Fusing Micromachine and Space Development Technologies

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Launching satellites into orbit currently requires several million yen per kilogram. As a result, developing lighter, smaller and less power consuming and more compact onboard equipment has been one of the most important issues in space development.

The U.S. is far ahead in R&D on applications of micromachine technology in space. While it is common knowledge that conventional satellites weigh from several hundred kilograms to several tons, designs for manufacturing a one-kilogram satellite primarily from silicon material have been published. Most functions required by a satellite-i.e. sensing, attitude control, data processing, communications, command processing, power supply, solar cells, thermal control, structure, and the like-can in principle be created on a silicon substrate using semiconductor lithography.

Accelerometers, gyros, infrared sensors, and microgravity sensors that apply micromachine technologies being developed on the ground are also being studied for an extremely large broad of space applications. Many are already at a stage of practical use in space.

On the other hand, microthrusters used for orbit and attitude control are considered important as being unique to space. There have been many published researches on the application of micromachine technology to the development of valves and nozzles, such as cold gas jet thrusters that eject compressed gas from nozzles at a high speed. While much research has been performed on methods of ejecting a liquid by applying heat with a microheater, microthrusters employing an array of micro-solid propellant , and methods for obtaining an efficient microforce by accelerating ions in a pulse, these technologies still require much development effort before being used in real space missions.

Additional research is being conducted on applications of micromachine technology on a wide range of components for use in space, including relays and switches, filters, pumps, DC/DC converters, and solar cells.

Micromachine technology is extremely compatible with space development where developing smaller equipment is a key issue. It is essential to promote communication between space engineers on the needs side and micromachine engineers on the seeds side. Many in the space community share a sense of crisis in having fallen behind America and, therefore, a strong sense of urgency to construct compact space equipment. On the other hand, Japanese ground researchers in micromachines possess some of the world's top level techniques and hope to expand their applications. Therefore, communication between the two parties should be extremely beneficial to both. Equipment used in space requires an extremely high level of reliability to operate in such severe conditions as vacuums, high temperatures, low temperatures, radiation, vibration and shock during launch. Attempting to clear these hurdles is a positive goal for ground micromachine technologies.

Investigative Study into the Integration of Micro-Flying & Micromachine Technologies

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It has been considered from the beginning of the development of micromachines that small flying devices could be used in the retrieval of information from disaster areas, nuclear power-generation plants, and other locations for which access may be difficult. Furthermore, a number of such unmanned flying devices are now being put to use in disaster areas and other similar locations. As element technologies for this type of small flying device, micromachine technologies including micro actuators and micro sensors are required.

In this research, we first conducted an investigation into the current state of unmanned aerial vehicles(UAV) which are now being put to practical use. The UAVs covered in this report vary from several tens of centimeters to approximately one meter in size. In Japan, these small UAVs are used during volcanic eruptions to photograph the areas of damage around the volcano's crater, to measure the thickness of volcanic-ash buildups, and for other similar tasks. Overseas, on the other hand, research and development is also being carried out for military purposes, and in recent years, this technology has been implemented for border security, highway patrol activities, narcotics control, waterway administration, and fire-prevention activities among others. Fundamental research is progressing in terms of aerodynamics for low Reynolds numbers, and recently, as a result of the attention being paid to the wings of insects of an identical size, research is also being carried out on flapping-wing flight for low Reynolds numbers.

Next, we studied the development of micro-actuators for application to small flying devices. Generally speaking, if the scale of the flying object is small, the actuation suitable for this object will also change accordingly. During this study, we investigated both the effect of reducing the scale of the actuation as used in jets and other modern aircraft, and also flapping and other types of actuation unique to small flying devices. In terms of achieving the driving forces required to allow flight, many reports have dealt with propulsion using propellers and jets. And while research into flapping-wing type propulsion continues, many problems remain to be overcome before this technology may be put to practical use. A method for the supply of energy will also be required so that flight may be achieved, and technologies such as solar batteries, microwaves, and polymer batteries are expected to prove useful in this regard. In the case of jet propulsion, however, the combustion of chemical fuels is an efficient means of propulsion.

Finally, we carried out an investigation into the sensors generally used in today's airplanes and also into those sensors which can be used in the control of small flying devices. Research has been carried out regarding visual sensors, accelerometer-type sensors, GPS, laser scanners, altimeters, and the like; furthermore, these are currently being put to use in autonomous helicopters. This type of element is crucial in the control of the position and attitude of the device, and valuable research in this field is expected to increase in the future.