Activities of the G-device Project

Under the guidance of Ryutaro Maeda, director of the Research Center for Ubiquitous MEMS and Micro Engineering (UMEMSME) under the National Institute of Advanced Industrial Science and Technology (AIST), G-device Center Kansai (center director Susumu Sugiyama) was established at Ritsumeikan University as a NEDO-sponsored project. The Center conducts joint research with Kyoto University and collaborates with four companies in MEMS-related industries, while aggressively promoting the project's development.

One of the most important activities implemented by the Ministry of Economy, Trade and Industry (METI) in its efforts to promote new growth strategies is "green innovation." Steps necessary for realizing green innovation include determining how to conserve resources in the manufacturing processes themselves by utilizing innovative next-generation devices and determining how to reduce environmental impact by implementing more efficient manufacturing processes. To this end, G-device Center Kansai is conducting R&D on high-performance MEMS sensors and developing a network system with these sensors in order to demonstrate that clean rooms used in MEMS fabrication can be made eco-friendly. The following is a detailed description of activities conducted in the G-device Project.

1) Development of a Sensor Network System

G-device Center Kansai is developing a wireless sensor network system configured of wireless MEMS sensors. The system is designed to allow a flexible layout of sensor nodes and to monitor multiple environmental conditions.

The Center will identify system requirements for acquiring detailed measurements at multiple points aimed at maintaining a consistent environmental quality and requirements for energy conservation control and will conduct basic and component studies of the control system. Plans call for experimental demonstrations to be conducted in a new MEMS clean room established at AIST Tsukuba East. The effectiveness of the system design will be verified through controlled operations and visual control of temperature, humidity, and particles, with the goal of reducing CO_2 emissions from energy use in clean rooms to 60% of 1990 levels.

2) Development of High-Performance Sensor Modules

The Center will also study sensor node platforms for a sensor network system comprising high-performance sensor modules arranged at multiple points.

The network system is provided with sensors for monitoring temperature, humidity, pressure, acceleration, and other conditions, with the sensors designed in the form of replaceable modules in order that the system may be adapted to different applications. Each module is configured of a sensor unit, battery, signal-processing circuit, wireless transmitting circuit, and antenna. With this construction, the module has functions for sensing ambient conditions influencing the air quality in a clean room, such as temperature, humidity, airflow, acceleration, and pressure, acquiring a signal from the sensor, and converting the signal to data that can be exchanged with a server through wireless communications. While a battery is used for powering circuits in this project, we hope to develop a self-reliant high-performance sensor module employing a vibration-based power generator or a wireless power supply system, for example. Each sensor module will be contained in a 30x30x10mm package and used as a network node in the system. One of the major objectives in developing sensor modules has been to create a concept of low power consumption in order to construct network nodes employing battery-free, self-reliant wireless sensors. To this end, we will study principle models for optimizing the sensor sampling rate, number of sensing categories, wireless data transfer rate, wireless communication protocol, and AD conversion rate in the signal processing circuit, with consideration for designing the sensor to be ultra-small, inexpensive, and highly sensitive.

3) Contaminant Gas Sensors

Currently clean rooms waste a lot of energy in draft ventilation because clean air is also being exhausted. Energy consumed when exhausting clean air can be reduced through real-time monitoring of fluctuations in contaminant gas. Specifically, the Center will develop MEMS sensors using a metal oxide semiconductor material, such as tungsten trioxide (WO_3) to produce a self-reliant, energy-efficient gas sensor for detecting ammonia (NH_3) and other inorganic gases.

4) Principles of Sensor Node Localization

While it will be important to develop an on-demand multi-point sensor network system capable of discovering the distribution of particulate in a clean room in real-time, today particle sensors are too expensive to equip a system with the number needed to achieve sufficient results. Therefore, the Center is working on an alternate method of developing principles of localization for wirelessly powered sensors that can be attached to workers' shoes, for example.

5) Functional Thin Films for Sensitive Temperature Sensing

The sensor network will require highly sensitive temperature sensors for determining the distribution of body temperatures and equipment temperatures over time, and self-reliant power-generating devices to implement a wireless network. In order to improve the performance and functionality of the temperature sensors, we will work to develop materials (including lead-free materials) and processes for forming functional thin films with pyroelectric/piezoelectric properties.

6) Development of Environmentally Friendly Processes for Polymer Sensor Integration

We are developing polymer sensors with biocompatibility (superior hemocompatibility) using polymer processes that are superior to the conventional silicon processes in exploiting the specific functions of bio/organic materials such as synthetic organic molecules and biomolecules. More specifically, the Center is manufacturing MEMS actuator prototypes (mirror devices) and evaluating their reflectance and surface roughness properties.