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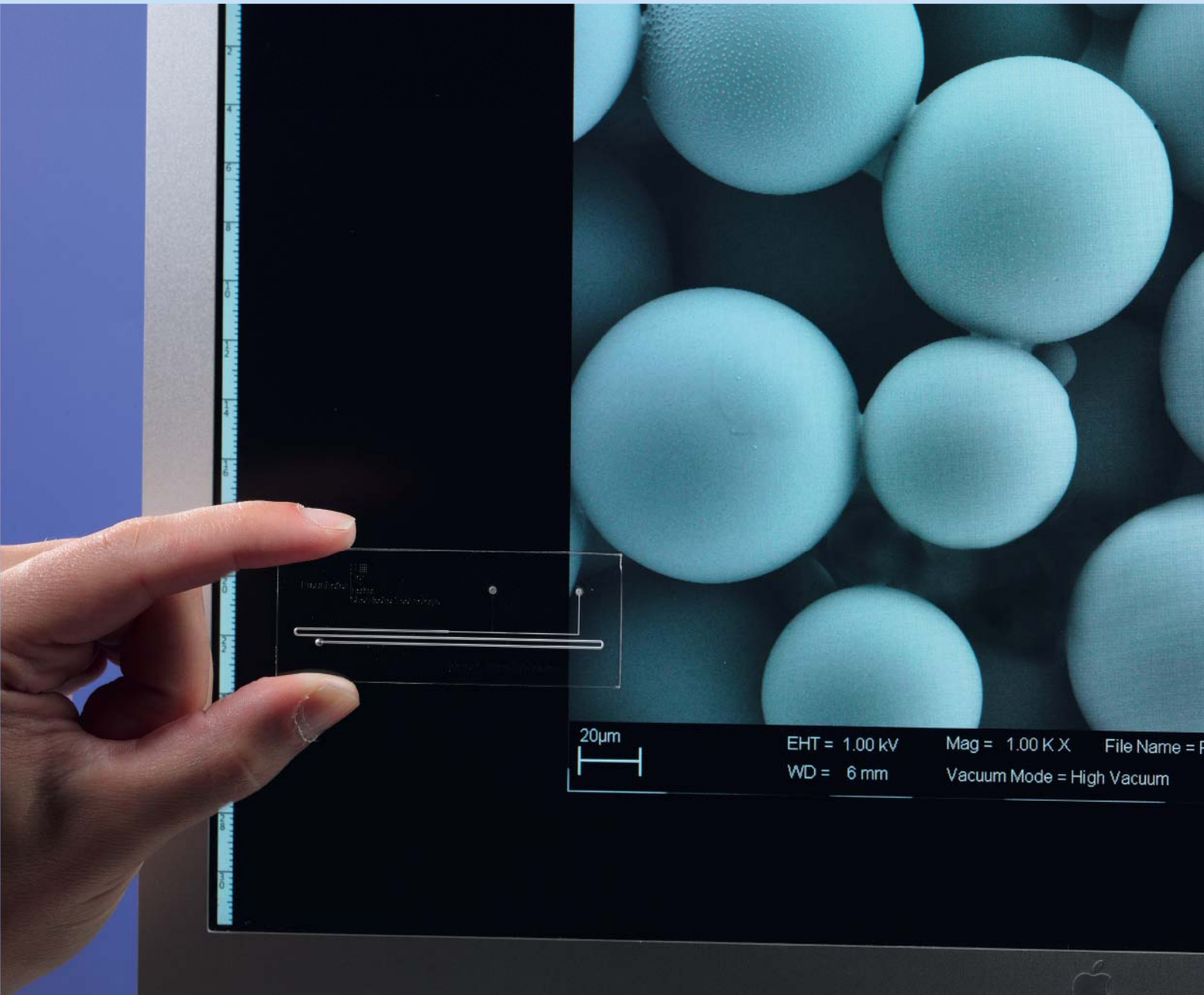
