Course Outline

MATS2003

Materials Characterisation

Materials Science and Engineering

Science

T2, 2020

1. Staff

Position	Name	Email	Consultation times and locations	Contact Details
Course Convenor / Lecturer	Dr Owen Standard	o.standard@unsw.edu.au	Room 243A, School of Materials Science and Engineering (Building E10) by appointment	Phone: 9385 4437
Lecturer	Dr Kevin Laws	k.laws@unsw.edu.au	Room 301, School of Materials Science and Engineering (Building E10) by appointment	Phone: 9385 5234

2. Course information

Units of credit: 6

Pre-requisite(s): N/A

Timetabling website: http://timetable.unsw.edu.au/2020/MATS2003.html

Teaching times and locations: Course in T2-2020 is delivered as distance delivery – there are no timetabled classes and instead students complete the course by self-study.

2.1 Course summary

Introduction to crystallography: crystal symmetry, Bravais lattices and crystal structures; Miller and Miller-Bravais Indices. Specimen preparation; optical and electron microscopy; image analysis and stereology; x-ray and electron diffraction; x-ray fluorescence, Raman spectroscopy, x-ray photoelectron spectroscopy; Secondary ion mass spectroscopy, Auger electron spectroscopy.

2.2 Course aims

The objective of this course is to develop an understanding of the principles, practice and application of optical microscopy, electron microscopy, X-ray diffraction, and spectroscopy in the characterisation of the internal structure of materials. This course will provide the intellectual framework for a number of materials science courses such as phase equilibria, kinetics and diffusion, phase transformations, mechanical behaviour, metal deformation, ceramic processing, etc. and will enable students to:

- Predict changes in materials structures as a function of composition, temperature, pressure, and time;
- Relate the structure of materials to processing required to make them;
- Relate the structure of materials to the resultant properties and applications.

2.3 Course learning outcomes (CLO)

At the successful completion of this course you (the student) should be able to:

1. Describe, identify, predict, and quantify the structure of materials at the following scales: crystal structure; nanostructure; microstructure and macrostructure.

2. Understand the principles of operation of major instruments used for characterisation of materials, practical skills in examining and quantifying material structures
3. Understand the importance of structure to mechanical, physical, and other properties of materials
4. Prepare appropriate test samples from host components using routine metallographic techniques.
5. Select and apply crystallography, X-ray diffraction, optical microscopy, electron microscopy, and selected spectroscopic techniques to characterise the composition and structure of materials.

2.4 Relationship between course and program learning outcomes and assessments

Course Learning Outcome (CLO)	**Program Learning Outcome (PLO)**	**Related Tasks & Assessment**
CLO 1	1.3, 1.4, 2.2, 3.2 & 3.4	1, 2, 3 & 4
CLO 2	1.3, 1.4 & 2.2	1, 2 & 4
CLO 3	1.3 & 3.4	1, 3 & 4
CLO 4	1.3	1, 2 & 4
CLO 5	1.3, 3.4 & 3.5	1, 2 & 4

3. Strategies and approaches to learning

3.1 Learning and teaching activities

- *Students are actively engaged in the learning process.*
  It is expected that, in addition to attending classes, students read, write, discuss, and are engaged in solving problems in the characterisation of materials and the analysis of materials behaviour. This is facilitated by interactive online tutorials, calculation- based assignments, and laboratory reports.
- *Effective learning is supported by a climate of inquiry where students feel appropriately challenged.*
  Understanding of the underlying theory and principles of metallography, crystallography, diffraction, microscopy, and spectroscopy are challenging – students will apply this to real-world materials and situations by performing calculations, solving problems, and completing practical laboratories.
- *Learning is more effective when students' prior experience and knowledge are recognised and built on.*
  This course is built on prior courses in materials science, computing, mathematics, chemistry, and physics.

- *Students become more engaged in the learning process if they can see the relevance of their studies to professional and disciplinary contexts*
  Students will use metallography, crystallography, diffraction, microscopy, and spectroscopy to understand and investigate the relationship between composition, structure, and properties in engineering materials. They will apply their understanding and skills developed in these key areas of materials science to interpret technologically-significant engineering materials. Also, implicit in the course is the exposure to, and development of, graduate attributes and professional skills.

Lectures: The core concepts will be taught in lectures, students will have access to the lectures notes before class for annotation during the lecture. Students will be engaged in the learning process through class discussions and problem-solving questions independently and working together with partners and groups.

Labs: Experimental techniques and procedures will be taught through laboratories classes and laboratory reports following the class. Students will actively complete the experiments gaining experience of important materials testing and characterisation techniques. Students will be able to reflect on the experiments and learn to process data through the lab reports after class.

Tutorials: Tutorials will consolidate the students learning of the core concepts through short-answer and problem-solving questions. Students will have the chance to work collaboratively in class and independently outside of class. Real world examples of the concepts will engage the students in the learning processing by connecting theory to practice.

