Designing and Validating Bridges on Stencils: Calculation, Simulation, and Verification

Master/Semester project

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(Section: Microengineering – Physics – Materials Science)

Stencil lithography is a resistless micro-fabrication method using a silicon nitride film stencil for pattern deposition or etching.[1] It enables sub-nanometer scale patterns without the need for photoresist or liquid environments. However, challenges include the inability to pattern closed-loop designs due to film detachment, and the risk of stencil curvature or breakage caused by inner stress. Researchers have explored stencil movement during deposition and other approaches to address these issues.

At LMIS1, a new solution was proposed, incorporating auxiliary bridges in stencils. These bridges serve dual purposes: securing the suspended part of the stencil and preventing membrane curvature. By maintaining a specific gap between stencil and substrate, blurring effects during deposition ensure continuous pattern coverage beneath the bridges. Extensive measurements of morphology and electrical properties have validated the effectiveness of the bridge stencil.

The focus of this student project will be on optimizing the design parameters of the bridge stencil. This includes investigating the width and density of bridges, determining their optimal placement, and establishing the ideal gap between the stencil and substrate. The ultimate goal of the project is to develop a set of guidelines for the automated design tool for bridge stencils.

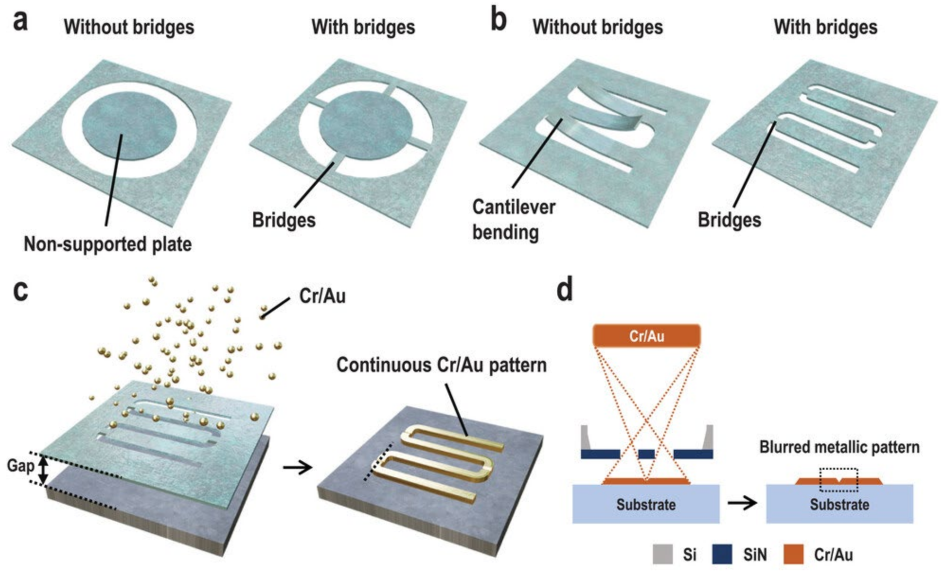

Figure 1 : *The concept of bridge stencils and the blurring effect. a,b) Schematic drawings showing the use of bridges for a) realizing unfeasible geometries on stencils (e.g., close-loop circular apertures), and b) suppressing the bending of cantilevers for meandering apertures. c,d) Schematic drawing showing the beneficial use of the blurring effect. [2]*

Possible tasks:

- Conduct stress calculations in simple models to analyze the relationship between bridge parameters and stress levels.
- Simulate stress distribution in complex patterns (e.g., circles, serpentines) to guide optimal bridge placement.
- Verify the concept of bridge placement in the clean room.

Contact : Chenxiang Zhang (chenxiang.zhang@epfl.ch)

[1] O. Vazquez-Mena et al, vol. 132, pp. 236–254, Jan. 2015.
[2] Y.-C. Sun et al, *Adv. Mater. Technol.*, vol. n/a, no. n/a, p. 2201119.