Optimization of Ion Beam Etching for IGZO Thin-Film Transistors on Biodegradable Substrates

Master/Semester project

(Section: Microengineering – Physics – Electric Engineering – Materials Science)

Electronic waste has become an increasingly severe environmental issue, with traditional non-degradable substrates contributing significantly to this problem. One potential solution is to replace these conventional substrates with biodegradable materials, such as Polyvinyl Alcohol (PVA), cellulose, or silk. However, these materials often face challenges, including low fabrication thermal budgets and poor water or chemical resistance. As a result, it is essential to adapt the material choices and fabrication processes to overcome these limitations while still maintaining performance in electronic applications.

At LMIS1, the research focuses on using Indium-Gallium-Zinc Oxide (IGZO) as the semiconductor channel for thin-film transistors (TFTs) on biodegradable substrates. IGZO is a widely used n-type semiconductor in display technology, known for its room-temperature deposition via RF sputtering and its moderate electrical properties, including a carrier mobility of approximately 20 $cm^2/(V·s)$ in its amorphous state. The team employs stencil lithography for patterning the IGZO film, enabling a liquid-free, room-temperature fabrication process. So far, the team has successfully achieved clear patterning with 5 μm structures, and electrical properties have been validated through resistivity and Hall effect measurements. Additionally, a trial using ion beam etching (IBE) was conducted, which resulted in a 5 μm blurring with 25 nm etching depth.

The goal of this student project is to optimize the ion beam etching parameters for IGZO films patterned with stencil lithography. The focus will be on achieving the steepest possible edge with a controllable etching speed. The project will begin with IGZO films on solid substrates, such as silicon chips with a thermal oxide layer, and may extend to soft and biodegradable substrates if time allows. The use of stencils with bridges to pattern closed-loop structures, such as isolating IGZO islands, will also be explored. The final objectives will be tailored to the student's interests, capabilities, and available time, providing a hands-on opportunity to contribute to the development of electronic devices on biodegradable substrates.

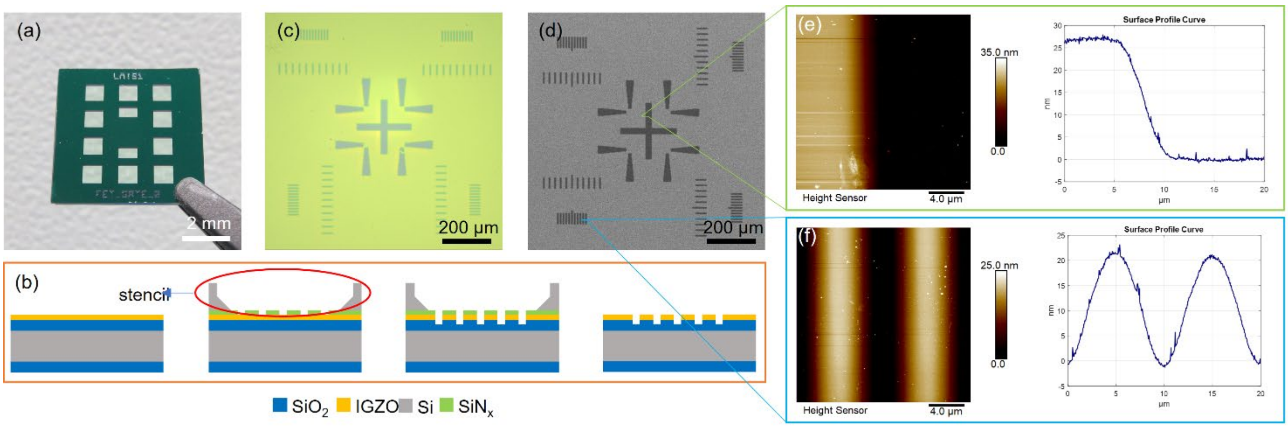

Figure 1 : *(a) A stencil chip. (b) Process flow of IBE with stencil. (c) Optical image and (d) SEM of IGZO structures patterned by IBE through stencil, with (e) and (f) AFM scans of it, showing a blurring of 5 μm by etching 25 nm in depth.*

Possible tasks:

- Optimize ion beam etching (IBE) parameters to achieve steep edge and controllable etching rate.
- Evaluate etching quality with AFM and SEM.
- Transfer process to biodegradable substrates.
- Fabricate closed-loop IGZO structures with bridge stencils.

