

# Standardization Activities

While the Micromachine Center (MMC) promotes standardization related to MEMS technology, this article will detail our current R&D projects.

## Developing Standards for Micro-gyroscopes and Electronic Compasses

Gyroscopes are indispensable for controlling the attitude of a device in a space by detecting fluctuations in attitude. Recent developments for reducing the size and cost of devices while improving performance through MEMS and other technologies have led to a more active role for micro-gyroscopes in various contexts of daily life.

Gyroscopes incorporated in controllers for game consoles detect movement in the controller and adjust the image accordingly. An image stabilizer has become a standard feature of digital cameras and is even provided in the cameras of cell phones. This function is achieved with a gyroscope that detects attitude changes in the camera and moves the lens and image-detecting unit accordingly. Gyroscopes having greater precision and resistance to impacts are the key components of safety systems installed in vehicles to control the engine and brakes when detecting impacts and changes in attitude. Even higher precision gyroscopes have appeared in aircraft and space applications. Now efforts are being made to replace the conventional gyroscopes, which have good precision but are heavy and bulky.

Compasses are age-old instruments that have been central to navigation for ships and aircraft. A compass detects the Earth's magnetic field and displays the directions north, south, east, and west. However, since geomagnetism itself is very faint, various compensations are needed to boost the precision of the compass, resulting in a large and heavy instrument. Recent years have seen the appearance of an electronic compass that combines a sensor element for detecting geomagnetism with a system for analyzing and processing the sensor signal. With their decreasing size and cost, electronic compasses are being provided in cell phones to configure a navigation system for pedestrians that can detect the user's position with the Global Positioning System (GPS) and directions with the electronic compass.

Consequently, the number of practical applications for micro-gyroscopes and electronic compasses continues to grow. The objective of our project is to standardize the specifications and methods of measurement needed to define the performance of these devices as sensors. This is expected to lead to more efficient communication between device manufacturers and users.

For micro-gyroscopes, we have established an absolute maximum rating, recommended operating conditions, and various characteristics, including sensitivity, cross-axis sensitivity, bias, output noise, frequency response, and resolution. We are also investigating methods for measuring these properties.

Similarly, we have established an absolute maximum rating, recommended operating conditions, and characteristics for electronic compasses, and are studying methods of measuring the analog circuit characteristics and DC characteristics of these devices. Further, although it is generally assumed that conventional compasses are installed in a more or less level orientation, cell phones obviously have a high degree of flexibility in how they are oriented. Therefore, we are suggesting new ways of conceptualizing the coordinate system of these compasses.

This project is being implemented under a three-year plan that began in FY 2008, and the findings of the project will be submitted to the Subcommittee on MEMS (SC 47F) of the Technical Committee on Semiconductor Devices (TC 47) under the International Electrotechnical Commission (IEC). Initially we intend to submit a new proposal on electronic compasses within the current fiscal year.

## Developing Standards for Measuring Microscale Dimensions

MEMS applies techniques used in semiconductor fabrication to produce three-dimensional structures. While dimensions and other aspects of the 3D profile are important elements of structures, a method of measuring such profiles has not been established. Accordingly, the goal of our project is to standardize a suitable method of measuring dimensions and shapes of microscale structures.

MEMS devices are fabricated using the time-consuming techniques of wet etching and deep dry etching. However, MEMS structures inherently have a microscale profile, and techniques have not yet been established for measuring the angle of a forward tapered or reverse tapered side wall, the depth and width of high-aspect-ratio trench structures, and the surface roughness resulting from etching. We are measuring microscale structures according to a variety of techniques with the goal of standardizing techniques for evaluating suitable methods of measuring the dimensions and shapes of such structures and of expressing such dimensions and shapes. Using the standard, it is likely that designers, manufacturers, and others involved in the various stages of MEMS fabrication can better communicate with one another. This is a three-year project that began in FY 2009, and we will be submitting our findings to the SC 47F of the IEC TC 47.

Our study involves creating specimen for use as a reference for measuring MEMS profiles, measuring these specimen according to a variety of techniques, and comparing and evaluating the results. Specimen are produced by creating structures having different aspect ratios (ratio of depth to width) and spacing their gauge marks at varying distances. Specimen are measured using an optical microscope, a laser scanning microscope, a scanning white light interferometer, an optical standing wave scale displacement sensor, a stylus-type contact profilometer, and other apparatus, and the results are analyzed through comparisons with reference measurements obtained using a high-resolution field emission scanning electron microscope (FE SEM). We have also included 3D microprotrusion structures as specimen.

As we enter the second year of the project, we are continuing to collect and organize data obtained through repeated measurements in order to develop standards for comparing and evaluating methods of measurement and for expressing dimensions and shapes of the microscale structures.

