**Heat Actuated Smart Materials
Study of heat transmission solutions for smart catheters**

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**Candidates profile:** ElectroMechanical / Biomedical / Civil / Chemical engineering

## **Introduction**

**Vascular occlusion**

In the medical field, during minimally invasive procedures, most of the devices (endoscopes, catheters, guidewires, etc.) need to be sufficiently flexible to avoid damaging patient tissues or causing pain, but have to be stiff enough to transmit force for support or for puncture. In the case of vascular stenosis, the guidewire has to be flexible to reach the stenosis (through the blood vessels), but it requires a rigid support to pass through the occlusion for treatment, to avoid buckling or deformation due to the force application. In order to solve this duality on the rigidity, controllable stiffness mechanisms can be used. Various mechanisms to control the stiffness can be found in the literature [1]. One of the promising solutions to achieve this objective is based on the use of “smart” polymers. This research aims at studying the scaling laws of such solutions for miniaturized applications (with diameters below 3mm), the mechanical rules of design and the optimization based on the stiffness performances.

Several different polymers can be used for controllable stiffness, amongst which some are already available in the lab. It is possible to use Shape Memory Polymer [2], PolyMorph and CoolMorph. The shape memory polymers have the faculty to be educated in a given shape and to recover their previous shape by heat stimulus. These Shape Memory Polymers have a large change of Young Modulus around their glass transition temperature and therefore their stiffness is greatly changed by heat transmission. The PolyMorph and CoolMorph polymers do not have the shape memory action but have a great change in Young Modulus around their glass transition temperature (of 62°C and 42°C respectively). They are easy to manufacture and suitable for smart catheters applications.

## **Objectives**

The aim of this project is to study and compare few methods to bring the stimulus to the material. Some methods have been studied in the past and have been used in proves of concept. A deeper study of these solutions has to be performed to validate their use in the described application. The experimental work will consist in developing prototypes and evaluating their performances (mainly thermo-mechanical characterizations). The design of the specimens, the integration of the heat transmission solutions and the prototypes will be realized by the student with help and supervision of the PhD student working on this thesis. **Based on the completion of the project, the final solution will be implemented in the main prototype.** Notice that a literature review may lead to the comparison of other heat transmission solutions or proposition of other materials to test. Furthermore, the cooling mechanisms may also be studied (use of liquid nitrogen for example).

[1] Kuder, I. K., Arrieta, A. F., Raither, W. E., & Ermanni, P. (2013). Variable stiffness material and structural concepts for morphing applications. *Progress in Aerospace Sciences*, *63*, 33-55.

[2] Leng, J., Lan, X., Liu, Y., & Du, S. (2011). Shape-memory polymers and their composites: stimulus methods and applications. *Progress in Materials Science*, *56*(7), 1077-1135.