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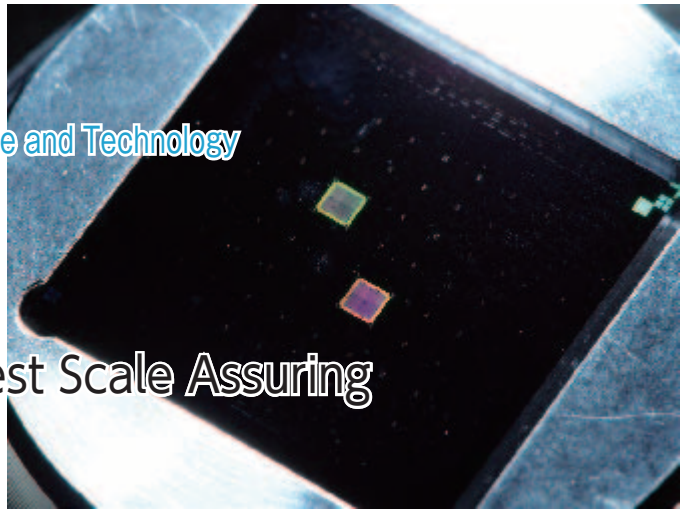
National Institute of Advanced Industrial Science and Technology
Hitachi, Ltd.
Hitachi High-Technologies Corporation

・R&D of 3D Nanoscale Certified Reference Materials Project (FY2002-2006)

Realized the World's Smallest Scale Assuring a Single Atom Size Error



Computers are now used in almost everything such as PCs, smart phones, home electric appliances, automobiles, and robots. LSI (large-scale integration), the brain of computers, has been made more compact and more highly functional by the microfabrication techniques. On the other hand, for ensuring the quality of ultrafine circuits, it is necessary to measure accurately the pattern width on a LSI using a reference "scale". Smaller scales are therefore necessary to manufacture smaller LSIs.

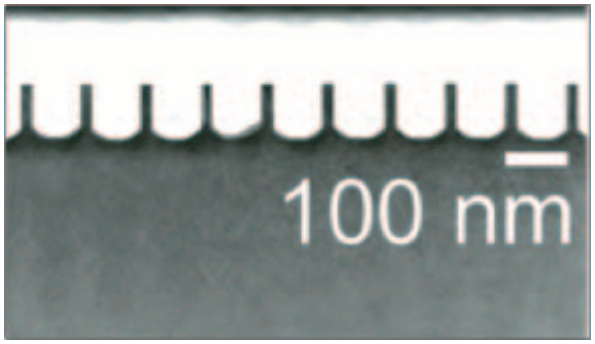
In the 2000s, a scale of 100nm scale resolution became necessary. In addition, international certification on the resolution was necessary, although there was no methodology or equipment to certify the 100nm resolution.

In 2002, the National Metrology Institute of Japan (NMIJ) at the National Institute of Advanced Industrial Science and Technology, through the NEDO Project, in collaboration with Hitachi, Ltd. and Hitachi High-Technologies Corporation. which developed the 100nm scaling resolution scale began to develop measurement equipment for strict measurement of 100nm based on the length definition of the International System of Units.

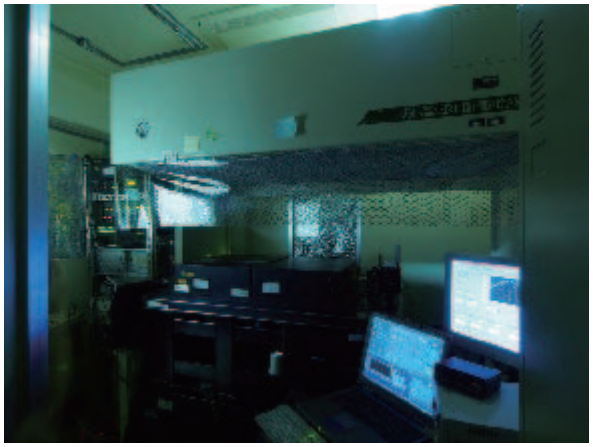
As a result, they succeeded in the development of highly-practical, extremely high-resolution measurement equipment, with which one could measure 100nm intervals with an error of ±0.04nm or smaller, for the first time in the world in 2006. Then it became possible to issue "calibration certificate," traceable according to the national standards of length, for a scale of 100nm scaling resolution.

A "reference microscale" of 100nm scale resolution with a calibration certificate was installed to a length measurement scanning electron microscope (length measurement SEM) of Hitachi High-Technologies Corporation, which began to be sold in December 2007.

In 2012, the microscales were installed to more than 200 length measurement SEMs and the world market share of the SEMs was about 90%.* (*Press release by Gartner, US.)



Cross sectional microscope image of ultra-fine scale at 100nm intervals



Deep ultra violet laser diffraction pitch calibration system at Japan Quality Assurance Organization (JQA)

Q. Why did this project start?

Nanotechnology is a source of Japan's industrial competitiveness and essential to the establishment of a technological base for the sustainable development of Japan's economy. The government made "Nanotechnology program" in its "Science and technology basic plan" approved by the cabinet in March 2001 to accelerate the development of necessary common basic technologies for the promotion of nanotechnology. This project was started to develop a technology of manufacturing a nano-size scale (called measurement scale or reference microscale). The nano-size scale is manufactured and formed by a nanotechnology and used to calibrate measurements of a nano-size shape or structure (in in-plane and depth directions).

Q. What was the aim of the project?

Technologies for nano structure dimensions are the base of measurement. There is a large need for the accuracy and reliability of measurement technologies for the progress of nanotechnology. The major aim of this project was to develop a technology of highly accurate measurement of the size and thickness of nano structures and to establish a measurement standard, since the establishment of a measurement standard was considered essential for the promotion of intellectual infrastructure development in order to develop and promote Japan's nanotechnology.

At the early stage of the project, however, applicable measurement methods were not quantitatively accurate enough, which constituted an obstacle to subjective evaluation of the nanotechnology and products manufactured by the nanotechnology. The project therefore aimed to develop a technology of creating a reference object that could be used for scale calibration in both in-plane and depth directions and to establish a technology of highly accurate measurement of the size and thickness of nano structures and the world's highest level national measurement standard for the development and promotion of Japan's nanotechnology.

Q. What is the role of NEDO?

Standardization of nano scale is a fundamental technology as infrastructure for the nanotechnology. However due to the difficulty of the technology development and low profit of the business, it was suitable that the National Institute of Advanced Industrial Science and Technology, which were in charge of measurement standards in Japan, handled this research and development and, it was a social challenge in which NEDO should be involved, so, it decided to support the research and development.

Since the goal of the project was set to be able to follow technological progress after 2010, the goal or the plan did not have to be changed in the course of the project. However, establishment of calibration technology and calibration scheme for 90nm technology node was urgently requested from the semiconductor industry. To respond to the request, NEDO added a budget in FY2003 to back up the research and development of a high-throughput calibration method using lasers. This greatly contributed as a result to Japan's 90% share in the semiconductor measurement equipment market.