Scanning Electron Microscopy vs Focused Ion Beam

Caitlyn Gardner
Quang T. Huynh

Concepts and fundamentals of Scanning Electron Microscopes

- Diffraction limit of light
- Any atoms are small than half of a wavelength of light is too small to see with light microscope
- Electrons have much shorter wavelength than light
- Secondary electrons
- Scattered electrons
- X-rays
- Auger electrons
- Specimen current

Application of SEM

- Generate high-resolution images (in nano-scales)
  - Texture
  - Chemical composition
- Examine microfabric and crystallography orientation in materials

SEM Components

- Electron source ("Gun")
- Electron lenses
- Sample Stages
- Detectors for all signals of interest
- Display/Data output devices
- Infrastructure requirements:
    - Power Supply
    - Vacuum system
    - Cooling system
    - Vibration-free floor
    - Room free of ambient magnetic and electric field

Structure of a SEM

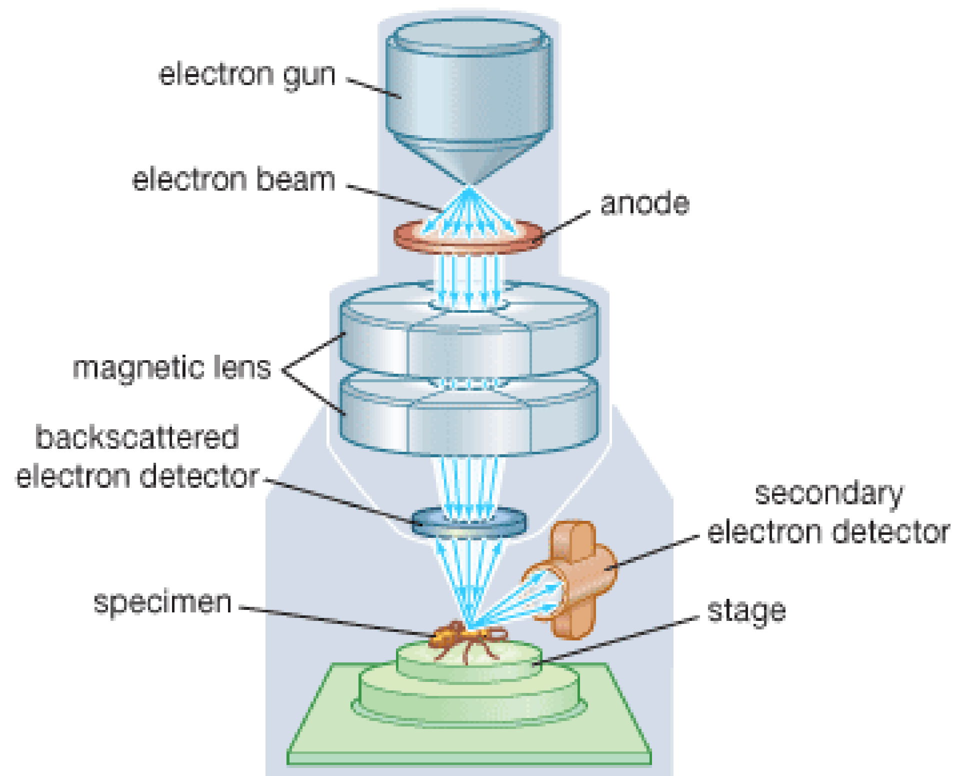
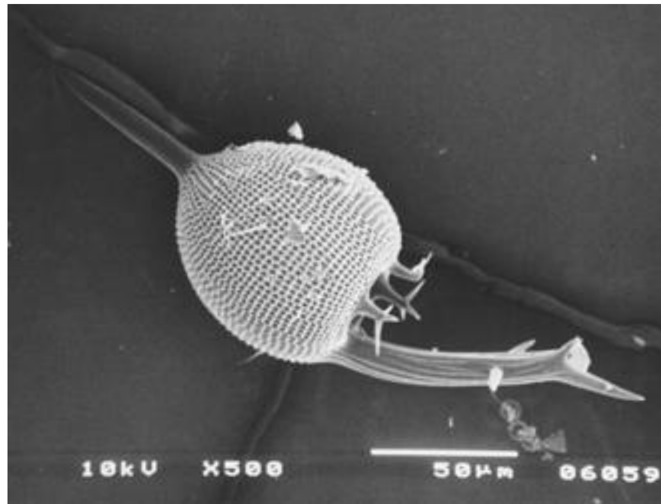
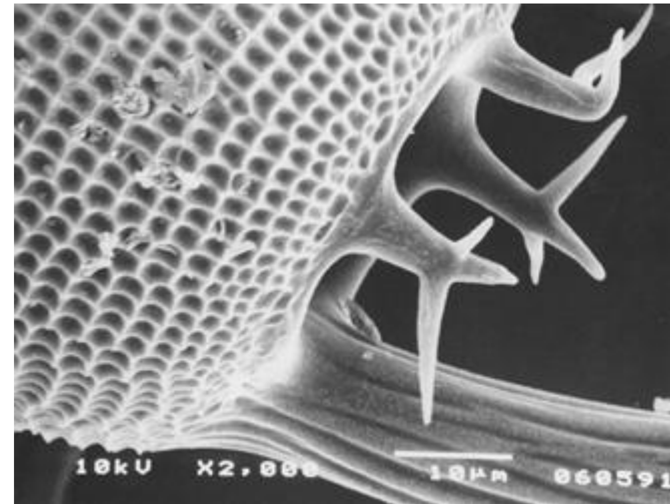


Figure: Typical structure of scanning electron microscope [1]

