EPFL

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 $cm^2/(V \cdot s)$ 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.

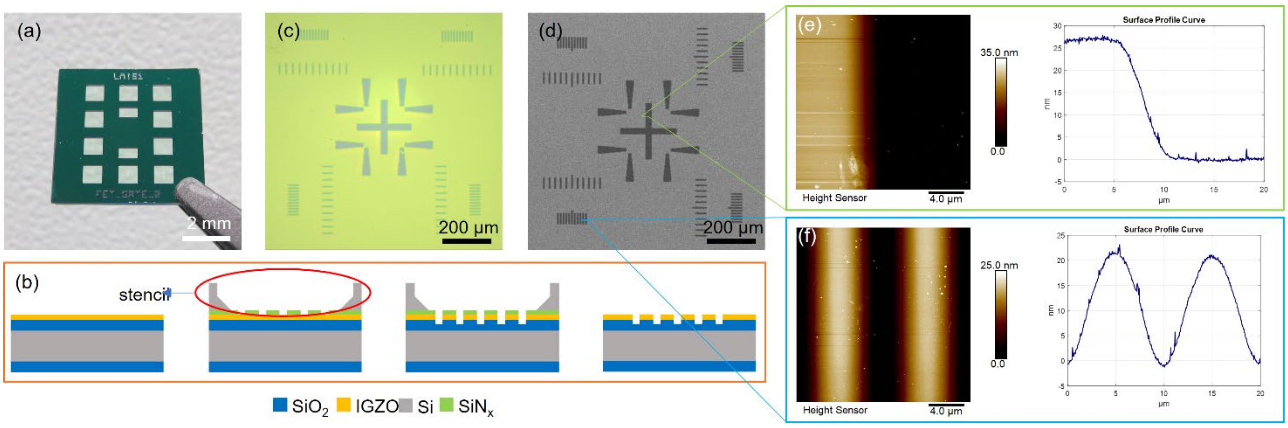

Figure 1 : *(a) A stencil chip. (b) Process flow of IBE with stencil. (c) Optical image and (d) SEM of IGZO structures patterned by IBE through stencil, with (e) and (f) AFM scans of it, showing a blurring of 5 μm by etching 25 nm in depth.*

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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