Silicone based sensors and actuators for medical diagnosis

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Aachen - Dresden - Denkendorf International Textile Conference
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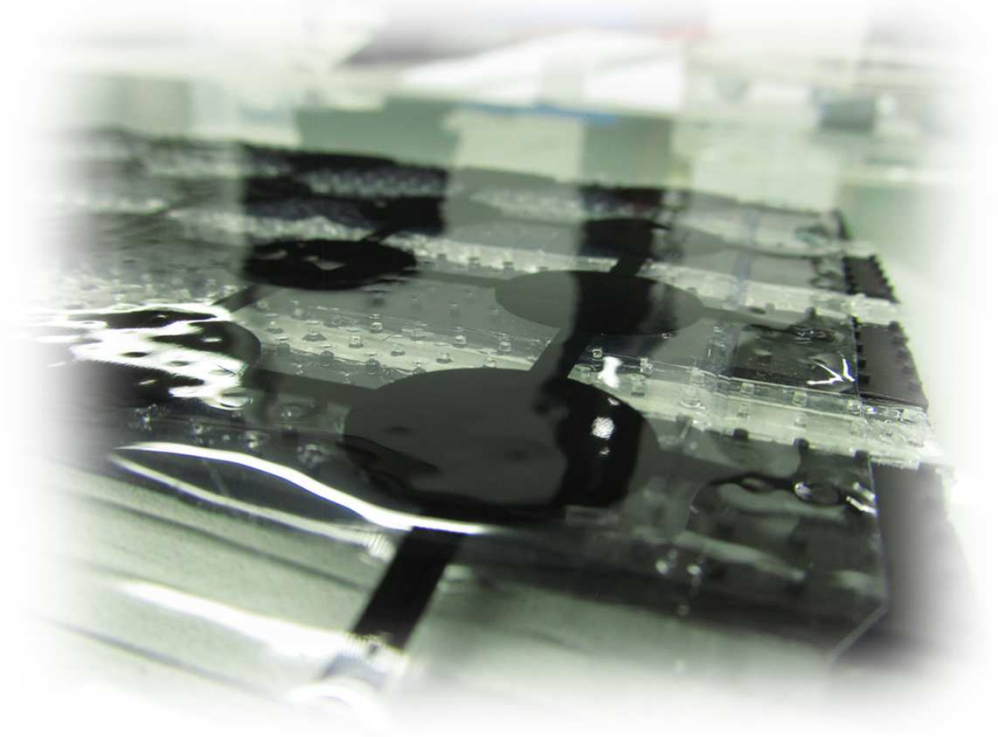

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The Fraunhofer Society at a glance

- **Largest organisation for applied research in Europe**
- **69 research institutes in Germany**
- **Appr. 24.000 staff, in majority engineers and natural scientists**
- **Budget 2016:**
  - **2.1 Mrd. € in total**
  - **1,9 Mrd. € by contracted research**
  - **70 % by industrial projects and publically founded projects**
  - **30 % basic financing by the federal state and federal countries (90 : 10)**

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Fraunhofer ISC overview – “It’s a material world“

Material-based solutions

Materials Chemistry
- Inorganic Sol-gel-materials
- Hybrid materials
- Barrier coatings
- Particles

Application Technology
- Micro-optics/ Electronics
- Specialty glass
- Dental/ Micromedicine

Services
- Applied Analytics
- Device Development
- Cultural Heritage

Center for Applied Electrochemistry
- Battery materials and components
- Testing
- Post mortem analysis

Center Smart Materials
- Adaptive Materials
- Sensors
- Energy harvesting

415 Employees (2016)
29.5 Mio € Budget (2016),
including 21.7 Mio € venue from contract research
approx. 10.000 m² labs and technical space
5 sites centrally located within Germany

Fraunhofer-Center HTL
High temperature lightweight materials, energy efficient heat treatment

