Technologische Plattform leistungsloser Sensoren

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Introduction

Motivation

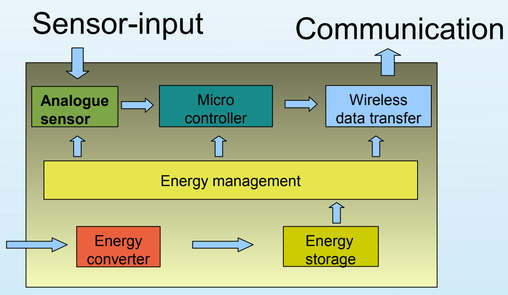
Primarily, energy-autarkic sensor and micro systems are sensory components which take the energy needed for operation and data transfer directly from their present environment. In addition to efficient energy harvesting strategies, ultra-low-power technologies are needed.
A significant reduction in the required electrical power could be achieved, if the current consumption of the sensors was reduced to **zero**, even in case they are **online**.

Basic Concept

Integration of stimuli-responsive functional materials, which swell as a function of the appropriate stimulus, into a micro switch.

Signaling System

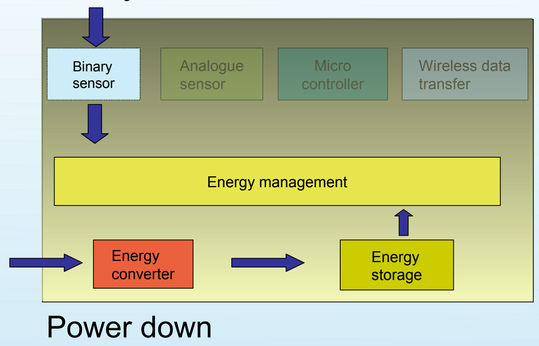
State of the Art



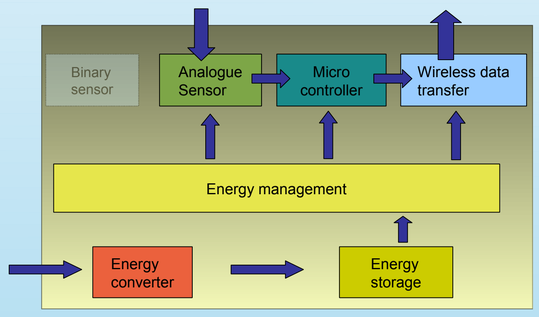
Working Principle

In contrast to the state of the art, this system remains in the **power-down** state even though the binary sensor is online. Thus, the consumption of electrical power is merely in the order of 30 µW.
On the occurrence of a well-defined event, the system is activated by the Binary-Zero-Power-Sensor, hence, **powered on**.

