Strategy towards Fusion of Nano and Micro Systems

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As I was introduced, my name is Isao Shimoyama. Allow me to explain how I came to be speaking at this symposium today on a "Strategy towards Fusion of Nano and Micro Systems." The Micromachine Center gave me an assignment to consider the state of Micromachine, or MEMS, five or ten years from now. For this reason, I was allowed to participate in various committees at the Micromachine Center. Based on my findings, I would like to relate to you what course I believe Micromachine, or MEMS, will take in the medium- to long-range future.

Although the English title for my discourse is "Strategy towards Fusion of Nano and Micro Systems," I will reveal the conclusion of my study first by saying that R&D in the field of Micromachine, or MEMS, will shift decidedly toward devices replete with functions in the fields of nanotechnology and nanomaterials. From this viewpoint, the key phrase of my speech will be "nano on micro," as I would like to talk to you about how the products of nano materials and technology will be provided on microsystems.

Features of Micromachine and Industrialization

To define Micromachine and their potential industries from the unrestrained standpoint of the university, the first thing we observe is that the elements of Micromachine are extremely small, allowing for the manufacturing of dense and highly integrated devices. For example, it is possible to manufacture machines from elements strung one-dimensionally in a long line, as in the example of an endoscope. By densely integrating elements two-dimensionally, it is possible to develop thin, lightweight televisions like wallpaper, for example, or extremely thin displays used in cell phones and the like. And while it may be possible to manufacture Micromachine that can be used in specific medical environments, it is also conceivable that there would be a large market for industries providing extremely small, lightweight, and thin devices. Another great feature of Micromachine, or MEMS, is their capacity to contain a driving unit, unlike IC or VLSI technologies. Based on the strict definition of movement, even an immobile solid object has within it molecules and atoms that are moving, and numerous functions are being emerged through this movement. The fact that there is intrinsically a high probability of movement is extremely advantageous, particularly in the small nanoworld. Therefore, it is sufficiently conceivable that Micromachine can be industrialized as next-generation devices, using their advantageous shapes and functions, and not simply as an extension of ICs and VLSI.

Anticipated Manufacturing Technologies and Materials

While it may be far in the future, I believe it is an important issue in manufacturing technology to discuss how we can put functions emerging on nanoscale to practical use. Further, it will be extremely important to develop new nanomaterials, and manufacturing technologies for mass-producing these nanomaterials at a low cost, since we have not yet been able to industrialize nano emerging functions that were first emergence on a nanoscale. In a sense, taking advantage of such as self-assembly phenomena on nanoscale and to obtain nanomaterials or nano emerging functions is what we call a bottom up approach. In contrast, Micromachine technology is an example of a top down approach used to process such as surfacing and removing by micro-machining methods that enabled microfabrication, assembly, and systems, as represented by lithography. These types of processes have raised the potential of manufacturing technology through innovation. Microfabrication systemization is another anticipated manufacturing technology for achieving 3-dimensional high-density integration, multiple functions, and fabrication of not only silicon, but also ceramics, polymers, and other materials together. High-speed analysis and sensing technologies in microarea have begun to be developed in microchemical processes and the field of μ-TAS. These technologies will be used to create a society and a lifestyle with satisfaction in which we can feel growth and development. When considering these from the binding of information, we can anticipate ubiquitous environments in which anyone, anywhere, at anytime can access data or another person with ease; and an environment in which an individual like me, only here and now, can obtain an order-made product or a regional service;

and a safe and secure living environment in which our privacy is protected when accessing a network. These are the goals of a vision to provide satisfying lifestyles to users. I have provided this scenario to show that the use of these technologies can elevate Japan to the top level internationally.

Innovation

Innovation required to achieve this goal includes progress in wearable, mobile, and interfacing technologies. For example, we are able to produce super-small batteries and low-power CPUs, or are becoming capable of producing them. We have developed, or will soon develop, sensors that appeal to the five senses, including hearing, sight, smell, and touch, or that correspond to stimuli of the senses, as well as devices that present and display these senses. Using Micromachine technology, we can develop light, thin devices. We can develop flexible devices using organic materials. Other innovations are devices that can display 3D images that are made from the above technologies to be light, thin, and flexible enough to fold up and put in your pocket. Also, optical communications or sensors placed on networks are appearing as innovations in the wearable, mobile, and interfacing fields.

Robots as an Example Achievement

When we see these from the viewpoints of robots, it has applications in such areas as healthcare, welfare, information, everyday living, safety and security. There are surgical robots in medical care. In welfare, we have nursing robots and attendant robots. In the field of information, there are human-like robots, robots with no strength but serving as an interface. There are robots that help with various household chores and, at night, can feasibly serve as night watchmen. If we broke down these robots into desired element technologies, we would have such abilities as taking diagnoses and giving medical care at the invasion stage of disease, reading vital signs, sensing and displaying the five senses, and performing wireless communications or telemetry. We would also like the robots to have a soft quality, an actuator, and a battery that can be powered externally, as well as reliability and adaptability to society. Breaking down manufacturing technologies into the key technologies, naturally one large key or breakthrough is MEMS, or what we are calling Micromachine technology. Using technologies to fuse these with nanoarea, we have been able to emerge new functions in nanoarea and have developed devices that can use soft, thin, and narrow curved surfaces, as well as small devices that are dense and highly integrated.

Policies and Markets

Markets for these technologies include devices, networks, learning and education, and security. Industries include semiconductors, system LSI, sensors, micro-fabrication, Micromachine, communications, content services, and fuel cells. With that in mind, what policies should we consider for these technologies? Since it is quite difficult to produce products simply by using of emerging nanofunctions and nanomaterials, it is necessary to promote manufacturing technologies in the micro-nano fusion domain or research on the fusion of systemization technologies and to establish a measurement evaluation technology. We must develop a foundation for the technology transfer from universities and development of these technologies in industries, R&D systems at National Institute of Advanced Industrial Science and Technologies, and R&D typified by foundries that use these facilities. We must create an infrastructure that can reduce barriers as much as possible, enabling anybody with an idea to participate in this industry or its research and development. I would like to ask government to fill up a mechanism or infrastructure at the national level for developing creative products through the active cooperation of industries in applying fundamental base technologies.

Conclusion

A recent newspaper article commented that Japan's manufacturing technologies have still globally competitive. In general, businesses are not healthy and tend to look toward short-term profits, as in how something will be profitable a half-year or a year from now. However, an issue being discussed at the universities is that we must strengthen our competitiveness while we are still strong. If we do not conduct R&D for the mid-term and long-term while outlining dreams that are feasible now, I ask you what will we do when Japan's strong manufacturing technologies die out? How will Japan survive in the future? The focus of our R&D should be on technologies vital for strengthening Japan, including micro-nano manipulation of 3-dimensional MEMS/NEMS, design simulation, and MEMS and NEMS created from multiple materials. Finally, I am often told that infrastructure as well as cooperation between industry and academia and the fostering of human resources is extremely vital. While cooperation between industry and academia creates an atmosphere in which universities are required to execute everything up to product development, the most important mission for universities is to educate- and to develop seeds. Through the combination of healthy industries and university initiative, I hope we can generate a great surge in the field. As we progress into the 21st century, Japan must continue to take action and earn respect in order to occupy a prestigious position in the world. For this reason, I conclude that there is no more time for debate.