U.S. National Nanotechnology Initiative and Nanoscale Length Metrology at NIST

Plática Plenaria

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ABSTRACT

Nanotechnology has been defined as the understanding and control of matter at dimensions between approximately 1 nm and 100 nm, where unique phenomena enable novel applications. Nanotechnology involves imaging, measuring, modeling, and manipulating matter at this length scale. In 2001, the United States government established the National Nanotechnology Initiative (NNI) to expedite the discovery, development, and deployment of nanoscale science and technology to serve the public good, through a program of coordinated research and development aligned with the missions of the participating agencies. In order to realize the NNI vision, the participating agencies are working collectively toward four goals:

- Advance a world-class research and development program,
- Foster the transfer of new technologies into products for commercial and public benefit,
- Develop and sustain educational resources, a skilled workforce, and the supporting infrastructure and tools to advance nanotechnology,
- Support responsible development of nanotechnology.

Under the NNI the National Institute of Standards and Technology (NIST) is the lead agency for instrumentation research, metrology, and standards for nanotechnology and is the co-lead with NSF for nanomanufacturing. Under the area of metrology, length metrology is especially critical for the verification of manufactured nanoscale electronic devices and particle-based delivery systems in medicine, and will be equally important for other nanotechnology products to be developed.

In this context we discuss details of recent nano-scale length measurements for linewidth and step height. These properties are of growing importance to the function and specification of semiconductor devices as the dimensions of semiconductor devices shrink below the 50 nm level.

The ability to manufacture ever smaller linewidths leads to semiconductor elements with increasing speed and storage density. NIST has recently developed a physical standard of calibrated linewidths, called the Single Crystal Critical Dimension Reference Material (SCCDRM). The standards consist of Si chips whose surfaces contain six calibrated lines having widths ranging from about 70 nm to about 225 nm. These lines are fabricated using directional etching techniques, which produce vertical sidewalls and uniform widths. The lines have been measured by critical dimension atomic force microscopes whose probe tip offsets are determined using high-resolution transmission electron microscopy (HR-TEM). The uncertainty of the calibrated widths ranges down to ±1 nm (k=1). This quoted uncertainty has been recently supported by two experimental comparisons.