CHE 694-3: Special Topics in Chemical Engineering – Materials Characterization  
*Spring 2014 Semester, U of L Chemical Engineering*

**Instructor:** Dr. Jacek Jasinski  
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**Meeting times:** No appointment required; walk-in welcome.  
**Class timings:** Tues & Thurs, 4:00 – 5:15 pm; **Class Room:** EH

**Teaching Assistants:** TBD

1. **Prerequisites by Topic:**
   - B.S. degree in Science or Engineering.
   - Undergraduate Course on in Materials Science (CHE 253 or equivalent). This can be substituted with research experience in materials science related project.

2. **Textbooks:** The following books are suggested as the text book but class notes, chapters from other books and handouts will also be used.
   - “Transmission Electron Microscopy” by David B. Williams and C. Barry Carter

3. **Course Objectives:** Following this course students will:
   - Learn and understand fundamental concepts of materials structure, with the emphasis on crystals
   - Understand fundamentals of electron microscopy and diffraction techniques
   - Apply theoretical methods and software tools to analyze and interpret various types of microscopic and diffraction data.

4. **Topics Covered:**
   a. Overview of basic concepts in materials science. Exploring materials science online tools at the Materials Project website. (1 week)
   b. Introduction to crystal structure and overview of fundamental concepts (1 week)
      - lattice, primitive cell, Bravais lattices and lattice systems, crystal structure, unit cell, miller indices, lattice planes, crystallographic directions, etc.
   c. Crystal structure modeling (2 weeks)
      - Application of software tools to build and analyze crystal structure models
   d. Electron microscopy – basic concepts (1 week)
      - SEM vs TEM, electron sources and optics, signals and detectors, etc.
   e. Introduction to diffraction (1 week)
      - waves, Bragg’s law, X-ray diffraction from crystals, etc.
   f. XRD powder diffraction (1 week)
      - Hands-on lab exercise. Indexing powder diffraction patterns
   g. Scattering: coherence and incoherence; X-ray scattering (1 week)
• phase and energy, wave amplitudes, and cross-sections; electrodynamics of X-ray scattering, inelastic Compton scattering, X-ray mass attenuation coefficients, etc.

h. Coherent elastic scattering (1 week)
  • Born approximation for electrons, atomic form factors – physical picture and general formulation, scattering of electrons by model potentials, etc.

i. Diffraction from crystals (1 week)
  • reciprocal lattice, Laue condition, equivalence of the Laue condition and Bragg’s law, structure factor, structure factors rules, crystal shape factor, Ewald sphere construction, Ewald sphere and Bragg’s law, Laue zones, etc.

j. Electron diffraction and crystallography (1 and ½ week)
  • indexing single-crystal diffraction patterns, relation between stereographic projections and electron diffraction pattern, Kikuchi lines, double diffraction, etc.

k. Convergent beam electron diffraction (1/2 week)
  • convergence angle, sample thickness determination, measurements of unit cell parameters, etc.

l. Electron diffraction analysis software (1 week)

m. High-resolution electron microscopy (1 week)
  • practical aspects and application of simulation software

5. Class Schedule: Two lecture sessions per week, each of 75 minutes duration.

6. Contribution of course to meeting the professional component:
  • Fundamental understanding of some of the most important materials characterization techniques
  • Focus on practical applications of electron microscopy and diffraction methods to phase identification and structure determination for crystalline materials

7. Relationship of course to the program objectives:
  • The course educates and trains graduates with the academic and practical background necessary to function as chemical engineering professionals in several modern, state of the art industrial enterprises such as electronics manufacturing, advanced materials, energy, nanotechnology and bio-medical engineering.
  • The course provides our graduates with the foundation for a successful career and enables life-long learning.

8. Grading Policy

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<th>Assignment</th>
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<td>Homework Assignments</td>
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<td>Computer Exercises (3-4)</td>
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