

MATE 6110

Transmission Electron Microscopy

- Lecturers:** Dr. Z.L. Wang, Regents' Professor of Materials Science and Engineering
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- Objective:** To introduce the kinematical electron scattering theory, optics in TEM, diffraction contrast imaging of crystals containing defects, and dynamical electron diffraction effects.
To introduce the concept of reciprocal space, basis for indexing electron diffraction patterns, and diffraction from twinned crystals.
To introduce the theory, techniques and applications of high-resolution transmission electron microscopy (HRTEM) in materials research.
To describe chemical microanalysis using EDS
- Text:** Functional and Smart Materials - structural evolution and structure analysis by Z.L. Wang and Z.C. Kang (Plenum Press, 1997)
- Reference book:** Elastic and Inelastic Scattering in Electron Diffraction and Imaging by Z.L. Wang (Plenum Press, 1997)
- Home work** 4 assignments
- Exams** Middle term and final
- Grade** 30% Home work
35% Middle term exam
35% Final exam

Topics to be covered

| Topic | Lecture hour |
|---|--------------|
| Diffraction and electron optics | |
| -- Introduction on all of the advanced TEM related techniques | 1 |
| -- Electron scattering by crystals | 1.5 |
| -- Some mathematics for diffraction physics | 2 |
| -- Kinematical diffraction of periodically structured crystals | 1 |
| -- Bragg's law and Ewald sphere | 1 |
| -- Different imaging techniques | 1 |
| -- Plotting electron diffraction pattern | 1 |
| -- Indexing electron diffraction pattern | 1 |
| -- Kikuchi patterns | 1 |
| -- Diffraction from twinned crystals | 1 |
| -- Double diffraction and Moire pattern | 2 |
| -- Kinematical diffraction from imperfect crystals | 1 |
| Imaging and defect analysis | |
| -- Electron optics | 1 |
| -- Ray diagram of TEM | 1 |
| -- Imaging dislocations | 1 |
| -- Dynamical scattering theory of perfect crystals | 3 |
| -- Dynamical theory of diffraction contrast imaging | 3 |
| High resolution transmission electron microscopy | |
| -- Electron-crystal interaction and phase contrast imaging | 1 |
| -- Information transfer through the optic system of TEM | |
| Spherical aberration | 0.5 |
| Chromatical aberration | 0.5 |
| Phase shift introduced by objective lens focus | 1 |
| Astigmatism | 0.5 |
| -- Abbe's imaging theory of TEM | 1 |
| -- Contrast transfer function and image resolution | 1 |
| -- Practical High-resolution TEM | 1 |
| -- Information transfer through the optic system of TEM | 1 |
| -- Dynamical scattering theory and image simulation | |
| Multislice theory | 2 |
| -- Limitation of HRTEM imaging | 0.5 |
| Energy dispersive x-ray spectroscopy (EDS) for microanalysis | |
| -- X-ray emission from solid | 1 |
| -- X-ray detector | 0.5 |
| -- Characteristic lines in EDS spectra | 0.5 |
| -- ZAF corrections | 1 |
| -- Measurement of k factors | 1 |
| -- Determination of chemical composition | 1 |
| -- Channeling effect in EDS | 1 |

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| Lab demonstrations | 4 |
| Exams | 1 |
| Total | 44 hrs |