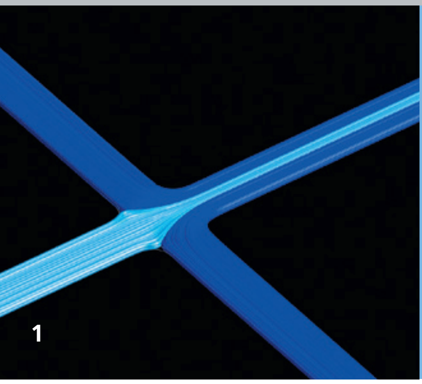
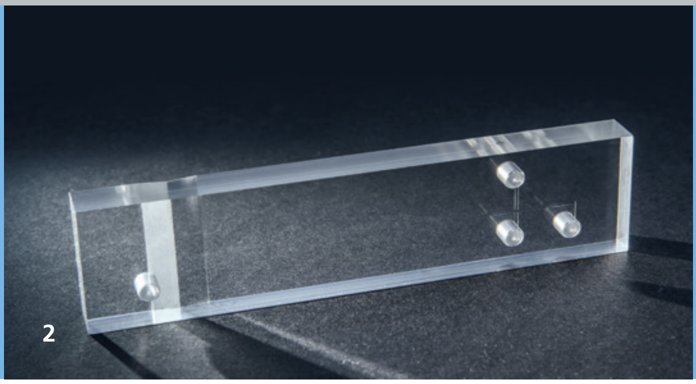
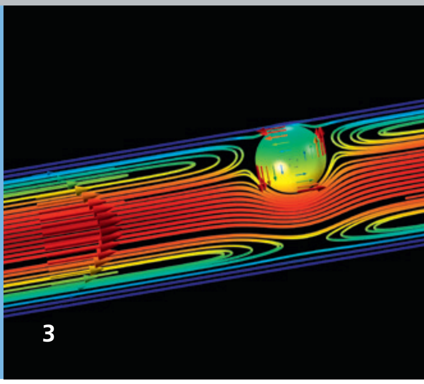
FRAUNHOFER INSTITUTE FOR MICROENGINEERING AND MICROSYSTEMS IMM







Dynamics in a microfluidic chip for cytometry application:
1 *Hydrodynamic focusing*
2 *Chip design*
3 *Inertial migration of particles in laminar flow*

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MODELLING OF FLUIDIC MICROSYSTEMS

Modelling for product development

A main challenge in product development is to find the fastest and economically most viable route to a product. Modelling is a valuable tool in order to accelerate and optimize the product development process. At Fraunhofer IMM modelling starts at the problem analysis, identifies the best tool and then results in the simulation and optimization of components, systems and processes.

Advantages for our customers are to

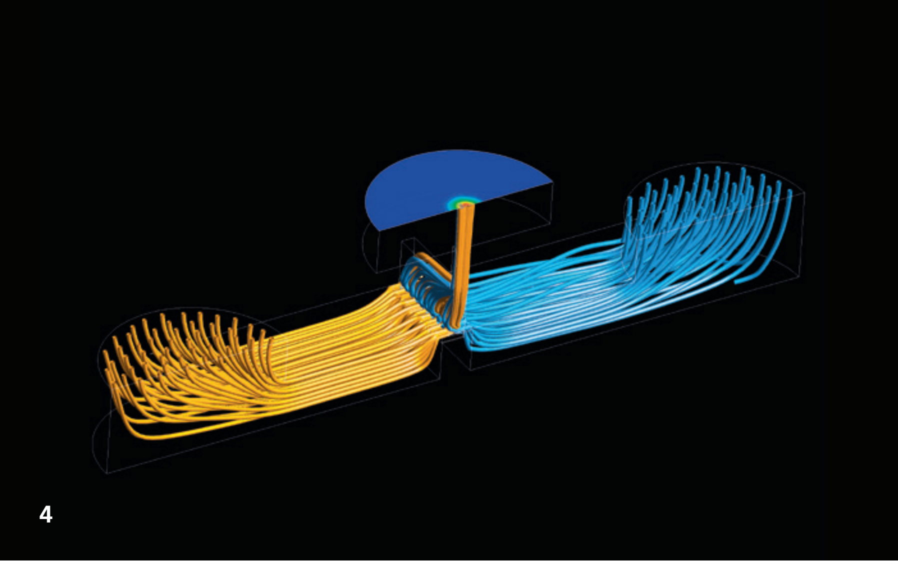
- Speed up development
- Reduce experimental cost due to better planning and data interpretation
- Improve performance
- Get more robust solutions
- Gain a better understanding of the product performance

