Development of a new manufacturing process to make miniature actuators for mesoscale robots

The mesoscale encompasses all structures ranging in size from a few centimeters down to a millimeter. Recently, research on mesoscale polyarticulated robotic structures on the order of centimeters has been dominated two main approaches: the first are structures made from multilayer composites that are cut, folded, and/or assembled (using origami/kirigami and/or split-and-splice techniques) [1], [2] (Fig. 1(A–E)). This approach has seen significant growth in terms of design and manufacturing technologies as well as application areas, primarily led by Harvard University but also in FEMTO-ST. The second is the use of microscopic 3D printing using the 2 photon polymerization (2PP) process in which the robotic structures are built without the need for assembly using plastic materials such as IP-S (Fig. 1(F)) [3]. However, the main roadblock for successful miniaturization of robots in both cases has been the development of compact actuators with a footprint of less than a mm^2 that are controllable and reliable. Recent developments have shown that many interesting compact actuators can be created using 3D printing. This internship aims to develop this second research axis at FEMTO-ST.

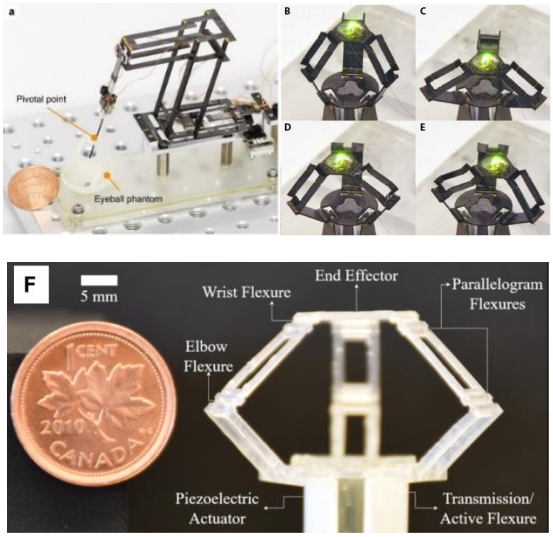


Figure 1 : Examples of poly-articulated robotics at the mesoscale [1-3].

Subject

The objective of this internship is to develop a manufacturing process using 2-Photon Polymerization (2PP) for microscopic 3D printing, to create miniaturized robotic actuators and robotic structures. For this we will use the NANOSCRIBE 3D printer at the MIMENTO lab, capable of creating 3D structures with resolutions down to 100 nm. The materials use will initially be IP-S (viscoelastic), but we shall also experiment with more linear isotropic materials.

This sub-millimetric scale inevitably introduces constraints related to manufacturing, integration, and operation; these constraints include: The use of compliant/flexible joints. This means no bearings, sliding or rolling connections, gear mechanisms, sockets or any other type of connection where one element slides or rolls relative to another. This means that all joints must be flexible/deformable solid structures (flexures), which are ideal in the case of 3D printing. This process will be used to fabricate and integrate one or more robotic structures with multiple

degrees of freedom at the sub-centimeter mesoscale. The student will also be required to experimentally validate the control and positioning accuracy of this structure. To do so, we will use microscope cameras and micrometric positioning platforms to conduct metrological tests.

Expected deliverables

- Definition of a standardized manufacturing procedure for the creation of miniaturized printed actuators.
- Development of metrological experiments to validate the precision and repeatability of said actuators.
- Development of an articulated structure with 2-dof (in the plane) or 3-dof (3 D) which integrates these actuators, with a footprint of less than 1 cm × 1 cm.

Desired skills:

- Experimental work (prototype development, iteration of manufacturing parameters)
- Knowledge of electronics (use of power supplies, analog and digital electronics, oscilloscopes).
- Knowledge of Finite Element Analysis (FEA) software.
- Organizational Skills to document the whole process.
- Knowledge of MATLAB and Simulink programming.
- Knowledge of articulated robotics (direct and inverse kinematics, transformation matrices).
- Ability to work in a team.

Internship Tutor: Freddy ROMERO LEIRO, Associate Professor, SUPMICROTECH-ENSMM

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- **Laboratory:** Institut FEMTO-ST, Département AS2M, Besançon, France.

Documents to apply:

- Resume in PDF format
- Cover letter (specific skills and how they align with the position)
- Most recent transcripts (for the last 3 years, if possible)

Duration of the internship: 5 to 6 months, **Stipend:** 550 € per month

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References :

[1] H. Suzuki et R. J. Wood, « Origami-inspired miniature manipulator for teleoperated microsurgery », *Nat. Mach. Intell.*, vol. 2, no 8, p. 437-446, août 2020, doi: 10.1038/s42256-020-0203-4.

[2] H. McClintock, F. Z. Temel, N. Doshi, J. Koh, et R. J. Wood, « The milliDelta: A high-bandwidth, high-precision, millimeter-scale Delta

[3] S. Adamovic, A. Karuppiah and R. Orszulik, "Structural Optimization for Additive Manufacture of a Compliant Mesoscale Delta Robot," *2026 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)*, Genova, Italy, 2026,