Column

Expectations for the New BEANS Project

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With microsensors now being widely used in game machine controllers and image stabilizers for cameras, among other applications, consumers are beginning to appreciate the true value of sensors as they are able to play TV games using gestures and body movements and can produce sharp photographs even when the camera moves slightly. While the same consumers might not fully understand that advances in MEMS technology are responsible for these sensors, we MEMS engineers are inwardly proud. Such advances in MEMS products directly help secure and expand our future areas of activity, making it particularly satisfying to see our efforts in development finally begin to bear fruit.

Already 20 years have elapsed since surface micromachining was developed in the late 1980s and since we were first amazed to see micro-gears and micro-turbines rotating on silicon chips. Through the development of many advanced process technologies during that time, including wafer bonding and deep reactive-ion etching (DRIE), microstructures can now be freely created and moved with precision. By devising various micromachining techniques adapted to CMOS circuitry and by incorporating electronic circuits on chips, we have added such advanced functions as temperature and sensitivity correction, self-diagnoses, and various data processing functions. We have accumulated much data on reliability and bettered our knowledge in packaging and other areas of industrial science through earlier achievements made in automotive pressure sensors and accelerometers and in projectors employing movable micro-mirror arrays.

Since the Micromachine Technology Project conducted from 1990 to 2000, Japan has supported technological development primarily at the corporate level through the MEMS Foundry Project, and the MEMS Open Network Engineering System of Design Tools (MemsONE) Project. Currently underway is the fineMEMS Project targeting highly integrated, complex MEMS. This foundation of progress has allowed us to make rapid advances in commercialization.

From another perspective, MEMS technology on the micro-scale has reached a high level of maturity, entering the domain of competitive development due to its direct link to commercialization. While it will be necessary to further enhance existing technologies and expand the product lineup in commercially viable fields, such as sensors, information and telecommunications, and optics, new fabrication techniques must also be created to prepare for future growth outside of these fields. By merging micromachining based on a typical top-down approach with nanotechnology or biotechnology based on a bottom-up approach, manufacturing processes for MEMS can be developed under unprecedented concepts. We anticipate that these process technologies could be used to produce products having such functions as biosensors for biological measurements, treatment, and diagnoses, efficient energy conversion based on nanostructures, and network-based measurements of extensive environmental data, which projects are anticipated to help resolve national and social issues faced in the 21st century, including issues in health care and welfare, the environment and energy, and safety and security.

From this point of view, the BEANS (Bio Electromechanical Autonomous Nano Systems) Project proposed by METI is aimed at researching manufacturing technologies required to create innovative devices through the integration of micro- and nanofunctions. The basic plan calls for developing processes enabling the fusion of biomaterials and organic matter, the formation of 3D nanostructures, and the continuous large-area manufacturing of micro-nano structures, and for constructing related knowledge databases. Research on processes for merging biomaterials and organic matter will involve harnessing the unique capabilities of biomaterials and organic matter, such as molecular recognition and self-assembly, and selectively adding these capabilities to silicon structures. These processes are expected to produce devices that can be adapted to organisms and operate stably therein for a long period of time, and structures employing nanopores or nanopillars to achieve cell culture and high-sensitivity sensing. Processes for forming 3D nanostructures include a process for creating smooth nanostructures with no internal flaws at the atomic level, and a process for uniformly coating the surfaces of or gaps in nanostructures with a functional film. Since nanostructures and nanoparticles exhibit properties unique to the quantum effect, such as good photoelectric energy conversion not found in bulk materials, they are thought to be useful in ultra-small devices capable of generating power efficiently, among other applications. Finally, research on processes for the continuous large-area manufacturing of micro- and nanostructures is aimed at finding a process to create devices inexpensively on large substrates using printing or embossing techniques rather than a semiconductor process, which, although capable of unrestricted 3D micromachining, is expensive and can only be performed on substrates of a limited size. This process should allow us to manufacture devices continuously over thin, soft substrates, much like a printing press can print newspapers quickly and in high volume.

Just as R&D on MEMS manufacturing techniques began some 20 years ago, the BEANS Project is being initiated with the goal of developing new processing techniques that will prove useful 20 or 30 years from now. Already we are anticipating with pleasure how consumers will come to appreciate the true value of devices developed from the fruits of this project.