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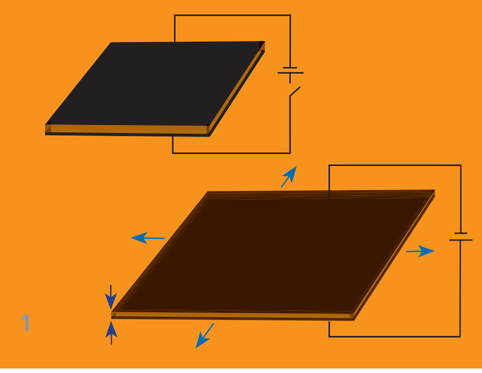

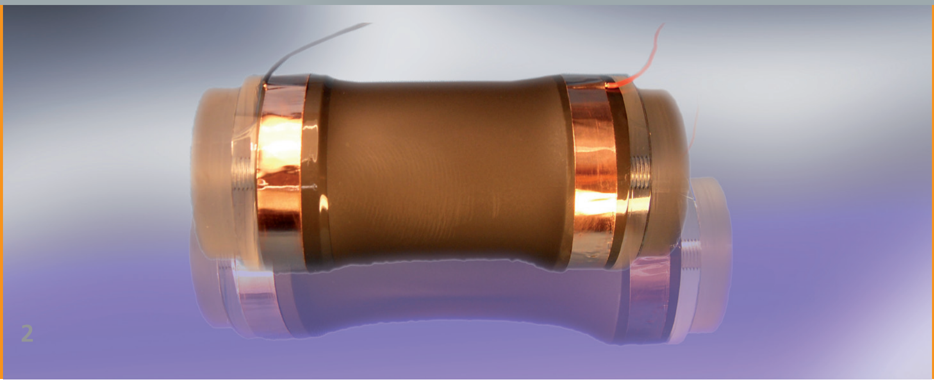

1 *Operating principle of a dielectric elastomer actuator: On applying a voltage the film expands in area*

2 *Simulated expansion of a rolled spring actuator*

HIGHLY EXPANDABLE ACTUATORS MADE OF DIELECTRIC ELASTOMERS

Dielectric elastomer actuators (DEA) are a new type of electroactive polymer composite which expand when a voltage is applied. They differ from piezoelectric actuators in having high lateral expansion of more than 10 % while transferring only a relatively low level of pressure. Further advantages are their low weight, mechanical flexibility, potentially low production costs and the fact that they permit a great variety of different construction designs.

These characteristics make DEAs ideally suited for applications in which large actuation strains are required but not high forces. Examples are the adjustment of covers, openings, mirrors or other optical elements, controllable valves and pumps for transporting fluids or gases, and tactile surfaces that give a tangible response on touching.

Actuation principle

Dielectric elastomer actuators consist of a highly flexible elastomer film with an electrode film on both sides, the conductivity of which stays consistent even under very high levels of strain. On applying a voltage the electrostatic forces between the two electrodes squeeze the elastomer film, compressing it in thickness and expanding it in area (Figure 1). This simple functional principle makes a multitude of different actuator designs feasible.

Materials

Silicone is the preferred basic material for the elastomer film, but other materials such as acrylate or polyurethane elastomers are also used. The hardness of the elastomer determines the achievable lateral expansion in the actuator on applying voltage. The advantage of silicone is that its hardness

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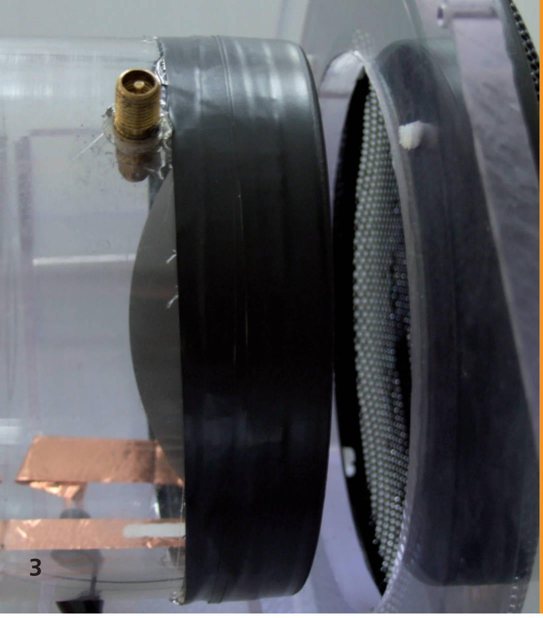

