Course Outline

MATS6112

Characterisation of Materials

Materials Science and Engineering

Science

T1, 2021

1. Staff

Position	Name	Email	Consultation times and locations	Contact Details
Course Convenor	Dr Daniel Sando	daniel.sando@unsw.edu.au	Room M65, Chemical Sciences Building (Building F10) by appointment	Phone: 9065 2469
Lecturer	Dr Owen Standard	o.standard@unsw.edu.au	Room 243A, School of Materials Science and Engineering (Building E10), by appointment	Phone: 9065 5356
Lecturer	Dr Shery Chang	shery.chang@unsw.edu.au	Room B65, Chemical Sciences Building (Building F10) by appointment	Phone: 9385 6709

2. Course information

Units of credit: 6

Pre-requisite(s): N/A

Timetabling website: http://timetable.unsw.edu.au/2022/MATS6112.html

Teaching times and locations:

Part 1:	Lecture	Lecture	Lecture	Mid-term Exam
Day	Monday	Tuesday	Friday	Monday
Location	Online	Online	Online	Online
Time	16:00-18:00	14:00-16:00	09:00-11:00	13:00-15:00
Weeks	1-5, 7	1-5,7	1-5, 7	7

Part 2:	Lecture	Lecture	Lecture
Day	Monday	Tuesday	Friday
Location	Online	Online	Online
Time	16:00-18:00	14:00-16:00	9:00-11:00
Weeks	8, 9	8-10	8, 10

2.1 Course summary

This course covers a range of methods in the analysis of materials including diffraction, microscopy, and spectroscopy methods. Emphasis is placed on the applicability of each technique to appropriate analysis and the limitations of each method.

The first half of the course (Weeks 1-7) will provide a fundamental understanding of crystallography, diffraction, and electron microscopy (taught with MATS2003). The second half of the course presents advanced topics in diffraction, microscopy, and 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 related advanced characterisation techniques in the characterisation of the internal structure of materials.

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 selected major instruments (including X-ray diffractometers, scanning electron microscopes, and transmission electron microscopes) used for characterisation of materials and practical skills in examining and quantifying material structures.
3. Understand the importance of structure to mechanical, physical, and other properties of materials.
4. Select and apply crystallography, X-ray diffraction, neutron diffraction, and other advanced microscopy and spectroscopy 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	3	1, 2, 3 & 4
CLO 2	2 & 3	1, 2, 3 & 4
CLO 3	3	3 & 4
CLO 4	2, 3 & 4	2, 3 & 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.

- *Effective learning is supported by a climate of inquiry where students feel appropriately challenged.*

  Problems involving microscopy, crystallography, diffraction, and spectroscopy are challenging; students will perform practical exercises that will motivate deep analysis of various phenomena in materials science and engineering. Much of the fundamentals that are learnt are applied in a practical way to real-world materials and situations.

- *Learning is more effective when students' prior experience and knowledge are recognised and built on.*

  The 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 be asked to analyse the role of crystallography, diffraction, microscopy, and spectroscopy in understanding the relationship between composition, structure, and properties in engineering materials.

3.2 Expectations of students

- Students must attend at least 80% of all classes with the expectation that students only miss classes due to illness or unforeseen circumstances
- Students must read through lecture notes and lab sheets prior to class
- During class, students are expected to engage actively in class discussions
- Students should revise lecture notes and work through lecture examples, tutorial and textbook questions
- Students should read through the relevant chapters of the prescribed textbook.
- Students should complete all assessment tasks and submit them on time.
- Students are expected to participate in online discussions through the Moodle page
- Students are expected to participate in tutorial sessions and submit assessment items

4. Course schedule and structure

This course consists of 56 hours of class contact hours per term (lectures 52 hours, formal exams 4 hours). You are expected to take an additional 56 hours of non-class contact hours to complete assessment tasks, study and readings, and exam preparation spread over the term.

Week	Topics	Activity
1	Course introduction Specimen Preparation Crystallography	
2	Crystallography	Crystallography assignment
3	X-ray diffraction	
4	X-ray diffraction Electron microscopy	X-ray diffraction assignment
5	Electron microscopy	Electron Microscopy assignment & tutorial
6	Flexibility Week	
7	Electron microscopy Mid-term exam	
8	Atomic Force Microscopy Synchrotron Spectroscopy Synchrotron Microscopy	
9	Neutron diffraction	Quiz 1. Atomic Force Microscopy and Synchrotron Spectroscopy Techniques
10	*In-situ* diffraction	Quiz 2. Neutron Scattering and Neutron scattering Techniques

5. Assessment

5.1 Assessment tasks

Assessment task	Description	Weight	Due date
Tutorials/ Assignments:	**Crystallography assignment:** Students will determine basic crystallographic relationships and perform crystal structure calculations.	8%	Week 3
	X-ray diffraction: 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 5
	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
In-class quizzes:	**Quiz 1. Atomic Force Microscopy and Synchrotron Spectroscopy Techniques:** This multiple-choice quiz will test students' comprehension of atomic force microscopy and synchrotron spectroscopy techniques.	7.5%	Week 9
	Quiz 2. Neutron Scattering and *in-situ* Methods: The students will be tested on their comprehension of the topics through a multiple-choice quiz.	7.5%	Week 10
Mid-term exam:	The mid-session exam will provide summative assessment of the fundamentals of 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 the X-ray Diffraction characterisation technique as well as its application to the practical characterisation of real materials.	20%	Week 7

Final exam:	The final exam will provide summative assessment of the topics of Atomic Force Microscopy, Diffraction, Electron Microscopy, and Spectroscopy as covered by formal lectures, nominated reading material (from course handouts), assignments, and laboratories. It will consist of a combination of 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 the materials characterisation techniques as well as their application to the practical characterisation of real materials.	30%	UNSW final exam period at end of Term

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.
- Satisfactory completion of the course includes the requirement to achieve ≥35% in the mid-term exam and ≥35% in the final exam, and ≥45% weighted average over the two exams. Students who fail to achieve this will be awarded an Unsatisfactory Fail (UF) grade for the course regardless of if they receive over 50% in total for the course.
- Please refer to the UNSW guide to grades: https://student.unsw.edu.au/grades

5.3 Submission of assessment tasks

- Assessment tasks must be completed and submitted by the dates set (these will be advised during session). 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.
- Late submission of assignments and laboratory reports is permitted for up to five days after the submission deadline; work submitted after this time will not be accepted.
- Assignments/lab reports submitted after the due date for submission will receive a penalty of 5% of the assessment task grade value for every day late, or part thereof.
- 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 course convenor/lecturer of the situation.
- Students who are enrolled in the face-to-face laboratory classes that do not attend a particular laboratory class in their allocated time will not be permitted to do the laboratory at another time nor permitted to complete the online laboratory class and will receive zero marks for the corresponding assessment task.
- Students who are enrolled in the online live-streamed laboratory classes that do not attend a particular laboratory class in their allocated time will not be permitted to do the laboratory at another time and will receive zero marks for the corresponding assessment task.

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 which questions were answered correctly and incorrectly. Overall comments and worked solutions may be provided to the class.

Final exam: Students will receive their final mark.

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

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.

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.

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

- *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.
- E. Bauer, *Surface Microscopy with Low Energy Electrons*. Springer, New York, 2004.
- A. Ziegler, H. Graafsma, X.F. Zhang, J.W.M. Frenken, eds. *In-situ Materials Characterization: Across Spatial and Temporal Scales*. Springer, Berlin, Heidelberg, 2014.
- Zhu, Y., *Modern Techniques for Characterizing Magnetic Materials*. Springer US, Boston, MA, 2005

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