Radiolarian



Magnification: X 500



Magnification: X 2,000

Figure 2: Radiolarian [6]

Advantages

- High magnification from 10 to 500,000x
  - By 2009, the world's highest SEM resolution is 0.4nm at 30kV
- Can be applied to wide range of applications in the study of solid materials
- Large depth of field
- Easy to operate with user-friendly interfaces
- Highly portable
- Safe to operate

Disadvantages

- Sample must be solid and small enough to fit in the chamber
- Vacuum
- Some light elements can not be detected by EDS detectors
- Many instruments cannot detect elements with atomic numbers less than 11
- Low conductivity sample must have conductive coating to prevent damage from conventional SEMs

Focused Ion Beam (FIB)

- Similar to SEM
- Energized Ga+ ions
- Applications
  - Sputtering (Ion Milling)
  - Imaging
  - Circuit Edit

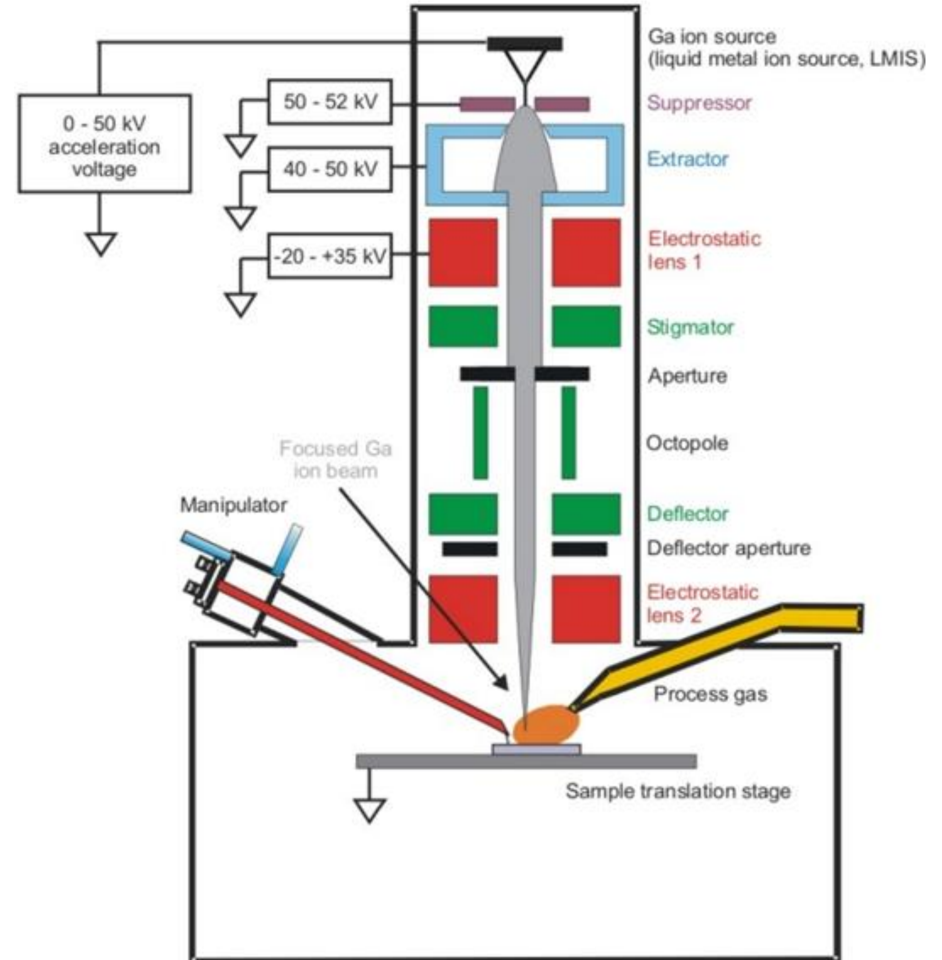


Figure: FIB system [4]

Sputtering And Imaging

- High beam current
  - sputtering
- Low beam current
  - imaging

- Strengths
  - Ability to cross-section small targets
  - Fast, high resolution imaging with good grain contrast
  - Very precise milling
  - Good SEM sample prep
- Limitations
  - Vacuum
  - Imaging process may spoil subsequent analyses
  - Residual Ga
  - Ion beam damage- lowered resolution

Circuit Edit

- Modifications can be made to circuits
- Cut traces or add metal connections
- Navigation system

- Strengths
  - Repair mistakes (multiple possible)
  - Quicker, easier, cheaper than new set in fab lab
  - Performance optimization
- Limitations
  - Backside modifications are time consuming
  - Smaller features- more complex

Dual Beam

- Combination of SEM and FIB systems
- Accurate ion milling or deposition of materials with high resolution imaging

References

- [1] Digivick, *Delicate*. [Online].Available: http://www.digitalsmicroscope.com/scanning-electron-microscope-5.[10/11/2011].
- [2] EAG, "Focused Ion Beam (FIB)". [Online]. Available: http://www.eaglabs.com/techniques/analytical_techniques/fib.php. [10/8/2011].
- [3] IBM, "Focused Ion Beam (FIB)". [Online]. Available: http://www.almaden.ibm.com/st/scientific_services/materials_analysis/fib/. [10/8/2011].
- [4] M. Brucherseifer, "SEM/ FIB". [Online]. Available: http://www.brucherseifer.com/html/sem___fib.html. [10/8/2011].
- [5] Swapp S, "Scanning Electron Microscopy(SEM)". [Online]. Available:http://serc.carleton.edu/research_education/geochemsheets/techniques/SEM.html. [10/9/2011]
- [6]*Museum of Science*.[Online].Available:http://www.mos.org/sln/SEM/newradio.html