nVoxels4MF

NanoVoxel 4 Microfluidics

Programm / Ausschreibung	IWI 24/26, IWI 24/26, Basisprogramm Ausschreibung 2024	**Status**	laufend
Projektstart	01.07.2024	**Projektende**	30.06.2025
Zeitraum	2024 - 2025	**Projektlaufzeit**	12 Monate
Keywords			

Projektbeschreibung

Die Alleinstellungsmerkmale der Firma NanoVoxel (Präzision, schnelle Durchlaufzeiten, Materialvielfalt und Kosteneffizienz) sind perfekt geeignet, um den high-value Markt der Mikrofluidik zu bedienen.
Mit dem Projekt "Nanovoxels for microfluidics" (nVoxels4MF) versucht NanoVoxel die technologische Lücke zu schließen, um in diesen Markt einzutreten, und entwickelt seine technologischen Lösungen für präzise und vielfältige mikrofluidische Komponenten und Verbrauchsmaterialien. Die Ziele des Projekts, die von diesem Markt benötigt werden, sind die Verkleinerung der minimalen Strukturgröße von 100 µm auf 1 µm, die Einführung der Option für 3D-Strukturen, die Entwicklung von Rapid-Tooling-Verfahren für das µ-Spritzgießen/Thermoformen von mikrofluidischen Chips (über Rapid-Tooling-Verfahren), die Reduzierung der Druckzeit um 90 % durch 2PP-Druck in kommerziellen Chips und die Entwicklung neuer Designs, die das volle Potenzial von 2PP für die Mikrofluidik demonstrieren. Diese Initiative steht im Einklang mit dem Motto des Unternehmens, "simplify miniaturization", um die Komplexität der Mikrofluidik anzugehen, bei der es um die effiziente Manipulation von Flüssigkeiten im Mikrobereich für Anwendungen in der Bioanalyse, Diagnostik und Materialwissenschaft geht.
Bis zum Abschluss des Projekts will NanoVoxel mikrofluidische Komponenten und Werkzeuge mit höchster Genauigkeit (± 1 µm) aus einer Reihe von Materialien herstellen, darunter PDMS, Silizium, Glas, Keramik und Metalle.

Endberichtkurzfassung

NanoVoxel Project Year 1 Summary – Advancing Precision Microfabrication for Microfluidics

The NanoVoxel project, launched in July 2024 and supported by FFG, is focused on revolutionizing microfluidic manufacturing through high-precision 3D printing technologies. Now concluding its first year, the project has delivered important scientific and technical breakthroughs in the development of photopolymer-based master fabrication, casting techniques, advanced tooling, and the scalable production of microfluidic components. NanoVoxel’s mission to become a comprehensive microfabrication partner, offering not just production, but also design and engineering, is now well underway.

Progress Highlights Across Work Packages

Project Coordination & Scientific Development

The project began on schedule with the establishment of robust project management workflows and monthly review meetings, and successfully filed two patents relating to advanced microfluidic manufacturing. One protects a novel electroforming process for microfluidic circuits, and another covers a hybrid 2PP and micro-injection molding method for producing micronozzles, both milestones that demonstrate NanoVoxel’s commitment to innovation.

In parallel, the company supported three master’s theses, one of which directly contributing to this project with the publication of an article with FH Technikum Wien, while simultaneously preparing a trade journal publication. The coordinated knowledge transfer underscores NanoVoxel’s role as a key contributor to Austria’s R&D landscape.

Mastering Precision Printing

The development of reusable, high-precision microfluidic masters using 2-photon polymerization (2PP) is a core pillar of the project. In Year 1, the NanoVoxel team successfully identified a primary material for these masters. Using this resin, printed structures demonstrated consistent dimensional accuracy within ±1?µm, meeting the rigorous demands of microfluidic applications.

Complementary advances included new in-house wafer holders, as well as hybrid printing approaches that combine fast 1PP printing for bulk structures with 2PP for fine features. A new Step-and-Repeat (S&R) printing task was also launched, allowing large-area prints to be built from tiled microstructures, crucial for expanding print size without compromising resolution.

