Big Idea: Tools and Instrumentation[1]

(1)- The Big Ideas of Nanoscale Science & Engineering: A Guidebook for Secondary Teachers. S.Y. Stevens, L.M. Sutherland, & J.S. Krajcik, NSTA Press, 2009.

Development of new tools and instruments helps drive scientific progress. Recent development of specialized tools has led to new levels of understanding of matter by helping scientists detect, manipulate, isolate, measure, fabricate, and investigate nanoscale matter with unprecedented precision and accuracy.[1]

Learning Goals (1)

1. Specialized tools are required to detect, measure, and investigate the nanoscale because structures on this scale are too small to be seen with optical microscopes.

2. Scientists and engineers have developed specialized tools and techniques in order to manipulate, isolate, and fabricate nanoscale structures.

3. Although the nanoscale world has always existed in nature, scientists and engineers were unable to study it, or to manufacture new nanoscale structure, until advances in technology allowed the development of highly specialized and sensitive tools.

4. The tools used to study and/or manipulate nanoscale structures interact with individual atoms or nanoscale particles by means of electrical forces. [1]

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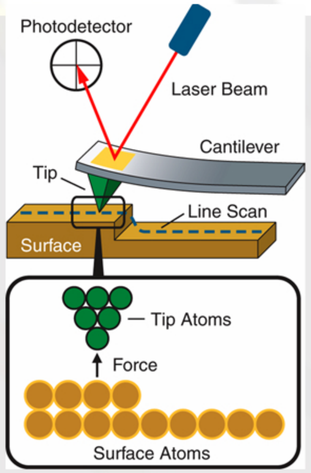


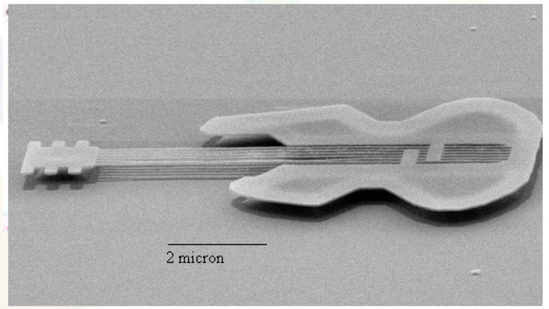
Image courtesy of Agilent Technologies

Examples

Tools and instruments have been important in opening new areas for investigation and discovery. The invention of the microscope allowed 17th century scientists to see microscopic organisms including bacteria, the cause of many diseases. Nanoscale science and engineering have advanced because of the development of tools such as the Atomic Force Microscope (AFM) and Scanning Tunneling Microscope (STM). These tools have allowed scientists and engineers to explore and investigate the nanoscale world.

Pictured: Model of Atomic Force Microscope.

Image courtesy of Cornell University Nanoscale Science and Technology Facility



Cutting-Edge Application

Electron beam lithography (EBL) is a technique that uses a focused beam of electrons to create patterns on a wafer coated with resist. The method creates extremely small structures because it uses electrons rather than light (photolithography) to make the features. EBL is not limited to the wavelength of light and has a wavelength so small that diffraction does not define the lithographic resolution. It is used in electronics to make smaller devices.

Pictured: Nano guitar created at Cornell University

Questions to Ponder

How does the size of a probe affect the precision and accuracy of a measurement?

Why are special tools needed to work with small objects?

How do the electrical forces that govern chemical bonding relate to the electrical forces the AFM uses to observe a sample?

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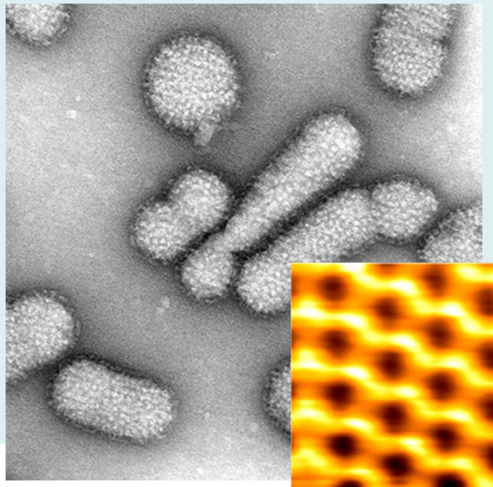

Pictured (AFM image of a virus (left); STM image of graphene (below)

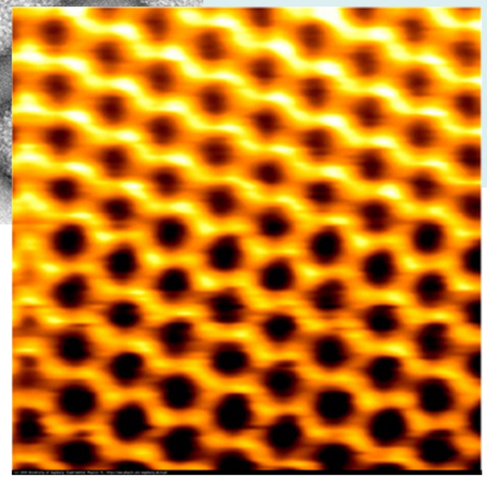

Image courtesy of R. Wiesendanger http://www.nanoscience.de/HTML/research/graphene.html