University of Limerick
Ollscoil Luimnigh

Faculty of
Science + Engineering

# ADVANCED ENGINEERING MATERIALS

## MASTER OF SCIENCE (MSC)


The University of Limerick undertakes programmes of education and research to doctorate level in the following areas: **business, computing, dance, education, engineering, humanities, mathematics, music, social science** and **science**. The extensive modern campus of the University is located on the banks of the River Shannon at the heart of the 640 acre National Technological Park, approximately 3 miles from the centre of Limerick city. The University has excellent educational, cultural, sporting and residential facilities and accommodates some 12,500 students.

## INTRODUCTION

This programme is designed to produce Masters graduates who have an in-depth knowledge of instrumentation involved in Materials analysis and characterisation together with a detailed knowledge of Materials Science, Materials Processing, and Surface Technology. The specialist modules will allow students to become fully briefed in the material science and engineering associated with high strength materials used in the aero-industry or with techniques for materials and coatings selection design, together with the materials selection methods typically employed by engineering consultants. From this knowledge base, graduates could expect to work in many manufacturing sectors or consultancy or, to continue their education to PhD level.

## OBJECTIVES

The objectives of the programme are:

- To provide science, engineering and technology graduates with a competitive edge for a career in high technology manufacturing industries
- To provide graduates with analytical skills and knowledge which prepare them for careers in manufacturing, R & D or product / process design
- To develop graduates with excellence in Materials Science and Engineering capability to underpin National and International Industrial development

Department of
**Civil Engineering and Materials Science**

## PROGRAMME OF STUDY

This Master of Science course is a two Semester plus Summer full time programme based on a modular credit system (90 ECTS) and the course outline is given below. In Semester 1, students study analytical techniques (microscopy, electron microscopy and X-ray analysis; X-ray diffraction; IR-, UV- and Raman-spectroscopy, particle size analysis, NMR spectroscopy, specimen preparation), structure of materials (structure – mechanical property relationships for metals, polymers and ceramics, phase transformations with associated strengthening effects, failure processes), advanced materials processing (manufacturing with metals, ceramics, polymers and composites and typical coating methods).

Semester 1 also includes the study of typical management systems which are needed to standardize and audit manufacturing processes and systems in Industry. Semester 2 involves further study of analytical techniques and modelling software used for materials development / analysis and affords students exposure to Research challenges in Materials Science.
Students choose one elective covering the detailed materials science / engineering associated with composite materials or aerospace metallic materials, and one elective in Semester 2 from either materials selection and design (interaction between material properties and engineering design criteria, in designing components and products for manufacture, computer aided materials selection) or surface degradation and protection (coatings for improved oxidation, corrosion and wear resistance).

During Semester 2 students choose and begin work on a 45 credit research project supervised by world class researchers in Materials Science & Engineering. These projects involve the use of state of the art instrumentation at the University to acquire information on materials and processes suitable for high impact publications or IP protection.

## CAREERS

Graduates will typically pursue careers in manufacturing in metallurgical, ceramic, polymer and composite technologies related to a diverse range of manufacturing sectors e.g. aerospace components and engines (including repair), chemical processing and process plant, power generation plant and many other manufacturing Industries. M. Sc. graduates in Advanced Engineering Materials would also be expected to gain employment in consultancy, research and development, product and process development or quality control and assurance.

## ENTRANCE REQUIREMENTS

Applicants for a Master's programme must normally have a first or second class Level 8 honours degree (NFQ or other internationally recognised equivalent) in a related physical science or engineering subject(s) or equivalent prior learning that is recognised by the University as meeting this requirement. Applicants must also satisfy the English Language Requirements of the University. The University reserves the right to shortlist and interview applicants as deemed necessary.

## PROGRAMME OUTLINE

### SEMESTER 1

- Structure of Materials
- Advanced Characterisation of Materials 1
- Advanced Materials Processing
- Management Systems

Electives (Choose One)
Aerospace Metallic Materials
Composite Materials

### SEMESTER 2

- Advanced Characterisation of Materials 2
- Research Challenges in Materials Science
- Materials Project 1

Electives (Choose One)
- Materials Selection and Design
- Surface Degradation and Protection

### SUMMER

- Materials Project 2

## FEES

Information on fees and semester dates is available from the university webpage **www.ul.ie/finance.**

## CONTACT

Applicants who wish to discuss detailed elements of the programme may contact the Course Director:

Prof. Mike Pomeroy
Email: michael.pomeroy@ul.ie
Tel: +353-61-202 200
Web: www.cems.ul.ie

## HOW TO APPLY

Please apply online at **www.graduateschool.ul.ie**
Postgraduate Admissions Office
Graduate School
Foundation Building
University of Limerick

