SUBPROJECT 8: Electromechanical modeling and metrological investigation of helical actuators with material-integrated sensors

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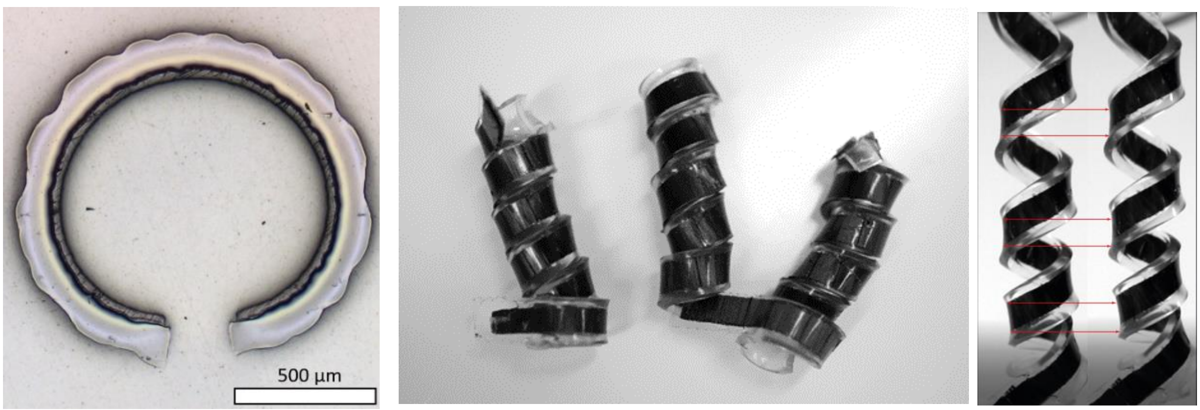
Motivation

Interactive fiber-elastomer composites require actuators that can provide significantly greater deformations and forces than today. The work of the first cohort also looked at the potential of helical actuators as an alternative approach to integrating active fibers into elastomer composites. Initial experiments have shown that significantly larger deformations can be achieved. Electroactive materials are of particular interest here, as they promise a fast response. The maximum achievable force of a dielectric elastomer actuator could be increased even further if stiffer materials were used than the elastomers used to date. In the specific example of helical actuators, the actuator properties, e.g. maximum force and deformation, can also be adjusted using the design parameters of the helical shape.

The relationship between shape and behavior is complex and crucially dependent on the actuator concept and manufacturing process. The aim of the project is now (i) to model the (thermo-) electromechanical behavior of helical actuators, (ii) to derive guidelines for an advantageous design of such actuators on this basis, (iii) to find corresponding possibilities for the implementation of other material combinations and (iv) to integrate sensors into the actuators with which the three-dimensional deformation behavior can be efficiently determined and monitored in real time.

State of the art and own previous work



Helix-shaped dielectric actuator [1-3]

In previous work [1-3] in the first two periods of the Research Training Group, a demonstrator of a helical dielectric actuator (see figure) was produced and it was shown that the deformation potential of the actuator could be increased by more than one order of magnitude by using the helical shape. Furthermore, it was demonstrated that the actuator can also be used as a strain sensor. This showed a clear dependence of the electrical resistance on the applied strain. In addition to electroactive polymer actuators, thermoactive polymer actuators were also produced from highly twisted monofilaments [4]. A combination of electroactive and thermoactive components would provide further degrees of freedom for the realization of 3D movements.

Scientific questions and project objectives

Electro-thermo-mechanical network models are to be developed for the behavior of electro- (and thermo-) active helical actuators (from projects 1 and 2), which allow the calculation of forces and deflections on the basis of the material and geometry parameters (as in [5]). Corresponding demonstrators (SP 11) are to be validated experimentally and compared with the models. In addition, possibilities are to be researched as to where and how sensor structures can be advantageously integrated to monitor the state of deformation and damage due to overstretching. Further objectives are the development of novel bisensitive actuator structures that are both electroactive and thermoactive.

Interaction is planned with SP 1 and 2 (fiber-based actuator and sensor elements as components of helical structures,) SP 3 (new elastomers), SP 6 (use of cross-scale models as components for electromechanical network models), SP 7 (integrated sensor-actuator concepts), SP 9 (use of adapted control concepts), SP 10 (in-situ testing strategies for actuator-sensor systems), and SP 11 (integration in multi-matrix composites).

References

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