Integrated circuits processing chemical information: prospects and challenges

A. Richter[1], A. Voigt[1], R. Schüffny[2], S. Henker[2], M. Völp[3]
[1] Polymeric Microsystems, [2] Highly-Parallel VLSI-Systems and Neuromorphic Circuits, [3] Operating Systems
Technische Universität Dresden
Dresden, Germany

***Abstract*— The unbelievable properties of our information processing capabilities regarding the processing of big data, resilience, and energy efficiency are inspiration sources for the optimization and the rethinking of the principles of electronic information processing. Here, we present an approach of integrated circuits intended to solve chemical problems by active processing of chemical information.**

Keywords—chemical ICs, lab-on-chip

Electronic information technology and the underlying semiconductor industry dominate our professional and private activities. However, almost unnoticed another kind of information processing plays a major role in our daily life: the processing of chemical information in the form of concentrations of special substances. For example, cooking, analytics, medical diagnostics, and manufacturing industry are based on the processing of chemical information. Most notably, we as living organisms do exclusively process chemical information. The unbelievable properties of our information processing capabilities regarding the processing of big data, resilience, and energy efficiency are inspiration sources for the optimization and the rethinking of the principles of electronic information processing. It is surprising that there are no suitable approaches for integrated and scalable technical systems processing chemical information.

Here, we present an approach of integrated circuits intended to solve chemical problems by active processing of chemical information. The platform is interesting for both, the "beyond CMOS" and the "more than Moore" approaches. The chemical ICs are based on components ("chemical transistors") with feedback function towards concentrations of chemicals. These devices regulate a liquid flow when the threshold concentration of a certain chemical is reached [1]. Their material base are phase change polymers that are able to alter their volume significantly. The chemical ICs consist of overlapping, micro-structured layers made from different phase change polymers, which are placed on polymeric substrates containing the channels. The possible impact of chemical ICs is explained on the example of the lab-on-a-chip technology. Here, our concept solves the probably most challenging problem, the scalability of microfluidic ICs [2,3]. We utilize chemical information as a control signal of the IC and as a data signal to be processed chemically. Therefore, both the control unit and the execution unit can be realized with only one type of components, the chemical transistors. The resulting highly functional integrated circuits introduce the concept of microprocessors into lab-on-a-chip technology.

However, the concept of chemical ICs is still in its infancy. Many challenges on the levels of technology, design and system still await resolution.

REFERENCES

[1] A. Richter, A. Türke, A. Pich, "Controlled double-sensitivity of microgels applied to electronically adjustable chemostats," Adv. Mater., vol. 19, pp. 1109-1112, April 2007.

[2] R. Greiner, M. Allerdißen, A. Voigt, A. Richter, „Fluidic microchemomechanical integrated circuits processing chemical information," Lab Chip, vol. 12, pp. 5034-5044, October 2012.

[3] M. Allerdißen, R. Greiner, A. Richter, „Microfluidic microchemomechanical systems," Adv. Sci. Technol., vol. 81, pp. 84-89, 2013.

978-3-9815370-2-4/DATE14/©2014 EDAA