Advanced Sensing Technology for Automobile

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1. Introduction
The automobile is made using the essence of many special mechanical techniques and highly developed electric and electronic technologies. The energy saving, safety, comfort, and communication systems of automobiles are progressing with electronic technologies. They are controlled with a lot of electronic devices. On a hybrid vehicle and an electric vehicle, an electric motor, battery, and power device are main components to drive them. ITS (Intelligent Transport Systems) is a communication system in cooperation with public electronic infrastructures. A probe car is expected as the moving sensor on the road.

The research and development of electronic devices and systems for the automobile is strongly required. The control system consists of a sensing (sensor), judgment (CPU), and action (actuator). Therefore, the sensor is a very important device which detects physical and chemical quantities like a human sensory organ. Many kinds of automotive sensors are used because the sensing targets, mounting positions, and environments are in wide range as shown in Table 1. An advanced automobile has more than one hundred sensors. In recent years, the automotive sensors have been developed with the MEMS technology in a complementary style.

2. Sensing Technology for Automobile
The sensors for the VDIM (Vehicle Dynamics Integrated Management) are shown in Fig. 1. The VDIM is a combined system composed of the VSC (Vehicle Stability Control), ABS (Antilock Brake System), traction control, and power steering. In this case, data of a yaw rate, acceleration, wheel speed, steering angle, steering torque, and brake pedal sensors are combined via an automotive LAN (Local Area Network) and are used for the body control.

The history of the MEMS technology with automotive sensors is shown in Table 2. This history is the same as the sensor history of miniaturization, reduction in size and weight, high performance, and low cost. The piezo-resistive effect was used for pressure sensors. A combustion pressure sensor measured the pressure in an engine cylinder, and the combustion of the engine was controlled with the sensor. An acceleration sensor was used for an air bag system, ABS and VSC.

A yaw rate sensor, which is an angular rate sensor well known as a gyro sensor, was used for an advanced safety of an automobile. At first, a quartz yaw rate sensor was developed, which was on-board as the first generation sensor of the VSC. The sensor element and housing are shown in Fig. 2. Next, a semiconductor yaw rate sensor was developed as the second generation sensor for the VDIM. The semiconductor type is made of an SOI (Silicon on insula-
A convex poly-Si stopper structure for a movable structure was developed for an anti-stiction technology. The convex structure is referred to as a poly-Si mushroom-shaped structure (pSiMS). A fabricated pSiMS with a height of 0.6μm and a diameter of 2.8μm is shown in Fig. 5. The pSiMS has a pileus and stipe with a diameter of 1.5μm. The fabrication method is shown in Fig. 6. Figures 6 (a) and (b) show cross-sectional view of a fabricated mold and a mold refilled with poly-Si, respectively. The pSiMS allowed preventing 2-mm long beams from sticking. This anti-stiction technology improves the reliability of the MEMS device for automobile use.

3. Next generation of the MEMS sensors and actuators

There are so many expecting sensors and actuators developed by MEMS technology. A 3-axis accelerometer and multi-axis angular rate sensor can control a vehicle action in dynamic zone. A laser scanner with an optical MEMS scanner will provide a new system for safety.

4. Conclusions

The sensors for the automobile have been advanced with the MEMS technology. The needs and applications of the sensor and devices are expanding. New sensors and devices will be created with the MEMS progress.