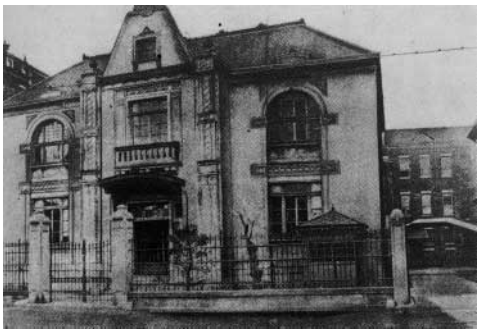
100th Anniversary of Measurement Standards

New Technology and Frontiers in Measurement Standards

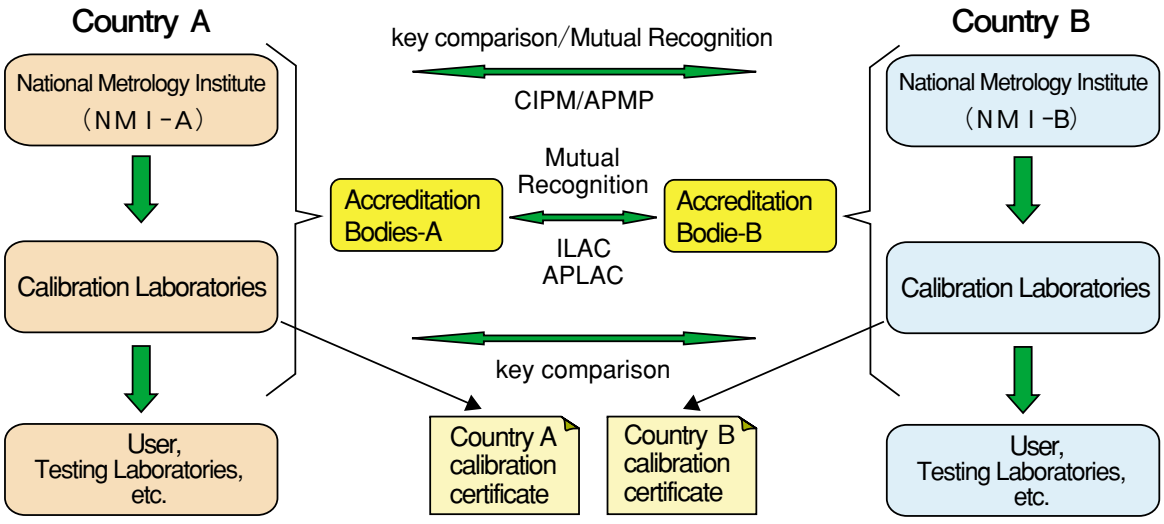
In 1903, the Central Inspection Institute of Weights and Measures was founded in Japan, and started on dissemination of the modern measurement standards. The year 2003 marked the 100th anniversary of the official introduction of the modern measurement standards in the country. Since the establishment of the core organization of measurement standard technologies, a national infrastructure for measurement in industry and science has largely contributed to the development of the country. Now, the AIST established a framework centering on the National Metrology Institute of Japan (NMIJ) that systematically addresses the issues related to measurement standards in physics, electricity and chemistry.



● Central Inspection Institute of Weights and Measures

The Need of International Trade and Commerce

Goods arriving from foreign countries often create concerns regarding the accuracy of the quantity, the reliability of the permissible level of toxic substances and so on. It is indispensable to provide factual data based on both measurement and testing in order to eliminate such suspicions. However, if the data presented by the country of origin disagrees with that shown by the importing country, the anxieties will continue. To solve this problem, the Traceability System and th e Mutual Recognition Agreement have been introduced in the metrology world, to provide uniform and accurate metrology system for domestic and international measurement, respectively (Fig.1). By the traceability system, the calibration basis of any given measurement tool can be traced to the national standards. The Mutual Recognition Agreement acknowl-



● Fig.1 Traceability system and mutual recognition agreement

edges that the measurement standards of the participating countries have been certified as exact equivalents among any national research institution or authorized calibration organization of the member countries. The certifications of calibration issued by these organizations are to be mutually approved. These two systems will offer the foundation for mutual trust on the measurement data of respective countries.

In order to respond to expanding globalization in this field, the NMIJ is advancing the establishment of the quality system based on the international standards, and carrying out the comparison of national measurement standards of various countries. The introduction of this system will facilitate international trading and assure the consumers of the reliability of the quality indications of the product.

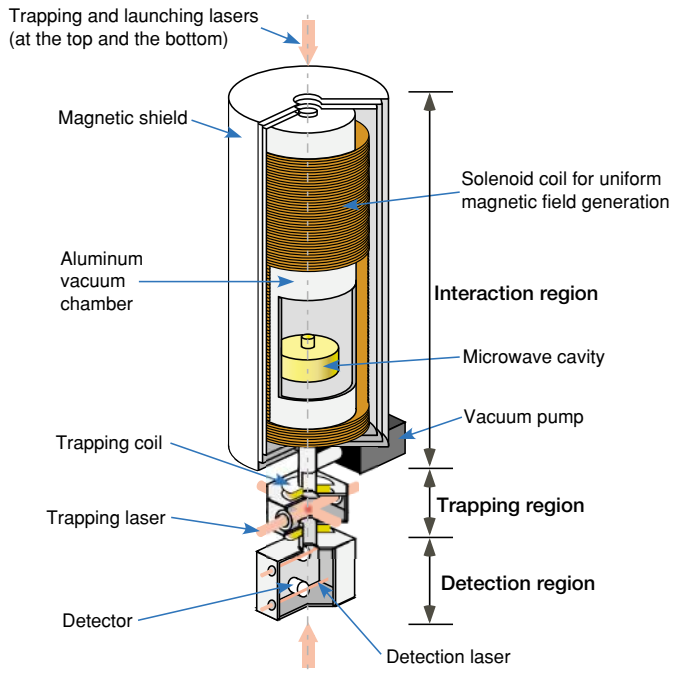
Development of Measurement Standards in Next Generation