3.2 Expectations of students

- Completion of the course is by distance delivery in which students learn the course content by self-learning. Students must study and learn the lecture notes and complete the various assignments and online laboratories.
- During class, students are expected to engage actively in class discussions
- Students should work through lecture, tutorial and textbook questions
- Students should read through the relevant chapters of the recommended textbooks.
- Students should complete all assessment tasks and submit them on time.
- Students should contact course lecturer(s) if they experience any difficulty with the course material

4. Course schedule and structure

The recommended pace of self-learning in the course is indicated in the table below. Nominally there are 3 x 2 hrs recorded lectures per week. The online laboratories are nominally 2 hrs each (for 4 labs). The formal mid-term and final exams are nominally 2 hours each. You are expected to take an additional 60 hours (2 hrs per week) of non-class contact hours to study and readings, complete assessment tasks, study and readings, and exam preparation spread over the term.

Week	Topics	Activity
1	Course introduction Specimen preparation Crystallography	Specimen preparation online lab.*
2	Crystallography	Crystallography assignment
3	X-ray diffraction	X-ray diffraction assignment X-ray diffraction online lab.*
4	X-ray diffraction Electron Microscopy	
5	Electron microscopy	Electron microscopy assignment Electron microscopy online lab.*
6	Study Week	
7	Electron microscopy	Mid-term exam
8	Spectroscopy Optical microscopy	Optical microscopy online lab.*
9	Optical microscopy Digital image analysis	
10	Stereology	Stereology online lab.*

*Online lab. assessment tasks due by end of Week 10 (but will be marked whenever they are done).

5. Assessment

5.1 Assessment tasks

Assessment task	Description	Weight	Due date
Tutorial/ Assignments:	Crystallography Assignment: Students will determine basic crystallographic relationships and perform crystal structure calculations.	8%	Week 4
	X-ray Diffraction Assignment: The principle of operation of a powder X-ray diffractometer will be demonstrated to students by means of a video. Students will determine crystallographic structure factors and diffraction intensities of a selected material from first principles and will use them to compare with measured XRD patterns and to determine the lattice parameters and density of the material. Identification of phases in a mixed-phase sample will also be done.	12%	Week 6
	Electron Microscopy Assignment and Online Tutorial Students will interpret topographical and compositional SEM images and data, plus use an online interactive SEM simulator to learn the basic operation of an SEM and to determine how image appearance is affected by SEM operating conditions.	15%	Week 8
Laboratory Work:	Online Lab. 1 Metallographic Sample Preparation: Students will learn selected metallographic preparation steps learnt in lectures to prepare a specimen suitable for microstructural examination by optical microscopy and SEM. Students will learn correct methodology to prepare metallographic specimens.	15% (Single Project-Based Report)	Week 10
	Online Lab 2. Operation of Powder X-ray Diffractometer (Demonstration): The principle of operation of a powder X-ray diffractometer will be demonstrated to students in groups and XRD measurements to determine phases present and/or lattice parameters of a material will be done. Students will apply crystallographic principles to the interpretation of the resultant XRD data.		
	Online Lab. 3 Operation of Inverted Light Microscope and Scanning Electron Microscope: Students will learn about the basic operation of an inverted optical microscope and to examine and interpret the effect of microscope settings on the resultant micrograph image; and 2) learn about SEM operating principles in a SEM online tutorial.		
	Online Lab. 4 Stereology: Students will use standard stereological relationships and methods to quantify selected microstructural parameters (e.g., volume fraction and grain size) from material micrographs using both manual and image analysis techniques. Students will also		

	learn the importance of bias and statistical accuracy in stereographical measurements.		
Mid-Term Exam:	The mid-session exam will provide summative assessment of the topics of Specimen Preparation, Crystallography, and X-ray Diffraction as covered by formal lectures, nominated reading material (from course handouts), and assignments. It will consist of a combination of short-answer style questions and calculations. Any derivations will assume knowledge of the material with relevant background equations provided (except Bragg's Law), rather than resorting equations to memory. The exam will assess both underlying principles of materials characterization techniques as well as their application to the practical characterisation of real materials.	20%	Week 7
Final Exam:	The final exam will provide summative assessment of the topics of Electron Microscopy, Spectroscopy, Optical Microscopy, Digital Image Analysis, and Stereology as covered by formal lectures, nominated reading material (from course handouts), assignments, and laboratories. It will consist of a combination of multiple choice questions and short-answer style answers and calculations. Any derivations will assume knowledge of the material with relevant background equations provided, rather than resorting equations to memory. The exam will assess both underlying principles of materials characterization techniques as well as their application to the practical characterisation of real materials. The exam will held in the formal UNSW examination period following term.	30%	UNSW final exam period

Further information

UNSW grading system: https://student.unsw.edu.au/grades

UNSW assessment policy: https://student.unsw.edu.au/assessment

5.2 Assessment criteria and standards

- All assessment standards and criteria will be available on the course Moodle page.
- Normal UNSW grading (HD, DN, CR, PS, FL) will not apply to the course in T2-2020. Instead students receive results of **SY (satisfactory), FL (Fail), or UF (Unsatisfactory Fail)**.
- Students who fail to achieve a score of at least 40% for the overall exam component (i.e., mid-session exam and final exam marks combined), but achieve a final mark >50% for the course, will be awarded a UF (Unsatisfactory Fail) for the course.