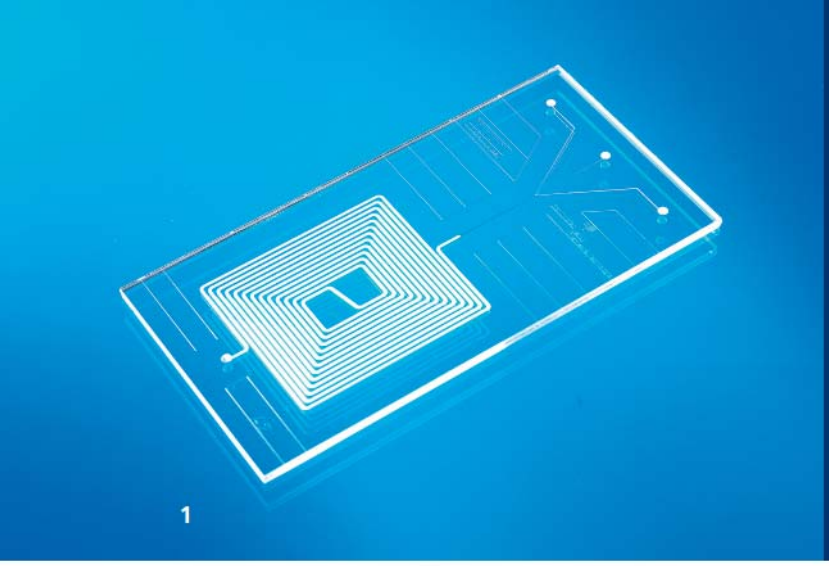
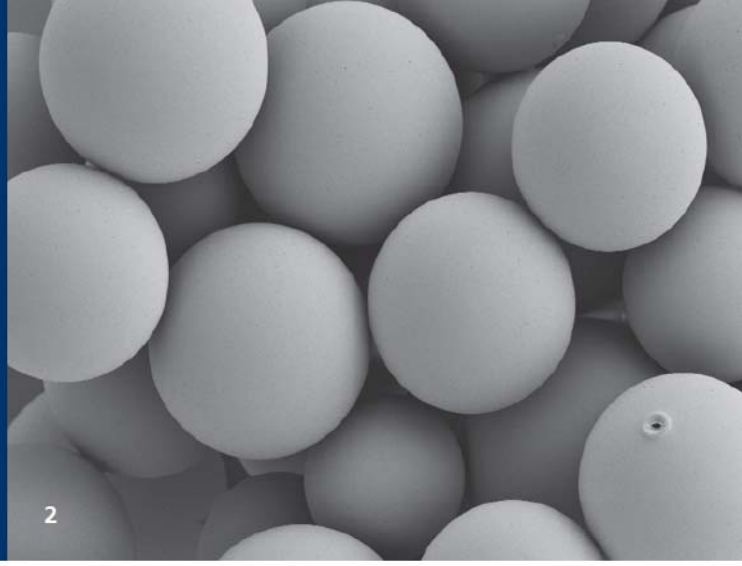
FRAUNHOFER INSTITUTE FOR CHEMICAL TECHNOLOGY ICT

