Design and Fabrication of Surfaces Suitable for Molecular Recognition and Signal Transduction: Towards the Development of Chemical Sensors

Fumio Mizutani

Since the pioneering works on semiconductor gas sensors by Professor Seiyama and Mr. Taguchi in 1962, members of The Electrochemical Society of Japan (ECSJ) have made great contributions in the development of chemical sensors, as well as the organization of international sensor meetings. The ECSJ Sensor Research Group was organized in 1977 to promote chemical sensor research in Japan and to initiate the International Meeting of Chemical Sensors (IMCS). The first IMCS was successfully held at Fukuoka in 1983. In 1985, the Research Group was reorganized to the ECSJ Japan Association of Chemical Sensors. The aforementioned Association organized the meetings for the Fourth IMCS (Tokyo, 1992) and Tenth IMCS (Tsukuba, 2004). At the latest Tsukuba Meeting, a number of scientists pointed out the importance of surface sciences and technologies for the fabrication and use of chemical sensors and microsensing systems.

The design and fabrication of surfaces suitable for molecular recognition and signal transduction are keys to obtaining chemical sensors with high performance characteristics, such as high sensitivities, high selectivities and rapid responses. In most chemical sensors, a physical or chemical signal is generated upon the binding of an analyte to a recognition element and a transducer translates the signal into a quantifiable output. The rate and efficiency of analyte recognition at the sensing element surface and those for signal transduction at the sensing element/transducer interface strongly affect the performance characteristics of chemical sensors.

Surface sciences and technologies also play important roles for the fabrication and use of micro-analytical systems consisting of micro-sensors and micro-fluidic devices. The control of interactions between samples and nano- or micro-walls in fluidic devices has been recognized as the most important technology to fabricate miniaturized systems with high sensitivities and reproducibilities. On the other hand, the miniaturization of sensor systems takes an inherent advantage of the interfacial nature of transducing processes involving electrochemical processes. That is, the detection at a transducer surface is easily carried out on exceedingly small quantities of samples. The rapid and highly sensitive determination of analyte can be achieved using a micro-or nano-sensor having a well-fabricated surface.

Implantable sensors are the greatest challenge to ensure quality of life in a society where the average life span exceeds 80 years of age. However, the problem of biocompatibility has not yet been solved adequately, which seriously limits the implantation of sensors. For the construction of sensor surfaces with high biocompatibility, further interdisciplinary collaborations among physicians, scientists and engineers (related to chemical sensors, biomaterials and electronics) are required.

We now have various techniques for the fabrication of surfaces with desired structures and functions. Molecular self-assemblies as well as top-down manufacturing techniques to produce novel micro- or nano-structural surfaces would give rise to more sophisticated, new sensor systems. Electrochemistry would not only be used for signal transduction but also for the fabrication of sensor systems. In the future, I hope that electrochemists will play an active role in the further significant development of chemical sensors.