Karlsruher Institut für Technologie

KNMF Karlsruhe NANO MICRO Facility

Polymer and Ceramic Components for Various Scientific Applications

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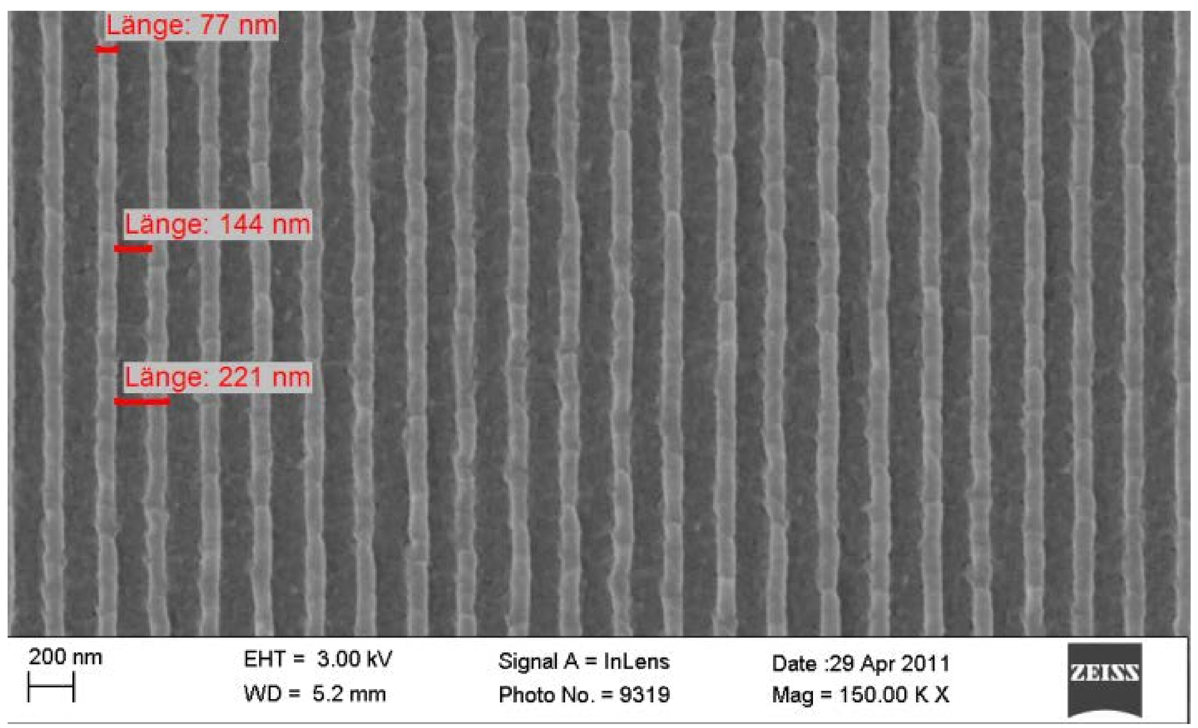
Three examples for scientific R+D projects which benefit clearly from the high performance of micro injection molding are presented.
The first concerns the production of PMMA-substrates with nano-sized wall structures on the surface. The replication process could be driven as unaltered micro injection molding or with an additional compression step (MicroICM).
Promising results in biotechnology are expected if cell growth can be performed on randomly structured polymer surfaces. For comprehensive investigations the partner required large numbers of such templates which could be provided by micro injection molding.
Both polymer replication projects used tool inserts produced at KIT-IMT.
Last not least micro powder injection molding (MicroPIM) has already reached a remarkable level. For example the high accuracy and reliability reached by this process will support project at DESY to image proteins with X-ray FEL pulses, by providing precise ceramic sample injection nozzles.

Injection Molding of Nano-sized Structures

Over the last decade micro injection molding of polymers has reached a mature status with a geometrical size limit of ca. 1µm in lateral resolution.
Many applications, however, require finer structures deep in the submicron area. Crossing the one-micron frontier requires not only enhanced methods for producing nano-structured mold inserts. Furthermore, special variants of process conduct might be required, e.g. the implementation of a compression step, would support complete cavity filling and homogeneous replication.

