Course Outline

MATS3002

Fundamentals of Ceramic Processing

Materials Science and Engineering

Science

T2, 2020

1. Staff

Position	Name	Email	Consultation times and locations	Contact Details
Course Convenor	Dr Owen Standard	o.standard@unsw.edu.au	Room 243A, School of Materials Science and Engineering (Building E10) by appointment (please contact by email)	Phone: 9385 4437
Lecturer	Prof Chris Sorrell	c.sorrell@unsw.edu.au	Room 248, School of Materials Science and Engineering (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/2020/MATS3002.html#S1-8530

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

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 reports 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 watching recorded lectures, 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 Course Information below).

Lectures: The core concepts will be taught in recorded lectures, students will have access to the lectures notes for annotation during the lecture. Students will be engaged in the learning process through class discussions (if requested).

Labs: Experimental techniques and procedures will be taught through online laboratory class and laboratory reports following the class. Students will actively complete the online laboratory class 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.

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.
- Students must read through lecture notes and lab sheets prior to class
- During online classes (if requested), 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 are expected to participate in online discussions (if requested) through the Moodle page

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 laboratory class is nominally 2 hrs. The formal mid-term and final exams are nominally 2 hours each. You are expected to take an additional 60 hours (6 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	Topic	Activity
1	Overview of ceramic materials and processing operations Ceramic raw materials and their processing	
2	Ceramic forming Dry forming processes Plastic formation processes	
3	Plastic formation processes Wet forming methods	Formative Quiz
4	Wet forming methods Drying of ceramics	Laboratory
5	Drying of ceramics Mid-term exam	Assignment Pt 1
6	Study Week	
7	Firing of ceramics	Assignment Pt 2
8	Firing of ceramics Ternary phase diagrams and specialised sintering processes	
9	Ternary phase diagrams and specialised sintering processes	
10	Ternary phase diagrams and specialised sintering processes	

5. Assessment

5.1 Assessment tasks

Assessment task	Description	Weight	Due date
Laboratory Review Questions:	Owing to the COVID-19 medical emergency a face-to-face lab. class is not possible and instead students complete this online activity incl. review questions. The online lab. activity consists of video demonstrations of: Extrusion: Investigation of 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. Slip casting: Investigate of rheological behaviour of ceramic particulate suspensions and their effects on slip casting behaviour. This laboratory will provide formative assessment of the understanding of ceramic raw materials and their behaviour in plastic and wet forming.	10%	Week 5
Assignment:	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. 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.	10% 10% (Total 20%)	Part 1 Week 7 Part 2 Week 10
Mid-term examination:	The mid-session exam will provide summative assessment of understanding and application of ceramic processing operations learnt in Weeks 1-6 up to and including Drying of Ceramics. The mid-session exam will be 2 hours in duration.	35%	Week 5
Final examination:	The final exam will provide summative assessment of understanding and application of sintering theory and ternary phase diagrams 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%	Formal 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.
- Owing to the course being run as distance delivery this term (and due to the ongoing stress and inconvenience on students arising from the COVID19 situation) normal UNSW grading (HD, DN, CR, PS, FL) will not apply to the course in T2-2020. Instead students will receive results of **SY (satisfactory), FL (Fail), or UF (Unsatisfactory Fail)**.
- Satisfactory performance in the course requires completion of all assessment tasks, a score of at least 40% for the overall exam component (i.e., mid-session exam and final exam marks combined), and a total mark in the course of at least 50%.
- 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

- Unless otherwise specified in the task criteria, all assignments must be uploaded via Moodle prior to the due date for submission.
- Assignments/lab reports submitted after the due date for submission will receive a 20% of maximum grade penalty 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 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 prior to, or at the commencement of, their course, or with the Equity Officer (Disability) in the Equity and Diversity Unit: https://student.unsw.edu.au/disability. Early notification is essential to enable any necessary adjustments to be made.
- 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 report: 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: 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

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 references which students may find useful.