Bayreuth

Project Group IWKS
Materials recycling, substitution, and ressource strategies

Alzenau/ Hanau

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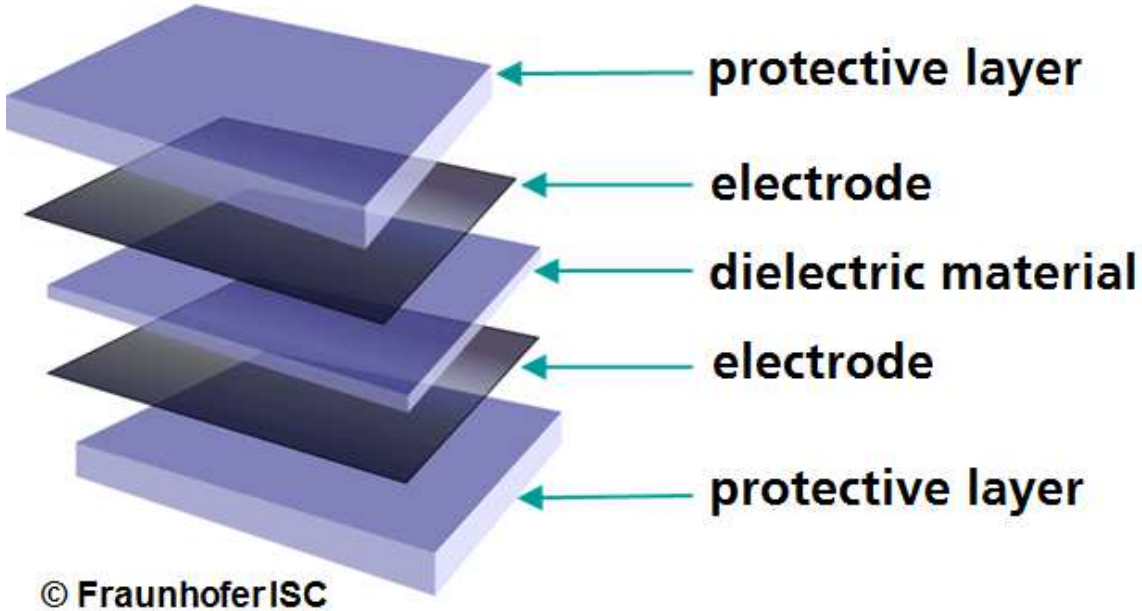
Dielectric elastomers: “smart rubber“

- Dielectric elastomer sensors (DES) consist of a very elastic elastomer film (silicone), coated on both sides with highly elastic electrodes (carbon black, graphite, metal particles)

- Highly stretchable (up to 100 % elongation)

- Soft and flexible characteristic is the basis for the integration into woven or knitted textile fabrics



Processing of Silicone

- Laboratory scale:
  + Compounding
  + Doctor blading
  + Silicone films (single- or multilayer)

- Upscaling:
  + modular slot - die - coating unit for large scale production of thin single- or multi-layer films (width up to 0,5 m, length up to 200 m)
  + adjustment of processing parameters: pot life, viscosity, curing
  + reduction of material and production costs

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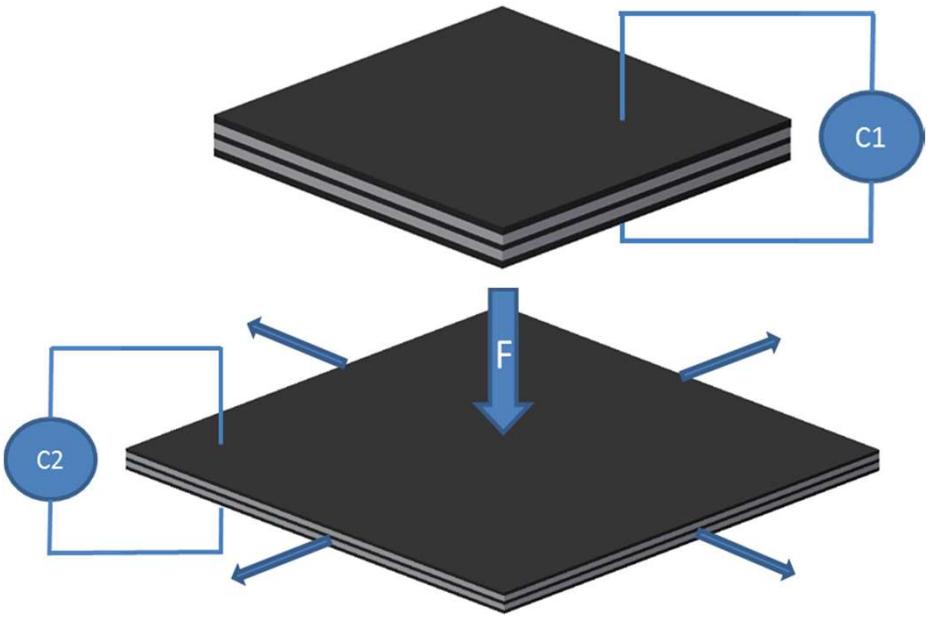
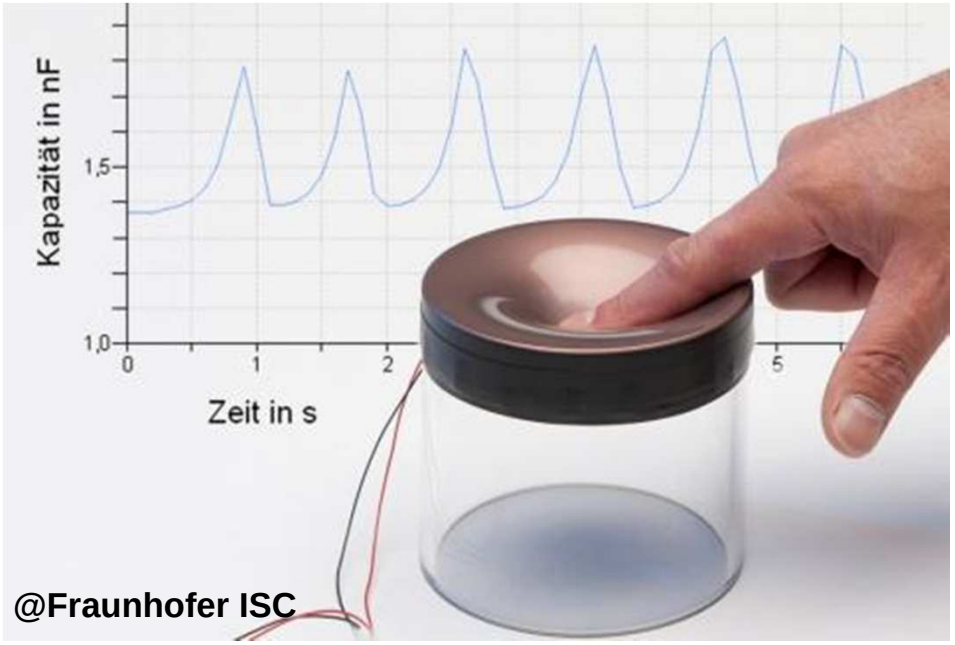
Dielectric Elastomers as Strain Sensors (DES)

