B7: Bi-sensitive Hydrogels in Chemical Sensors with Force Compensation

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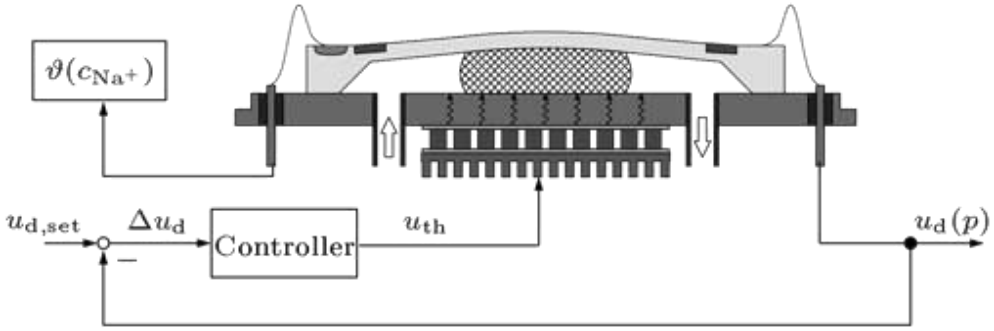
Motivation:

Polyelectrolytic gels are electroactive materials that can achieve large volume changes by absorbing solvent. They have both sensory and actuator abilities. Although existing hydrogel-based sensors already allow measurements of concentrations with accuracies in the range of a few percent, they – due to the ion transport and the viscoelestic behavior of the material – require longer time to reach the steady state.

Force compensation largely prevents the swelling of the hydrogel by the measurement solution by generating a counter pressure equal to the swelling pressure.

In the second period of the Research Training Group, it was examined to what extent bi-sensitive hydrogels are suitable [1]. In this case, the swelling caused by the change in concentration of a solution was controlled to zero by means of the simultaneous temperature dependence of the same hydrogel (Figure) [2]. This ensures that ideally the sensor remains constantly in a defined state, whereby creep and hysteresis effects can be reduced and the response time after pH value changes is significantly shortened.



Scientific questions and project goals:

Based on these previous results, the understanding of the sensor effect will now be deepened. The following scientific questions are in the focus of the future work:

- The surface of the hydrogel is affected by the measurement solution, whereas the majority of the volume is not. On the other hand, a temperature field is applied, which is largely constant in the volume of the hydrogel. Thus, integral force compensation is achieved, but not in the local. It has to be clarified, which effects this has on the sensor kinetics.
- Are there any technical approaches, e.g. by inductive heating, to limit the temperature-dependent swelling to the area close to the surface. Which improvement of the response could be achieved in this way?
- The hydrogel in the cavity is sterically confined during swelling, i. e. is under compressive stresses. It should be deduced how the properties of constrained hydrogels can be deduced from those of free swelling.
- A control strategy should be developed to further improve the transient response.

Literature:

[1] S. Binder, A. T. Krause, B. Voit, G. Gerlach: Bisensitive hydrogel with volume compensation properties for force compensation sensors. IEEE Sensor Letters 1 (2017) 6, 4501004.

[2] S. Binder, G. Gerlach: Kraftkompensierte chemische Sensoren auf Basis bisensitiver interpenetrierender Polymernetzwerke (Force-compensated chemical sensors based on bi-sensitive interpenetrating polymer networks). Technisches Messen 85 (2018), S45–S51.