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Hydrogel-based chemical sensors

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Abstract:
Hydrogels are cross-linked polymer networks able to absorb or to release large amounts of water that can be excited by a large spectrum of different physical (e.g. temperature, electrical voltage, magnetic field) and chemical factors (e.g. pH value). The water uptake is associated with a considerable volume change and a swelling pressure, respectively. Hydrogels can easily be tailored with respect to a certain measurand. Hydrogel-based sensors utilize the hydrogel's swelling by its influence, e.g., on the swelling pressure, the deflection or the refractive index. This contribution will report on recent sensor developments at the Solid-State Electronics Laboratory at Technische Universität Dresden, Germany.

Key words: hydrogels, hydrogel-based sensors, piezoresistive sensors, swelling

Hydrogels for Sensor Applications

Hydrogels are cross-linked polymer networks able to absorb or to release large amounts of water. The water uptake is associated with a considerable volume change. In doing so, hydrogels show two remarkable properties: (a) The strong volume change can be excited by a large spectrum of different physical (e.g. temperature, electrical voltage, magnetic field) and chemical factors (e.g. pH value). (b) This swelling process is reversible. These properties make hydrogels a promising candidate for being used in sensors and actuators and allow their integration into microsystems. Hence, hydrogel-based microsystems enable novel sensor solutions in microsystem technology which are miniaturized and cost-effective.

Since 2013 the German Research Foundation (DFG) has been funding the Research Training Group "Hydrogel-based Microsystems" which focuses on novel, specially tailored hydrogels and on applications of hydrogels in sensor technology, microfluidics and in microsystems.

Challenges

Particular challenges for this novel type of sensors are advanced functionality, high sensitivity, selectivity and long-term stability as well as a fast response time. In this contribution the following aspects will be considered:

- Piezoresistive hydrogel sensors [1]
- Tailoring hydrogels for sensor applications [2, 3]
- pH-sensitive sensors [4]
- Faster sensor response by using porous hydrogels [5, 6]
- Sensors with force compensation to improve uncertainty and response time [7 - 9]
- Hydrogels with interpenetrating networks for simple force-compensated chemical sensors [10 - 12]
- Sensor arrays for medical applications, e.g. for diabetes [13, 14]
- Sensors with plasmonic readout [15]
- Sensor switches for zero-power threshold-dependent switching applications (e.g. as humidity switches) [16, 17]

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