Toshiba Corporation

Nobuyuki Toyoda
Deputy Director
Corporate Research & Development Center

1. Achievements of Micromachine Technology

Under the Industrial Science and Technology Frontier Program, Toshiba, along with Denso and Sanyo Electric, has developed an "Experimental Wireless Micromachine for Inspection on Inner Surface of Tubes" for applications in confined areas like the narrow piping in electric power plants. This "microrobot" can move along a pipe having a diameter of 10 mm, while transmitting images ahead and debris inside the pipe. The microrobot is driven by energies received wirelessly from external microwave and laser sources.

In this project, Toshiba was in charge of developing a "CCD Microvision System" to be mounted on the front of the microrobot. The microvision system comprises a color video camera with built-in focusing mechanism mounted on a 2-DOF universal head, all powered-driven, in the body-size of 25 mm in length and 8.9 mm in diameter. In developing this system, we achieved various advances in camera size and image quality that have not been paralleled under such restricted energy conditions and transmission capacity.

We also developed various element technologies necessary to develop this microvision system, including micromachining, high-density three-dimensional packaging, electrostatic micromotor, and thin catadioptric system technologies. We further developed assembly technology for integrating the above components and a method for constructing images to support the small transmission capacity, along with technical development on systematization.

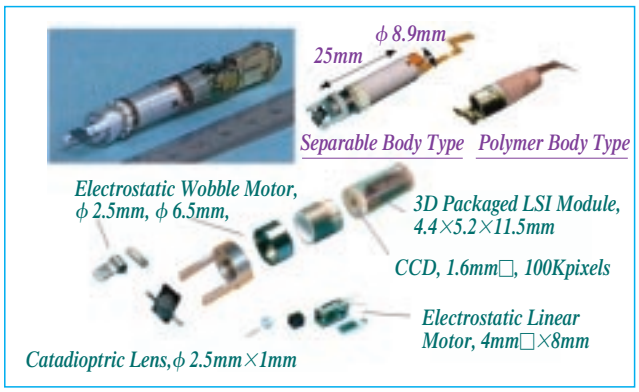

Fig.1

2. Future Activities

In addition to mounting the microvision system on the in-pipe inspection microrobot, we hope to apply this system to new applications using the entire system or individual element technologies. The first applications that come to mind are in the security and medical fields. In terms of the former, the development of information network services as household and social infrastructures is likely to make wireless image transfers from remote locations possible in the near future. The microvision system is expected to have few restrictions in the number and location of installation because of its ability to freely change viewing angles and the fact that it has 1/1000 the volume of conventional devices.

In the medical field, it is likely that the microvision system can be applied to examination apparatus used in laparoscopic and endoscopic surgery, which are now receiving much attention as minimally invasive operating methods that allow quick recovery period. By combining the

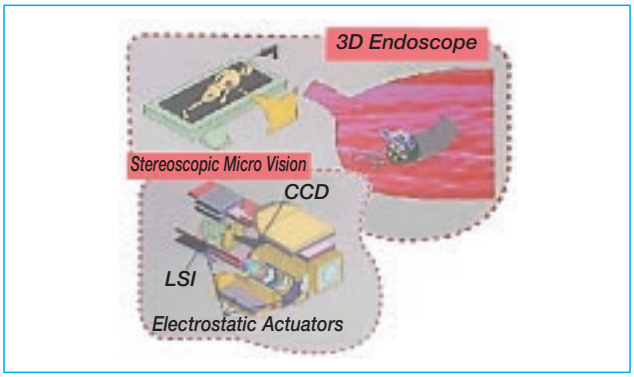

Fig.2

micro-sized CCD unit and electrostatic linear motor mounted in the microvision system, it is possible to construct a stereoscopic camera that can fine-tune the three-dimensional effect and should contribute greatly to examinations and surgery.

We also developed new systems applying some of the element technologies that were developed in the microvision system for the trial production and verification of practical devices. In Fig. 3, the electromagnetic micromotor has been applied to an in-pipe inspection robot with wheels. An electromagnetic motor having a diameter of 5 mm is mounted on a 7-mm diameter case for a 400,000-pixel CCD. Observing the inner pipe walls are performed using a focusing mechanism formed of a shape-memory alloy (SMA). The robot can observe debris as small as 20μm in a pipe with a minimum diameter of 20 mm. Powered by wiring, the robot can be used in environments in which microwaves or lasers cannot.

