Turning MEMS ideas into MEMS products

Stephen D. Senturia, Professor Emeritus, Massachusetts Institute of Technology, U.S.A.

Today I would like to talk about MEMS, on how to think the MEMS.

In July 2003, I had a lecture on "Turning MEMS ideas into MEMS products" at the conference of "Transducers 03'" which held in Boston, U.S.A. and Professor Fujita, who is here today, was participating in my lecture. After that I was asked by Professor Fujita to have a lecture on the same theme in Tokyo. This is why we are meet here today. And I feel happy to have a lecture here for you. The contents have modified to make much more interesting. The items in my talk are MEMS's viewpoint in the future and review in the past and I would like to talk on "Turning MEMS ideas into MEMS products" in the last.

Let's review the MEMS in the past

The conference of Transducers was initiated in 1981, then there was no name of the abbreviation "MEMS" and the field of research and development initially called solid-state sensors and actuators, which over time, morphed into Micro Electro Mechanical Systems MEMS or Microsystems. The state of the MEMS field in the early 1980's, I can divide such three groups as basic research, engineering science and product development. There was much work in basic research on materials, sensing methods, actuation methods and phenomena on a micron scale. There was even more work on the engineering science of building practical devices, with emphasis on materials and process technology, integration methodologies, and system design. At that time there were only a few microfabricated devices such as pressure sensor, gas sensor and ion sensor on the market. However there were no journals devoted to MEMS, no regular conferences, and limited access to design and fabrication infrastructure. The impact is sufficient that there are now multiple journals devoted to MEMS and a variety of technical meetings. Individual disciplines that have a MEMS component are now holding their own meetings, and it is now possible to go to a meeting involving MEMS or microsensors almost every week of the year. There are newsletters and trade magazines devoted to the microworld, and a growing infrastructure of fabrication vendors and equipment suppliers. Whereas only a few of these were on the market in the early 1980's, sensors for acceleration, flow, and angular rate as well as a variety of optical MEMS and microfluidic and bioMEMS devices are now commercially available. And there are products - many products.

Trends for the Future

Looking forward from today, several trends are clear. The first is that both the emphasis and the funding for basic research are shifting into "nanotechnology," whatever that means. To some, it means simply making smaller versions of what is already familiar in the "micro" world. But to most, it is a completely different subject, building objects from the bottom up, with molecular manipulation and self-assembly. Nanometer-sized objects are being built for research uses. Such devices inherently must include quantum effects in their description. Given this shift, the MEMS practitioner has a choice: either go into "nanotechnology" (and many are doing that), or get into an area that does not depend on basic-research funding, namely, products. The problem, of course, is that building products is difficult.

MEMS vs. MEMS-Enabled Products: An Example

It is useful to distinguish between two types of MEMS-based product. In the first category, referred to as a "MEMS product", the MEMS chip, with or without its primary package, is the product. Electronics may be integrated into the chip, as in the Motorola pressure sensor and the Analog Devices accelerometer. The second category, referred to as a "MEMS-enabled" product includes not only the MEMS chip and its package but also ancillary components, external electronics, possibly embedded software or firmware, and an overall product package. Both categories of product require test, calibration, documentation, and some kind of quality-management system (ISO or equivalent). The Polychromix Dynamic Channel Orchestrator provides a good example of a MEMS-enabled product. The core technology is the polychromator, an electrically programmable diffraction grating with up to several thousand parallel mirror elements suspended above a substrate, each one of which can be actuated to change its height above the substrate. This creates an aperiodic programmable diffraction engine capable of creating synthetic spectra. While this technology was originally developed for chemical sensing applications using optical spectroscopy, it is now being applied to optical telecommunications by Polychromix. The product operates over the telecommunications C-band (wavelengths near 1.55 microns), controlling the power in 100 channels spaced 50 GHz apart over a 40dB dynamic range under program control.

Conclusion

I have explored some of the challenges facing real-world MEMS products, with emphasis on the higher-value-added MEMS-enabled products. Even with these many difficulties, there is enormous vitality and creativity in the MEMS community, and with appropriate attention to the many risks and challenges ahead, it will be possible to build, and successfully sell, new MEMS-based products to a welcoming world. As a conclusion, ideas for MEMS have been already fulfilled and the development of MEMS technology has been become ready in every relating fields. Moreover infrastructures to fabricate commercial products such as foundry services, and CAD tools have been completed. What the next step for MEMS is only to make products.