Tel: +353 61 234377
Fax: +353 61 233287
Email: postgradadmissions@ul.ie
http://www.graduatestudies.ul.ie



UNIVERSITY of LIMERICK

OLLSCOIL LUIMNIGH

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## SEMESTER ONE CORE MODULES outline content

#### MT5001 STRUCTURE OF MATERIALS

Metals (metal structures, equilibrium constitution and phase diagrams, case studies in phase diagrams, driving force for structural change, kinetics of structural change, diffusive transformations, nucleation, displacive transformations, light alloys, steels, alloy steels). Ceramics and glasses (structure of ceramics, mechanical properties of ceramics, cements and concretes). Polymers & composites (structure of polymers, mechanical behaviour of polymers, composites: fibrous, particulate and foamed, wood). Designing with metals, ceramics, polymers & composites. Case Studies and laboratory experiments incorporating examples of mechanical testing, failure analysis, design and materials selection.

#### MT6011 ADVANCED CHARACTERISATION OF MATERIALS 1

Microscopy: image formation, resolution, light microscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM), scanning transmission electron microscopy (STEM), . Diffraction and scattering: elastic and inelastic scattering, Bragg's law, the reciprocal lattice, Laue equations, x-ray diffraction (XRD), selected area electron diffraction in the transmission electron microscope (SAD). Scanning probe microscopy, atomic force microscopy, scanning tunnelling microscopy; Spectroscopy: energy-dispersive x-ray spectroscopy (EDS), x-ray photoelectron spectroscopy (XPS), Fourier transform infrared spectroscopy (FTIR), Raman spectroscopy, solid state nuclear magnetic resonance (NMR), mass spectroscopy, secondary ion mass spectroscopy; Thermal analysis, differential scanning calorimetry; Particle size analysis, porosimetry, surface area measurements.

#### MT6021 ADVANCED MATERIALS PROCESSING

Metallurgical forming: Casting, rolling extrusion, drawing, development of grain structure for specific properties, Polymer processing: extrusion, injection moulding blow moulding, rotational moulding, vacuum forming and related processes processing of cellular polymers, Processing of composites: lay up methods, press / autoclave / resin transfer moulding, RRIM, poltrusion and filament winding, Powder metallurgy and ceramic processing: green fabrication methods, sintering, hot pressing, HIPping, spark plasma sintering, development of microstructure in powder processed materials, Coating methods: PVD methods, CVD methods, electro-deposition and electroforming methods, joining: fusion welding, solid state welding, adhesive bonding and mechanical joining machining: Electromachining (electrochemical and electro-discharge) and mechanical machining

#### MT6031 MANAGEMENT SYSTEMS STANDARDS

Definition of quality systems in terms of management systems and the difference between quality assurance (QA) and quality control (QC): Quality / business function interrelationships – quality / price / delivery: historical development of quality, environmental and health and safety management systems historical development (ISO 9001, ISO 13485, ISO 14001, ISO 19011, OHSAS 18001): Elements of ISO 9001-quality documentation, purpose of quality manual, procedures and work instructions, organising for quality - importance of management commitment and leadership and the role of the quality function within a company: Control of vendors - purchasing criteria and control of raw materials and service suppliers, vendor assessment: Auditing and registration - how to conduct audits, auditor criteria, how to apply for registration and related requirements: Product testing and ISO 9001: ISO 13485 and the conformity of Medical Devices and In-vitro Diagnostic Medical Device according to EEC-decrees 93/42/EEC, 90/385/EEC and 98/79/EEC: Elements of ISO 14001 - environmental aspects and associated impacts: Elements of OHSAS 18001 - hazard identification and risk assessment, environmental and health and safety legislation: outline of the elements of ISO 50001 (energy management), ISO 26000 (corporate social responsibility and sustainability) ISO 20121:2012 (Event sustainability management systems): Quality issues related to Materials and the environment, integrated management systems

# M. Sc. ADVANCED ENGINEERING MATERIALS

## SEMESTER 2 CORE MODULES outline content

**CH6002 RESEARCH CHALLENGES IN MATERIALS SCIENCE**

Detailed overview of advanced research topics in Materials and Surface Science, National and EU programmes in Materials and Surface Science, forefront research in Materials and Surface Science, use of latest experimental techniques used in preparation and analysis in Materials and Surface Science research, exposure to world experts in students own and other specialist area  Support original, independent and critical thinking, and ability to develop theoretical concepts.

