Column

Frontiers of Future MEMS Devices : “White Devices”

Shoji Takeuchi, Associate Professor, The University of Tokyo (Institute of Industrial Science)

The previous column introduced some of the future devices being studied by the Micromachine Center. In this column, Dr. Takeuchi will provide an overview of the devices in the field of health care and medicine.

In the society of 20 years in the future, with its low birthrate and aging population, the keyword will be “healthy till the very end.” An environment in which everyone is able to work for a long time while continuing to maintain an independent lifestyle will be indispensable.

However, chronic health disorders have reached epidemic proportions. For example, there are said to be some 300 million diabetics worldwide. It is clear that devices that can measure blood sugar and other biological data 24 hours a day and conduct diagnosis and treatment, in such a way that the individual is unaware that he or she is being monitored, are needed even by healthy people. Fig. 1 shows the devices being studied by the White Devices Working Group, which are expected to support the health care and medical treatment needs of people 20 years from now. A brief description of these devices is provided below. In addition, Table 1 shows the working group members who conducted this study.

(1) Ultra-miniature in vitro embedded devices

These ultra-miniature devices can be embedded in various locations in the human body for extended periods of time. They can reside in the abdominal cavity and digestive system and operate autonomously to actively locate and treat tumors, cancerous cells and so on. This will dramatically increase early detection and cure rates. Capsule type devices that do not require a power source may also be a possibility. These can reside in liver portals or in the veins of the arms, functioning as the contrast medium in observations conducted from outside the body, and they will be able to monitor blood sugar, temperature, pressure and other data in the area around the capsule 24 hours a day. In the case of diabetes or other condition for which data from blood must be monitored constantly, this type of ultra-miniature capsule will dramatically reduce the burden on the patient.

(2) Biomechanical hybrid devices

These hybrid devices are created by fusing together biomolecules, cells and so on. The use of biomaterials and functional high polymer materials enables these devices to sense information about the human body and the environment with greater speed and sensitivity than conventional sensors. As the devices are built from materials and mechanisms that are compatible with the human body, they will be powerful tools for interfacing between the human body and machines (for example, the Brain Machine Interface or BMI). To cite one example, a protein film or the like might be reformed on the top of a manmade film as biomolecules with their active state maintained, and the resulting mechanism might function as an ultra-high sensitivity smell or taste sensor or other stoichiometric sensor. Or nerve cells might be cultured on a flexible substrate and these might be placed in contact with the surface of the brain, enabling the cells to extend axial fibers into the brain and connect to the desired cells. Such controllable cultured cells are expected to make it possible to create a highly compatible and precise interface in the event that bioelectricity or chemical signals are detected or a stimulus is applied.

(3) Sheet type health monitoring devices

This device is attached to the surface of the body like a poultice to monitor the status of the patient’s health. Countless sensors and actuators and the like are embedded in layers, enabling the device to display data on the area inside the body at the location where the device is attached. The device can also dispense medications inside the body, promote the healing of wounds and conduct other simple processes. For example, thin ultrasonic sensor arrays might be integrated on the surface of the sheet, and the back of the sheet might have a flat-screen flexible display. This would enable even a non-professional to observe the acquired data on a large 2-dimensional display area. Moreover, as the device is not invasive and is merely attached to the outside of the body, it can be used to determine the blood flow and heart condition of even a healthy person, enabling it to be used for health maintenance as well. The device can also be used as a tool to allow doctors to easily observe conditions inside the body during an operation. In these ways, the device is expected to lead to the improvement of medical technology.

20 years from now, values are likely to have changed as well. Trying to accurately predict such a future is probably doomed from the start. Therefore, we decided to go all the way and create a “wish-list” for the future. We were a bit hesitant at first with regard to embedded devices, but we received support from health care professionals who assured us that embedding is commonplace in health care situations. So we went ahead and included those embedded devices to which MEMS could make a contribution. Regardless of whether or not these predictions turn out to have been on target, they successfully reflect the desire on the part of committee members regarding the devices that should be built.

The future 20 years from now is a blank page, on which no one can predict what will be written. In filling this empty white page with our “wish list” of white device technologies, we hope to start a dialogue about the future of medicine and health care.

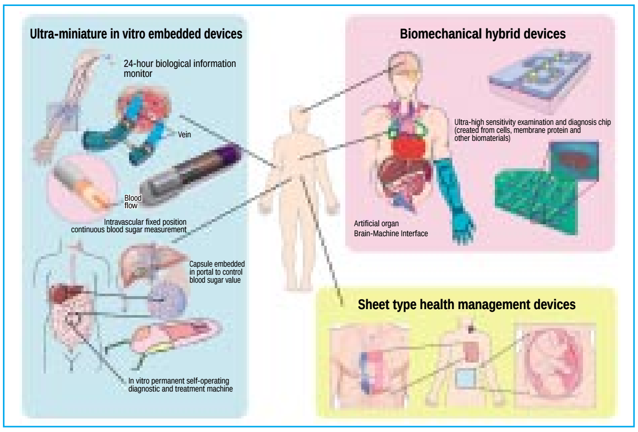

Fig. 1 Devices that will support health care and medical technology 20 years from now

Table 1 White Device Working Group Members (in no particular order)

Shoji Takeuchi	Institute of Industrial Science, The University of Tokyo
Yoichi Haga	Biomedical Engineering Research Organization, Tohoku University
Satoshi Konishi	College of Science & Technology, Ritsumeikan University
Akira Okitsu	Kyoto University Hospital
Takafumi Suzuki	Graduate School of Information Science and Technology, The University of Tokyo
Souhei Matsumoto	National Institute of Advanced Industrial Science and Technology (AIST)
Takuya Iwasaki	Mizuho Information & Research Institute, Inc.
Tomoyasu Hasegawa	Olympus Corporation
Yasuharu Hosono	Toshiba Corporation
Hiroyuki Fujita	Institute of Industrial Science, The University of Tokyo