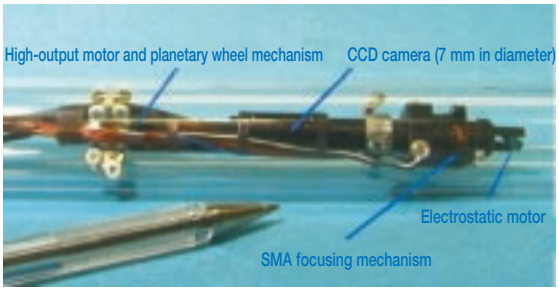

Fig.3

3. Future Stances

Other conceivable applications for the microvision system include PDAs and robot eyes. We plan to continue these studies as deemed appropriate for satisfying the needs of society.

Hitachi, Ltd.

Hiroshi Ohki
General Manager
Mechanical Engineering Research Laboratory

1. The Challenge of Micromachine Technology

Hitachi, Ltd. manufactures a comprehensive array of electrical machinery and appliances, such as nanometer-sized electronic devices, consumer products, power and energy systems, and industrial machinery. We supply products and services in a wide range of fields and are implementing projects on a global level.

Micromachine technology is a cutting-edge basic technology that will shape the 21st century. The Mechanical Engineering Research Laboratory is chiefly responsible for R&D on micromachines at Hitachi, Ltd.. The entire research laboratory is working together on this research and development with the aim of incorporating our basic technologies in mechanical systems as a base to provide the best customer solutions in such fields as medical and human-care, the environment, information, and communications.

2. Development of Micromachine Technology

Hitachi, Ltd. participated in the planning for "Micromachine Technology," part of the Industrial Science and Technology Frontier (ISTF) Program sponsored by the Ministry of Economy, Trade, and Industry that was completed in March 2000, and oversaw research and development on element technologies and system integration technology for developing a microfactory, the concept of which is a micro-sized system for producing small numbers of many products. The anisotropic wet etching process for single-crystal silicon, which Hitachi, Ltd. has developed over many years, is gradually having a rippling effect on the creation of micromachines, which will benefit society.

2.1Achievements of the Industrial Science and Technology Frontier Program

In overseeing the research and development on a microfluid operation technology, we developed a microfluid operation device for supplying corrosive working fluid for micromachining and a holding device for assembling microparts. By incorporating surface treatment and forming techniques on a micrometer order, we developed a microfluid sealing method for rotary driven trochoid and scroll pumps. In this way, we achieved a micro size while maintaining high output. These features were applied to a fluid pump for supplying fluid and a vacuum pump for holding microparts. Both devices were then incorporated into a trial microfactory system to verify the processing and assembly operations of a microgear. Fig.1 shows a holding device (vacuum chuck; outer diameter of 7mm and length of 26mm) mounted on the end of a microarm (manipulator) used in assembly operations. The holding device conveys a microgear having a diameter of 2.6 mm.

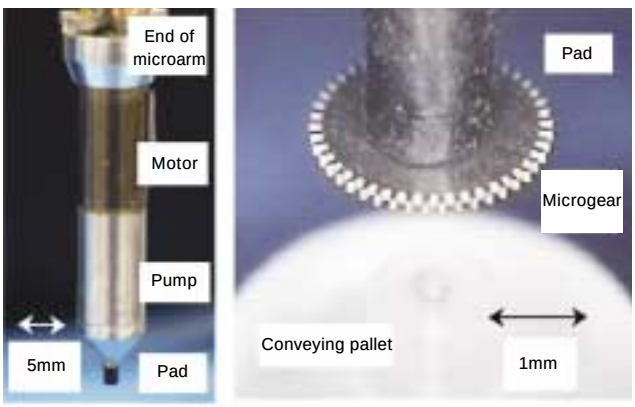

Fig.1 Vacuum chuck and operation of chucking microgear

2.2Achievements in Silicon Micromachining Technology

We applied silicon micromachining technology to the development of a small sized water quality monitor the size of an A4 sheet of paper (1/100 the conventional volume). This device contributes to human safety and health management by automatically measuring residual chlorine and the like in water pipes for general households that have extremely limited installation space. The primary feature of this device is that it employs microfluid channels produced by silicon anisotropic wet etching (see Fig.2).

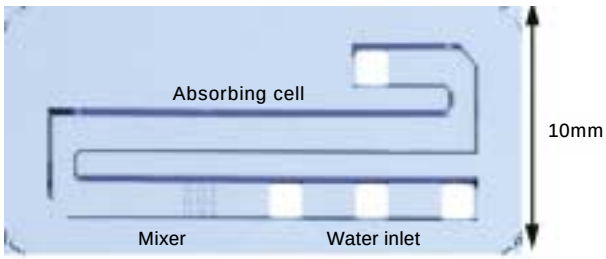

Fig.2 Microfluid circuit for a small sized water quality monitor

3. Future Stances

In our future challenges, we would like to apply the achievements of the Industrial Science and Technology Frontier Program to the field of micro total analysis systems (μTAS) to develop an analyzer for medical and environmental applications.