

## Plenary Lecture

**Kiyoshi Takamasu (The University of Tokyo)**

### **"Uncertainty estimation for profile measurement by multi-sensors method"**



**Prof. Dr. Kiyoshi Takamasu**, was born and brought up in Tokyo, Japan. He graduated from the University of Tokyo in 1977 and obtained Dr. Engineering in 1982. Then he entered Tokyo Denki University as lecturer and associate professor. He went over to United Kingdom in 1990 as research fellow at Warwick University. In 1992, he came back to the University of Tokyo as associate professor. He is currently in charge of the professor in the Department of Precision Engineering at the University of Tokyo. He is the chairman of the technical committee of intelligent measurement with nanoscale in JSPE (Japanese Society of Precision Engineering)

He is currently interested in Precision metrology, Coordinate metrology, Coordinate Measuring Machine, Kinematic calibration, Uncertainty estimation, Nanometer metrology, Standard and traceability

#### **Abstract**

Profile measurement of high precision mirror surfaces is carried out using multi sensor method with 2 or 3 distance sensors and an angle sensor. The uncertainty estimation is key technology to design and evaluate the multi sensor measurement system. In this article, the least squares calculation is applied on the multi sensor method and the error propagation of the least squares calculation is theoretically analyzed. The calculation procedure of the uncertainty estimation of the multi sensor method is theoretically defined. Then, we apply the uncertainty estimation procedure for two applications such as a multi cantilever AFM and a two dimensional linear motor stage. Using the multi cantilever AFM system, profile of resist surface is measured in wide area with nanometer accuracy. The experimental results and the uncertainty analysis of profile measurements are demonstrated for the multi cantilever AFM system. The two dimensional linear motor stage consists of a Sawyer type motor, two bar mirrors and three laser interferometers to control the position of the stage. The profiles of the bar mirrors are measured and the uncertainty of the profile measurement is estimated for high accurate position control of the stage.