- ASM International, Engineered Materials Handbook, Volume 4: Ceramics and Glasses. The Materials Research Society, 1991.
- M. Barsoum, Fundamentals of Ceramics. McGraw Hill, New York, 1997.
- W. Bender and F. Handle, Brick and Tile Making, Procedures and Operating Practice in the Heavy Clay Industries. Bauverlag GmbH, Berlin, 1982.
- H. Beutelspacher and H.W. van der Marel, Atlas of Electron Microscopy of Clay Minerals and their Admixtures. Elsevier Publishing Company, Amsterdam, 1968.
- W.E. Brownell, Structural Clay Products. Springer - Verlag, New York, 1976
- Y.-M. Chiang, D.P. Birnie, and W.D. Kingery, Physical Caramics. Principles for Ceramic Science and Engineering. John Wiley and Sons, New York, 1997
- W.F. Ford, Institute of Ceramics Textbook Series 4: Effect of Heat on Ceramics. Maclaren, London 1967.
- D. Ganguli and M. Chatterjee, Ceramic Powder Preparation: A Handbook. Kluwer Academic Publishers, Boston, 1997.
- R.M. German, Sintering Theory and Practice. John Wiley and Sons, New York, 1996
- W.D. Kingery (Editor), Ceramic Fabrication Processes. Tech. Press of Mass. Inst. of Tech., Cambridge, Massachusettes, 1968.
- W.D. Kingery, H.K. Bowen, D.R. Uhlmann, Introduction to Ceramics, Second Edition. Wiley, New York, 1976.
- R. König, Ceramic Drying. Novokeram, Krumbach, Germany, 1998.
- R.E. Loehman, Characterisation of Ceramics. Butterworth-Heinemann, Boston, 1993.

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

- F. Moore, Institute of Ceramics Textbook Series II: Rheology of Ceramic Systems. Maclaren, London. 1965.
- D. Ganguli and M. Chatterjee, Ceramic Powder Preparation: A Handbook. Kluwer Academic Publishers, Boston, 1997.
- R.E. Grim, Applied Clay Mineralogy. McGraw-Hill, New York, 1962.
- R.E. Grim, Clay Mineralogy, 2nd Edition. McGraw-Hill, New York, 1968.
- R.W. Grimshaw, The Chemistry and Physics of Clays and Allied Ceramic Materials, 4th Edition. Wiley-Interscience, New York, 1971.
- H. Insley and V.D. Frechette, Microscopy of Ceramics and Cements including Glasses, Slags, and Foundary Sands. Academic Press Inc., New York, 1955.
- J.T. Jones and M.F. Berard, Ceramics: Industrial Processing and Testing, 2nd Edition. The Iowa State University Press, Ames, Ohio, 1993.
- W.D. Kingery (Editor), Ceramic Fabrication Processes. Tech. Press of Mass. Inst. of Tech., Cambridge, Massachusettes, 1968.
- R. König, Ceramic Drying. Novokeram, Krumbach, Germany, 1998.
- R.E. Loehman, Characterisation of Ceramics. Butterworth-Heinemann, Boston, 1993.
- F.H. Norton, Elements of Ceramics, 2nd Edition. Addison-Wesley, Reading Massachusettes, 1974.
- M.N. Rahaman, Ceramic Processing and Sintering. Marcel Dekker, Inc., New York, 1995.
- T.A. Ring, Fundamentals of Ceramic Powder Processing and Synthesis. Academic Press, San Diego, 1996.
- F. Singer and S.S. Singer, Industrial Ceramics. Chapman and Hall, London 1963 (reprinted 1978).
- T.A. Ring, Fundamentals of Ceramic Powder Processing and Synthesis. Academic Press, San Diego, 1996.
- L.J. Thomas, An Introduction to Mining. Hicks Smith and Sons, 1973.
- 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 – a starting point for assistance is: https://www.library.unsw.edu.au

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