European XFEL Workshop

Opportunities for microfluidic devices at Free-Electron Lasers

Towards high throughput sample delivery for serial crystallography

Dominik Oberthüer[1]

[1] Center for Free-Electron Laser Science, DESY, Hamburg, Germany

Serial femtosecond crystallography (SFX) both required and enabled new sample delivery techniques. While for certain experiments the classic ways of how to get a crystal into the X-ray focus can still be used, it is often desired to replenish the sample at much faster rates, to be able to introduce much smaller crystals and to reduce the X-ray background from the sample carrier as much as possible. Initially gas-dynamic virtual nozzles (GDVN) were used for this purpose, since then a huge variety of sample delivery methods has been developed and used for SFX: viscous extrusion jets (LCP-jets), electrokinetic injection, conveyor belt injection, acoustic droplet ejection, piezo-electric droplet generation and various fixed target sample delivery systems. All of these approaches aimed to make sample delivery more efficient: reducing sample consumption and increasing the fraction of X-ray pulses that interact with the crystalline sample and give rise to indexable diffraction patterns. The original GDVN were produced in an artisanal fashion. The quality of a nozzle depended entirely of the capability of its producer and was neither reproducible nor predictable. For efficient sample delivery it is important to have nozzles that are all of the same high quality and that identical nozzles can be produced in large amounts. The most promising approach towards this goal is to make use of the microfluidic technologies developed the past decades. It's inherent advantage is the possibility of rapid prototyping, enabling a certain flexibility in design crucial for the handling of different samples. We combine 3D-printed microfluidics using a NanoScribe system with fluid-dynamics simulations to design, develop and produce GDVN, double flow focusing nozzles and mixing injectors for high throughput ultrafast SFX and time-resolved studies.