

# Body cavity sensors offer monitoring solutions in daily medicine

**Kohji Mitsubayashi**

Professor of Biomedical Devices and Instrumentation at TMDU

## Q What prompted this informative review on biosensors?

**A:** We have made rapid strides in recent decades in biosensor fabrication, applications, and readouts. I wanted to write a systematic review of significant breakthroughs and challenges that remain, and to highlight promising avenues for further research and development. Biosensors are valuable tools that measure levels of biological factors in ocular or oral body cavities. They are wearable, non-invasive, long-term sensors that provide rapid, continuous quantification of physiologically relevant chemicals in perpetually present body fluids or gaseous exchanges. Human secretions, including urine, feces, perspiration, breath, nasal discharges, body odor, or even tears, can provide valuable snapshots of an individual's health, anxiety level, genetics, and immune status.

## Q Please highlight key applications of biosensor technologies.

**A:** Body cavity sensors have changed medical monitoring. Transcutaneous oxygen sensors are user-friendly for preventing premature retinopathy in infants. Ocular telemetry sensors monitor glaucoma by correlating easily meas-

**Dr. Mitsubayashi** received his PhD from the Department of Advanced Interdisciplinary Studies at the University of Tokyo in 1994. He became Associate Professor at Tokai University and in 1999, he joined the University of Perpignan in France as a visiting associate professor. Since 2003, he has been Professor at the Institute of Biomaterials and Bioengineering (IBB) at TMDU.



urable corneal curvature as a readout for nocturnal variations and instabilities in ocular pressure. Tear glucose levels correlated to output current, which significantly corresponded with blood level, albeit with time delays and concentration differences. Interestingly, amperometric sensor-based contact lenses or modified commercial lenses were found to measure tear glucose and hypoxia reproducibly, mitigating interference confounders.

Salivary levels of risk factor uric acid in stress, gout or diabetes correlate with blood levels and are estimated non-invasively with electrode-based mouthguard platforms. Alternate applications include lactate measurement for fitness and sensors for measuring bacteria on teeth.

## Q How have advances in fabrication technologies promoted biosensor development?

**A:** Microfluidics, MEMs and biomaterial-based

technologies have revolutionized biosensor fabrication. Microsystems enable measurement of biological readouts in small volumes, reducing costs and increasing accessibility. Purpose- and microenvironment-specific biomaterial design with adaptable, biocompatible features have led to advances in polymer technologies with utilization of PEG, PTFE, or PDMS-DMA, the use of phospholipids MPC or PME, chemical coatings including gold or titania sol-gels, Nafion™ to reduce chemical interference, and even "smart" 3D reversible hydrogels.

## Q Please describe how your research fits in with TMDU's objectives?

**A:** My interests in developing biological materials and microsystem technologies are closely associated with biosensors. Body cavity sensors are convenient for the vulnerable aging population of Japan. For example, by quantifying flow, there are flexible, conductometric sensors that measure tear electrolyte concentrations and turnover rates, which can indicate tear gland malfunction in older patients with Keratoconjunctivitis sicca.

## Q Please share your future targets and anticipated challenges.

**A:** While highly sensitive "biotransferables" are gaining traction in the clinic, the next steps include making them less cytotoxic and more affordable for a broader range of applications.

## Cavitas biosensors for non-invasive biomonitoring in daily medicine



Soft contact lens-type biosensor with biocompatible polymers for tear glucose monitoring (left); Mouthguard telemetric sensor (right: front & side views) with Bluetooth 4.0 LE (low energy) transmitter

*Electroanalysis*, doi: 10.1002/elan.201600083