- Mechanical deformation (elongation or compression) leads to a reduction of thickness and simultaneously to an increase of surface
- Electric capacitance as measured parameter increases
- Applicable to measure breathing or posture on the body or in clothings





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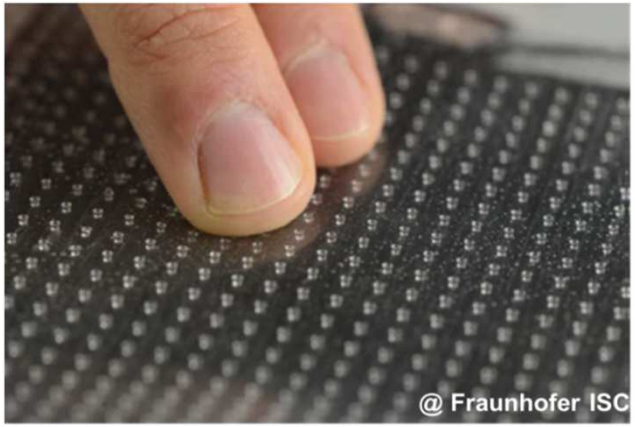
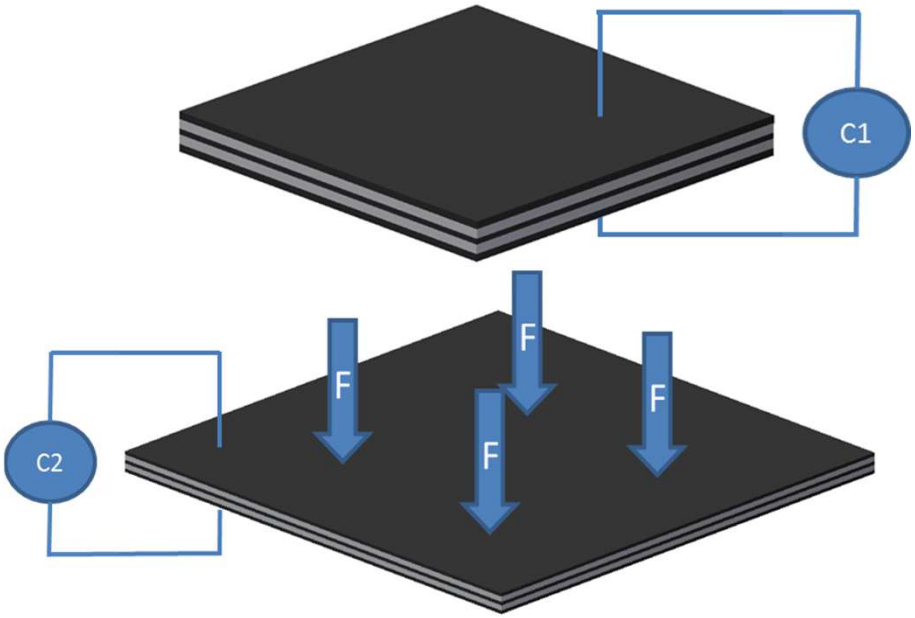
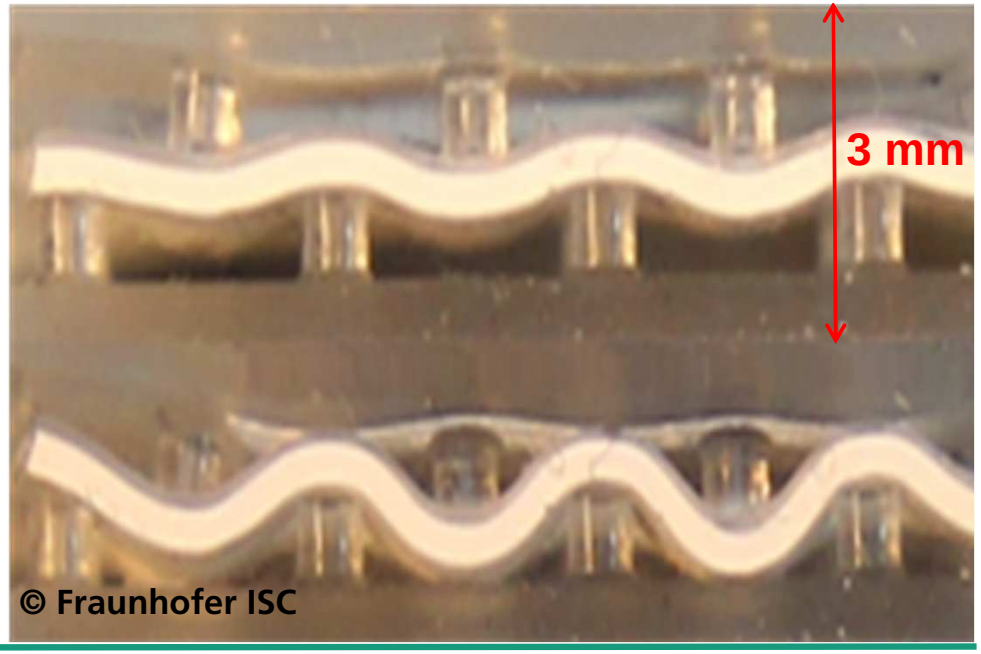
Dielectric Elastomers as Pressure Sensors

Adding a special profile (naps) to the DES increases the sensitivity under compression load







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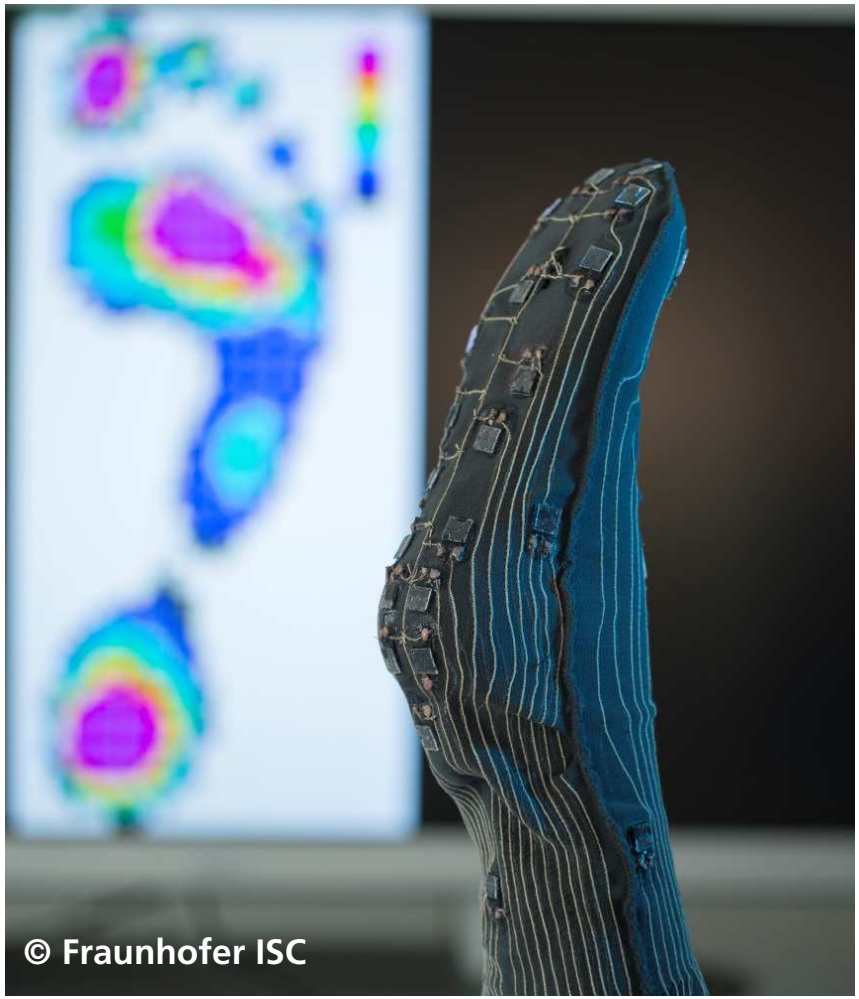
Textile-integrated elastic sensor for foot pressure measurement

