**465, Spring 2017, TTh 11:00-12:30**

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**Prerequisite: 460 or an equivalent course with hands-on TEM experience**

**COURSE DESCRIPTION:** The primary focus of this course is to provide both the fundamental theory as well as hands on practice with the use of transmission electron microscopy for more adavanced imaging and diffraction experiments.

**FUNCTIONAL GOALS:** A student completing this course will have a basic understanding of dynamical electron diffraction and imaging theory for transmission electron microscopy, as well as selected more specialized topics.

**PREREQUISITES:** A requirement for this coarse is an adequate background in transmission electron microscopy from a course such as MSE 460 or 360, or an equivalent elsewhere. It is expected that students will understand basic crystallography and kinematical diffraction, and be reasonably comfortable with using a transmission electron microscope.

**Course Outline (Provisional)**

**1. Imaging Theory (See** [**Notes**](file:///C:\Users\LDM\Desktop\465\imaging.doc)**, which will be updated)**

Short introduction to HREM imaging, experimental aspects (review)

Source Coherence, Energy Spread

Instability sources: vibration, drift

Resolution, sampling and noise

Detectors: film and digital

Coherent and Incoherent imaging

Definitions of coherence

Definitions of partial coherence

Mutual coherence – example of source coherence

Derivation of linear and non-linear imaging models

Coherent Aberrations

Incoherent Aberrations

Mutual Coherence forms

Contrast Transfer and Envelopes

Numerical Methods of Image Analysis

CTF simulation

Digital Image Analysis

More Advanced Issues

Prefield and Postfield Effects

Coma-Free Imaging and Related Topics

Image Localization

Aberration Correction

**2. Dynamical Diffraction (See** [**Notes**](file:///C:\Users\LDM\Desktop\465\proj.doc)**, which will be updated)**

2-D Model derived from Schroedinger's equation

Schroedinger's equation in 3D

Bloch-wave solutions & Dispersion surface

Bethe Potentials

Simplification to 2D

Multislice integration

Reduction and simplification to atomic-string model

Channeling solutions: 1s, 2s, 2p….

Application to HREM Imaging

Depth variations via channeling model

Application to Z-contrast

Isolation of 1s states

Application to Analytical Electron Microscopy

**3. Advanced Techniques for Solving Structures (Notes to be written)**

Basics of Direct Methods

Sigma-1, Triplets and Statistics

Sayre Equation and Tangent Formula

Feasible-Set Analysis

Techniques for solution

Multigrid Methods

Structure Completion

Charge Flipping

Theoretical Basis

1s Channelling reduction

Necessary Conditions

Application to Surfaces

Off-zone and related techniques

Precession Diffraction

Experimental Aspects

Limitations

Textbook: None

**Suggested Reference/Reading**

**Transmission Electron Microscopy** by Williams and Carter

Good because it is fairly new. Does not go into the more advanced topics covered in this class..

**High Resolution Electron Microscopy** by Spence

Very good coverage of HREM, the later editions being much better than the first. Does not have much information about non-linear imaging.

**Diffraction Physics** by Cowley

Wonderful chapter on Fourier Transforms, and extensive coverage. A fault is that many of the equations appear rather than being derived.

**Transmission Electron Microscopy** by Reimer

Very good coverage of most topics, albeit a little difficult to read and find material.

**Electron Microscopy of Thin Films** by Hirsch et al

The bible, at least for diffraction theory, Bloch waves and low resolution microscopy. Unfortunately it does not contain any material on newer techniques.

**High Energy Electron Diffraction and Microscopy** by Peng et al

A good coverage of dynamical diffraction, more modern, useful as it has the math for more advanced methods.

**Other**

Other (literature) references will be provided as appropriate, particularly for the sections on Direct Methods and Surfaces

**Grading**

Lab Reports: 30%

Assignments: 30%

Project: 20% Presentation, 20% written