MATERIALS 724

Materials Characterization by Electron/Ion Microscopy

Instructor: Prof. Nabil Bassim, JHE 258, bassimn@mcmaster.ca, x 24102

Course Schedule: September 9, 2020 - , December 9, 2020, Wednesdays,12-2 pm EST, demos Thursdays, 12-2 pm

Office Hours: Tuesdays, 1 pm- 3 pm or by appointment.

Course Description:

This course will introduce students to the various concepts of electron microscopy as a method for high resolution characterization of materials microstructures. We will explore topics such as electron optics, electron-sample interactions, image interpretation, x-ray microanalysis, focused ion beam optics, chemical analysis and applications of these techniques. There will also be a focus on practical applications, such as specimen preparation, and microscope operation in a laboratory environment. Due to the pandemic, students will not be able to come on campus for practical training with the microscopes, but will have demonstrations provided by the staff of the Canadian Centre for Electron Microscopy (CCEM) on techniques in scanning electron microscopy (SEM), focused ion beam microscopy, and other techniques during the course term.

Course Objectives:

Develop an understanding of the working principles and applications of the characterization of materials using Scanning Electron Microscopy, Focused Ion Beam Microscopy and related Spectroscopy techniques.

• Understand the physical principles underlying the processes involved in Electron and Ion Microscopy.

• Learn the operating principles of the SEM and follow demonstrations of electron microscopy during the practical portion of the course which will take place online broadcast from the CCEM.

Course Materials Delivery:

All lectures and chat room and live interactions/office hours will be held on Teams. Avenue to Learn will host lecture uploads and all official course material.

The course will be delivered in a blended synchronous fashion, with talks recorded and played live during the session. They will then be available for remote viewing after the live session. The instructor will stop after playing a 20 minute lecture to offer a 10-minute Q&A session, which will also be recorded. This will be repeated 4 times durin the 2 hour of the weekly course.

Essentially: 4 20-minute lectures, with 10 minute Q&A after each. All of this will also be recorded and placed online.

We will set up a virtual chat room for additional Q&A and the instructor will check this daily to answer questions.

Evaluation:

Research Report (30%): Each student will choose a new technique in electron microscopy or FIB microscopy to perform a literature review, and write a 10 page research report describing this work (~10 pages – 1.5 space, including figures and references). This report is due on at the end of the term. The report should resemble a journal paper. The focus of the report should be a description of the technique and and could a critical review of the literature, including a discussion of the hardware, operating principles, advantages and drawbacks.

Research Report Presentations (20%): Each student will present the work from the research report on Nov. 20 and Nov. 27 in a 10-minute presentation. Evaluation will be based on comprehensiveness, clarity and correctness.

Mid-term exam (20%): There will be a mid-term on lecture covering concepts taught to end of the lecture class. Students will be evaluated on conceptual understanding and solve a series of microscopy problems in an online timeframe devoted to the exam. Exam will be open book but should apply concepts to image analysis, solving a microscopy problems or a quantitative analysis.

Final Exam (30%): A final exam will take place during finals exam week to encompass the full curriculum of the course. Students will be evaluated on conceptual understanding and solve a series of microscopy problems in an online timeframe devoted to the exam. Exam will be open book but should apply concepts to image analysis, solving a microscopy problem or a quantitative analysis.

Basic timeline for the course:

- Week 1 (Sept 9): Course Outline, introduction; planning
- Week 2 (Sept 16): Goldstein Chapter 2: The SEM and Its Modes of Operation, Lenses, Sources, Goldstein Chapter 1,2 : Electron Beam-Specimen Interactions: Backscatter Electrons and Secondary Electrons

- Week 3 (Sept 23): Goldstein Chapters 3,4: Electron Beam-Specimen Interactions: Backscatter Electrons and Secondary Electrons
- Week 4 (Sept. 30): Goldstein Chapters 5,6: The lensing system, sources, brightness; detectors
- Week 5: (Oct. 7) Mid-term exam
- Week 6: (Oct. 14): Goldstein Chapter 4, Inelastic Processes (Auger, X-ray generation)
- Week 7: (Oct. 21): Elements of Goldstein Chapters 16-20: EDS: Qualitative and quantitative compositional mapping
- Week 8: (Oct. 28): Goldstein Chapter 30, Instructor notes: Focused Ion Beam Microscopy
- Week 9: (Nov. 4): Catch-up, Q&A
- Week 10 (Nov. 11): – Goldstein Chapter 29: EBSD
- Week 11 (Nov. 18): Sample preparation
- Week 12 (Nov. 25): Guest lecture – Dr. Brian Langelier – Atom Probe Tomography
- Week 13 (Dec 2): Class presentations
- Week 14 (Dec. 9): Class presentations
- Final Exam

Basic Timeline for the Laboratory Sessions (Thursdays 1-3):

Sept. 17: An introduction to the SEM

Sept: 24: An introduction to sample preparation (1 hour Materials, 1 hour Bio)

Oct. 1: Introduction to EDS analysis

Oct. 8: Break

Oct. 15: LVSEM (6610), Ultrahigh resolution SEM, Low-voltage EDS (Magellan)

Oct. 22: Introduction to Focused Ion Beam

Oct. 29: FIB applications (done on PFIB)

Nov. 5: Break

Nov. 12: Introduction to Image Analysis.

Nov. 19: EBSD/TKD analysis

Nov. 26: A tour of atom probe.

References:

Scanning Electron Microscopy and X-Ray Microanalysis, Joseph Goldstein, Dale Newbury et al.,, 4th edition

Introduction to Focused Ion Beams: Instrumentation, Theory, Techniques and Practice, Giannuzzi and Stevie

Recent advances in focused ion beam technology and applications, MRS Bulletin, 2014

This is a course under development by the instructor; subject matter and evaluation methods are subject to change at the discretion of the instructor.

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EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.