MAT 571 Introduction to Electron Microscopy

Lectured by: Burç Mısırlıoğlu

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Office hours: N/A yet (BM: As long as I am available, feel free to stop by and ask questions)

In this course, we will cover the principles of imaging a sample using electrons starting from the basics. The content of the course involves and is not limited to: Imaging conditions, limits of resolution, how electron microscopes differ from optical microscopes, principles of elemental spectroscopy in electron microscopy, diffraction of crystals in TEM, various case studies to have a better grasp of suitable techniques to obtain a particular type of information from a sample. Depending on the availability of the SEM at FENS, there could be demonstrations of imaging and analysis.

The content will be more or less as follows:

1. Concepts in "magnification and imaging", a brief survey on microscopy (including optical) and available techniques for magnified imaging.

2. Concept of resolution and radiation

    a. Abbe resolution limit, Airy Disc, diffraction from a slit.
    b. Light vs. electrons as radiation source
    c. Manipulation of light and electrons via lenses
    d. Definition of numerical aperture
    e. Depth of field, depth of focus

3. The electron beam

    a. Electron guns.
    b. Concept of optical axis.
    c. Condenser lenses, image formation
    d. Electron-sample interactions.
    e. The objective lens (Briefly for TEM)

4. Scanning Electron Microscopy (SEM)

    a. Comparison of the SEM with optical microscope
    b. Main components of a SEM column
    c. Science of electron detection in SEM, image formation.
    d. Samples that are suitable for use in SEM
    e. Limitations of SEM, aberrations, depth of field/focus.
    f. Types of SEM for a variety of purposes
    g. Elemental spectroscopy in SEM: Energy dispersive and wavelength dispersive techniques. (~ 2 weeks)
    h. Case studies

5. Transmission Electron Microscopy (TEM)

    a. Comparison of the TEM with SEM and optical microscopy
    b. Main components of a TEM column
    c. Diffraction in TEM: Real space and reciprocal space definitions, condition of diffraction using Fourier analysis, the Ewald sphere, Kikuchi lines/bands.
    d. Bright field and dark field imaging.

e. Diffraction contrast in imaging, aberrations and their limitations, the two-beam condition.
f. Other modes of imaging in TEM (Mass/thickness contrast, phase contrast).
g. Resolution in TEM and its limits, phase contrast, contrast transfer function.
h. Types of TEM (High Resolution TEM, Scanning TEM and etc.)
i. Elemental spectroscopy in TEM: Energy dispersive spectroscopy and EELS (Electron energy loss spectroscopy).
j. Sample preparation for TEM
k. Case studies

Reference books at the Information Center:

Transmission electron microscopy : a textbook for materials science / David B. Williams and C. Barry Carter.

Physical principles of electron microscopy : an introduction to TEM, SEM, and AEM / Ray F. Egerton.

Scanning electron microscopy and x-ray microanalysis / Joseph I. Goldstein ... [et al.]

Transmission electron microscopy and diffractometry of materials / Brent Fultz, James Howe.

Scanning electron microscopy : physics of image formation and microanalysis / Ludwig Reimer.

Scanning and transmission electron microscopy : an introduction / Stanley L. Flegler, John W. Heckman, Jr., Karen L.

Scanning electron microscopy and X-ray microanalysis : a text for biologists, materials scientists, and geologists / Joseph I. Goldstein ... [et al.]

+ search engine results using keywords such as “electron microscopy, transmission electron microscopy, scanning electron microscopy, microanalysis, electron spectroscopy, diffraction from crystals, conditions of electron diffraction, electron-sample interaction, numerical aperture, resolution in electron microscopy, energy dispersive spectroscopy, wavelength dispersive spectroscopy, condenser lens, objective lens, secondary electrons, back scattered electrons, EELS, samples for electron microscopy” and etc.