The Development and Spread of Nanotechnology and Related Measurement Standards

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Research and development in nanotechnology is making impressive strides. Surprisingly, the roots of this discipline are ancient, even prehistoric. It is known, for example, that the civilizations of Mesopotamia created colored glass such as eye beads, which they fashioned into jewelry and the like. Much later, around 500 AD, stained-glass techniques that had been developed in the Byzantine Empire began to find currency through much of the ancient world.

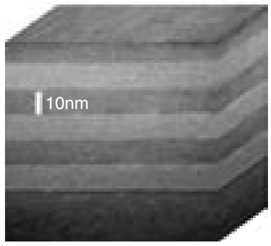
Nanotechnology Blooms in the Age of Advanced Measurement Technology

Recent advances in measurement technology have opened an exciting new chapter in nanotechnology. Ancient "nanotechnologies" guided by rough experience are taking on new life, thanks to measurement technology. Developers can now manipulate the colors in stained glass with high precision, based on a clearer understanding of the relationship between color and the oxides and metal particles embedded in the stained glass. Today these particles are being manipulated at the nanoscale level to develop new functional materials, requiring measurement technologies with unprecedented resolution and quantitative sensitivity.

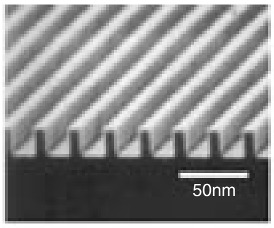
Nanotechnology makes use of unique functions discovered in individual structures and configurations thereof on a nanometer (billionth of a meter) scale, yielding new and unprecedented applications that transcend conventional scientific disciplines. To maximize the benefit from these unique properties, these tiny individual structures and the functions discovered for them must be evaluated in terms of universal values. The most effective route to achieving this ability is to introduce measurement standards that offer a universality transcending the differences among disciplines. AIST's NMIJ is at the forefront of activities to prove the equivalence of Japan's national measurement standards with international standards. Among the many benefits of this research is its effectiveness in protecting intellectual property rights.

NMIJ is working proactively to develop a battery of valuable measurement standards. For example, NMIJ is working on certified reference materials for scales that are useful as measures for the evaluation of various nanoscale three-dimensional structures, which form the building-blocks of nanotechnology. Evaluation methods and certified reference materials for the sizes of nanoparticles and nanopores are also under development. To serve the need for design and evaluation of optical recording media, the demand for which is growing exponentially, NMIJ is devising methods of evaluating the thermal properties of nanoscale fields and interfaces. This Institute is also working on methods of evaluating the density and hardness of ultrathin films. AIST expects that these new measurement standards will not only find application in certain specialized fields, but will also serve as the foundation on which the fusion and integration of nanotechnology with other fields is maximized.

The World's Finest Scales with Minimum Measurements of Several Nanometers



Schematic representation of a nanoscale for depth direction



Schematic representation of a nanoscale for in-plane direction

A Young Researcher Offers Her Views

Yukiko SHIMIZU,
The editor interviews a young scientist, Dr. Yukiko Shimizu, Radiation Thermometry Section, Temperature and Humidity Division, Metrology Institute of Japan

—What is your research activity?

I'm constructing a dissemination system of the radiation temperature standard in the middle temperature range from 100°C to 500°C. Radiation thermometers are widely used in the fields of industry and science. Non contact and fast determination of the temperature of even nano scale material can be achieved using radiation thermometers. We have already constructed a fast detection system with an infrared radiation thermometer and a laser source modulated at very high frequency. We succeeded in measuring the temperature and thermal conductivity of a 10μm thick metal thin film with a time constant of 300 nanoseconds. This technology should lead to the development of the next-generation measurement standards such as nano-scale temperature standards.

—What interests you in this line of research?

Many national institutes of standards are now competing in the construction of radiation temperature standards in the middle temperature range. It is challenging to develop a more accurate standard in an original way. It may have enormous impacts in the fields of science and technology. Research on temperature standards in the nanoscale domain necessarily goes hand-in-hand with the development of leading-edge measurement technologies.

—What are your future prospects?

Although the principle of thermal-radiation thermometry is based on the Planck radiation formula and the quantum devices such as semiconductor detectors, but the actual measurement processes are being developed on the classical physics technologies such as design and fabrication of black-body furnaces and set up of geometrical optics. By introducing techniques of micro-optics and quantum optics, we hope to develop a new thermal radiation measurement standard which is more accurate, faster, and easier to use. Specific techniques we are working on include high-resolution measurement of wavelength dependence of Planck radiation by using those of quantum optics and molecular spectroscopy.