3D printed soft microrobotics: from motion generation paradigm to complex microrobots

Advisory board: Cédric CLEVY, and Kanty RABENOROSOA

AS2M department at the FEMTO-ST Institute, University of Bourgogne Franche-Comté, invites applications for a fully-funded 3-year PhD position in 4D printed soft microrobotics in the framework of ANR PNanoBot. The starting date for the position can be discussed.

1 Context

The proposed thesis work is part of the collaborative research project PNanoBot, supported by the National Research Agency, in which are associated IS2M (Mulhouse), Femto-ST (Besançon) with two involved departments. PNanoBot intends to address in deep the paradigm of motion generation for micro/nanorobotics purpose with a particular interest to fabrication methods and innovative kinematic design at the considered scale. The proposed paradigm will be different from the one known up to now in [SLY+16, FAN13, NDA16], where micro/nanorobotic manipulation systems are composed of multiple degrees of freedom (DOFs) centimetric high accuracy positioning stages.

To respond to increasing needs in healthcare and in manufacturing, micro/nanorobotics has to change paradigm to overcome the current limitations on dexterity, compactness, range, and precision. PNanoBot aims at investigating the development of Two-Photon Stereolithography (TPS) micro/nanorobotic structures made in photo-actuated material [ABR+21, SW20] mounted at the tip of optical fibers (see Figure 1). The main idea is to design the next generation of tethered micro/nanorobotics by combining complex 3D structures tailored with metamaterial parts and photo-thermo multi-responsive polymers. The actuation will be achieved through the laser beam in the fiber core by controlling simultaneously or successively the optical flux and the wavelength. PNanoBot aims to drastically increase the state of-the-art workspace to robot volume ratio while preserving robotic performances required at the micro/nanoscale. Two promising strategies (hydrogels and liquid crystal elastomers) will be studied and improved to overpass proof-of-concepts to ensure controllability, repeatability, and long- life. The ability of PNanoBot will be highlighted through two demonstrators for healthcare and manufacturing.

2 Objectives

This PhD project aims at the development of dexterous nanomanipulators which are compact (smaller than 1 mm3), and ensure at least 3 DOF, high precision, and repeatability, are missing to widespread the use of nanorobotics for nanomaterial characterization, and nano-assembly of complex devices. PNanoBot envisions to bring the workspace to robot volume ratio four times more than the state-of-the-art while maintaining low footprint, multi-degrees of freedom, and keeping robotic performances suitable for micro/nanoscale: a few tens of micrometers range, ten nanometers, and tens rad repeatability.

To achieve these objectives, the candidate will interact with the project's partners and will focus on :

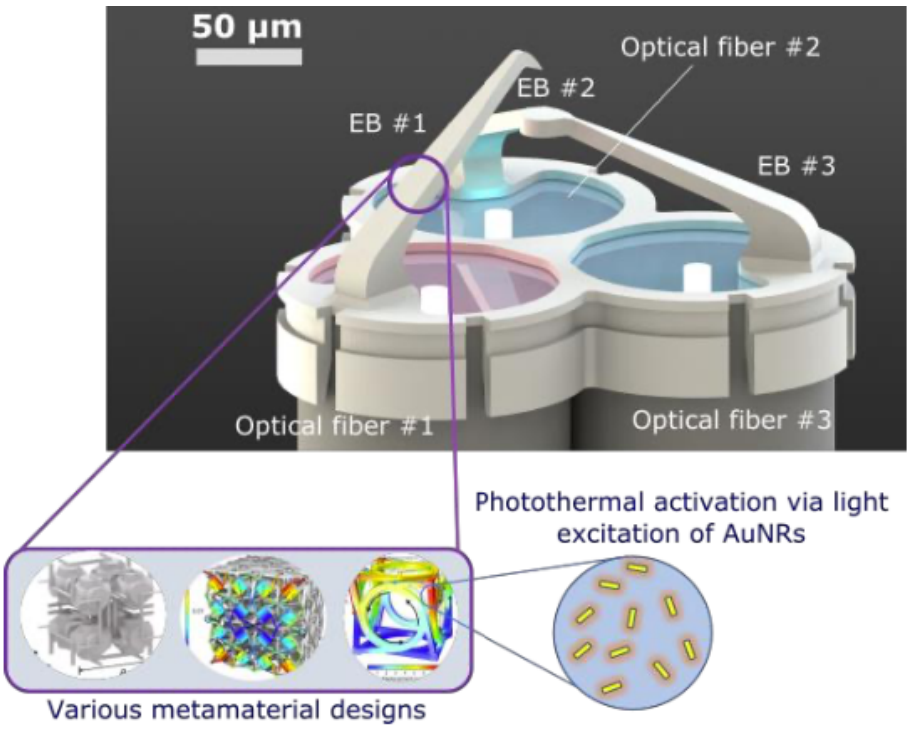

Figure 1: The envisioned concept for the next generation of 3D printed soft-tethered nanorobotics: three Elementary Blocks (EB); each one being mounted on a fiber tip and composed of complex structure with metamaterial part that can be actuated independently through the fiber core with various optical flux and wavelength (indicated by optical fiber color)

- Fabrication and characterization of each Elementary Block (EB) in terms of motion range and force capability.
- Design and study the kineto-static behavior of EB arrangement in order to obtain multi-DOF.
- Develop one demonstrator which will enable to highlight the robotic ability enabled by PNanoBot results.

3 Profile

We are seeking a highly motivated, a team player, an open mind, and result-oriented candidate. The candidates are expected to have the following skills:

- Master degree in mechanical, mechatronics, robotics engineering or equivalent with distinction.
- Strong background in solid mechanics, continuum mechanics, robotics, and manufacturing (micromachining).
- Familiar with Matlab, Python or C++, CAD software and Finite Element Methods.
- Interest/experience on experimental investigations/validations.
- Candidates must be fluent in English. French would be an advantage but not necessary.

4 Additional information

AS2M department is a rich environment for high quality research with facilities[1] at the cutting edge of the state-of-the-art [BWR+21, JMC+21]. We design, build and program next-generation robots that use compliance and active matter as part of their intelligence to adapt to complex tasks.

5 Scientific contact

Please send your Curriculum Vitae (CV), a covering letter including research statement and the last year marks in a single PDF file to Kanty Rabenorosoa rkanty@femto-st.fr and Cédric Clévy cclevyy@femto-st.fr. The selection process is ongoing and will last until the position is filled.

References

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[1] Mimento and Centre of Micro and Nano Robotics