Column

MEMS-Enabling Technologies

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I joined the Department of Mechanical Engineering at Keio University as assistant professor and launched the "Miki Laboratory," the only laboratory for the field of MEMS in the department, in April 2004. Currently we have nine graduate students and five senior undergraduate students, and are becoming a full-fledged laboratory.

When launching the new laboratory, I struggled first and foremost on determining the direction of our research. Before coming to Keio University, I was a research engineer in the Department of Aeronautics and Astronautics at the Massachusetts Institute of Technology where we researched a button-sized micro-engine and a micro-rocket in the MIT Microengine Project. I was primarily involved in the manufacturing of and experimentation with devices and, in particular, studied Deep Reactive Ion Etching (DRIE) and wafer bonding technologies that require rigid manufacturing precision. I might be able to continue the work here at Keio University, but a change in location is also a good opportunity to change the subject of study. Therefore, emulating the researchers in US, who customarily change their research themes every 3−5 years, I decided to tackle a new topic of research for the new laboratory at Keio.

When considering new topics of research, I remembered a term used by Dr. Senturia, a former professor at MIT and now the CTO at Polychromix: "MEMS-enabling technologies." In his lectures, Dr. Senturia suggested that we should not sell only MEMS devices but technologies that are made possible through the MEMS devices; that is, entire systems that incorporate the MEMS devices. (One can derive from this meaning that MEMS devices alone may not be discriminated against the competitors given their low cost accounting for only a few percent of the overall system.)

Hence, we searched not for MEMS devices, but for MEMS-enabling technologies, i.e., technologies that would benefit dramatically from MEMS and micromachining technologies. As one example, we introduce a pupil-tracking and line-of-sight (LOS) detecting technology. The LOS detecting technology has numerous promising applications in the fields of medical care, information technologies, and safety and security. For example, the severely disabled who are capable of moving only their eyes can utilize LOS to communicate with others. LOS can be a novel input tool replacing the mouse and keyboard. Detecting the LOS of pedestrians, in particular, children, and drivers helps the effective display of hazard signs. Most of today's LOS detecting systems, however, employ a stationary camera or a helmet with a camera mounted in the front to track the subject's pupil, which obstructs the subject's movement and field of vision and, most importantly, affects the subject psychologically.

In light of these issues, we have been developing transparent pupil-tracking devices that can be fabricated on eyeglasses, as shown in **Fig. 1**. We employed dye-sensitized devices, which are currently studied as solar cells, as transparent optical sensors to detect differences in reflected light between the whites of the eyes and the pupils and thus derive the position of the pupils. Since these devices can be worn as glasses, they do not obstruct the subject's movement or field of vision and have a negligible psychological impact, thereby resolving the issues of today's LOS detecting devices. Hence, this technology will contribute to the rapid implementation of the promising applications of LOS detection mentioned above. Since the device has no movable parts, it is not a MEMS device in the strict sense of the term. However, patterning of arrayed electrodes, and processes to encapsulate pigments and electrolytes are made possible through MEMS manufacturing technologies. Thus the proposed system is an MEMS-enabling technology. To date, we have succeeded in detecting the movement of a pupil using a single dye-sensitized device (patent application no. 2006-018591).

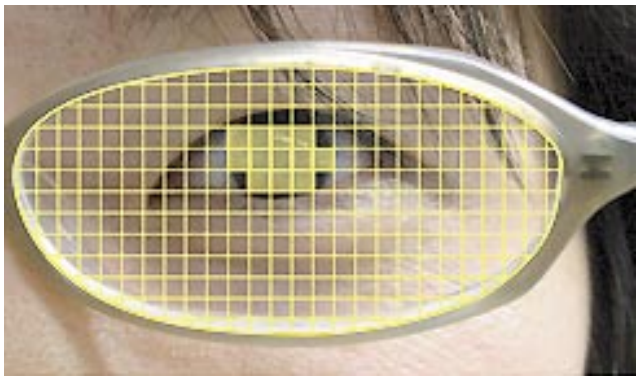

Fig. 1 A mounted transparent pupil tracking device

When studying MEMS-enabling technologies, I believe it is vital that we make full use of the resources at the Faculty of Science and Technology of Keio University. MEMS-enabling technologies are, in effect, technologies of other fields that can make remarkable advances with the help of MEMS. Hence, the key for establishing a research theme lies in how we can discover the potential needs in other fields. In this regard, the Faculty of Science and Technology at Keio University has been a blessing. Owing partially to the rather compact Yagami Campus at the university, we have enjoyed lively intercourse with diverse researchers in the eleven departments of our faculty. Miki Laboratory is currently conducting collaborative research with six other laboratories in four departments.

As you know, MEMS development is highly dependent on expensive equipment. Miki Lab currently has equipment capable of performing basic photolithography, but we do not possess expensive DRIE or sputtering devices, nor do we have measuring instrumentation. Fortunately, however, our Faculty of Science and Technology has the Central Service Facilities for Research complete with measuring instruments and analyzers (http://www.sfr.st.keio.ac.jp/), and a laboratory equipped with a deposition system. Hence, we have endeavored to share the use of this equipment as much as possible. At the same time, we have made our facilities at Miki Lab available to other laboratories having an interest in MEMS. In the future I would like to establish an open MEMS laboratory at the Faculty of Science and Technology.

However, sharing resources in this way leads all too frequently to some laboratories monopolizing the equipment, establishing rules of usage that are too strict, and accidents caused by inexperienced users. We are currently drawing up management guidelines to eliminate these problems while studying the systems used at MITs Microsystem Technology Laboratories and MEMS laboratories in Japan. We are actively engaged in implementing a research environment to facilitate MEMS-enabling technologies, i.e., "a research environment enabling MEMS-enabling technologies" in our Faculty of Science and Technology.