Column

"Green" Devices: Future Devices on the Frontier of MEMS Research

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With the promotion of the Highly Integrated / Complex MEMS Manufacturing Technology Development Project that began in 2006, even greater growth in the MEMS field is anticipated. At the same time, many innovative achievements are being produced in new fields such as nanotechnology and biotechnology. To see if fusing MEMS technologies with these achievements in the nano-bio field would produce sporadic innovation, in 2006 the Mechanical Social System Foundation commissioned the Micromachine Center to conduct a study entitled "Future Device Technologies Created through Fusion with Nano-bio Technologies as the Frontier of MEMS Research." The future devices targeted by this study are defined as "devices based on MEMS technology, produced by fusing nano-bio materials with MEMS, that will create new lifestyles and have a revolutionary impact on society 20 years from now." As shown in Fig. 1, these future devices will be achieved using, as an infrastructure technology, process integration that fuses microfabrication (a top-down process) with nano-bio processing (a bottom-up process). The devices will be used in three domains that are expected to be critical issues in the society of 20 years from now: environment / energy, health / medical care and safety / security. For this study, the future devices in each of these domains were named "Green" Devices, "White" Devices and "Blue" Devices, respectively, and – together with Process Integration – four working groups (WG) were formed and activated. In this column, I will discuss green devices based on the study conducted by the Green Devices WG, for which I served as chairperson.

Table 1 shows the membership of the Green Devices WG. The WG studied the green devices that are expected to have a major impact on the environmental and energy fields in the society of 20 years in the future. Discussions in the working group were conducted from two approaches: the qualities that these green devices of 20 years in the future should possess (needs) and the achievements that can be accomplished 20 years from now by combining nano-bio technologies with present-day MEMS technology (seeds). Ultimately, the Working Group proposed the following three green devices. In each case, the "localized, on-site" quality of MEMS is utilized to achieve both high performance and advanced functions in combination with nano-bio technologies.

(i) Energy harvesting

Light, heat, vibration, biotechnology and other heretofore unused sources of environmental energy will be used effectively to provide energy. For example, this technology will enable on-site supply of power to sensors distributed in a network. Medical devices implanted into the human body will not require battery replacement, leading to improved patient quality of life. Other anticipated devices include ultra-high efficiency organic solar cells created by means of three-dimensional nanopillar structures, ultra-high efficiency thermoelectric conversion elements created using nanocomposites and nanoporous structures, and high-performance storage battery devices that obtain energy from the environment and store it until it is needed.

(ii) On-site environmental cleanup

Substances such as carbon dioxide emitted by automobiles and water heaters and wastewater from homes are difficult to collect and clean up once they have been discharged, due to their extremely low concentrations in the environment. These substances will be purified on-site at the source, where they are still at high concentrations. Nanoporous filters that separate out pollutants, microorganisms to purify toxic substances and other biotechnology solutions are expected to be applied.

(iii) Ultra-sensitive environmental substance detection devices

These devices are capable of on-site detection of extremely small quantities of environmental substances with great sensitivity. Measuring systems will be compact and will form nodes in a distributed sensor network. For example, Surface Enhanced Raman Scattering (SERS) that uses nanostructures of gold, silver, etc. are anticipated.

Discussions regarding future devices that will be developed 20 years from now are necessarily somewhat lacking in specifics. Progress in research will give us a clearer picture of such devices. Green devices and the other future devices on the frontiers of MEMS research will form the foundation of MEMS technology. At the same time, such devices will no longer be MEMS devices. For this reason, the working group also proposed a new name for these devices: Bio Electromechanical Autonomous Nano Systems (BEANS). I am confident that this new term will soon be in widespread use in many industries.

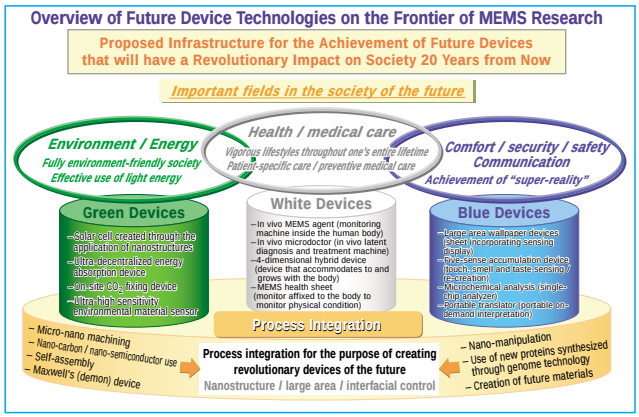

Fig 1 Future Devices on the Frontier of MEMS Research

Table 1 Members of the Green Device WG

Norihisa Miki	Keio University, Faculty of Science and Technology
Koji Miyazaki	Kyushu Institute of Technology, Graduate School of Life Science and Systems Engineering
Chihaya Adachi	Kyushu University, Center for Future Chemistry
Isao Shimoyama	Tokyo University, Graduate School of Information Science and Technology
Takao Ishida	Advanced Industrial Science and Technology (AIST)
Kazuyoshi Furuta	Seiko Instruments Inc.
Akihiro Koga	Toshiba Corporation
Ryo Miyake	Hitachi, Ltd.
Yuji Saisho	Matsushita Electric Works, Ltd.
Hitomichi Takano	Matsushita Electric Works, Ltd.
Junji Adachi	Micromachine Center (MMC)
Hiroshi Fukumoto	Mitsubishi Electric Corporation
Nobuhiro Tsukada	Hitachi, Ltd.