SUBPROJECT 7: Advancing structure-integrated actuator-sensor systems by using alternative electroactive polymer materials

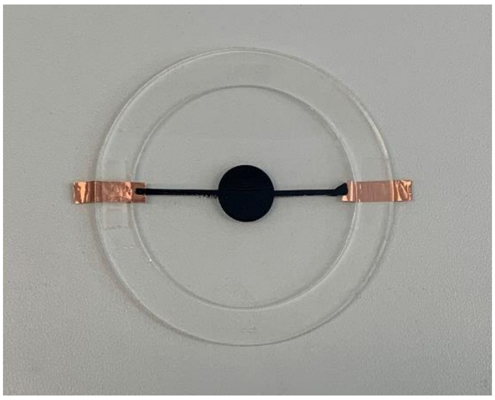
G. GERLACH (IFE) in cooperation with S. WIEßNER (IPF);
external supervisor: I. ANDERSON (University of Auckland/ NZ)

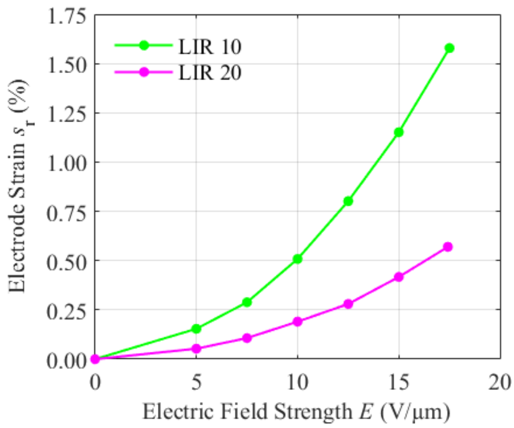
Motivation

By using dielectric elastomer actuators (DEA), fiber-elastomer composites can be actively deformed. The integration of sensors in these composite structures allows the simultaneous detection of the deformation state. Such actuator-sensor systems are suitable for the production of adaptive and interactive soft robotic components that can be used, for example, in soft robot grippers and bionic robots. The actuator-sensor systems implemented so far in SP 7 consist of silicone-based DEA and sensors for one-dimensional deformation detection. As a continuation of this sub-project, actuator-sensor systems are now to be developed with which three-dimensional deformations can be both generated and detected.

State of the art and own previous work

Silicone and acrylic-based DEAs have great potential for use in extremely gripping-sensitive applications [1], linear actuators [2], pneumatic valves [3] and liquid pumps [4]. As part of the first two cohorts of the RTG, approaches were pursued in which mechanically anisotropic behavior could be achieved by reinforcing the actuator structure with textiles [5,6]. In [7], additional strain sensors were investigated with which the elastic deformations can be monitored. Furthermore, simple electro-mechanical network models were presented for calculating the deformations in the plane, with which essential properties of the overall system could be explained. This made it possible, for example, to determine how point actuators should be optimally designed [8]. The design, dimensioning, function and properties of actuators with better material properties were presented in [9].





Dot actuator and electro-active response

Scientific questions and project objectives

There is still a need for research into the development of adaptive systems that combine actuators, sensors and textile reinforcement and that enable movements that are as three-dimensional as possible. Corresponding electro-mechanical network models are to be developed for such systems, which can be easily used in system models for the targeted control and regulation of movement behavior. In SP 7 and 8, DEA-based actuator-sensor systems are to be developed that achieve an improved actuator effect compared to current DEAs. New constructive, e.g. biomimetic, approaches and integrated sensors will be used to detect the three-dimensional deformation state of the I-FEV with sufficient precision. Another focus will be on the development of construction elements with constructively achieved auxetic behavior, i.e. that negative transverse contraction behavior is achieved in certain directions and thus three-dimensional deformations can be easily induced. Another focus is on the development of suitable mechanoelectric network models and the metrological characterization of such systems.

There is close interaction with SP 2 (textile-based actuator reinforcement for the generation of constructive anisotropies), SP 3 (new elastomers), SP 5 (heat transport in actuator structures), SP 8 (electromechanical network models for sensor-actuator systems, novel (e.g. helical) sensor-actuator structures), SP 9 (use of adapted control concepts), and SP 10 (in-situ testing strategies for actuator-sensor systems).

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