Smart multi-sensor systems enabling real time water quality assessment and early prediction of pollutants

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We present in that talk a research line of the Institute of Microelectronics of Barcelona (IMB-CNM) devoted to the development of predictive multiparametric monitoring probes for precise control of industrial aquatic processes based on innovative smart microsensing technology. These probes are made up with different sensors developed at the IMB-CNM Clean room with microelectronic technology, which confers robustness, miniaturisation and scalability to its production. In addition, they incorporate neuromorphic intelligence that further allows to correct aging and interferences for the sensors during operation, thus minimising the need for calibration. This solution has been evaluated in several scenarios like the entrance of river water to a drinking-water plant (DWP) from the company AGBAR and a recirculating aquaculture system in close partnership with IRTA.

To build a healthy planet for all, the European Green Deal requires the EU to better monitor, report, prevent and remediate pollution of air, water, soil and consumer products. There are also new EU directives to control contamination of drinking water. These include the obligation of Member States to guarantee access to drinking water for all European citizens, and establish very high-quality standards for its supply. For all these reasons, water analysis is key to preventing environmental, health and industrial risks for sustainable development. Sectors such as drinking water networks, aquaculture and hydroponics need to continually monitor water composition to avoid contamination, increase productivity and/or comply with increasingly strict regulations. However, commercial analytical devices are currently expensive, bulky, limited to a few parameters, and require frequent calibrations. None of them is capable of autonomously predicting and controlling variations in water quality and industrial processes, requiring instead intensive manual maintenance that increases operating costs.
In this context, we propose the development of smart multi-sensor systems fabricated with cost-effective microelectronic technology combined with powerful data fusion tools like neural networks, to achieve a predictive system for on-line water quality monitoring. This system contains multi-sensor electrochemical sensors manufactured with microelectronic technology, being therefore robust, miniaturizable and scalable in its production. They detect indicators like pH, conductivity, temperature, chlorine, and ions (nitrate, phosphate, ammonium. Sensors are combined with local neuromorphic intelligence that, in addition to its predictive capabilities, allows to correct sensor drift, aging and interferences produced during their operation: These corrections minimize and even avoid need for calibration during long-term periods of continuous monitoring. This smart system has been evaluated in two industrial scenarios: A drinking water treatment plant and a pilot aquaculture production plant.
Results of these two applications and discussion of the technology feasibility will be presented.

1 The European Green Deal COM(2019)640.
2 https://ec.europa.eu/commission/presscorner/detail/en/ip_20_2417
3 Sensors and Actuators B: Chemical, Volume 353, 2022, 131123, ISSN 0925-4005/ Frontiers of Neuroscience, 2021, volume 15, 771480