Sub-project B5: Chemical Transistors

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Motivation:

Chemomechanical transistors (or so-called chemostats) combine actuatory and sensory properties in a single component. This specific feature enables them, analogous to their electronic equivalent, to regulate a flow. But whereas electronic transistors regulate electron flow, chemical transistors control material flow: When their threshold or switching concentration, respectively, has been reached, they cut of any further flow of material. As miniaturized, integrable components they also form, analogous to their electronic equivalent, the basis for automated, microchip-based processing of chemical information both for continuous and discrete computer paradigms. However, chemical transistors have not yet been fully understood, nor have they been addressed theoretically.

At the institute of Semiconductors and Microsystems (IHM), in cooperation with the Leibniz Institute of Polymer Research Dresden e.V. (IPF), the theoretical-experimental foundations for this new type of fluidic components shall be established.

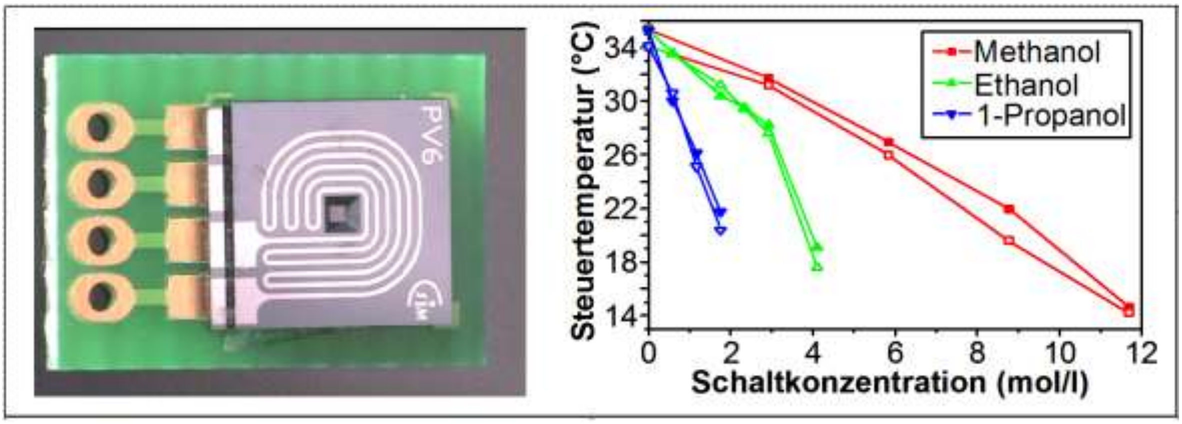

Figure 1: Chemical Transistor and the dependency of its switching value on the control temperature [2].

State of research and and own preliminary work:

At the TU Dresden, a technology platform for actuatory and sensory microsystems based on stimuli-responsive hydrogels has been developed [1]. This platform not only allows for a high degree of integration, but also offers a unique multifunctionality. In the field of microfluidics, not only micropumps and microvalves, but also chemical microsensors and the hitherto unknown chemical transistors [2,3] can be implemented. The threshold value (e.g. a concentration) that determines the closing and opening behavior of such transistors, is electronically adjustable. While considering how to integrate these elements into fluidic circuits, it became apparent that their nature and property profile is still not fully understood. Obviously, they are not only controllable fluidic resistors, but can also be seen as storages.

Scientific research question and project objectives:

The objectives of the project are to improve the understanding of the nature of these devices and to gain knowledge about fundamental questions: Is the threshold value of the transistor sharp enough to enable a discretization of chemical information? Under what conditions is which computer paradigm suitable? The components will be modeled based on the formation of an electro-analogeous network. This method allows to exactly describe and understand the transistor using sub models, whereby the model parameters should be selected so as to be easily determinable with simple experiments. To validate the models, applicative investigations have to be performed. A second focus of the project lies on studying different options to design chemical transistors. The principles of the design and the control of the elements have to be investigated. Here, hydrogels with two responsivities that have been developed at the IPF play an important role.

Literatur:

[1] A. Richter, Hydrogels for actuators. In G. Gerlach, K.-F. Arndt (Eds.): Hydrogel Sensors and Actuators. Chapter 7. Springer Berlin 2009.

[2] A. Richter, A. Türke, A. Pich, Controlled double-sensitivity of microgels applied to electronically adjustable chemostats. *Adv. Mater*. **19** (2007), 1109-1112.

[3] A. Richter, J. Wenzel, K. Kretschmer, Mechanically adjustable chemostats based on stimuli-