INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES HAUTS-DE-FRANCE

PhD position

Membrane based on polymeric micro-transducers for innovative micro-pump.

Key words: Micro-pump, modelling, micro-fabrication, actuators based on conductive polymers,

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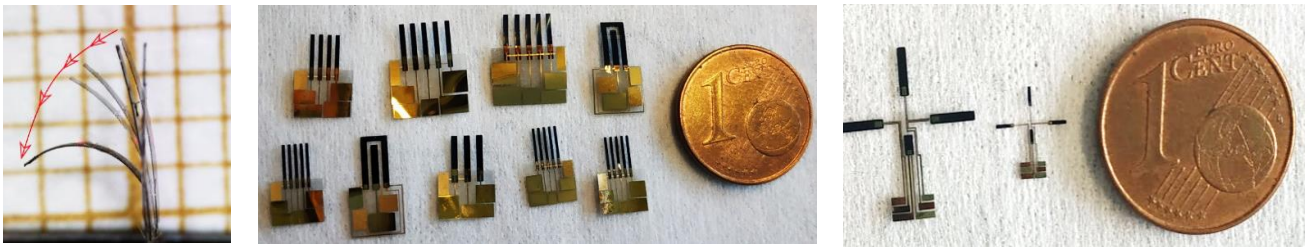
Context:
The IEMN Bioinspired MEMS team has been working for the past ten years on the integration of ionic-electroactive polymers in order to realize flexible microtransducers. Theses polymers have specific characteristics that allow them to be now used for various applications, whether in applications requiring actuation and/or sensor functions. Several micro-actuators for different applications have been developed by our team as reported in Figure 1. Ionic- electroactive polymers are a promising candidate for MEMS such as development of Micro pumps which are devices that can control and manipulate small fluid volumes.



(a) (b) (c)

Fig. 1: Ionic- electroactive polymers based micro-actuators, (a) Response of the micro-actuator subjected to an applied voltage, (b) integrated micro-actuators for different applications, (c) micro grippers with 3 fingers, 2 as actuators and 1 as sensor.

Objective:
Micro-pump is an essential technological node to overcome smart chemo-sensing challenges in many up-to-date platforms such as lab- & organ-on-chip systems in research, as well as in more applicative microsystems for the IoT. Many concerns such as co-integrability, energy costs and low voltage supply have to be taken into account for the given micro-pump actuating technology to interface the appropriate sensing ones. In that respect, ionic- electroactive polymers based micro-actuators reported above, are a perfect match for an all-polymer fully co-integrated organ-on-chip platform. For example, diaphragm pumps have a pumping chamber and two valves oriented in the opposite direction, which defines the inlet and outlet of the pump as reported in Figure 2. In this case, the diaphragm pumps or / and valves can be designed from our micro-actuators.

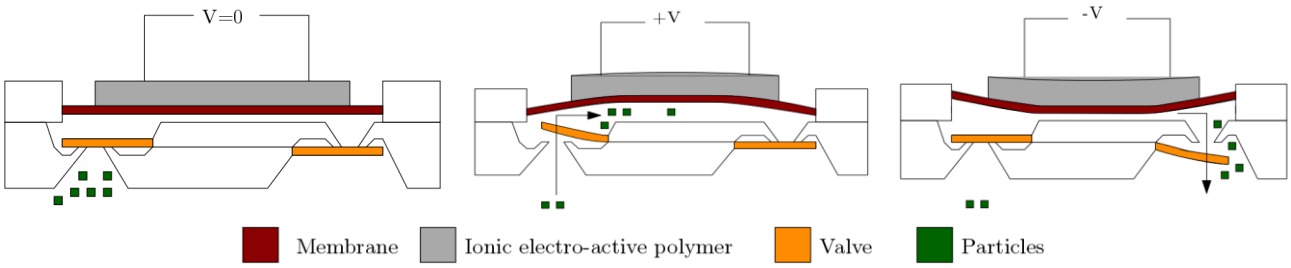


Fig.2: Operating principle of a micro pump based on "intelligent" materials

In this framework, the PhD student will have to challenge the applicability of our electroactive polymer actuators[1-3] as a functional micro-pumps co-integrated at the vicinity our state-of-the-art neuromorphic biosensing elements,[4-7] for compact biomimetic microsystems and her/his main tasks can be divided into four axis detailed hereafter.

- **In task 1** A review on micro-pump will be done, with their applicative field in microfluidic and in other potential area of use.

- **Task 2** will focus on the design, modeling and simulation of different designs of micro-pumps on the basis of dimensional constraints and flow to be generated. The objective is to place it as close as possible to the neuromorphic biosensing elements. Therefore, the researcher should consider all options to achieve the desired flow rate by taking into account the performance of actuators based on conductive polymers. This design will require also consideration of the check valves.

- **Task 3** is dedicated for the study of micro-actuators with different geometries and different boundary conditions in order to determine the actuation mode performances.

- **Task 4** will use the results of task 2 and 3 to micro-fabricate the PDMS micro-pump in IEMN clean room and characterize and validate the gaseous fluid flow performance. This step will be iterated with task 2. The compatibility of actuators based on conductive polymers with the gaseous fluids injected into the micro-pump will be evaluated over time. The use of liquids as fluids (water, organic solvents and/or ionic liquids) will be evaluated also and will iterate again with task 1. In close collaboration with Nanostructures and Molecular Components team of IEMN, the micro-pump will be controlled electronically and associated with the neuromorphic biosensing elements.

Candidate profile:
The PhD candidate will be in charge of the four tasks described above. Experience in micro/nano fabrication in a cleanroom environment is mandatory. Skills among the following research fields would be an advantage: micro-nanofabrication processes, mechanical engineering, and electrical engineering. In addition, experience and strong interest in polymeric materials will be a plus.

Environment:
The IEMN is spread over sites of Valenciennes and Villeneuve d'Ascq in France. The candidate will work in a state of the art cleanroom environment and will have full access to the micro & nanofabrication and characterization platforms of the IEMN laboratory (https://www.iemn.fr/plates-formes/cmnf/equipements). She/He will work in close collaboration with experts from micro-nanotechnology. The Phd researcher will integrate the Bioinspired MEMS Team. This team has been working for several years on the integration of ionic-type electro-active polymers in order to realize microsystems.

References:

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