

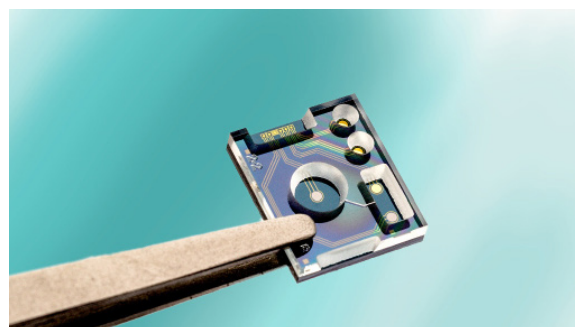
REAL-TIME CHECKS OF pH AND IONS IN LIQUIDS WITH ULTRA-SMALL SENSORS

Understanding the content of liquids and fluids is required for many applications. Continuous water quality analysis is needed to guarantee safe drinking water and safe swimming. Constant liquid analysis also enables optimization of water usage in horticulture, checking nutrients in agriculture and fermentation process control in food production. Also measuring hydration of athletes is enabled by continuous fluid monitoring provided the sensors can be made very small to work with minimum amount of fluid. And that's exactly what imec has realized with its revolutionary miniaturized sensor technology with built-in reference to enable continuous sensing without the need for recalibration. Even the use in blood dialysis, optimizing time and accuracy of the dialysis process can enable higher life expectancy of kidney patients. This broad variety of applications is now within reach by the sensor technology developed by Imec in the Netherlands for real-time liquid monitoring to measure pH, conductivity and ions and which can be expanded to many other ions in the near future.

APPLICATION DOMAINS

The imec ion sensor allows accurate long-term measurement of ion concentrations in applications such as:

- Clean water: surface water, waste water, tap water, swim water
- Agri-tech: agriculture, fish farming, horticulture, herd management
- Health: blood testing, sweat analysis, urine analysis, ingestibles and organoids
- Fermentation: food production, pharmaceuticals and bio-fuel



Solid ion sensor

TECHNICAL PROPOSITION

Imec developed a highly integrated, multi-parameter ion-selective liquid sensor technology in two different forms. The first is based on ion sensitive electrodes on a small silicon substrate including micro-fluidics structures designed for mass production. It can be used for continuous monitoring of water quality or industrial process control. The second uses similar miniaturized ion-selective electrodes, but instead of using a silicon carrier, these are screen-printed on a flexible foil. The flexible device can be made low cost and would typically be used as a disposable after the monitoring is completed from an hour to several days. The silicon version enables continuous monitoring for many months before replacement is needed.

Examples of ions that can be measured are pH, chloride, sodium, nitrate, potassium and calcium. The sensitivity for these ions has been verified according to table 1. Also conductivity (the total amount of dissolved ions), dissolved oxygen (DO), and oxidation reduction potential (ORP) of liquids can be measured. Additional ion selective membranes can be added, which enables a sensor function finetuned for specific applications. The main breakthrough that imec realized is the improved lifetime of an on-board miniaturized reference electrode that enables the continuous monitoring for days or even months.

THE IMEC ION SENSOR DEVELOPMENT KIT

The ion development kit can measure pH, conductivity, and dissolved oxygen. The highly miniaturized ion-selective electrodes, fabricated on silicon substrates, enable multiple parameters to be measured by a single device. We can even integrate a temperature sensor in the same device.



The ion sensor development kit



Flexible ion sensor

Parameter*	Range	Accuracy	Sensitivity
Reference electrode	-	Drift < 0.1 mV/day	-
pH	2-10	0.02 pH point	>59 mV/pH
Conductivity	5 – 100000 μS/cm	<10% of reading	adjustable
ORP (Oxidation Reduction Potential)	-1 V - +1 V	10 mV	-
CL- (Chloride)	128 kB	<10% of reading	50-59 mV/dec
Na+ (Sodium)	10-4 – 1 M	<10% of reading	50-59 mV/dec
K+ (Potassium)	10-4 – 1 M	<10% of reading	50-59 mV/dec
Ca2+ (Calcium)	10-4 – 1 M	<10% of reading	23-26 mV/dec
NO3- (Nitrate)	10-4 – 1 M	<10% of reading	50-59 mV/dec
DO (Dissolved oxygen)	0 – 9 mg/L	50 ppb	

* , extension to other ions possible like Mg2+, NH4+

Table 1

CALL FOR PARTNERS IN THE INTERNET OF WATER

At imec the Netherlands we work to expand our mature ion sensor technology into dense sensor networks for real time water quality monitoring. Algorithms and data analysis ensure constant quality of water or fermented liquid and bio compounds. Currently we are looking for partners to apply real time constant liquid analysis to the next level. Please contact imec the Netherlands for more information.

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