Seminar Announcement

Smart Microdevices Based on Electrochemical Principles

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Abstract

Miniaturization of analytical devices or laboratory equipment has advanced remarkably over the last two decades in a trend of the micro total analysis system (µTAS) or Lab-on-a-Chip researches. In these devices, one of the key technologies is microfluidics. Although current systems rely on transport by techniques such as pressure driving and valve operation using external instruments, smarter user-friendly systems will be realized if the components work by judging what to do by themselves.

To realize such systems, electrowetting and capillary action provide a good solution. Wettability of gold surface can be changed significantly by applying an appropriate potential with respect to a reference electrode in an electrochemical three-electrode system. By taking full advantage of these phenomena, a simple valve can be realized by forming a gold electrode in a constricted region of a flow channel consisting of hydrophilic glass and hydrophobic polydimethylsiloxane (PDMS). Solutions can be injected into selected flow channels or extracted from a solution reservoir when necessary. Furthermore, by using a composite electrode consisting of gold and zinc, a valve that works autonomously sensing the arrival of a solution can be realized. The composite electrode can also be used to fabricate a clock circuit and logic circuits such as AND and OR gates. These techniques facilitate complicated processing of solutions.

In conducting the determination of analytes in the plugs, electrochemical devices are advantageous. Although amperometry is often used, it becomes increasingly difficult to use this method as the volume of the plug decreases. On the other hand, coulometry facilitates measurement. With a microelectrode array and a constricted flow channel, sensitive detection of H_2O_2 could be realized with a lower detection limit of 410 nM. Furthermore, to improve the detection sensitivity and lower the detection limit, H_2O_2 was converted into silver deposited on the other part of the same electrode in the other flow channel. The amount of the deposited silver was measured by coulometry. By using this method, the charge could be measured before the background increases. The lower detection limit of 30 nM has been achieved.

Although the technologies are still in their infancy, sophisticated microfluidic systems that are comparable with an electronic microprocessor may be realized in the near future.