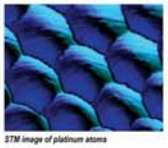
The Exploration of Student Engagement and Understanding of Nanoscience and Technology

THE SCANNING PROBE MICROSCOPY GROUP

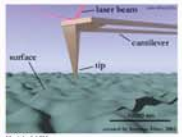
RESEARCH STRATEGY

Focus of Project

- Promote and probe student understanding of nanoscience concepts
- Use nanoscale concepts and phenomena as research/educational tools



STM image of platinum atoms



Model of AFM

Research Questions

How can nanoscience concepts be introduced into the K-12 classroom?

- At what grade level or range of grade levels is it appropriate to introduce them?
- Which science classes will support these concepts
  - Chemistry
  - Physics
  - Biology

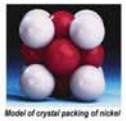
Can introducing nanoscience concepts into the classroom enhance student understanding of current science curricula?

APPLICATION TO SCANNING PROBE MICROSCOPY

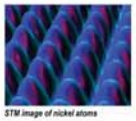
Research Questions -- Designing Activities

How can we use a scanning probe instrument to help students learn about atoms, molecular structure, and forces at the nanoscale?

- Which method or combination of methods is the most effective in promoting student learning?
  - DVD/CD simulation, tabletop student activities, remote access?
- How do students interpret macromodels?
- How do students translate macromodels to the nanoscale?



Model of crystal packing of nickel



STM image of nickel atoms

Big Ideas and Learning Goals

All matter is composed of atoms

- How do we know that atoms exist?
- How can we "see" atoms?

Understanding size and scale

- Relate nanoscale to macroworld
- How small is an atom?

The scale of matter determines its properties

- Students will explain how properties change with scale
- Dominant forces depend on scale

It is possible to observe phenomena without using sight

- Extend our senses

National Science Standards/Mapping to Learning Goals

NRC (grades 5-12)

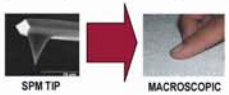
- Content standard A: Science as inquiry: use appropriate tools and techniques to gather, analyze, and interpret data.
- Content standard B: Physical science: Changes of properties in matter.
- Content standard E: Science and technology: Science and technology are reciprocal, and technological designs have constraints.
- Content standard G: History and nature of science: scientific knowledge changes over time, and builds on earlier knowledge.

AAAS Benchmarks (grades 6-12)

- 4D: Structure of matter: An enormous variety of biological, chemical, and physical phenomena can be explained by changes in the arrangement and motion of atoms and molecules.
- 4G: Forces of nature: Electromagnetic forces acting within and between atoms are stronger than the gravitational forces acting between atoms.

Scanning Probe Microscopy (SPM)

SPM is an important measurement technique of nanoscience that is a touch-based method used to characterize properties of materials at the nanoscale.



Observing with Touch

Learning Goals

- Understanding of size and scale-- relate nanoscale to macroworld
- Students will understand that it is possible to observe phenomena without using sight

Student Preconceptions

- Bacteria and atoms are of similar size
- Observations can only be made visually

Activities

Sensing with Touch

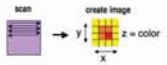
- Reproduce a Braille pattern "seen" only by touch

The Importance of the Tip

- A surface is scanned using tips of different sizes and materials

Creating an image

- Scan to create 3-D image of a lego pattern



Exploring Forces

Learning Goals

- The scale of matter determines its properties
- Dominant forces depend on scale

Student Preconceptions

- Properties of matter and its particles are the same
- Gravitational forces are stronger than electrostatic forces

Activities

Sensing with touch

- Use fingertip scanning of an unknown surface to create 2-D image

Magnetic interactions

- Use a magnet to probe a surface containing magnets of different polarities

Electrostatic interactions

- Compare behavior of various forms of sugar when poured from a plastic cup

Measuring Nanovariations

Learning Goals

- Students will be able to relate nanoscale to macroworld
- Students will understand how scientists overcome problems involved in making nanoscale measurements

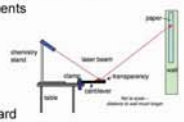
Student Preconceptions

- Some objects are too small to measure
- Anything can be measured accurately

Activities

Make your own Ruler

- Use various objects as measuring standard



Relate to Atomic Force Microscope (AFM)

- Measure cantilever stiffness as a function of displacement

AN INTERDISCIPLINARY WORKING GROUP

Joe Krajcik
Prof. of Science Education, Michigan

Nick Giordano
Prof. of Physics, Purdue

Emma Tevaarwerk
Ph.D. Materials Science, Post-doc, Northwestern

Shawn Stevens
Ph.D. Chemistry, Post-doc Michigan

Molly Yunker
Ph.D student, Science Education, Michigan

Kelly Hutchinson
Ph.D. student, Chemistry Education, Purdue

Jeremy Schroeder
Research Scientist, Materials Engineering, Purdue

Namsoo Shin Hong
Research Scientist, Ed. Psychology, Michigan

Mike McLennan
Software Architect, Network for Computational Nanotechnology, Purdue

Bill Fornes
NCLT Program Coordinator, Purdue

SOURCES

NCLT

NU • UM • PU • UIC • UIUC • ANL • AAMU • FU • HU • MC • UTEP • PSS