Column

Can MEMS become an Academic Discipline?

Osamu Tabata, Department of Mechanical Engineering,
Graduate School of Engineering, Kyoto University

One of the many questions that I have long been asking myself is "Can MEMS become an academic discipline?" If it were you, how would you answer? Here I would like to present the background behind this question and my own tentative answer, which has finally begun to take shape. I would appreciate any comments you may have.

Before getting into the main topic, I would like to explain briefly about how I become involved with MEMS. I first became interested in the field commonly known as MEMS in 1979 when I was a 1st year Master's student. I was part of Prof. Naito's research laboratory in the Instrumentation Engineering Department of the Nagoya Institute of Technology, but I also researched information processing of electrocardiogram under Prof. Yamada of the Division of Circulation, Research Institute of Environmental Medicine, Nagoya University (RIEM), with which our department conducted joint research. My days were taken up with conducting animal tests jointly with medical doctors; devising an machine language for programming the just-released microprocessor, 8080, jointly with engineers working for medical instrument manufacturers; and going back and forth to the computing center, my arms heavy with bundles of punch cards. One day, when I was in the RIEM library reading the Journal of Bio Medical Engineering, my eyes were arrested by an article on silicon chip with multi hole active electrodes that could be used to measure the action potential of nerve fiber bundles.[1] This was my first encounter with silicon microfabrication technology, and I was fascinated. This led to my meeting with the late Dr. Igarashi, who was conducting research on silicon piezo-resistive semiconductor pressure sensors, and to my joining in 1981 Toyota Central R&D Labs., Inc., where I was involved in research on silicon micro-flow sensors. At that time, the terms "Micro Electro Mechanical Systems (MEMS)" and "micromachines" did not exist. K. Petersen's historic review[2] was published the following year, and I remember my excitement as I collected and read through all the reference materials listed. After that, the micromachine boom began in earnest with the release of the microgear[3], and as many of you will know, the Micromachine Project was begun in 1991 under the direction of the former Ministry of International Trade and Industry (now the Ministry of Economy, Trade and Industry). In 1996, I moved to Ritsumeikan University and poured my energies into establishing a MEMS research laboratory even as I pondered how MEMS research could be integrated into academia. In September 2003 I moved to Kyoto University, where I am in charge of micromachine engineering.

To think, it's been 25 years since my introduction to MEMS in 1979. During this time, I have been frequently asked, "What's your background?" My reply is always, "I began in instrumentation engineering, which is a jack-of-all-trades field including electricity/electronics, machinery, physics, control, and mathematics, so it was excellent preparation for MEMS research." Certainly, on the one hand, the field of MEMS research has thus far more than satisfied my intellectual interest and curiosity. However, on the other hand, I am always asking myself, "What is my field of specialization?" and I found that there was a part of me that was not satisfied by the answer "MEMS." This was because I felt uncomfortable claiming as my specialization a field that was not recognized as an academic discipline.

Here I will use my own definition of "academic discipline" without delving into a deep discussion of how to define the term. I regard an "academic discipline" as a research field in which the essence of various phenomena and questions pertaining to a particular field are probed and theories explaining the structures and phenomena therein and techniques for resolving these questions are systemized. There are sure to be some fields in which this cannot be achieved by simply adapting theories and techniques developed in other disciplines. Taking mechanical engineering as an example, it used to be that the so-called "3 dynamics" -hydrodynamics, thermodynamics, and material mechanics - were the basic "academic disciplines." These "academic disciplines" centered on analysis, and it was the vital mission of those in academia involved with mechanical engineering to perpetuate and deepen these "academic disciplines." However, when MEMS came on the scene in the late 1980s, it took the opposite approach to that of conventional "academic disciplines." MEMS is a systemized body of knowledge incorporating a broad range of science and technology that supports modern civilized society. In other words, it is an unprecedented, sophisticated system built from a base comprising various conventional "academic disciplines": at its core is not analysis, but synthesis (generation/combination). This complex system involving synthesis in areas measuring several tens of millimeters or less, as a result of complex interactions between physicochemical phenomena, is gradually showing the way to an amazing range of new possibilities.

After much thought, I decided to clearly acknowledge that synthesis, which had not conventionally been regarded as an "academic discipline," was in fact an academic discipline. By doing this, I am able to answer the question I posed initially, "Can MEMS become an academic discipline?" with a "Yes." However, at the present time MEMS is still far from being an "academic discipline." The insight and efforts of many people is still very much needed if MEMS is to not simply adopt theories and techniques from other fields, but to systemize knowledge and theories as to how best to create a system that most effectively synthesizes multidisciplinary phenomena in minute areas. In MEMS, which has shifted focus from analysis to synthesis, there are many opportunities for young researchers who can perform synthesis without being influenced by the conventional "academic discipline" framework. One of my colleagues, who specializes in heat transfer engineering, told me that when he recently reviewed the latest heat transfer developments in the MEMS field, he had been impressed by the remarkable contributions of young researchers. At the first faculty meeting I attended after arriving at Kyoto University, all the newly appointed Professors and their areas of specialization were introduced by the director of graduate school of engieering. In the introduction I wrote for myself, I listed my areas of specialization as "cutting-edge processing," "nano-system integration engineering," "micromachines/micro-electro mechanical systems."

References

(1) Jun Yamaguchi. Trial Production of multi hole active electrodes for Use with Nerve Fiber Bundles. 17th ME Society Meeting 1978; awarded the Science News Research Advances Prize, April 28, 1979
(2) K. Petersen. 1982. Silicon as a Mechanical Material. Proc. IEEE, Vol.70, No.5: 420-457.
(3) Fan L.S., Tai Y.C., Muller R.S. Pin joints, gears, springs, cranks and other novel microstructures. Tech. Dig., 4th Int. Conf. on Solid-state Actuators and Sensors: 849-852.