Signaling System including a Binary-Zero-Power-Sensor



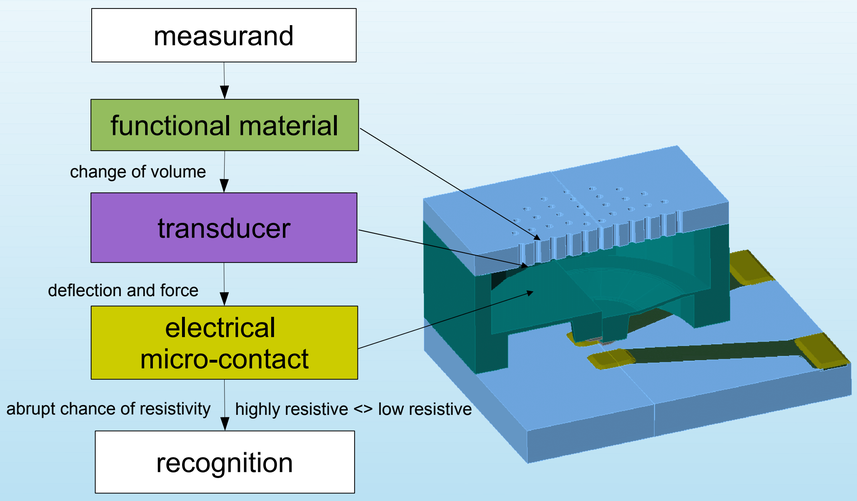
Power down



Power on

Functioning and Components

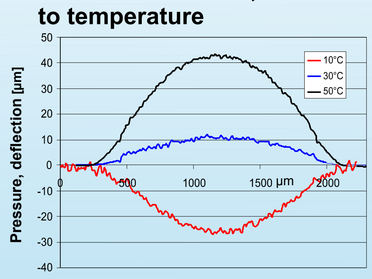
of the power-free binary sensor



Sensor-Actuator Functional Materials

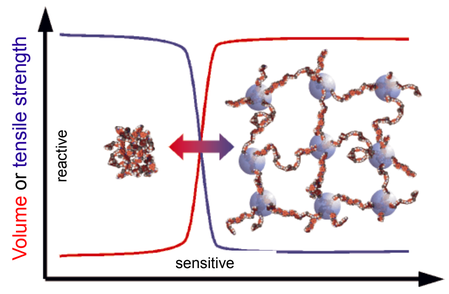
Principle:
volume change as a function of the measurand (stimulus)

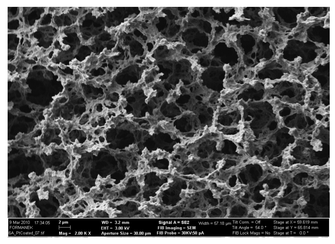
Strechable material, sensitive to temperature



Deflection of a square bending plate made of silicon due to the thermal expansion of the enclosed fluid (n-hexane). Surface area: 4mm², thickness: 20µm

Hydrogel, sensitive to humidity and pH





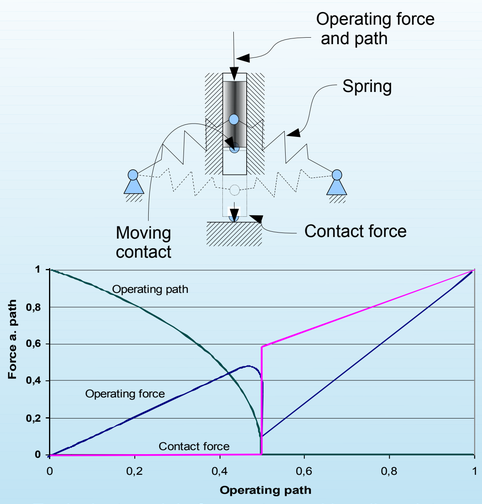
nano-porous hydrogel used to improve the signal modulation

Transducer

The **movement converter** establishes the **connection** between the **identification system** and the **contacts**. It converts the volume change provided by the functional material into a switching motion and a contact force.

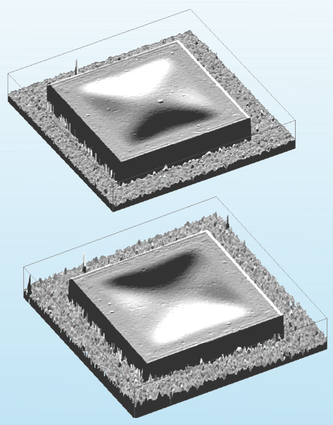
In the case of classical mechanical switches, the contact resistance decreases with increasing contact force. A gradual approach of the two contact areas could lead to the formation of welding arcs and is therefore to be seen critical. Hence, an abrupt switching operation is advantageous. Undefined states between “open“ (R=∞) and "closed" (R=0) result in a higher power loss and have to be avoided.

Equivalent model



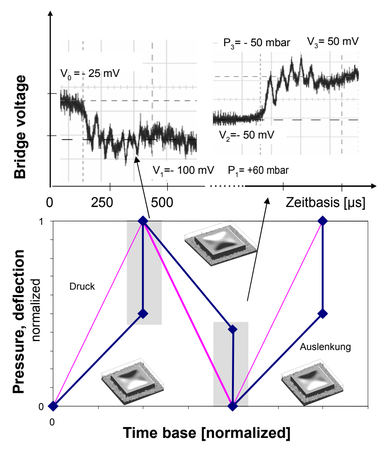
Equivalent model of a prestressed bending plate. Operating path, operating force and contact as function of the operating patch of the equivalent model

Mechanically prestressed silicon membrane



In order to dinamically characterise the switching motion , a mechanically prestressed silicon bending plate belonging to a pressure sensor was used. Using the measured bridge voltage, one can directly deduce the mechanical stress inside the bending plate (deflection: ca. 90 µm).

Dynamics of the silicon membrane



Voltage response function to a +60 mbar increase and -50 mbar decrease respectively.
Pressure and corresponding deflection curve as a function of time, measured using a digital storage oszilloscope,