



Course Outline

MATS3002

Fundamentals of Ceramic Processing

Materials Science and Engineering

Science

T1, 2022

1. Staff

Position	Name	Email	Consultation times and locations	Contact Details
Course Convenor	Dr Owen Standard	o.standard@unsw.edu.au	Room 243A, Hilmer Building (Building E10) by appointment (please contact by email)	Phone: 9065 5356
Lecturer	Prof Chris Sorrell	c.sorrell@unsw.edu.au	Room 248, Hilmer Building (Building E10) by appointment (please contact by email)	Phone: 9385 4421

2. Course information

Units of credit: 6

Pre-requisite(s): MATS2003 and MATS2008

Timetabling website: <http://timetable.unsw.edu.au/2022/MATS3002.html>

Teaching times and locations:

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

*Laboratory classes are completed as face-to-face classes or online (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

Processing of ceramics and its relationship to structure, properties and performance of ceramic materials; Starting materials, ceramic processing fundamentals, and processing technology taught in context of the main classes of ceramic materials (polycrystalline monolithic ceramics, glasses, and films/coatings) and the determination of structure, properties and performance; Ternary phase equilibria in ceramic systems.

2.2 Course aims

The Course is a core course in Year 3 of the BE in Materials Science and Engineering and is intended to teach students the fundamentals of ceramic materials and their processing and the importance of processing in determining the composition-microstructure-property relationships for ceramic products. Specific objectives include:

- Understand the main processes and technology involved in the manufacture of the each of the main classes of ceramic products from the initial raw materials through to finished products.
- Understand the critical importance of ceramic processing in determining the composition-microstructure-property relationships for ceramic materials.
- Understand the raw materials used to manufacture ceramic products, the chemical and physical material changes that take place when manufacturing a ceramic, and the resultant effects on microstructure and properties.
- Ability to determine fundamental design aspects and perform calculations relevant to specific forming operations, drying operations, and firing operations used in ceramic processing.
- Understand and design basic processing routes for ceramic materials and components, and undertake practical problem solving.

2.3 Course learning outcomes (CLO)

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

1. Identify key features pertaining to the design and operation of powder processing equipment, forming equipment, dryers, and kilns used in industrial ceramic processing.
2. Design basic processing routes suitable for the forming of specific types of ceramic products, including selection of specific equipment and identification of potential processing problems and their prevention.
3. Predict and explain the effect of heat treatment conditions on the high temperature reactions of specific ceramic materials and resultant microstructure and properties.
4. Perform calculations related to static and kinetic aspects of drying and firing processes used in ceramic manufacturing
5. Solve problems and undertake design in the area of ceramic processing.

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, 3.2, 3.4 & 3.6	1, 2, 3 & 4
CLO 2	1.3, 3.2, 3.4 & 3.6	Lab report Assignment 1
CLO 3	1.3, 1.4 & 2.2	Assignment 2 Mid-term exam Final exam

CLO 4	1.3, 1.4 & 2.2	Assignment 1 Assignment 2 Mid-term exam Final exam
CLO 5	1.3, 1.4, 2.2 & 3.2	Mid-term Final exam

3. Strategies and approaches to learning

3.1 Learning and teaching activities

(Based on UNSW Learning Guidelines)

- *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, both qualitatively and quantitatively, in the processing of ceramic materials. This is facilitated by interactive 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 ceramic processing is challenging – students will apply this to real-world ceramic materials and processing 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 introductory materials science, physics, chemistry, materials characterisation, kinetics and diffusion, phase equilibria, heat transfer, etc.

- *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 principles of several key areas of materials science and engineering (including physical properties, heat transfer, diffusional and kinetics, and phase equilibria) to understand and investigate the importance and role of ceramic processing operations on the resultant composition, structure, and properties of ceramic materials. Students will apply their understanding and skills developed in ceramics processing to interpret technologically-significant engineering ceramic products and to understand the main classes of modern scientific and industrial ceramic products. Also, implicit in the course is the exposure to, and development of, graduate attributes and professional skills (see Section 2).

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 ceramic processing. Students will be able to reflect on the experiments and learn to process data through the lab reports after class.

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 should read through lecture notes and laboratory class notes 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 recommended reference books.
- Students should complete all assessment tasks and submit them on time.
- Students are expected to participate in online discussions.

4. Course schedule and structure

This course consists of 54 hours of class contact hours (48 hours of lectures, 2 hours of laboratory, and 4 hours of formal exams). You are expected to take an additional 54 hours of non-class contact hours to complete study and readings, assessment tasks, and exam preparation spread over the term.

Week	Topic	Activity*
1	Course Introduction (OS) Overview of Ceramic Materials and Processing Operations (OS) Ceramic Raw Materials and their Processing (OS) Ternary Phase Equilibria (CS)	Formative Quiz
2	Ceramic Raw Materials and their Processing (OS) Powder Compaction (OS) Ternary Phase Equilibria (CS)	Formative Quiz
3	Dry Forming Processes (OS) Plastic Formation Processes (OS) Ternary Phase Equilibria (CS)	Formative Quiz Laboratory
4	Plastic Formation Processes (OS) Wet Forming Methods (OS) Ternary Phase Equilibria (CS)	Laboratory
5	Wet Forming Methods (OS) Problem Solving (OS) Ternary Phase Equilibria (CS)	Laboratory
6	Flexibility Week	
7	Mid-term Exam Drying of Ceramics (OS) Ternary Phase Equilibria (CS)	Assignment Pt 1
8	Drying of Ceramics (OS) Ternary Phase Equilibria (CS)	
9	Firing of Ceramics (OS) Ternary Phase Equilibria (CS)	Assignment Pt 2
10	Commercial Ceramic Manufacturing (OS & Guest Lecturer t.b.c.) Ternary Phase Equilibria (CS)	

* The lecture topics occur in the weeks indicated and occur in two streams: ceramic processing (taught by Owen Standard (OS)) and ternary phase equilibria (taught by Chris Sorrell (CS)). The activities are listed against their corresponding lecture topic(s) but this is not necessarily the specific weeks in which they are issued or submitted. Laboratory classes are held in selected weeks during Weeks 2-5,7-9 of Term (the laboratory schedule will be issued separately after Week 1 when class enrolment is finalised).