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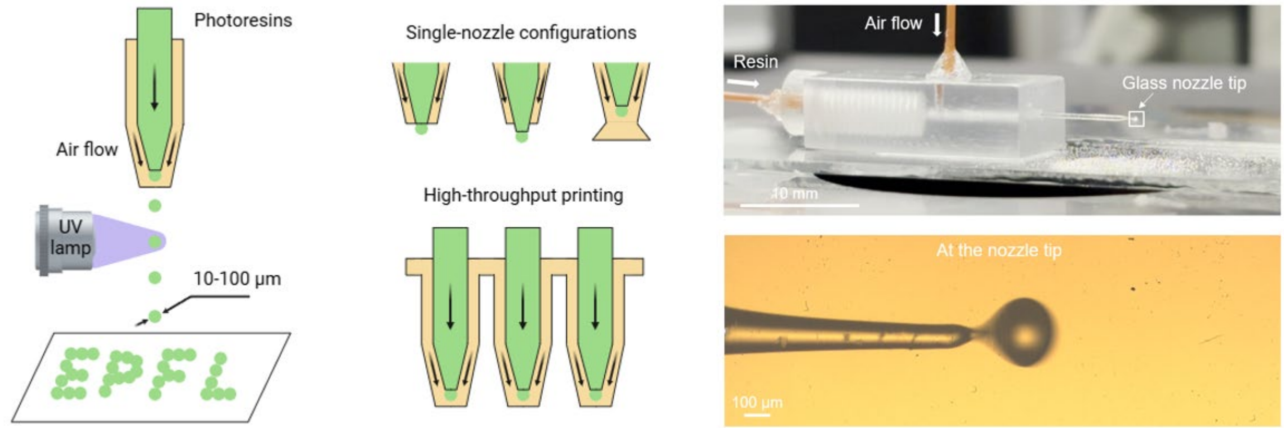
Call for 2025 Fall Semester Project / Master Thesis Students

In-Air Droplet Generation & Solidification via Microfluidics

Fields: Additive Manufacturing | Microengineering | Materials Science

Project Overview

Join us in pioneering a novel 3D printing approach that leverages in-air droplet microfluidics to fabricate microscale polymer beads for voxel-by-voxel assembly of 3D structures. Traditional water-oil microfluidics pose challenges for direct printing. This project explores air-assisted droplet generation as an innovative solution. We investigate how polymerizable resin droplets can be formed mid-air using co-axial nozzles and immediately solidified via UV light before substrate deposition. Foreseeable challenges include optimizing nozzle geometry, droplet trajectory, and scaling up via multi-nozzle systems.



(**Left**): Illustration of a voxel-based 3D printing process. Resin droplets, formed through focused air flow at a co-axial glass nozzle, undergo UV-induced polymerization mid-air before reaching the substrate. (**Middle**): Various nozzle configurations are investigated to improve droplet formation consistency and increase printing throughput. (**Right**): Top: A printed structure composed of large resin droplets generated using a single-nozzle setup. Bottom: High-resolution capture of a resin droplet detaching from the nozzle during the printing process.

What You'll Work On

Tasks will be tailored to your background and interests and may include:

- Designing 3D-printed units for assembling co-axial glass capillary nozzles
- Generating resin droplets using air flow in microfluidic devices
- Characterizing droplet size, frequency, and dispersity as functions of flow parameters
- Exploring in-air UV polymerization for real-time droplet solidification
- Developing multi-nozzle setups for high-throughput 3D printing

Why Join?

- Cutting-edge research team in advanced manufacturing
- Hands-on microfluidic experimentation

Interested? Reach out now to learn more or apply. **Contact:** Tao Zhang (tao.zhang@epfl.ch), Dr. Arnaud Bertsch (arnaud.bertsch@epfl.ch), Prof. Juergen Brugger (juergen.brugger@epfl.ch)

[1] Zhang, *et al. Trends in Biotechnology* (2023). [2] Takagi, *et al. Microfluidics and Nanofluidics* 25.9 (2021). [3] Yang, *et al. International Journal of Bioprinting* 10.1 (2024).

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Call for 2025 Fall Semester Project / Master Thesis Students

Designing MR Guidance for Microfabrication via Real-World Interaction

Fields: Microengineering | Robotics |

Project Overview
In LMIS1, we have been developing different affordances of a mixed reality system for microfabrication learning. This is a continuous work based on the previous project. In this project, we would like to handle the learning task by using Unity 3D and extensions. We have already developed and implemented a mixed reality platform, and are looking forward to a low-threshold implementation in the lab with real-world object interaction. Additionally, this project requires organizing a small-scale study and testing the usability and microfabrication experimental practices' adaptability. Based on the feedback and data, an iterative design and development for improvement is needed.

What You'll Work On
Tasks will be tailored to your background and interests and may include:

- Exploring real-world sensor events through Azure IoT Hub/Socket for secure messaging
- Developing and prototyping new communication solutions for HoloLens
- Designing 3D models that fit the microfabrication process, for example, plasma generation.
- Exploring the network communication for collaboration synchronization.
- Exploring the low-cost implementation of a virtual reality system based on the current project
- Evaluate and assess the usability test for the mixed-reality platform

Why Join?

- Hands-on design and development experience for mixed reality
- The cutting-edge extended reality (XR) development experience

What do we expect?

- A proactive student who would like to contribute to the challenging problem
- Able to program at least one language fluently, preferably C# or Python
- Previous project experience or related background knowledge in communication
- Curious about the mixed reality technology, if you also have a microengineering background, it will also be preferred

Interested? Reach out now to learn more or apply. **Contact:** Qinglan Shan (qinglan.shan@epfl.ch)

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