Course Outline

MATS6105

Chemical Properties of Materials

Materials Science and Engineering

Science

T3, 2019
1. Staff

<table>
<thead>
<tr>
<th>Position</th>
<th>Name</th>
<th>Email</th>
<th>Consultation times and locations</th>
<th>Contact Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Convenor</td>
<td>A/Prof. Sammy L.I. Chan</td>
<td><a href="mailto:sli.chan@unsw.edu.au">sli.chan@unsw.edu.au</a></td>
<td>Room 245, School of Materials Science and Engineering (Building E10), by appointment</td>
<td>Phone: 9385 4441</td>
</tr>
</tbody>
</table>

2. Course information

Units of credit: 6
Pre-requisite(s):
Timetabling website: TBA
Teaching times and locations:

<table>
<thead>
<tr>
<th>Part 1:</th>
<th>Lecture</th>
<th>Lecture</th>
<th>Lecture</th>
<th>Laboratory</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day</strong></td>
<td>Tuesday</td>
<td>Wednesday</td>
<td>Friday</td>
<td>See the timetabling website for details</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>Chemical Science</td>
<td>Electrical Engineering</td>
<td>Webster Theatre A</td>
<td></td>
</tr>
<tr>
<td><strong>M17</strong></td>
<td></td>
<td>G22</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Time</strong></td>
<td>11:00-13:00</td>
<td>14:00-16:00</td>
<td>9:00-11:00</td>
<td>3-9</td>
</tr>
<tr>
<td><strong>Weeks</strong></td>
<td>2-5</td>
<td>2-5</td>
<td>1-5</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Part 2:</th>
<th>Lecture</th>
<th>Lecture</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day</strong></td>
<td>Tuesday</td>
<td>Wednesday</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>Rupert Myers Theatre</td>
<td>Law Theatre G23</td>
</tr>
<tr>
<td><strong>Time</strong></td>
<td>114:00-16:00</td>
<td>14:00-16:00</td>
</tr>
<tr>
<td><strong>Weeks</strong></td>
<td>6-10</td>
<td>6-10</td>
</tr>
</tbody>
</table>

2.1 Course summary

This course covers the chemical properties of materials, especially corrosion and oxidation. Focus is placed on strategies to prevent the corrosion and oxidation of engineering materials. Students will understand the practical consequences of corrosion and oxidation and the role of materials selection and design in reducing these phenomena.
2.2 Course aims
To learn the behaviour of surfaces, wear and friction phenomena, electrochemical series, corrosion and corrosion prevention, and applications of electrochemistry in materials technology. Examples of materials selection for corrosion and wear resistance, energy materials, and processing of materials by electrochemical means will be introduced to illustrate some of these principles involved.

2.3 Course learning outcomes (CLO)
At the successful completion of this course you (the student) should be able to:
1. Understand the theories of different surface treatment processes and the properties of surfaces produced, so as to employ surface treatment processes professionally in engineering applications.
2. Understand the relationships between materials, microstructures and environments on corrosion behaviour of metals.
3. Enhanced critical thinking, analytical and problem-solving skills in corrosion science and engineering to stop or prevent corrosion from happening.
4. Understand advanced electrochemistry and its applications in materials technology.

2.4 Relationship between course and program learning outcomes and assessments

<table>
<thead>
<tr>
<th>Course Learning Outcome (CLO)</th>
<th>LO Statement</th>
<th>Program Learning Outcome (PLO)</th>
<th>Related Tasks &amp; Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLO 1</td>
<td>Understand...</td>
<td>3</td>
<td>1 &amp; 3</td>
</tr>
<tr>
<td>CLO 2</td>
<td>Understand...</td>
<td>2</td>
<td>1, 2 &amp; 3</td>
</tr>
<tr>
<td>CLO 3</td>
<td>Enhanced...</td>
<td>2 &amp; 5</td>
<td>1, 2, 3 &amp; 4</td>
</tr>
<tr>
<td>CLO 4</td>
<td>Understand...</td>
<td>3 &amp; 4</td>
<td>4</td>
</tr>
</tbody>
</table>

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 will read, write, discuss, and engage in analysing the course content.
• Effective learning is supported by a climate of inquiry where students feel appropriately challenged.
Students are expected to be challenged by the course content and to challenge their own preconceptions, knowledge, and understanding by questioning information, concepts, and approaches during class and study.

