

- 1 DES with a pimpled rubber layer
 - 2 Measure stocking with DES
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TEXTILE-INTEGRATED ELASTIC SENSORS

FOR STRAIN AND COMPRESSION LOAD MEASUREMENT

Dielectric elastomer sensors (DES) are a new class of mechanical sensors which can be used to measure deformations, forces and pressures. Because of their high elasticity and their soft and flexible characteristic the DES are especially suitable for integration into woven or knitted fabrics.

Potential for the application of DES exists in medical care e.g. for preventing bedsores or for localizing the pressure distribution in shoes. They can also support personal training by measuring the poise in clothes. In collision detection systems, DES improve industrial safety, e.g. of human-machine interfaces.

Measurement principle

Dielectric elastomer sensors consist of a very elastic elastomer film, coated on both sides with highly flexible electrodes. The sensor effect stems from the measurement

of the electrical capacitance. Under tensile load or deformation, the surface expands while at the same time the thickness of the sensor film decreases, causing an increase in capacitance.

Materials

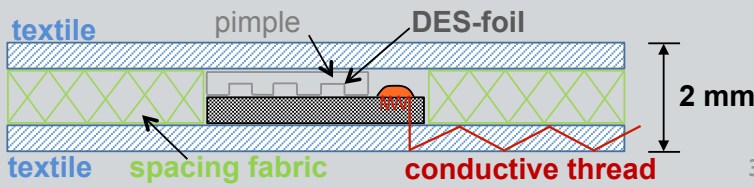
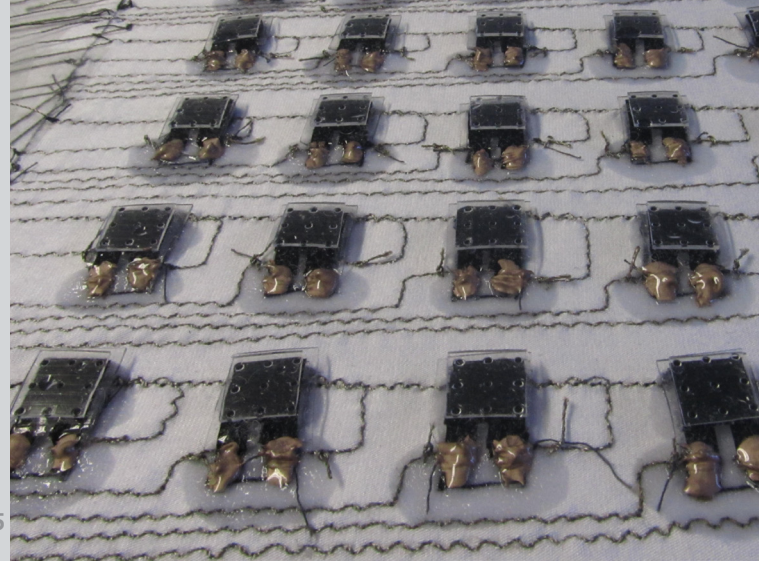
Silicone rubber is the preferred basic material for the elastomer film, but other elastomer materials such as natural rubber, acrylate or polyurethane elastomers can also be used. Apart from the design and the geometric dimensions, the hardness of the elastomer determines the sensitivity of the sensor. Silicone rubber offers a broad variability of hardness through chemical cross-linking. As a result, the material can be adapted to the specific requirements of the sensor. The electrodes on the elastomer film consist of electrically conductive particles which are integrated in a matrix. To reduce wear, the sensor can be encapsulated.

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Textile integration

The basic structure is shown in Fig. 4. The integration is achieved by bonding or sewing the DES into the textile. While a special spacing fabric is used to reduce height differences, the measuring signal is passed into a conductive yarn. Finally the whole structure is covered with an additional textile to mask the sensor and ensure the breathability.

Strain sensor

A DES film can easily be used to measure linear strain deformations up to 100 % elongation, even of curved surfaces. Actual linear deformation, e.g. postural defects of the human back, can be detected.

Pressure sensor

The capacitance signal of a pure DES film stays almost unaffected by compression deformation. By adding a variable profile to the DES it is even possible to measure compression loads in almost every pressure range and resolution. By using an elastomer profile the pressure sensor remains soft and flexible. The working principle is shown in Fig. 3 on the top. Under pressure the symbolized DES film (white) gets stretched into the cavities of the profile. This small elongation is sufficient to measure a significant change in the capacitance signal. Measurements of the time-dependent pressure variation in a shoe while walking showed the fast response of the sensors.

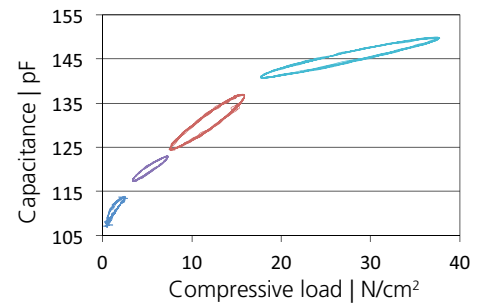
Applications

Textile integrated pressure and strain sensors based on DES can be used in the following applications:

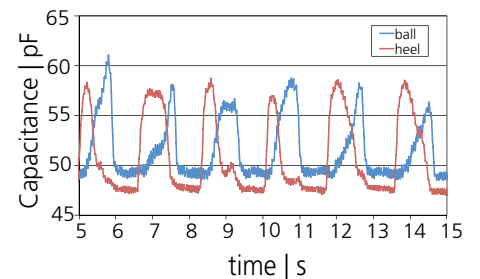
- 3-dimensional foot pressure measurement in a stocking
- 3-dimensional pressure measurement integrated in a glove
- Pressure measurement pad: portable balance; input device for game and fitness device controlling
- Collision detection in human-machine-interfaces
- Flexible and elastic pressure sensor as switch beneath textile and curved cover
- Pressure sensitive cover in seats
- Pulse rate measurement
- Detection of postural defects of the human back

Technical data of DES - pressure sensors

- Pressure range 1 - 50 N/cm²
- Pressure resolution 0.1 N/cm², hysteresis approx. 7%
- Measuring frequency at least 50 Hz
- Temperature operating range from -40 to +180 °C up to 80% relative humidity
- Very thin, flexible and elastic (up to 100 % elongation)
- Resistant against water, washing and disinfecting agent (except petroleum)
- Softness adaptable for intended use
- Textile integration by bonding or sewing



Change of capacitance under compression load



Capacitance of the sensor sole while walking

3 DES-pressure sensor with high sensitivity in an elastomer profile

4 Structure of a dielectric elastomer sensor integrated in a textile

5 Dielectric elastomer sensors (each 10x10 mm²) integrated in a sensor mat as an array of 5 x 8 DES