**MT6032 ADVANCED CHARACTERISATION OF MATERIALS 2**

Magic Angle Spinning -Nuclear Magnetitic Resonance spectroscopy {MAS-NMR}, Detailed X-ray analysis: e.g. analysis of mesoporous materials, order/disorder, crystallite size, small angle scattering, preferred orientation, residual stress / strain, prediction of X-ray diffraction data using atomistic modelling software, Detailed backscattered electron diffraction analysis, electron and FIB tomography, Fine structure analysis: high energy diffraction (radial distribution function {RDF}), Extended X-ray Absorption Fine Structure {EXAFS} and variants), nanoindentation, profilometry, Materials modelling: understanding of HSC Chemistry, Factsage, Calphad, MTDATA and Dictra packages, molecular dynamics methods, prediction of material properties and FTIR / Raman spectra.

**MT6042 MATERIALS PROJECT 1**

Definition of research project title in conjunction with MSSI member / researcher with potential for development or original information, Definition of problem area, Appraisal of relevant literature, Definition of project aims and objectives, Development of project plan to achieve project aims and objectives, Definition of experimental technique requirements, Preparation and delivery of written and oral interim presentations, Collection of experimental data, rationalisation of that data with existing knowledge, writing up and oral presentation of research findings with clear conclusions derived from the rationalisation. The final deliverable from the research project will be a paper of between 6,000 and 8,000 words which will be reviewed and graded by the project supervisor and an independent academic as well as the external examiner.

## SUMMER CORE MODULE outline content

**MT6003 MATERIALS PROJECT 2**

Continued appraisal of relevant literature, Continued collection of experimental data, rationalisation of that data with existing knowledge, writing up and oral presentation of research findings with clear conclusions derived from the rationalisation. The final deliverable from the research project will be a paper of between 6,000 and 8,000 words which will be reviewed and graded by the project supervisor and an independent academic as well as the external examiner.

# M. Sc. ADVANCED ENGINEERING MATERIALS

## ELECTIVE MODULES outline content

| Elective - Choose Min 1 Max 1 | Elective - Choose Min 1 Max 1 |
|---|---|
| **SEMESTER 1** | **SEMESTER 2** |
| **ME6091 AEROSPACE METALLIC MATERIALS**<br>The chronological development of materials for aircraft structural applications. Quantitative materials selection to determine materials performance indices for selected aircraft components - illustrated by selecting optimised material for fuselage, wing and undercarriage. Properties and processing of metallic monolithic and composite materials. Review and advanced examination of the concepts of stiffness, strength, fracture toughness, stress corrosion, general corrosion, fatigue and damage tolerance. Demonstration of how these properties affect ab initio structural performance and in service degradation. Physical metallurgy and structure property relationships of aluminium alloys, titanium alloys, magnesium alloys, alloy steels metal matrix composites. Corrosion characteristics. Development of new advanced metallic materials and processes to counter the competition from polymer composites | MT5032 MATERIALS SELECTION AND DESIGN<br>[The interaction between material properties and engineering design criteria, in designing components and products for manufacture] Basic principles of materials selection. Assessment of design function. Constraints on property requirements. Selection procedures. Selection for mechanical properties including stiffness, strength, fracture toughness and fatigue resistance. Selection for surface durability. Design considerations. Computer aided materials selection. |
| **MT4107 COMPOSITE MATERIALS**<br>Fundamental concepts of composite materials] Continuous and discontinuous reinforcements. [Ceramic, Metal and Polymer matrix systems] [Stiffness and strength of composites, with particular reference to continuous fibre materials. Macro mechanical and micro mechanical approaches. Laminae and laminates] Geometric considerations. Fatigue behaviour and impact toughness. [Processing techniques] for polymer matrix composites. [Typical applications] including component and material design. | **MT6052 SURFACE DEGRADATION AND PROTECTION**<br>Basic electrochemistry associated with corrosion: electrode potentials, activation overpotential, concentration overpotential, IR drop, potential – current density curves: galvanic, intergranular, selective leaching and differential aeration corrosion mechanisms, mechanically aided corrosion aided corrosion mechanisms – exfoliation, cavitation and stress corrosion cracking: cathodic protection, metallic/ceramic/polymeric coatings for aqueous corrosion protection<br>Thermodynamics and kinetics of high temperature oxidation; thermodynamics and kinetics of high temperature corrosion, corrosion by deposits (gas turbine corrosion) self protection of alloys by formation of chromia or alumina coatings, coating chemistries for oxidation and corrosion protection of alloys, chromide, aluminide and silicide coatings, overlay MCrAlY coatings, smart coatings, formation of coatings<br>Friction & wear, wear mechanisms, adhesive, abrasive (gouging, ploughing) protection from wear - hard material coatings, multi-layered coatings: heat treatments & mechanical working processes to develop wear resistant surface layers |