5. Assessment

5.1 Assessment tasks

Assessment Task	Description	Weight	Due Date
Laboratory:	<p>Plastic Forming: Students observe the operation of a laboratory-scale auger extruder for plastic extrusion of a commercial clay body and will investigate the effect of selected material and extruder parameters on the rate of extrusion and the properties of the extruded/fired product. This laboratory will provide formative assessment of the understanding of ceramic raw materials and their behaviour in plastic forming.</p> <p>Wet Forming: Students will investigate the electrokinetic and rheological behaviour of ceramic particulate suspensions and to analyse their effects on slip casting behaviour and the resultant properties of the cast/sintered materials. This laboratory will provide formative assessment of the understanding of ceramic raw materials and their behaviour in wet forming.</p>	10%	Week 9
Assignment:	<p>Part 1, Psychrometry: Students will undertake psychrometric calculations involving air-water vapour systems and apply them to mass and energy balances calculations for ceramic drying processes. This assignment will provide formative assessment of the understanding of psychrometry as applied to ceramic drying processes.</p> <p>Part 2, Sintering: Students will complete descriptive and numerical problems related to sintering including application of diffusion equations to model specific sintering and grain growth mechanisms, and interpretation of ternary phase equilibrium diagrams. This assignment will provide formative assessment of the understanding of sintering processes as applied to ceramic densification processes.</p>	10% 10% (Total 20%)	Part 1 Week 5 Part 2 Week 7
Mid-term examination:	The mid-session exam will provide summative assessment of understanding and application of ceramic processing operations and ternary phase equilibria learnt in Weeks 1-6. The mid-session exam will be 2 hours in duration.	35%	Week 7
Final examination:	The final exam will provide summative assessment of understanding and application of ceramic processing operations and ternary phase equilibria learnt in Weeks 7-12. The final exam will be 2 hours in duration and held in the UNSW end of semester formal exam period.	35%	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

Assessment criteria and standards for each assessment task are available on the course Moodle page.

NOTE: 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

- Unless otherwise specified in the task criteria, all assignments and laboratory reports must be uploaded via Moodle prior to the stated submission deadline.
- 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 have a disability that requires some adjustment in their teaching or learning environment are encouraged to discuss their study needs with the course coordinator and/or UNSW Equitable Learning Services (<https://www.student.unsw.edu.au/els>) prior to, or at the commencement of, the course. Early notification is essential to enable any necessary adjustments to be made. Any adjustments will be approved by the University in writing.
- Rules governing conduct during exams are given at: <https://student.unsw.edu.au/exam-rules>

5.4. Feedback on assessment

Formative in-class quiz: Feedback from this quiz will be given prior to the census date and allow students to determine how they are progressing in the course.

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 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 course 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>

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

There is no single textbook for the course. Below is a list of reference books which students may find useful (although some a bit old they are authoritative texts in the discipline).

- M. Barsoum, *Fundamentals of Ceramics, Second Edition*. McGraw Hill, 2019.
- C. Burt, *Sintering of Ceramics: Prominent Processes and Methods*. NY Research Press, 2015.
- C.G. Bergeron and S.H. Risbud, *Introduction to Phase Equilibria in Ceramics*. American Ceramic Society, 2004.
- Y.-M. Chiang, D.P. Birnie, and W.D. Kingery, *Physical Ceramics. Principles for Ceramic Science and Engineering*. John Wiley and Sons, 1997
- D. Ganguli and M. Chatterjee, *Ceramic Powder Preparation: A Handbook*. Kluwer Academic Publishers, 1997.
- R.M. German, *Sintering Theory and Practice*. John Wiley and Sons, 1996.
- F.A. Hummel, *Introduction to Phase Equilibria in Ceramic Systems*. Marcel Dekker, 1984.
- R.E. Loehman, *Characterisation of Ceramics*. Butterworth-Heinemann, 1993.
- W.D. Kingery, H.K. Bowen, and D.R. Uhlmann, *Introduction to Ceramics, Second Edition*. Wiley, 1976.
- R. König, *Ceramic Drying*. Novokeram, 1998.
- M.N. Rahaman, *Ceramic Processing, Second Edition*. CRC Press, 2017.
- M.N. Rahaman, *Ceramic Processing and Sintering, Second Edition*. CRC Press, 2003.
- M.N. Rahaman, *Sintering of Ceramics*. CRC Press, 2007.
- James S. Reed, *Principles of Ceramics Processing, Second Edition*. John Wiley and Sons, 1995.
- T.A. Ring, *Fundamentals of Ceramic Powder Processing and Synthesis*. Academic Press, 1996.
- H. Saka, *Introduction to Phase Diagrams in Materials Science and Engineering*. World Scientific Publishing, 2019.
- W.E. Worrall, *Ceramic Raw Materials, Second Edition*. Pergamon Press, Oxford, 1982.

The majority of these books are in the UNSW library. Students seeking resources can also obtain assistance from the UNSW Library: <https://www.library.unsw.edu.au>

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

8. Administrative matters

School Office: Room 137, Hilmer Building E10

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>