Fuji Electric Co., Ltd.

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1. The Challenge of Micromachine Technology

Micromachine technology at Fuji Electric Co., Ltd. began with the development of sensors. Examples of our current products include accelerometers for activating automobile airbags, pressure sensors for plant monitoring, and gas leakage sensors for domestic use.

In a government research program called "Research on Hazardous Environment Robots," we developed 3-axis tactile sensors to be fitted in the fingertips of robots. Here, multiple micromachined strain sensors are mounted on a silicon substrate to detect three-dimensional force components. Robots equipped with these sensors are now able to grip soft objects, like a rubber ball.

2. Development of Micromachine Technology

Fuji Electric Co., Ltd. took part in the Micromachine Technology Project of the Industrial Science and Technology Frontier (ISTF) Program from the beginning, studying primarily the manufacture of micro-actuators. In Phase I of the project that began in FY 1991, we pursued the feasibility of such micro-actuators as an electromagnetic motor with a rotor diameter of just 1 mm.

Phase II, which began in FY 1996, saw seven companies collaborate to develop a "microfactory." The microfactory was an attempt at extreme size-reduction of manufacturing equipment, shrinking processing and assembly units to fit into a space about the size of a desktop. In Phase II, we were responsible for a two-dimensional micro-conveyor used to convey parts and finished products between operating units.

Fig. 1 shows an external view of the micro-conveyor, the surface of which is lined with square coils having a side length of 1 mm. By controlling an electric current supplied to each coil separately, it is possible to move a carrier with a permanent magnet in a desired direction.

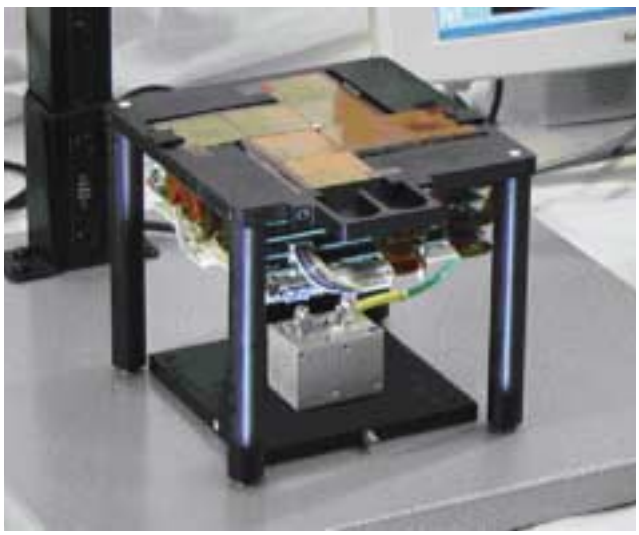

Fig.1 Micro-conveyor

3. Future Stance

While achievements from the ten-year ISTF Program range from actuator driving technology to micromachining/assembling technology, thin-film formation technology, and material technologies, we consider thin-film technology and micromachining technology to be the most promising areas for future development. In addition to actuators, we expect these technologies will be applied to a wide range of products, including sensors and electronic parts.

Fig. 2 shows a thin-film coil having sides 4 mm in length directly formed on the surface of an IC using thin-film formation technology. This process will be useful in manufacturing smaller power sources for portable equipment. In this way, we hope to apply technologies cultivated in the Micromachine Technology Project in the development of many products.

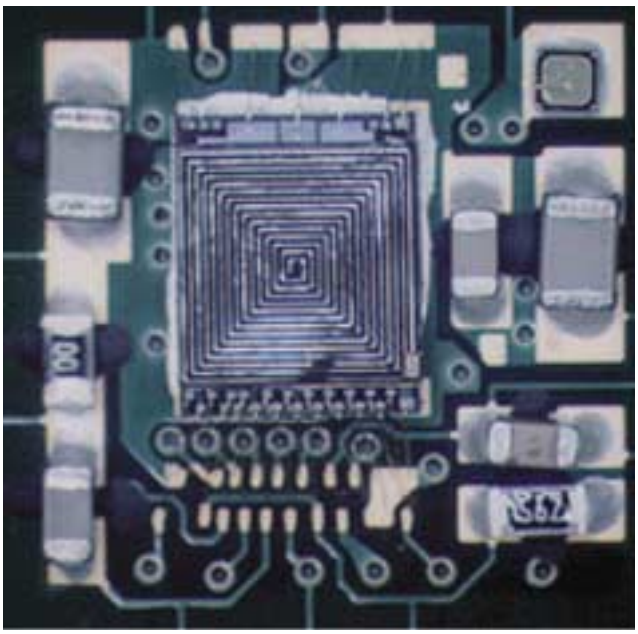

Fig.2 Thin-film coil formed on an IC (4x4 mm)

Matsushita Electric Industrial Co., Ltd.