MULTIPHASE PROCESSING IN MICROREACTORS







MULTIPHASE PROCESSING IN MICROREACTORS

Micro-structured reactors can be used for the high-precision processing of multi-phase fluid systems (e. g. liquid/liquid or gas/liquid) in the form of segmented flows and unimodal emulsions, opening up new application opportunities.

Segmented flow: the droplet as a reactor

At the Fraunhofer ICT specially-developed microfluidic structures are used to generate fluid segments in the form of droplets and bubbles by continuously shearing them off or constricting them into a second liquid phase. The size of the formed droplets or bubbles and the frequency of the segmentation can be controlled very precisely through the selected flow conditions, reactor geometries and other process parameters. The droplets or fluid segments function as closed reaction vessels, having no chemical interaction with the transport phase. Within the fluid segments – each with a volume of just a few nanoliters – the syntheses of high value products can be performed by suppressing cross-contamination, dilution and dispersion effects caused by convection and diffusion. Moreover, mixing of the reagents in the nanoliter segment is strongly intensified by advection, without the need for complex static mixing structures which are usually required in microreactors. Consequentially, even liquids containing solid matter can be handled, for example in nanoparticle synthesis.

On the other hand, segmented flow processing can also be used to deliberately intensify interaction between two-phase systems. By providing large interfacial areas we can significantly accelerate the mass transport over the phase boundary layers compared to macroscopic processes. Typical applications are phase transfer catalysis and other two-phase organic syntheses.

1 *Microreactor for manufacturing of spherical polymer particles and micro-capsules.*
2 *Spherical polymer particles with adjustable porosity.*
3 *Segmented flow in microchannels (top: gas/liquid; below: liquid/liquid).*
4 *Multiple emulsions for manufacturing of micro-capsules.*

COVER PHOTOGRAPH:
Microreactor for manufacturing of spherical polymer particles.

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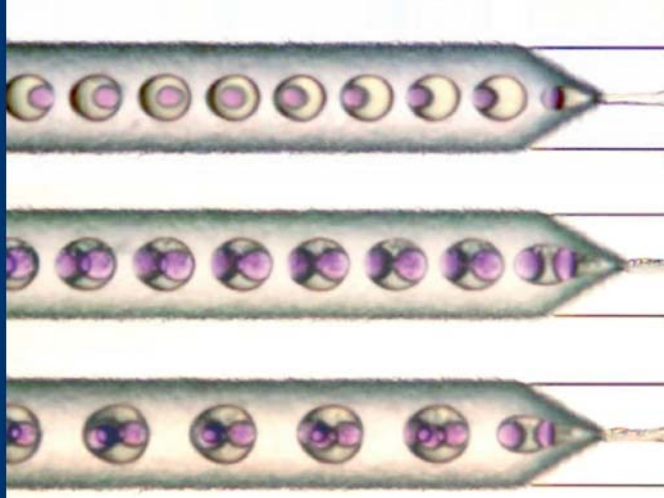

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Manufacturing of microscale particulate products

Segmented flow processes in microreactors are also used for manufacturing microscale particulate products. For example, the precise control of the droplet size of emulsions is used to synthesize monomodal spherical polymer particles in microreactors. With regard to various future applications the particles can be highly functionalized even during synthesis, for example by adjusting a particular porosity or by applying molecular imprinting techniques. The size of the polymer particles is infinitely adjustable over a broad range, e.g. between a few micrometers and several hundred micrometers.

The high precision in droplet formation also enables the formation of complex and highly regular multiple emulsions. On the basis of such emulsions polymer microcapsules can be manufactured with a solid shell approx. 100 nm thick. During the process the capsules can be filled with a well-defined amount of a solid or liquid material. Encapsulation is used for the protection, masking or transport of active core agents or other ingredients.

Phase separation

For many multiphase processes, the final separation of the individual phases is also of great importance. Together with our sister institute, the Fraunhofer IST, we apply special coating techniques to develop microfluidic separators with confined areas of different wetting behavior. In combination with the high surface-to-volume ratio in microchannels these coatings allow a continuous and efficient phase separation.

Our offer

We support our customers and project partners in exploring the various capabilities of fluidic multiphase systems. As R&D services, we offer feasibility studies, parameter screenings and targeted analysis of individual process steps by using segmented flow. Furthermore, we develop products together with our customers in the areas of fine and specialty chemicals as well as functionalized polymer particles and customized microcapsules.

We design, manufacture and test tailored microreactors for customer-specific applications using segmented flow. We apply the latest measurement and analysis techniques for the real-time monitoring of microfluidic processes and the identification of optimal process conditions. Numerous analytical techniques are available for the characterization of the chemical products, microcapsules and other particles formed in our processes.

To achieve a fast process development we apply numerical simulation techniques based on CFD for the development of tailor-made microfluidic structures. We apply laser structuring techniques for the fast manufacturing of microreactor prototypes in various materials, e.g. glass, ceramics, polymers, and metals.

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For more information on microreaction technology at the Fraunhofer ICT, please visit:
www.microreaction-technology.info

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