- Development of a foot pressure measurement system for medical application:
  3-dimensional pressure distribution inside a shoe for long-term measurements e.g. diabetic foot syndrome

- Dielectric elastomer sensors are extremely suitable for textile integration: soft and flexible behaviour does not create additional pressure points while wearing the textile



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Textile-integrated elastic sensor for foot pressure measurement

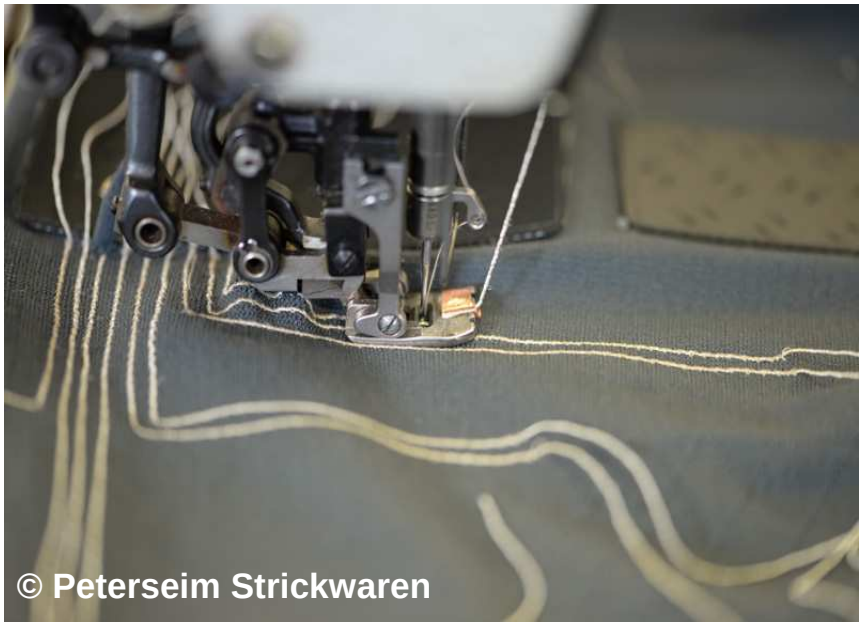
Stocking:

- **Processing of the highly stretchable stocking on a flat knitting machine**

- **Properties of the knitted fabric: hard-wearing, flexible, elastic and moisture-regulating**
  → highly suitable for the application in clothing, even under strong mechanical stress
  → high wearing comfort

- **Pressure sensor integration by gluing, bonding or sewing**

- **Signal transmission to the flex-board electronics:**
  → signal wires: electrically conductive and elastic yarn
  → sewed on the textile by a special machine



