8 Summary and Outlook

This thesis begins from the necessity to study and characterize the behavior of pH sensitive smart hydrogels. These hydrogels present interesting characteristics, as volume dependence on temperature or pH variations on its fluidic phase, and these characteristics can be utilized to design new sensors. The general sensor properties of polyelectrolyte hydrogels, the detection possibilities and limits, and the response time of such sensors were investigated and discussed

The microgravimetric principle of quartz micro balance (QMB) is well suited for a precise investigation of the behavior of thin hydrogel films. This procedure is applied to smart hydrogels, to observe its dependence of changes in pH value. The possibilities and limits of hydrogel coated QCMB sensors were discussed.

It was designed a measurement cell to test variations on frequency and damping of a PVA/PAA coated quartz crystal. The cell incorporates both temperature and pH sensors, and allows the combination of results of these signals with the quartz electric response. A complete test bench was designed and tested, to use the cell and to automate its operation. It was connected to a network analyzer and a datalogging system. The network analyzer connected to the quartz electrodes gives information about the transmission impedance, in terms of values of maximum frequency and bandwidth. A PC controls the testbench and process and saves the acquired data.

The experimental results open the possibility to use hydrogel coated quartz crystals as liquid sensors to observe special state values of liquid medium in real-time, concretely the pH variations were studied. Two data acquisition channels are used for the recognition of the sensor behavior. Firstly, the frequency shift is a function of changes in mass and volume of thin hydrogel films, and secondly the change of damping depends on the changes in elasticity of hydrogel film.

PVA/PAA coated quartz crystals can be used for pH measurements in the range up to pH 3.5. Combining the results of both measured signals, measurements with a precision larger than 0.005 pH are possible. Effects like non-linearities and ions concentrations – particularly cations – influence the response of the sensor, and need to be studied and adapted to the special application.

Two volume phase transition effects where observed. Firstly, the screening effect induces a hysteresis behavior, which limits the range where the response is repeatable. For PVA/PAA hydrogels, the influence of this hysteresis is minor up to 3.5 pH. Secondly, a shift of the phase transition from about 4.5 to 3.5 pH was observed, what brings it out of the hysteresis zone. The origin of this second phenomenon is not yet reliable explainable. These effects should be studied in other polymer systems to consider if this effect is a general behavior of thin hydrogel structures.

Through the use of QCMB technique, it is possible to use hydrogels as sensor materials for the liquid sensorics. As smart hydrogels offer a number of different responses to substances and concentrations, they can open the path to several new sensorics systems. This almost-linear volume phase transition behavior allows de development of high sensitivity real time sensors. Using an array of quartz coated with different hydrogel, the range and the possibilities, resolution and range could be extended.