Masaaki Adachi
Director
Advanced Technology Research Laboratories

1. Endeavors in Micromachine Technology

Matsushita Electric Industrial Co., Ltd. has been working toward establishing design technologies for micromechanisms, as well as micromachining, assembly, and evaluation techniques to cope with the increasing integration and size-reduction of information-processing equipment. We participated in the Industrial Science and Technology Frontier (ISTF) Program by conducting research on the system integration of travelling devices.

2. Development of Micromachine Technology

A travelling device developed by Matsushita Electric Industrial Co., Ltd. (Fig. 1) implements locomotive functions by rapidly decelerating the high-speed rotations (40,000 rpm) of a motor and increasing torque. We developed micromachine base and system integration technologies for developing micromechanisms by applying these integrated functions to a chain-type micromachine system for inspection of outer tube surfaces in cooperation with Mitsubishi Electric Corporation and Sumitomo Electric Industries, Ltd. In particular, we developed such element technologies as mechanical interfacing (a design technology for micromechanisms that involves tribology), high-precision micromachining and measuring technologies, and high-precision assembly technology. We manufactured numerous uniform micromachine parts, assembled reducers, and worked to achieve a low loss in drive trains.

Mechanical interfacing is a technology for improving performance through studying reduction methods and improving the contact surfaces of components in order to develop a reducer suitable for use in micro-spaces. We succeeded in developing a reducer with a reduction ratio of 1/200 and a size of 5 x 3.5 x 1.5 mm based on the planetary gear system (Fig. 2) constructed of a micro-gear in a 0.03 module. We attempted to improve the drive train efficiency by studying the bearing construction and improving the surface quality to decrease the friction coefficient and wear of the gear.

High-precision micromachining, measuring, and assembly are technologies for efficiently processing and assembling numerous microparts and with great precision and uniformity. By developing a more sophisticated form of electric discharge micromachining, we can reliably supply many microparts for constructing travelling devices. In our attempts to further improve precision in machining, we demonstrated the value of a method for on-machine measuring of micro-textures using a microvibration probe (minimum diameter of 20 mm and length of 1 mm). In order to produce many micromachines from machined parts more efficiently, we developed and demonstrated the effects of a self-aligning/self-assembly technology using excimer laser beam machining to etch a sacrificial layer.

We integrated these basic technologies to mount a travelling device in the tube inspecting micromachine system, demonstrating that the rotational drive of the drive device can be converted to horizontal and vertical locomotion of the inspection system.

3. Future Endeavors

Matsushita Electric Industrial Co., Ltd. hopes to add to its achievements in the ISTF Program by combining those results with other micromachine technologies and applying these technologies to such products as information-processing equipment.

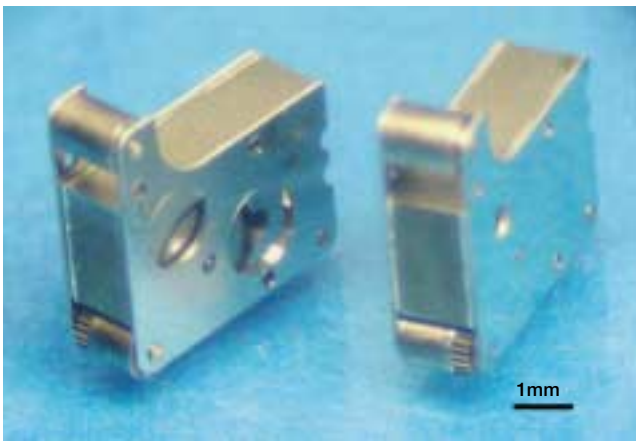

Fig.1 Traveling device

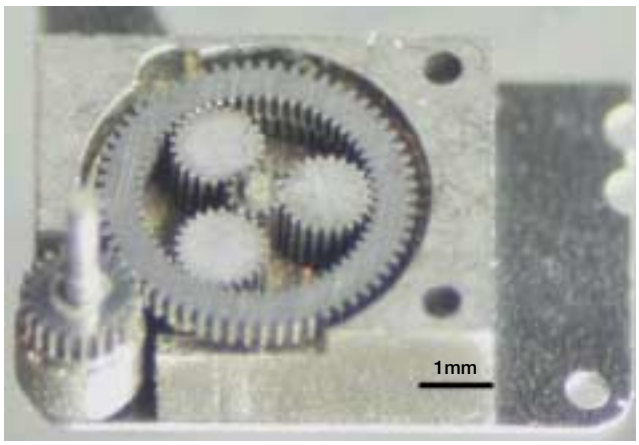

Fig.2 Planetary gear system