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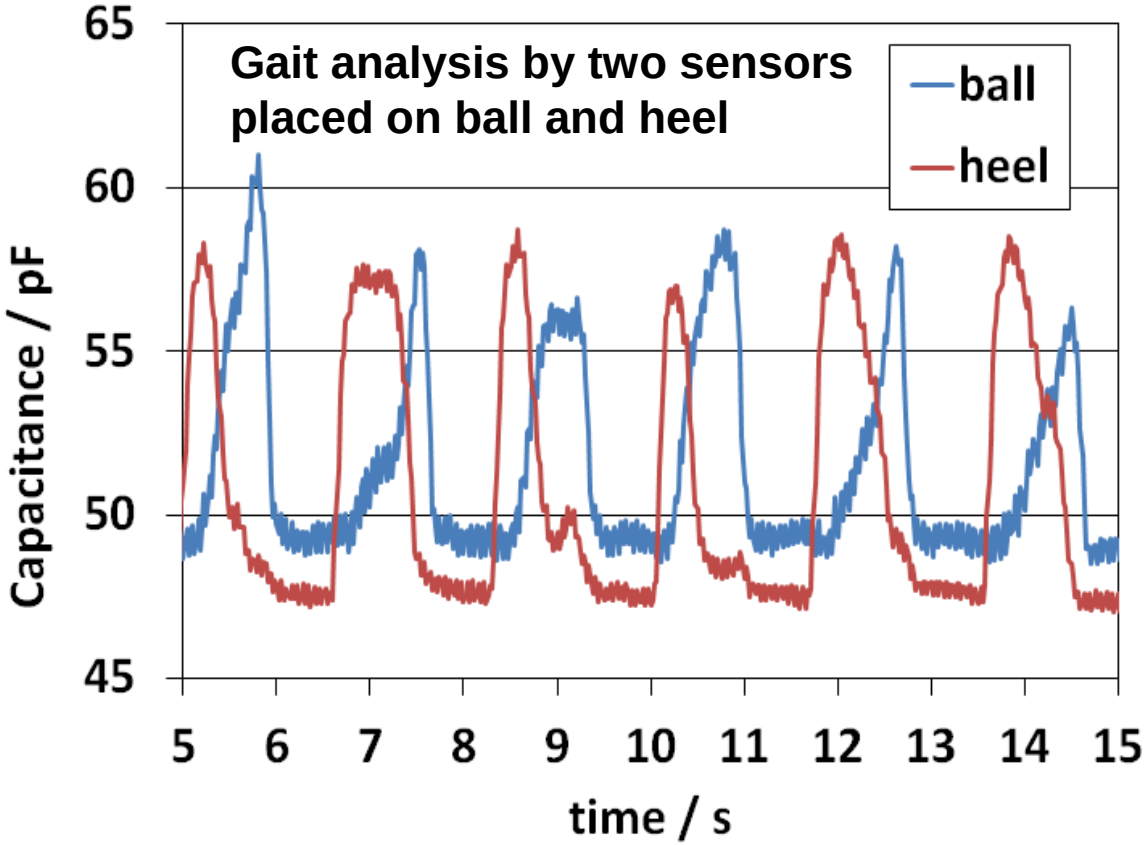
Technical data for DES – pressure sensors

- Pressure range 1 - 50 N/cm² (10 – 500 kPa), resolution 0.1 N/cm²
- Response time 20 ms
- Operating temperature range
  from -40 to +160 °C
  up to 80 % rel. humidity
- Thickness (~ 0,5 - 1 mm)
- Size 5 to 500 mm²



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Advantages of textile-integrated silicone sensors

- Thin (1 – 3 mm), flexible, stretchable (up to 100%)
- Chemically stable to: water, washing agent, desinfectant
- Washproof up to 60 °C (tested 15 times in a washing machine)
- Antimicrobial finishing by silver ions possible
- Colouring possible
- Freedom of design, adaptable to body form
- Softness adaptable to the application
- Low cost (~ 1 € / cm^2)