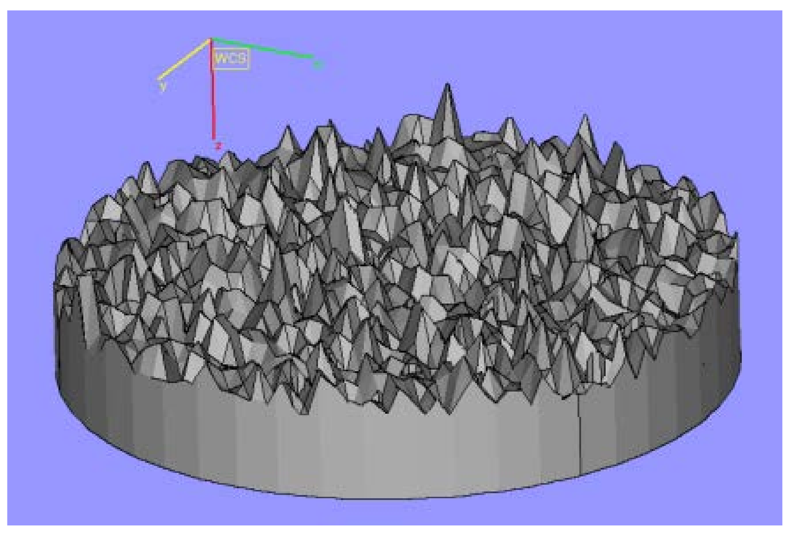
In the frame of a collaboration project with the Christian-Albrechts University in Kiel (Dr. Nazirizadeh) mold inserts had been made by e-beam writing and subsequent galvanoforming. Smallest structural details were in the range of 70-80 nm to be used as photonic crystal slabs for surface contrast microscopy. Replication even at such small sizes could be performed quite sufficiently.



SEM figure of replicated polymer part (PMMA) made by micro injection molding (IAM-WPT)
„Länge“ means width of grooves or bars

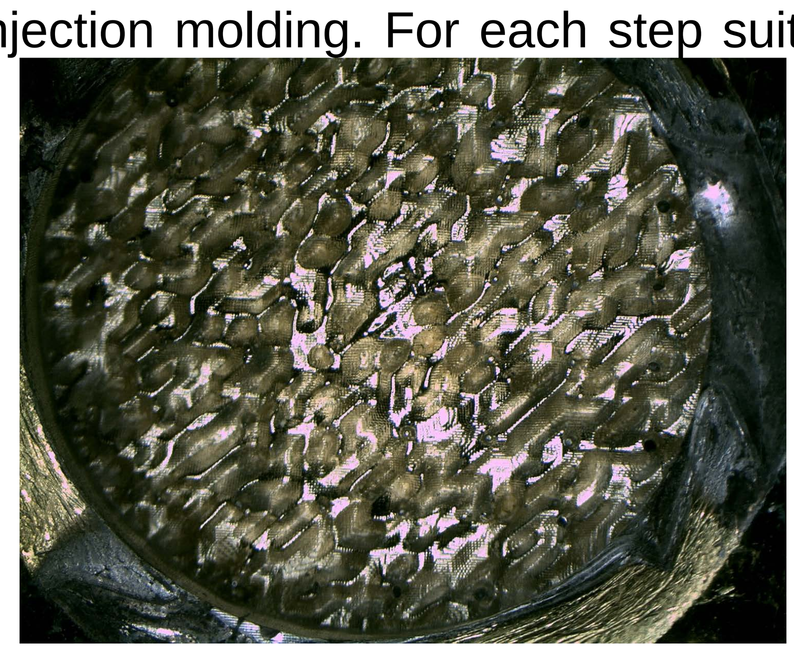
Polymeric Fractal Scaffolds in Biotechnology

The main task of this project with the Universidad Politecnica de Madrid (UPM, Dr. A. D. Lantada) was to validate the use of fractal surfaces to promote cell motility and to achieve controlled growth. To obtain statistically significant results, application of replicative processes for obtaining series of identical scaffolds was necessary.
For this purpose a production chain starting with polymer masters made by stereolithographic methods which had to be replicated by galvanoforming was developed. The metallic structures were used as mold inserts for polymer replication by injection molding. For each step suitable materials and appropriate parameters had to be determined.



