



Course Outline

MATS2003

Materials Characterisation

Materials Science and Engineering

Science

T1, 2022

1. Staff

Position	Name	Email	Consultation times and locations	Contact Details
Course Convenor / Lecturer	Dr Owen Standard	o.standard@unsw.edu.au	Room 243A, Hilmer Building (Building E10) by appointment	Phone: 9065 5356
Lecturer	Dr Shery Chang	shery.chang@unsw.edu.au	Rm 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/MATS2003.html>

Teaching times and locations:

	Lecture	Lecture	Lecture	Laboratory* (In-Person)	Laboratory* (Online)	MT Exam
Day	Monday	Tuesday	Friday	Wednesday	Wednesday	Monday
Time	16:00-18:00	14:00-16:00	09:00-11:00	12:00-14:00	15:00-17:00	13:00-15:00
Location	Online	Online	Online	Hilmer Bldg (In person)	Online (Live Streamed)	Online
Weeks	1-5, 7-9	1-5, 7-10	1-5, 7-8, 10	2-5, 7-10	2-5, 7-10	7

*Laboratory classes are completed as face-to-face classes or online (live streamed) classes. Schedule for the laboratory classes (and locations for face-to-face classes) will be issued separately via Moodle after Week 1 (when course enrolment is finalised). Please note that students are strongly encouraged to attend the face-to-face laboratory class; online laboratory should be attended only by students who are overseas or have medical reasons.

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 laboratory work gaining experience of important materials testing and characterisation techniques. Students will be able to reflect on the laboratory work 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

- Students should 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 work through lecture, tutorial, and reference book 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 in class.

4. Course schedule and structure

This course consists of 58 hours of class contact hours per term (lectures 52 hours, laboratory activities 2 hours, and formal exams 4 hours). You are expected to take an additional 54 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 (OS +SC) Specimen Preparation (OS) Crystallography (OS)	
2	Crystallography (OS)	Crystallography assignment
3	X-ray Diffraction (OS)	
4	X-ray Diffraction (OS) Electron Microscopy (SC)	X-ray Diffraction assignment X-ray Diffraction laboratory activity
5	Electron Microscopy (SC)	Electron Microscopy assignment & tutorial Electron Microscopy laboratory activity
6	Flexibility Week	
7	Electron Microscopy (SC) Mid-Term Exam	
8	Spectroscopy (SC) Optical Microscopy (OS)	Optical Microscopy laboratory activity
9	Optical microscopy (OS) Digital Image Analysis (OS)	
10	Stereology (OS)	Digital Image Analysis and Stereology laboratory activity

* The lecture topics occur in the weeks indicated. The activities are listed against their corresponding lecture topic but this is not necessarily the specific weeks in which they are issued or submitted. Laboratory classes are held in selected weeks during Weeks 2-10 of Term (the laboratory schedule will be issued separately after Week 1 when class enrolment is finalised).

OS = Owen Standard, SC = Sherry Chang

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 structural parameters such as lattice parameters, unit cell volumes, and densities of crystalline phases from measured XRD patterns. 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.	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
Laboratory Work:	Laboratory classes will be held as online or face-to-face for the following: 1) Metallographic Sample Preparation: Students will learn correct methodology to prepare metallographic specimens suitable for examination by optical microscopy and SEM. 2) Powder X-ray Diffractometry: The principle of operation of a powder X-ray diffractometer will be demonstrated to students 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. 3) Electron Microscopy: SEM operating principles will be employed in an SEM online tutorial to the imaging of a specimen and compositional/topographical analysis. 4) Optical Microscopy: students will learn the correct operation of an inverted optical microscope and to examine and interpret the effect of microscope settings on the resultant micrograph image. 5) Digital image Analysis and Stereology: students will learn about basic digital image processing operations and use these to process selected material micrographs; 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.	15%	Week 10

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 characterisation 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 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 $\geq 35\%$ in the mid-term exam and $\geq 35\%$ in the final exam, and $\geq 45\%$ 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 report that were not answered correctly. Feedback will be provided through Moodle, two weeks after submission.

Midsession exam: 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: 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>, and
- The *ELISE* training site <http://subjectguides.library.unsw.edu.au/elise/presenting>

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

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.
- *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>