• Learning is more effective when students’ prior experience and knowledge are recognised and built on.

Coursework, tutorials, assignments, laboratories, examinations, and other forms of learning and assessment are intended to provide students with the opportunity to cross-reference these activities in a meaningful way with their own experience and knowledge.

• Students become more engaged in the learning process if they can see the relevance of their studies to professional and disciplinary contexts

The course content is designed to incorporate both theoretical and practical concepts, where the latter is intended to be applicable to real-world situations and contexts.

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 work through lecture, 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
## 4. Course schedule and structure

This course consists of 38 hours of class contact hours. You are expected to take an additional 112 hours of non-class contact hours to complete assessments, readings and exam preparation.

<table>
<thead>
<tr>
<th>Week</th>
<th>Topics</th>
<th>Activity</th>
</tr>
</thead>
</table>
| 1    | Introduction to corrosion  
Basic principles and classifications of corrosion |                                |
| 2    | Thermodynamics of corrosion 1  
Thermodynamics of corrosion 2  
Electrode kinetics 1 |                                |
| 3    | Electrode kinetics 2  
Passivity and pitting |                                |
| 4    | Atmospheric corrosion and oxidation  
Corrosion in soil and biological corrosion |                                |
| 5    | Corrosion under stress  
Revision | Written assignment-corrosion |
| 6    | Structure of electric double layer | Written assignment-corrosion  
Mid-term exam (Tuesday 11:00 Chemical Sci M17) |
| 7    | More applications of Pourbaix diagrams  
Advanced electrode kinetics and applications 1 |                                |
| 8    | Group Project |                                |
| 9    | Advanced electrode kinetics and applications 2  
Energy Materials | Group Project |
| 10   | Project presentation | Group Project presentation |

### Course Content

**Part I - Surface Treatments**

- *Introduction*- Purposes of surface treatments, types of surface treatments, selection of surface treatments, surface hardening of steel by thermal treatment
- *Surface Hardening of Steel*- Different case hardening processes, carburising, nitriding, diffusion and equilibrium
- *Thermal Spray Coating*- Basic theory of thermal spray, properties of thermal spray coating, applications of different thermal spray processes.
- *Coating by electrochemical/chemical methods*- Electroplating, electrodeposition, electroless plating, anodizing, chemical conversion coatings, galvanising.
• **Physical Vapour Deposition (PVD) and Chemical Vapour Deposition (CVD)**- Thermal evaporation, sputtering, ion implantation, advantages and disadvantages of PVD, thermal CVD, plasma CVD, thin film coating by CVD, structure building on surface by CVD.

**Part II - Corrosion and Control**

• **Introduction to corrosion**- Importance of corrosion control, basic principles and classifications of corrosion

• **Thermodynamics of corrosion**- Electrochemical, galvanic and electrolytic cells, standard electrode potentials, Nernst equation, Pourbaix diagrams and their constructions, applications and limitations.

• **Electrode kinetics**- Exchange current density, polarization, electrode kinetics, Evans diagrams, combined polarization, effect of polarization on corrosion rate.

• **Passivity and pitting**- Anodic passivation, stability of passivity and Flade potential, maintenance of passivity and breakdown of passivity.

• **Atmospheric corrosion and oxidation**- Types of atmosphere for corrosion, atmospheric corrosion of different metals, introduction to high temperature corrosion.

• **Corrosion in soil and biological corrosion**- Corrosivity of soil, control of soil corrosion of metals, types of biological corrosion.