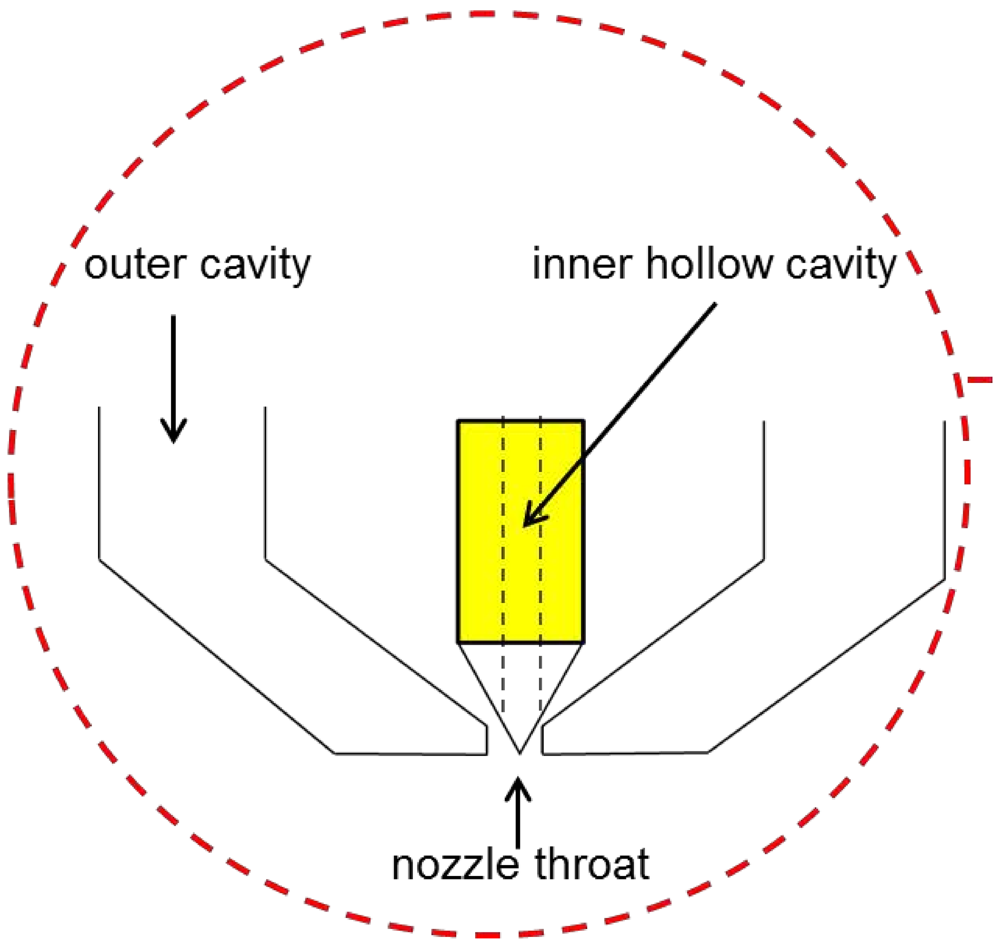
Schematic drawing of a fractal, i.e. randomly structured, surface (UPM, left).

