Course Outline

MATS6008

Advanced Functional Materials

Materials Science and Engineering

Science

T2, 2022

1. Staff

Position	Name	Email	Consultation times and locations	Contact Details
Course Convenor	Prof. Jan Seidel	jan.seidel@unsw.edu.au	Room 340, School of Materials Science and Engineering (Building E10), by appointment	Phone: 9385 4442

2. Course information

Units of credit: 6

Pre-requisite(s): None

Timetabling website: TBA

Teaching times: **lectures are pre-recorded, every Tuesday 9am a live consultation / tutorial / student feedback session will be held using Blackboard (Moodle)**

MATS6008

Week	Tuesday 3-5pm	Thursday 2-4pm
1	Lecture	Lecture / consultation
2	Lecture	Lecture / consultation
3	Lecture	Lecture / consultation
4	Lecture	Lecture / consultation
5	Lecture	Lecture / consultation
6		
7	Lecture	Lecture / consultation
8	Lecture / lab (online)	Lecture / lab (online)
9	Lecture / lab (online)	Lecture / lab (online)
10	Lecture / review	Lecture / consultation

2.1 Course aim and description

Aim: This course aims to provide students with a detailed understanding of a range of functional materials. These are a rapidly emerging class of materials that exhibit novel physical properties and find applications in a wide range of fields such as catalysis, electronic devices, actuators and sensors.

Description: Students will investigate the design, composition, processing methods, structure, physical properties and applications of a range of advanced functional materials. You will learn a number of techniques associated with the fabrication and physical property testing of functional materials. You will explore how the properties of these materials can be tuned through careful control over material chemistry or the fabrication method chosen for their production. You will learn to apply what you have learned to design new functional materials suitable to specific applications from the viewpoint of Materials Science and Engineering.

Teaching Strategies and Rationale

Key teaching/learning activities in the course include lectures. Lectures will cover core concepts, theories and approaches, which will then be contextualised and consolidated through assignments. Teaching material will utilise real-world key studies in the development of these materials to provide students with an opportunity to identify, evaluate and reflect on the innovative solutions these materials provide worldwide and locally. Where applicable, the course will use online learning technologies to consolidate, support and extend student learning.

Course Learning Outcomes- Make a higher level

1. Compare the key structural elements of particular sub-classes of functional materials that control their behaviour.
2. Apply an understanding of these materials' behaviour to the design of new materials with novel properties
3. Examine the relationships between composition, processing route, microstructure, properties and applications of advanced functional materials.
4. Critique how variations in composition and processing route can lead to the tuning of properties for specific applications.

Assessments

1. Assignment 1 30%
   You will be required to undertake brief essay-style writing and calculations involving the application of modern advanced materials topics covered throughout the course. This assignment will enable you to achieve the desired learning outcomes and develop graduate attributes.

2. Assignment 2 (Lab report) 25%
   You will be required to undertake data analysis and simple calculations involving the concepts and phenomena on modern advanced topics covered throughout the course. This assignment will enable you to achieve the desired learning outcomes and develop graduate attributes.

3. End of Session Examination 45%
   This exam is devoted to all parts of the course consisting of lectures, nominated reading material and assignments and will include, where appropriate, relevant equations. It will consist of a combination of essay-style answers and calculations. (2hrs)

2.1 Course summary

The last few decades have witnessed tremendous growth in functional materials that exhibit novel electronic, thermal, magnetic or ferroelectric behaviours. Such materials underpin advances in a range of fields including information technology, energy storage, catalysis, water purification etc. This includes a range of so-called '2-D' materials such as graphene.

Course content:

- Introduction to advanced functional materials and nanotechnology: definitions and background, a brief history, scales and sizes, size effects, elegant examples from nature and materials science, nanotechnology as business - jobs and products.
- Functional materials applications: 2D, 1D, and 0D - Thin films and interfaces, nanotubes, nanowires and nanoparticles, bio-nanotechnology and medical applications, surface coatings, sensors, energy applications – photovoltaics, batteries, supercapacitors, water splitting, fuel

cells, H2 storage, catalysis, nano-optics - near field optics, plasmonics; nanoelectronics - dimensionality, Coulomb blockade, resonant tunnelling, electron localisation.

- Functional materials characterization: Spectroscopy (UV-VIS-IR, THz, Raman, XRD, XAS, XPS/UPS, EPR/ESR/NMR, RBS, SIMS), Microscopy (SPM, TEM, SEM, …).
- Functional materials synthesis: a brief history of human history and materials, energy and matter - units and terminology, Fabrication techniques: nanolithography/imprint, MBE, PLD, ALD, VLS, sputtering, thermal/e-beam evaporation, CVD, arc synthesis, liquid based synthesis, self-assembly, Langmuir-Blodgett technique.
- lab classes on advanced solar cell materials and advanced scanning probe characterization (KPFM) of such materials

2.2 Expectations of students

- Students must read through lecture notes and lab sheets.
- During class, students are expected to engage actively in class discussions.
- 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.

2.3. Assessment comments

- Unless otherwise specified in the task criteria, all assignments must be handed in to the lecturer prior to or on the due date for submission.
- Assignments submitted after the due date for submission will receive a 10% of maximum grade penalty for every day late, or part thereof.
- Students unable to submit assignments on time or attend the mid-term or final exams on health grounds should make a request for special consideration. 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.
- Students who fail to achieve a score of at least 40% for final exam but achieve a final mark >50% for the course, may still be awarded a UF (Unsatisfactory Fail) for the course.
- Please refer to the UNSW guide to grades: https://my.unsw.edu.au/student/academiclife/assessment/GuideToUNSWGrades.html
- Rules governing conduct during exams are given at: https://student.unsw.edu.au/exam-rules

2.4. Feedback on assessment

Assignments: Feedback will be given after submission of the assignment and take the form of the marked assignment, comments on how the class performed, and any common areas that were not answered correctly. Additionally, personal feedback and how each student performed may be given. A solution sheet for each assignment, showing the worked answers and relevant comments, will be uploaded onto Moodle after their submission.

Final exam: Students will receive their final mark.

2.5. Literature and resources

Preferred textbooks:

- Gateway to Nanotechnology, Sanghera, Paul Infonential, ISBN: 978-1-4392308-7-9

Other suitable books at elementary level:

- *Introduction to Nanoscience*: S. M. Lindsay, Oxford University Press, 2010.
- *Nanophysics and Nanotechnology*: E. L. Wolf, Wiley-VCH,2004.
- *Nanoscale Multifunctional Materials*: S. M. Mukhopadhyay, Wiley, 2012.
- *Nanostructures & Nanomaterials*: G. Cao, Imperial College Press, 2004.
- *Nanotechnology – A Crash Course*: R. J. Martin-Palma and A. Lakhtakia, SPIE Press, 2010.
- *Optical Properties and Spectroscopy of Nanomaterials*: J. Z. Zhang, World Scientific, 2009.
- *Functional Metal Oxide Nanostructures*: J. Wu, J. Cao, W.-Q. Han, A. Janotti, and H.-C. Kim, Springer, 2010.
- *Computational Approaches to Energy Materials,* A. Walsh, A.A. Sokol and C. R. A. Catlow, Wiley Publications, 2013
- *Scanning Probe Microscopy Atomic Force Microscopy and Scanning Tunneling Microscopy*: Bert Voigtländer. Springer, 2015.

2.5. 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/

2.5. 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