• **Corrosion under stress**- Stress corrosion cracking, hydrogen embrittlement and corrosion fatigue.

**Part III- Advanced Chemistry of Materials**

• **Structure of electric double layers**- Interfaces and interphases, electric double layers, structure of interphases, isotherms for ionic adsorption on electrodes, adsorption of molecules at interfaces.

• **More applications of Pourbaix diagrams**- Use of Pourbaix diagram in battery science, extraction, refining and processing of metals and materials.

• **Advanced electrode kinetics and applications**- Kinetics of interfacial charge transfer, thermal activation and activation energies of electrochemical reactions, current density/potential correlations for different limiting conditions, reaction controlled current voltage curve, electrocatalysis, electrodeposition, electroforming, electrochemical machining, electrochemical etching, electroplating, electroless plating.

• **Energy materials**- Battery characteristics, battery specifications, evaluation of battery performance, battery components, present battery systems, batteries under development, fuel cells, other energy materials.
5. Assessment

5.1 Assessment tasks

<table>
<thead>
<tr>
<th>Assessment task</th>
<th>Description</th>
<th>Weight</th>
<th>Due date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual assignment:</td>
<td>Four short ongoing assignments on the following topics:</td>
<td>30%</td>
<td>Week 5, Week 6, Week 9, Week 11</td>
</tr>
<tr>
<td>Corrosion Labs:</td>
<td>Lab 1 can be performed by each student on their own. Lab 2 the students will be divided into groups of 5 ~ 6, depending on the number of students in the class. Details of the labs will be provided in a later stage.</td>
<td>10% (5% each)</td>
<td>Various dates see Moodle</td>
</tr>
<tr>
<td>Mid-term exam:</td>
<td>The in-class exam will cover the topics taught in weeks 1-5.</td>
<td>30%</td>
<td>Week 6</td>
</tr>
<tr>
<td>Group project:</td>
<td>Report: A detailed review of literature on a topical area selected by the group of students based on course material Presentation: 7-10 minute oral presentation given to the class based on the group’s project</td>
<td>30% (25% report, 5% presentation)</td>
<td>Week 10</td>
</tr>
</tbody>
</table>

Further information
UNSW grading system: [https://student.unsw.edu.au/grades](https://student.unsw.edu.au/grades)

5.2 Assessment criteria and standards

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

Students who fail to achieve a score of at least 40% for the mid-session exam but achieve a final mark >50% for the course, will be awarded a UF (Unsatisfactory Fail) for the course.

Please refer to the UNSW guide to grades: [https://student.unsw.edu.au/grades](https://student.unsw.edu.au/grades)

5.3 Submission of assessment tasks

- 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](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.
• Unless otherwise specified in the task criteria, all assignments must be uploaded via Moodle prior to the due date for submission.

• 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.

• Submit hardcopy of your assignments and lab reports in the Assignment Box next to the MSE School Office (Rm 137) by the due date. Also submit electronic copy to Moodle as proof of submission. Late submission without appropriate documentation will receive a penalty of 10% per day late. Work that is more than 10 days late will not be accepted and will receive zero mark.

5.4. Feedback on assessment

Assignments and group project: 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 what questions were answered correctly and incorrectly. Overall comments and worked solutions may be provided to the class.

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.

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7. Readings and resources

Textbooks
- D.A. Jones, Principles and Prevention of Corrosion, 2nd Ed. Prentice Hall

References
- M.G. Fontana Corrosion Engineering, McGrew Hill
- K.R. Trethewey and J Chamberlain, Corrosion- for students of Science and Engineering, Longman
- J.M. West, E. Horwood Basic Corrosion and Oxidation, John Wiley & Sons
- U.R. Evans, An Introduction to Metallic Corrosion, Edward Arnold

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
- Special Consideration: https://student.unsw.edu.au/special-consideration