NanoVoxel also made breakthroughs in substrate adhesion, seeing improvement from 50% to 80% by applying surface treatment protocols, as well as coatings to enhance chemical compatibility.

Tooling, Casting & Material Innovation

The project advanced significantly in toolmaking and replication processes. A casting protocol was established for both epoxy and silicone, delivering high-resolution molds. Feature replication quality has been excellent, though efforts continue to reduce minor shrinkage through design and process adjustments.

Recognizing the limitations of commercial ceramics, the team developed an in-house ceramic slurry with particle sizes up to 50 times smaller than off-the-shelf products. This innovation has enabled finer detail resolution and supports the development of durable ceramic tools for micro-injection molding (µIM). Glass-based tools also showed promise, with the successful casting and early sintering of materials like Glassomer.

Epoxy and ceramic tools are being evaluated for their performance in µIM workflows. In fact, one notable highlight was the successful production of a PCR chip using PP molded from an epoxy master, showing that the technology is well-suited for real-world biomedical applications.

Work on electroplated nickel shims has started, both in-house and through external collaboration, setting the stage for further tool diversification in Year 2.

Microfluidic Replication & Molding

NanoVoxel achieved reliable low-temperature µIM with several thermoplastics using epoxy molds. With in-house ceramic tools becoming viable, molding of higher-temperature plastics like PEEK is now within reach, potentially expanding the company’s addressable market in diagnostics and life sciences.

Thermoforming activities were postponed in Year 1 due to resource reallocation but remain part of the roadmap. A vacuum-forming machine will be acquired in Year 2 to resume development. Meanwhile, bonding techniques saw unexpected progress through customer-driven overmolding trials, laying the foundation for future integrated assembly methods.

2PP Microfluidic Chips & Hybrid Techniques

Significant progress was also made in the direct 2PP printing of complete microfluidic structures. NanoVoxel’s hybrid 1PP-2PP process demonstrated a powerful path forward for rapid and flexible design, while printing directly inside commercial chips was shown to be feasible using the established master printing resin. These results sparked external interest and led to a collaboration with a chip supplier and research publication with FH Technikum Wien.

Cleaning protocols were overhauled and semi-automated, cutting the time required from four hours to just 15 minutes, a major gain in process efficiency.

Use Case Development & Commercial Applications

Application-specific components like nozzles for controlled microfluidic dispensing were prototyped, where these components were manufactured using a hybrid 2PP and µIM process, demonstrating feasibility for high-throughput production. A patent application was filed accordingly.

Use cases such as PCR devices and organ-on-chip platforms are now being explored, with full process workflows, from master to mold to chip, successfully demonstrated. Surface engineering work to achieve superhydrophobic properties in nozzle designs is also underway and will continue in Year 2.

The Introduction of Simulation Work Package

One of the most strategic outcomes from Year 1 was the identification of simulation as a critical area of development. Many of NanoVoxel’s potential customers externalize this need, but integrating simulation internally would position the company as a one-stop provider of design, simulation, and manufacturing services. This not only expands the technical capabilities of the company, but also generate job opportunities that could attract talents to Vienna.

As a result, a new work package was added to the project, extending it into a third year. Year 2 will focus on foundational research and capability building, including the recruitment of a simulation expert. Year 3 will shift toward implementation and integration, with the goal of optimizing design, reducing material waste, and improving fabrication efficiency across all process stages.

Conclusion

NanoVoxel’s Year 1 achievements set a strong foundation for growth in both technical capability and market reach. From breakthrough materials to new printing methods and IP filings, the project is not only meeting its original goals but expanding its ambition to include simulation-driven engineering. With the continued support of FFG, the next phases promise to solidify NanoVoxel’s role as a leader in microfabrication for next-generation microfluidic systems.

Projektpartner

- NanoVoxel GmbH