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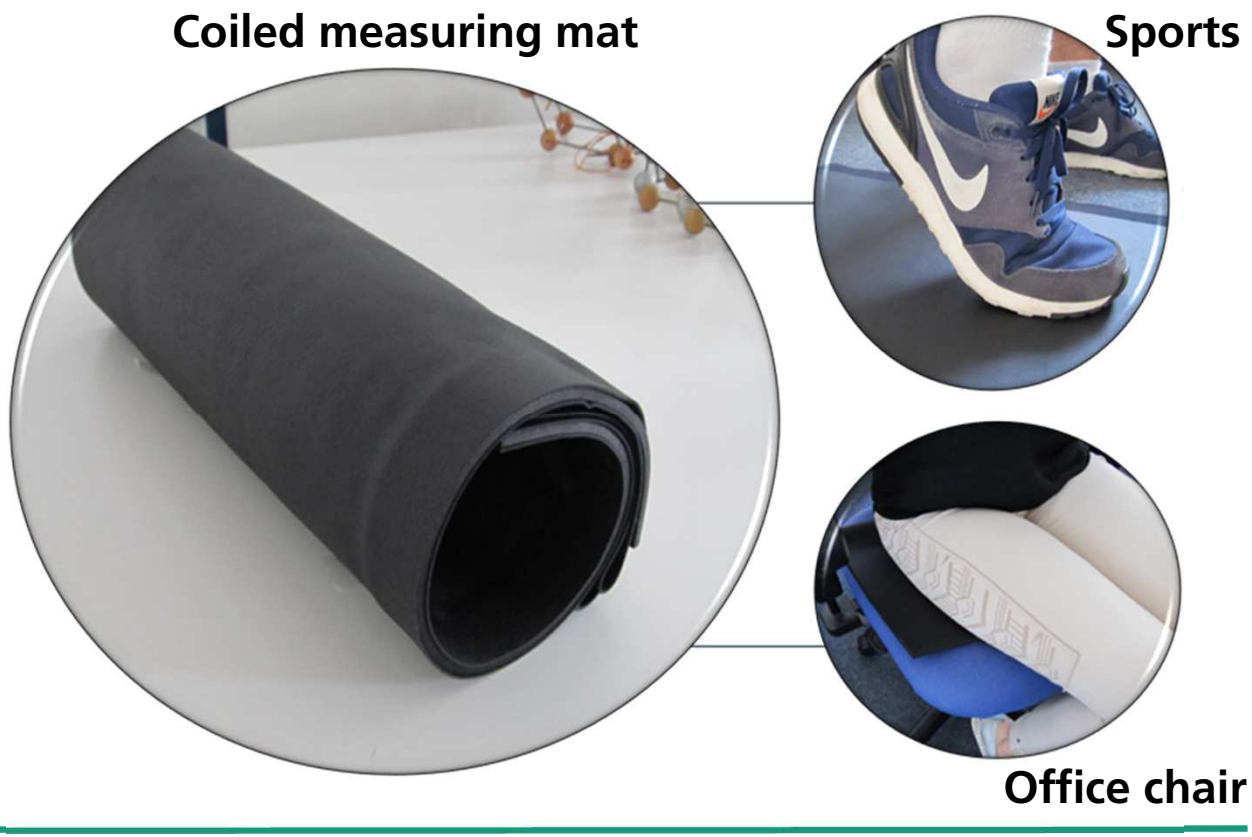
Medical applications for textile-integrated elastic sensors

Space resolved pressure sensors in seats / matress, preventing bedsores (bed or wheelchair), Decubitus



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Medical applications for textile-integrated elastic sensors

Pressure measuring in gloves, prosthetics, orthosis or bandages prosthesis, grippers

Posture monitoring in ergonomics

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Elastic electrodes

- **Silicone with conductive particles for electrodes (specific conductivity ~ 0,1 S/cm)**
  → thin (0,5 mm) and stretchable (100 %)
  → „softness“ adaptable to the application, no restrictions to (human) mobility
  → dermatologically proven skin compatibility
- **Integration of the electrode pads by glueing into the textile guarantee a strong bonding and high wearing comfort**
- **Elasticity and flexibility of the soft elastomere pads ensure stable long time electrical contact to the skin without contact gel**

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Silicone electrodes for sensors, actuators and heating

- **Monitoring of vital parameters like**

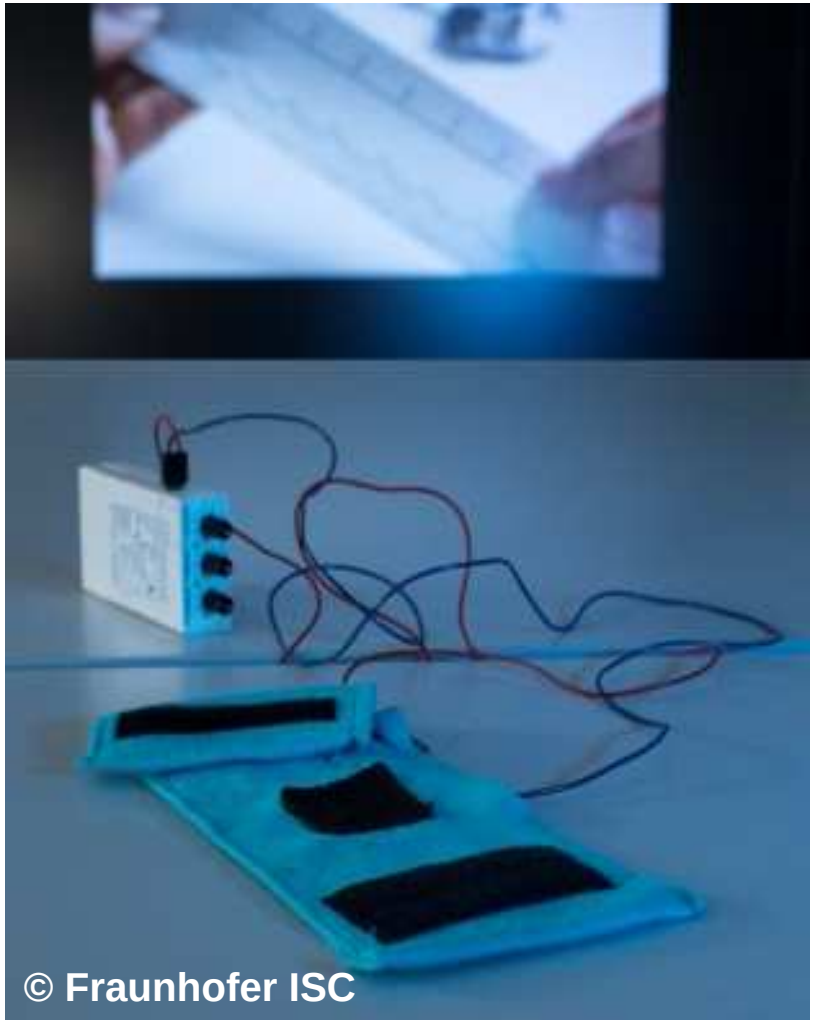
  - continous ECG measurement in clothing