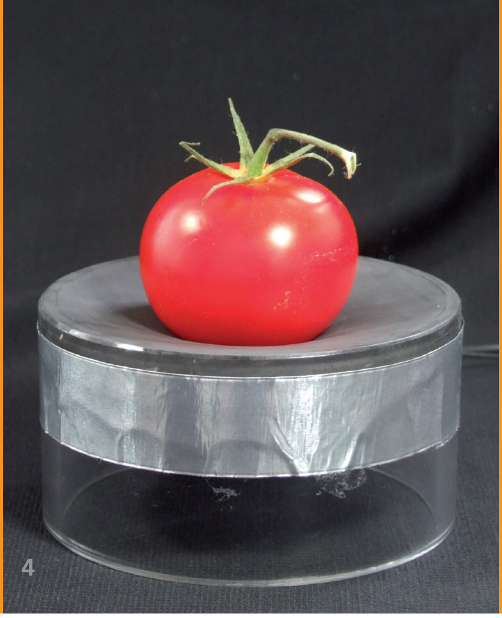

can be varied widely by use of adjustable chemical cross-linking. By increasing the permittivity of the silicone, the expansion and actuation stress can be boosted.

The electrodes consist of electrically conductive particles integrated in a matrix. This combination of materials achieves high conductivity even when the electrode is extremely stretched. The actuation strain or force is further increased thanks to multilayer structures.

Diaphragm actuators

The diaphragm actuator consists of a circular elastomer film sandwiched between electrodes and then mechanically pre-stressed and fixed on a round frame. The electrodes can be designed to partially obscure the film in such a way that, when a voltage is applied, they expand to cover the transparent silicone entirely. This allows control of the transmission of light.

If the film is completely obscured by the electrodes, it is the film's mechanical stress state that changes on applying a voltage. Any object lying atop the film will be lowered, only to rise again when the electricity is switched off (Figure 4).

Linear actuators

Double diaphragm actuators consist of two mechanically coupled diaphragm actuators which can be controlled alternately using electricity (Figure 5). This results in controlled linear movement perpendicular to the diaphragm's surface. Rolled spring actuators work in a similar way (Figure 2).

Loudspeakers

DEAs are also capable of high actuation frequencies into the kilohertz range. This permits the construction of lightweight loudspeakers of extremely simple design. Figure 3 shows such a DEA loudspeaker made using a mechanically pre-stressed diaphragm.

Applications

Dielectric elastomer actuators are attractive for a number of technical applications including the following:

- Moving coversflaps and other mecha nical components
- Adjusting mirrors and other optical elements
- Controlling (micro-)valves and pumps to transport fluids and gases
- Surfaces and arrays with tactile stimuli
- Multi actuator systems for generating complex movements
- Loudspeakers

Different applications require different properties of the dielectric elastomer. These can be obtained by changing the composition of the materials, the film geometry and the actuator design. Furthermore, the same class of materials allows the integration of sensor functions into highly flexible actuators.

Fraunhofer ISC competences

- Development and adaptation of materials for dielectric elastomer actuators for customer-specific applications
- Conception, development and implementation of new actuator designs
- Adaptation of dielectric elastomer actuators for specific applications
- Integration of actuators in mechatronic systems
- Coupling of sensors and actuators

3 *View of the interior of a DEA loudspeaker*

4 *Lifting and lowering of an object with a diaphragm actuator*

5 *Double diaphragm actuator*