Simulations can further address questions that can hardly be answered experimentally:

- Parameter variations can be realized easily, fast and cost efficient
- Insight into a process beyond the experimentally addressable range can be gained

Factors of success

The close interaction with the experimental validation and the technical prototyping makes modelling at Fraunhofer IMM outstanding. Hence, our key to success is not only the modelling experience but also a broad interdisciplinary understanding of applications and processing technologies.



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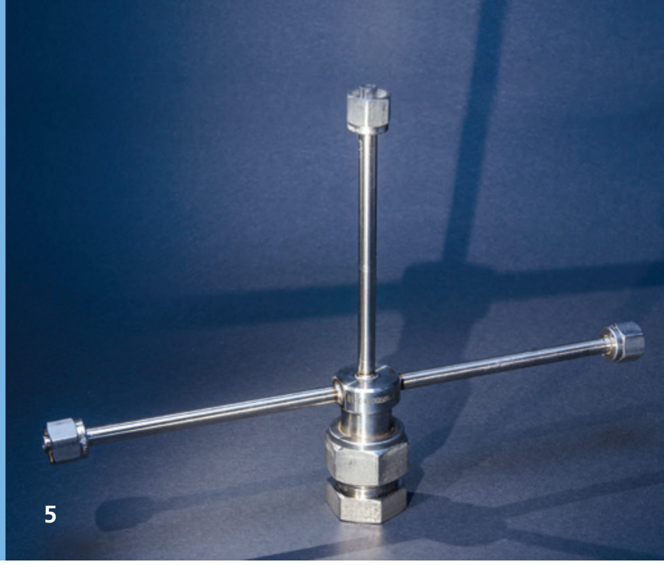

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In short, the factors of success of modelling at Fraunhofer IMM are:

- Long-standing experience in interdisciplinary developments, modelling of microsystems (especially microfluidics)
- Continuous development of proprietary modelling tools (optimized for microsystems)
- Active networking with academic and industrial partners

Topics and Tools

In order to address the plethora of questions arising in a product development process, a multitude of tools are available at Fraunhofer IMM.
Among them are CFD tools for the simulation of microfluidic systems, which are based on finite element or finite volume methods. These simulations often include multiphysics investigations.

Typical topics that can be addressed comprise

- Fluid dynamics
- Heat transfer
- Mixing and chemical reactions
- Multiphase simulations (solid-liquid, gas-liquid or gas-solid)
- Optical beam propagation

Such multiphysics simulations can be complemented by numerical or semi-analytical modelling. Additionally, process simulations can be performed.

Besides using commercial software, we also use various tools that were developed at Fraunhofer IMM tailored to the special needs of configuring, understanding and optimizing microfluidic systems.

Microreactors

Microreactors have a long-standing history at Fraunhofer IMM, both from the experimental and the modelling side. As for liquid chemical reactions where two fluids have to be mixed, micro mixers are required. At Fraunhofer IMM a variety of micro mixers have already been designed and optimized by simulations in the past, such as multilamination mixers (e.g. superfocus mixer) or split and recombine mixers (e.g. caterpillar mixers). The typical needs regarding micro mixers are to reduce mixing times, concomitantly increase mixing efficiency and homogeneity, while keeping the pressure drop low enough for technical realization.

Multiphase simulation

Multiphase applications play a significant role in (micro)fluidic systems. These range from plug flow through microfluidic chips or the transport of cells in microfluidic cytometry to the transport of solid reagents in microfluidic reactors. Some of these applications are closely connected to more fundamental questions, which need adequately adapted modelling methods to be addressed.

At Fraunhofer IMM there is a strong research focus in the migration of particles in microfluidic channels with a successful symbiosis between experiments and simulations: While on the one hand simulations can be directly validated by experiments, in return they help to explain and unify experimental data. Finally, this will enable to deduce design rules for future applications.

4 – 5 *Interdigital mixer: Simulation and technological realization*