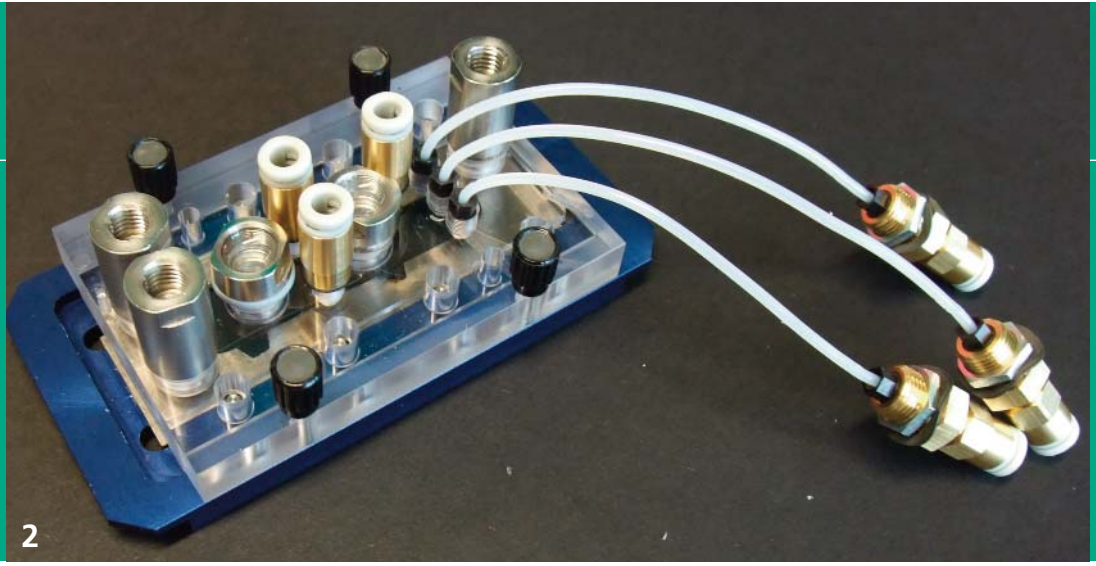
Microreactors are highly miniaturized and automated. They implement complex chemical and biological processes with minimal technical and personnel effort. These systems require low investment and operational costs. They have a compact design, high functionality and are easy to handle. Short information paths enable short reaction times. The miniature design reduces wiring and thus increases reliability. Heat and mass transport are intensified. This implies reaction technological advantages such as improved product cleanliness, improved yields and selectivities, higher process stability as well as access to new processes and applications. The integration of complex microstructures enables the realization of defined microenvironments.

Microreactors are becoming increasingly important in many areas of chemical and pharmaceutical synthesis, environmental analysis, molecular biological diagnostics, and general substance research. A dynamic microreactor platform is required to develop new processes and to transfer existing processes to a microreactor. The platform would provide necessary basic components such as pumps, valves, reaction chambers, mixers and heat exchangers and allows them to be quickly combined with each other. The resulting reactors have to be chemically, mechanically and thermally stable to handle a wide range of process parameters.

OUR SOLUTION

Fraunhofer IWS engineers have achieved very good results with customized microreactors. These are made from multilayer systems of material combinations from silicone, glass and metals or polymers. To build the microreactor, a polydimethylsiloxane flow cell is molded onto a metallic or polymeric connector plate and protected by a cover plate. The connector and cover plates contain microstructures, connectors, sensors (electrodes, microlenses, optical fibers) and actuators (heaters, electromagnets, piezovibrators). The flow cell contains the microfluidic system, which consists of channels, micromixers, pumps and valves as well as optional sensors and actuators. The cell is cast from a master die. The master die is fabricated using IWS laser micro material processing techniques or lithographic processes. The thickness of the pump and valve membranes is adjusted by changing the position of die elements.

The microreactors are very modular, which makes them easily adaptable to specific applications. Reaction chambers are made optically accessible but electrically insulated by using glass, polymers and silicone materials. Processes can be optically monitored. Photo and electrochemical functionality can be integrated. A metal connector plate provides efficient thermal transport.



RESULTS

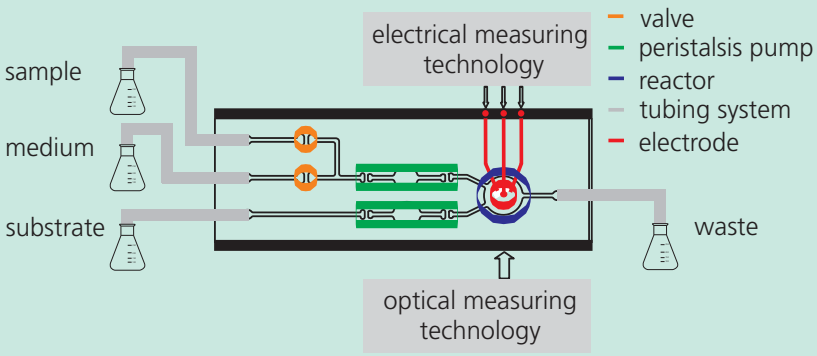
Customized microreactors with integrated micropumps and microstructures were successfully built and characterized based on an established dynamic microreactor platform.

Example 1:
A microreactor was developed and successfully tested to analyze environmentally relevant substances using a yeast cell sensor with optical and electrochemical detection mechanism. The microreactor selectively supplies the yeast cells with nutrition, sends a defined sample volume to the cells or adds a defined amount of reactive ingredients for the enzymatic reaction (Fig. 1). The cells form enzymes, which are monitored optically via fluorescence or electrochemically via amperometry using microelectrodes. Microstructures are integrated to trap genetically modified cells in specifically designed compartments.

Example 2:
Another microreactor was developed to implement a standardized wet chemical nitrate quantification process via photometric detection. The reactor was successfully tested. A defined sample volume of an aqueous solution can be precisely and accurately injected into the carrier flow. The carrier flow transports the sample while reactants are added for the chemical reaction. The sample then travels through a micromixer into a photometric flow through detector (Fig. 3).

The developed dynamic microreactor platform serves as a tool for the fast and flexible implementation of existing processes on microreactors and also for the development of new processes (Fig. 2).

Schematic setup of a microreactor for the electrochemical detection of environmentally relevant substances



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1 *Microscope image of a microstructure to trap genetically modified yeast cells inside of the microreactor*

2 *Dynamic microreactor with integrated micropumps, valves and microstructures*

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