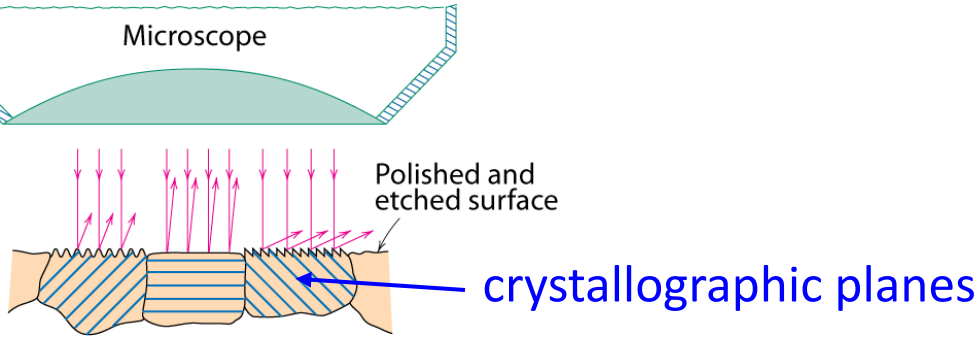
Microscopic Examination

- Crystallites (grains) and grain boundaries. Vary considerably in size. Can be quite large.
  - ex: Large single crystal of quartz or diamond or Si
  - ex: Aluminum light post or garbage can - see the individual grains
- Crystallites (grains) can be quite small (mm or less) – necessary to observe with a microscope.

Optical Microscopy

- Only the surface is observed, reflecting mode.
- Useful up to 2000X magnification.
- Polishing removes surface features (e.g., scratches)
- Etching changes reflectance, depending on crystal orientation.



Adapted from Fig. 4.13(b) and (c), *Callister & Rethwisch 8e.* (Fig. 4.13(c) is courtesy of J.E. Burke, General Electric Co.)

Micrograph of brass (a Cu-Zn alloy)

Electron Microscopy

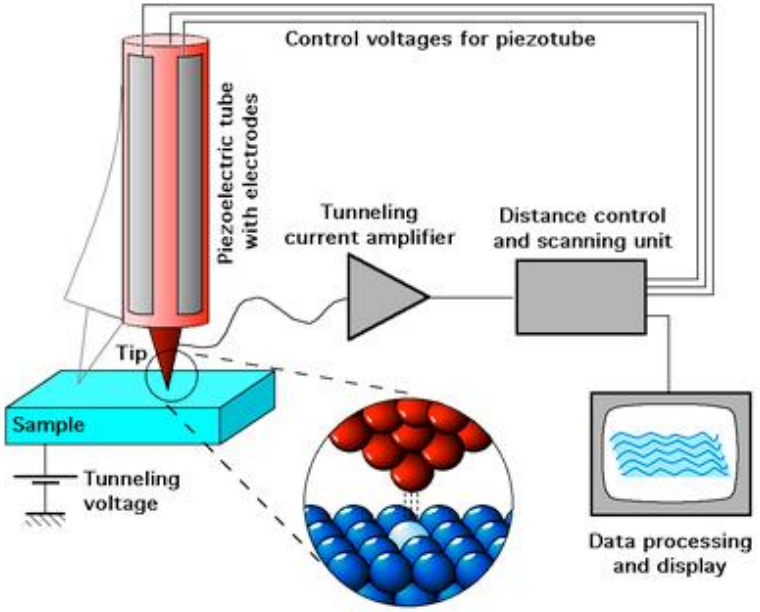
- Transmission Electron Microscope (TEM)
  - Electron beam passes through the specimen
  - Specimen must be a very thin foil
  - Magnifications 1,000,000 X
- Scanning Electron Microscope (SEM)
  - Surface is scanned with an electron beam
  - Surface must be electrically conductive
  - Magnifications 10-50,000 X
  - Elemental composition of very localized surface areas are possible

- http://www.youtube.com/watch?v=5qcJySNLs84&feature=related
- http://www.youtube.com/watch?v=VH5H6uSQUFE

Scanning Probe Microscopy (SPM)

http://www.mobot.org/jwcross/spm/

http://www.teachnano.com/education/tech-overview.html



The three most common scanning probe techniques are:

Atomic Force Microscopy (AFM) measures the **interaction force** between the tip and surface. The tip may be dragged across the surface, or may vibrate as it moves. The interaction force will depend on the nature of the sample, the probe tip and the distance between them.

Scanning Tunneling Microscopy (STM) measures a **weak electrical current** flowing between tip and sample as they are held a very distance apart.

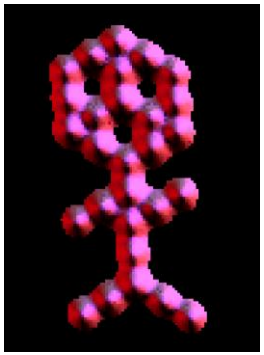
Near-Field Scanning Optical Microscopy (NSOM) scans a very **small light source** very close to the sample. Detection of this light energy forms the image. NSOM can provide resolution below that of the conventional light microscope.

Examination on the nanometer scale and Magnifications as high as 10^9 x

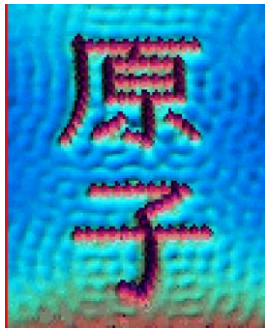
Can be operated in a variety of environments (vacuum, air, liquid, etc)

Scanning Tunneling Microscopy (STM)

- Atoms can be arranged and imaged!



Carbon monoxide molecules arranged on a platinum (111) surface.



Iron atoms arranged on a copper (111) surface. These Kanji characters represent the word “atom”.

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Grain Size Determination

(a) Determine the ASTM grain size number of a metal specimen if 45 grains per square inch are measured at a magnification of 100X?
(b) For this same specimen, how many grains per square inch will there be at a magnification of 85X?

ASTM grain size number

$N = 2^{n-1}$

number of grains/in^2 at 100x magnification