The rapid advancement of science and technology requires measurement standards which feature a new concept and has higher accuracy and stability. The AIST is taking a role to promote the development of the next generation measurement standards that contribute to the advancement of science and technology.

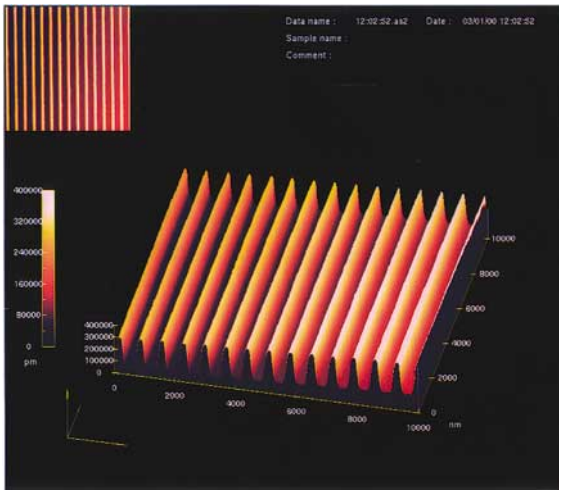
Taking a standard of time for instance, the NMIJ has developed an optically pumped Cs frequency standard. The uncertainty of the standard frequency is 2.9×10^{-14} and it serves as a reference for Coordinated Universal Time as one of the primary frequency standards. For further improvement of the accuracy of the frequency standard, the NMIJ is conducting the development of Cesium atomic fountain frequency standard (Fig. 2). The principle of this frequency standard is to grasp Cesium atoms using radiation pressure of laser light, launching them upwards and letting them fall down freely. It is expected to attain at least a single-digit decrease in the uncertainty compared to the conventional standards.

Measurement Standards in High-Tech Industry

There is the rapid progress in the micro-fabrication technology in the field of semi-conductors and micro machines. It has long been suggested that the development of a high precision scale measurable of nanometer digits is essential to support these fabrication technologies



● Fig.2 Cesium atomic fountain frequency standard



● Photo.1 AFM image of a one-dimensional diffraction grating

(nanometrology). Currently, the NMIJ is developing the technology that enables accurate measurement of minute surface features. The scope of research includes the development of a nanoscale "yardstick" that is applicable to the measurement in depth direction.

The newly developed atomic force microscopy (AFM) combined with a homodyne laser interferometer is utilized for the calibration of dimension and shape in minute scales. This apparatus serves for the calibration of grid spacing of one-dimensional diffraction grating for a nanoscale "yardstick"(Photo.1). Additional research on measurement standards will further the advancement of high technologies and contribute to industrial developments.

Measurement Standards in Biotechnology

Although there has been remarkable progress in the field of biotechnology, it is only recently that the question was posed regarding the reliability of analysis methods and analytical instruments. The Consultative Committee for Amount of Substance (CCQM) of International Bureau of Weights and Measures (BIPM) ensures the traceability of analytical data to the International System of Units (SI) and international consistency of measurement standards in the biotechnology field. Furthermore, Joint Committee on Traceability in Laboratory Medicine (JCTLM) was set up with the purpose of establishing traceability in the field of pharmaceutical products. Thus, the metrological concept that involves evaluation of uncertainty has been rapidly adopted in the fields of biotechnology and clinical analysis. The NMIJ is proactive in promoting measurement standards for the biotechnological field in close cooperation with the related research units in response to the rapid advancements in this area.

● Photo.2 Sea bottom reference materials for analyzing butyltins and poisonous metals

Measurement Standards in Environment, Safety and Health

In recent years, there has been a growing interest in environmental, safety and health issues. Even an extremely small amount of environmental pollutants such as sick house gas, PCB and environment hormone may cause seriously harmful effects to not only humans but also to ecological systems. As the volume of the substance to test is extremely minute, it is likely that the test results may vary depending on the test methodology and the testing organization even though an identical sample is used. Therefore, the NMIJ is supplying reference materials for precision calibration of the testing equipment. For example, the NMIJ has developed two types of sea bottom reference materials for analyzing butyltins and poisonous metals. These materials enable the analysis of trace amounts of harmful substances contained in sea-bottom soil (Photo.2). In addition, their reference materials for environmental hormone disruptors have become available. The NMIJ will proceed with the development of reference materials in order to cope with various environmental issues.

Expanding Role of NMIJ

Starting from weights and measures, the application of measurement standards has been gradually broadened. At the start of the 21st century, the importance of measurement standards will be enhanced for the advancement of high-tech industries, and will contribute to solve environmental, health and safety issues.