5.3 Submission of assessment tasks

- Assessment tasks must be completed and submitted by the dates set (these will advised during Term). All submitted work must contain a completed student declaration sheet. Unless stated otherwise, submission of assessment tasks is done by uploading electronic copy to the Moodle course module. Marked work will be returned within two weeks of submission.

- Assessment tasks submitted after the deadline will receive a penalty of 20% of the max. grade for every day late, or part thereof. Assessment tasks submitted 5 or more days after the deadline will not be accepted nor marked.
- UNSW operates under a Fit to Sit/ Submit rule for all assessments. If a student wishes to submit an application for special consideration for an exam or assessment, the application must be submitted prior to the start of the exam or before an assessment is submitted. If a student sits the exam/ submits an assignment, they are declaring themselves well enough to do so. Information on this process can be found here: https://student.unsw.edu.au/special-consideration. Medical certificates or other appropriate documents must be included. Students should also advise the lecturer of the situation.

5.4. Feedback on assessment

Assignments: Feedback will be given two weeks after submission of the assignment and take the form of the mark for the assignment, overall comments on how the class performed, any common areas that were not answered correctly. Additionally, personal feedback and how each student performed may be given.

Lab reports: Students will receive their mark and individualised feedback on the areas they excelled at and which areas of the reports that were not answered correctly. Feedback will be provided through Moodle, two weeks after submission.

Midsession exams: Students will receive their marked exams indicating what questions were answered correctly and incorrectly. Overall comments and worked solutions may be provided to the class.

Final exam: There is no formal feedback nor mark given for the final exam. Students instead will receive their final overall mark for the course.

6. Academic integrity, referencing and plagiarism

Referencing is a way of acknowledging the sources of information that you use to research your assignments. You need to provide a reference whenever you draw on someone else's words, ideas or research. Not referencing other people's work can constitute plagiarism.

Further information about referencing styles can be located at https://student.unsw.edu.au/referencing

Academic integrity is fundamental to success at university. Academic integrity can be defined as a commitment to six fundamental values in academic pursuits**:** honesty, trust, fairness, respect, responsibility and courage.[1] At UNSW, this means that your work must be your own, and others' ideas should be appropriately acknowledged. If you don't follow these rules, plagiarism may be detected in your work.

Further information about academic integrity and **plagiarism** can be located at:

- The *Current Students* site https://student.unsw.edu.au/plagiarism**,** and
- The *ELISE* training site http://subjectguides.library.unsw.edu.au/elise/presenting

The *Conduct and Integrity Unit* provides further resources to assist you to understand your conduct obligations as a student: https://student.unsw.edu.au/conduct.

[1] International Center for Academic Integrity, 'The Fundamental Values of Academic Integrity', T. Fishman (ed), Clemson University, 2013.

7. Readings and resources

- C. Barrett and T.B. Massalski, Structure of Metals, 3rd Revised Edition. Pergamon Press, Oxford, 1980.
- B.D. Cullity and S.R. Stock, Elements of X-ray Diffraction, 3rd Revised Edition. Prentice-Hall Inc., 2001.
- R. Jenkins & R.L. Snyder, Introduction to X-ray Powder Diffractometry. John Wiley & Sons Inc., 1996
- N.F. Kennon, Patterns in Crystals. John Wiley, Chichester, 1980.
- M.H.Loretto, Electron Beam Analysis of Materials, Second Edition. Chapman and Hall, New York, 1994.
- Metals Handbook, Ninth Edition, Volume 9 Metallography and Microstructures. American Society for Metals, USA, 1985.
- J.C. Russ, The Image Processing Handbook, Third Edition. CRC Press, Boca Raton, Florida, 1999.
- G.F. Vander Voort, Metallography Principles and Practice. McGraw Hill, New York, 1984.
- Y. Waseda, E. Matsubara, and K. Shinoda, X-Ray Diffraction Crystallography: Introduction, Examples and Solved Problems. Springer, Berlin, 2011.

8. Administrative matters

School Office: Room 137, Building E10 School of Materials Science and Engineering
School Website: http://www.materials.unsw.edu.au/
Faculty Office: Robert Webster Building, Room 128
Faculty Website: http://www.science.unsw.edu.au/

9. Additional support for students

- The Current Students Gateway: https://student.unsw.edu.au/
- Academic Skills and Support: https://student.unsw.edu.au/academic-skills
- Student Wellbeing, Health and Safety: https://student.unsw.edu.au/wellbeing
- Disability Support Services: https://student.unsw.edu.au/disability-services
- UNSW IT Service Centre: https://www.it.unsw.edu.au/students/index.html
- Assessment Implementation Procedure: https://www.gs.unsw.edu.au/policy/documents/assessmentimplementationprocedure.pdf