Worldwide R&D

Nano Coordinate Measuring Machine and Nanoprobe

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One objective at our laboratory is to develop a three-dimensional measuring instrument called a Nano CMM (Nano Coordinate Measuring Machine) for measuring objects three-dimensionally with nanometer resolution. Currently, we can measure the three-dimensional surface of objects with nanometer resolution using STM and AFM. However, we are unable to truly measure three-dimensional shapes, such as the diameter of holes formed in the side of an object, surface direction, or related dimensions. We believe that a device for measuring three-dimensional sizes, positions, and other shapes on a nanometer order will be an indispensable basic tool in the future development of micromachines. The necessity for this research was first proposed at our laboratory, after which we began development. Recently, however, many other countries, including Germany, Holland, and UK, have been developing instruments for the three-dimensional measurement of objects on a nanometer order.

Fig. 1 shows the construction of a Nano CMM. This three-dimensional measuring instrument was made more compact for measuring three-dimensional shapes and dimensions in the automobile industry and the like. About 300 x 300 x 200 mm in size, this device has a measuring range of 10 x 10 x 10 mm and a resolution of 10 nm. The measuring device has a symmetrical construction with a double Vee groove guiding mechanism and employs a position sensing method using an optical scale to achieve high stability. Fig. 2 shows a prototype of the Nano CMM. When measuring the absolute shape and dimensions of objects on a nanometer order, the factor causing greatest error is temperature drift. When a 100-mm length of iron rises 1 degree in temperature, 1μm of thermal expansion occurs. This effect is directly reflected in the measured value. This prototype can restrain thermal drift of about 10 nm in an environment of about 0.1 degrees, as the entire mechanism is constructed of material having low thermal expansion and is designed to restrain the effects of temperature.

The most problematic point in Nano CMM research worldwide lies in the probing system. Numerous contact-type probing systems have been used in three-dimensional measuring devices in order to achieve stable measurements of three-dimensional positions and dimensions for objects formed of a variety of materials and having a variety of surface conditions. A contact-type Nanoprobe having two-dimensional or three-dimensional sensing capacity and resolution on the nanometer order is necessary for Nano CMM.

Fig. 3 shows the construction of a Nanoprobe and a prototype that we developed. The object to be measured is contacted by a small ball having a diameter of less than 0.5 mm. An optical sensor detects the movement of the ball. By combining a contact-type measuring instrument and optical sensor in this way, it is possible to construct a reliable Nanoprobe capable of high resolution.

Fig. 1 Construction of a Nano CMM

Fig. 2 Prototype of the Nano CMM

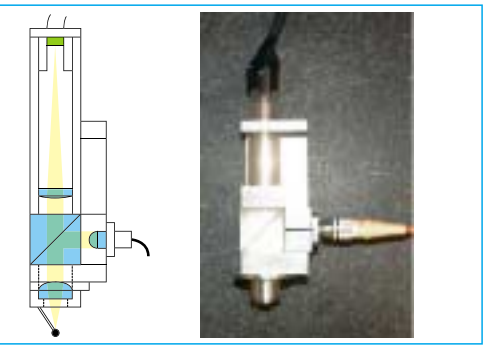

Fig. 3 Construction and prototype of a Nanoprobe

As described above, development is proceeding on Nano CMM and Nanoprobe, which will become basic tools for developing future micromachines. However, various issues remain before these devices can be put to actual use, such as the establishment of a method for calibrating the measuring instrument, as well as evaluations of the reliability and the durability of the device. Our laboratory hopes to continue leading the world in research on establishing Nano CMM.

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