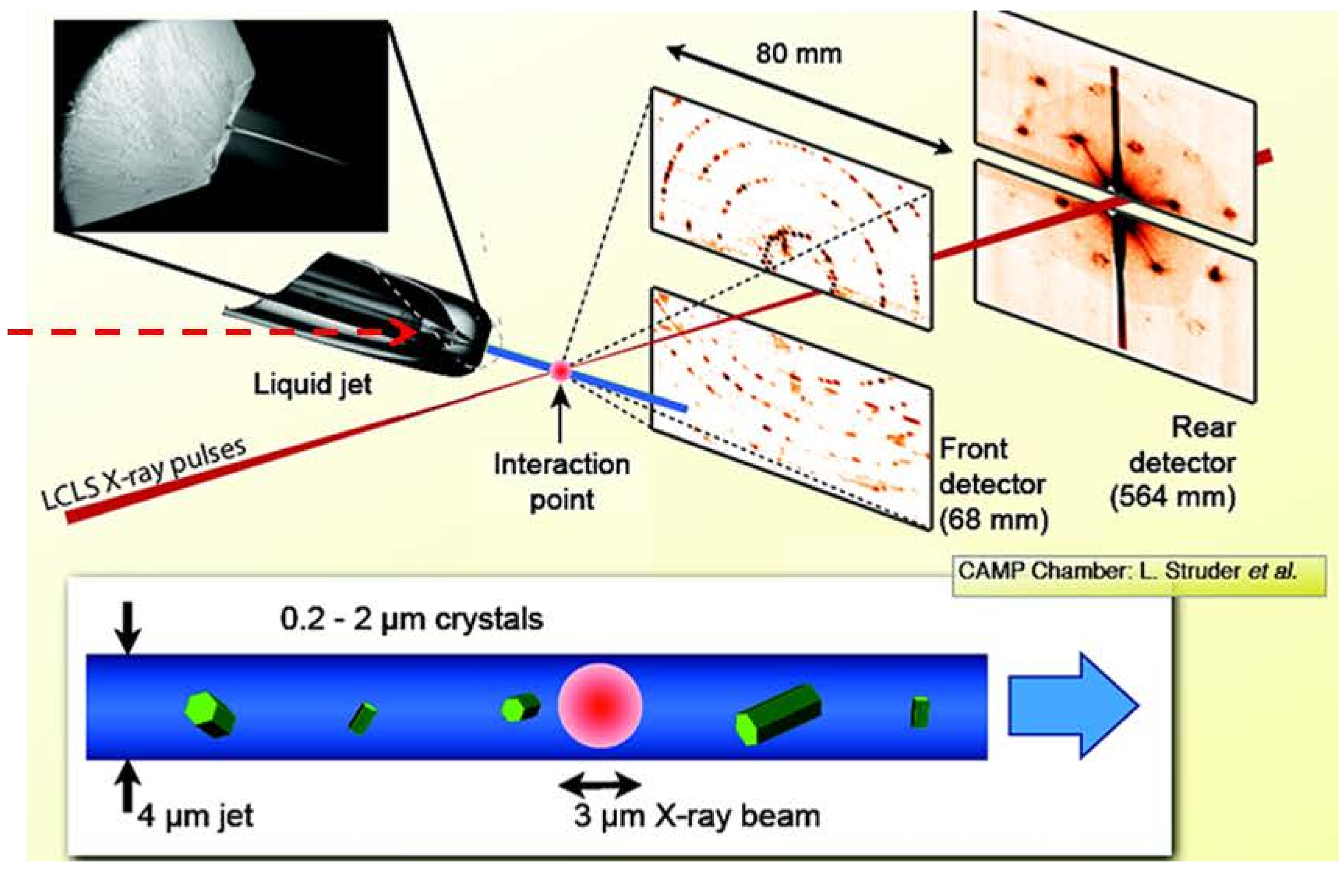
Microscopic view of the mold insert used for replication by injection molding (right). Some hundred replicas made of PMMA and PC have been produced.



Development of Ceramic Nozzles for Femtosecond Laser Applications

The Center for Free-Electron Laser Science at DESY (Hamburg) and KIT have recently agreed on a collaborative project to develop ceramic nozzles to be used in experiments with X-ray free-electron lasers (such as the LCLS in California, and the European XFEL in Hamburg which is currently under construction). Such nozzles are required to generate a strongly focused liquid jet of the analysis sample perpendicular to the beam of intense femtosecond pulses of X-rays at the LCLS (see drawing from DESY below). KIT will bring in its knowledge on manufacturing ceramic micro components to provide reproducibly accurate nozzles feasible for the aspired utilization.





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