  - measurement of pulse, heart rate variation

  - measurement of electromyogram (EMG) of muscles activity

- **Activating of muscles (EMS) or nerves (TENS) for muscle and cardiovascular training**

- **Heating for rehabilitation and comfort**



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Medical Sensor Systems & Biosignal Processing

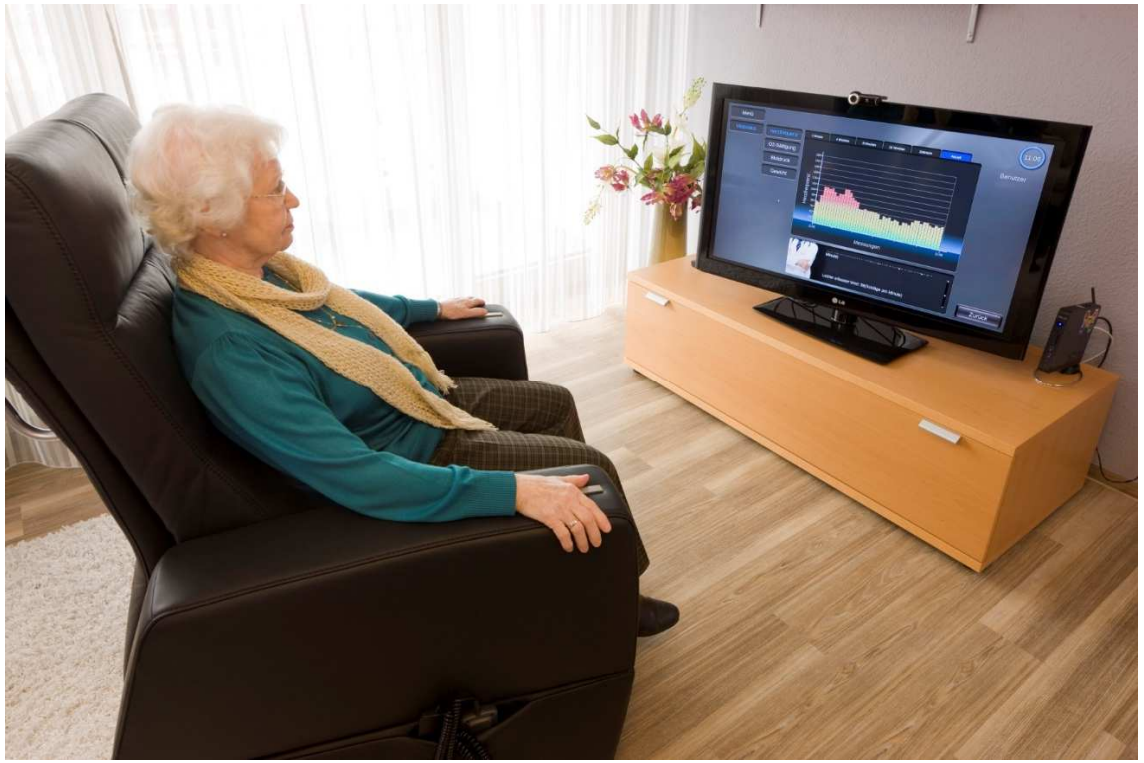
Sensor Integration: Ambient Assisted Living by Fraunhofer IIS

- Electrocardiogram (ECG) electrodes integrated into arm chair

- Measurement of ECG raw data → calculation of secondary parameters (Heart Rate Variation)

- uniformly distributed pressure sensors:
  → mobility
  → posture

⇒ storage into patient record, trend analysis, early prevention



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Thank you for your attention!

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