Printing and Performance Evaluation of Terpolymer Electroactive Materials for Endoscope Actuation

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Despite great technological advances, endoscopes are still handled manually by surgeons, which is not the most comfortable for them. Therefore, there is a need for endoscopes with highly precise automated and programmable actuation. In soft robotics, electroactive polymers (EAP) are used to induce actuation on flexible structures. Among EAP, Poly(vinylidene fluoride) (PVDF) is known to show electroactive properties, due to the presence of dipolar moments (C-F bonds) inside a specific crystalline microstructure. Specific chemical modifications of this polymer lead to the relaxor ferroelectric Poly(vinylidene fluoride-trifluoroethylene-chlorotrifluoroethylene) P(VDF-TrFE-CTFE) with reduced size polarization domain that induce reversible large strain [1].

In this work, two processes have been selected to manufacture actuators compatible with non-conventional structures such as endoscopes: screen-printing and dip-coating. The first one is a well-known and mature printing method, whereas the latter is more compatible with the cylindrical shape of traditional endoscopes. In both techniques, a multilayer approach is used to reduce high voltages (~100V/µm) required in electrostrictive materials to induce actuation. [1]. To characterize the performance of the actuators fabricated, the angle of deflection at a field of ~100V/µm is measured. This angle is influenced by several parameters such as the Young's modulus, the thickness of the electroactive layer and the substrate, or the length/width ratio of the geometry as shown in Figure 1. The higher the thickness of the polymer layer is, the higher the angle of deflection is. Moreover, the higher the length/width ratio is, the higher the deflection is. Furthermore, analytical models can help us selecting more precisely and optimizing those parameters [2]. Similarly, a study of the different parameters that influence dip-coating has been conducted. This approach produces enough mechanical force to move the tip of the endoscope.

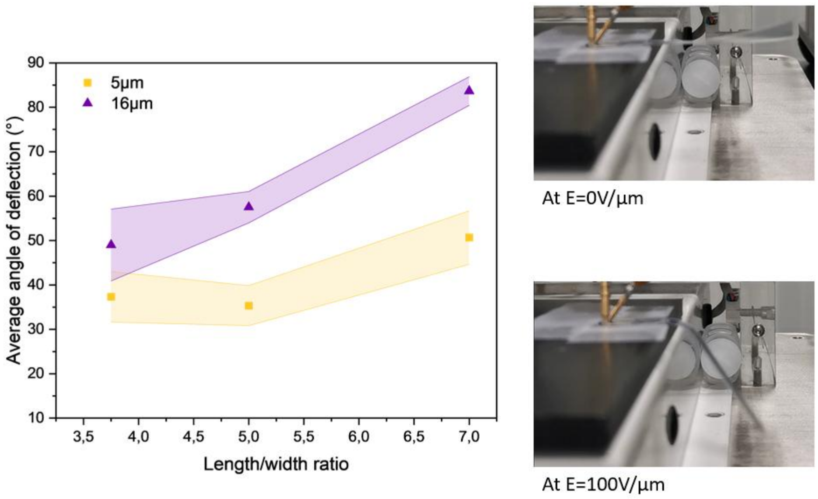

Figure 1 : Average angle of deflection vs. length/width ratio (left) and images showing the deflection profile of a 5µm thick actuator under 0 and 100V/µm (right)

[1] S. Ahmed *et al*, « Electric field-induced bending and folding of polymer sheets », *Sens. Actuators Phys.*, vol. 260, p. 68-80, 2017.

[2] Q. Jacquemin *et al*, « Design of a new electroactive polymer based continuum actuator for endoscopic surgical robots », in *2020 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2020, p. 3208-3215.