1.3. Department of Materials Engineering

■ General Information

The Department of Materials Engineering aims to train students to become creative and competent engineers in the field of materials engineering. Students study basic theories of electronic materials engineering and the applied knowledge of metals, composites, ceramics, and electric materials. The major courses in the department include Material Dynamics, Thermodynamics in Metals, Material Science, Ferrous Metallurgy, Ceramic Materials, Polymers, Composite Materials, Nonferrous Metallurgy, Materials Engineering Experiments, and Aircraft Structures. Successful completion of the courses accord a Bachelor's degree of Engineering and students may take exams to obtain certificates for 1st Class Materials Engineer, 1st Class Ceramic Engineer and Thermal Processing Engineer. After graduation, students can advance into industries such as mechanics, ship construction, aviation, and electronics. Students can continue further studies in master's or doctoral programs of graduate schools for more professional research in the field of materials engineering.

■ Objectives

1) To provide a well-rounded education in materials science and engineering to meet the needs in the aircraft and aerospace industry, academies, and government.
2) To train engineers who can provide leadership in the interdisciplinary materials community.
3) To provide fundamental undergraduate level education for further advanced studies in graduate schools to conduct frontier research.
4) To train experts who can meet the ever demanding technological needs in rapidly growing societies all over the world.

■ Courses Offered

Required Course

MA3103 Introduction to Materials for Aerospace Vehicles 3(3) 1-2
MA3213 Elementary Materials Science I 3(3) 2-1
MA3203 Metallurgical Thermodynamics I
MA3207 Material Physics 3(3) 2-1
MA3204 Elementary Materials Science II 3(3) 2-2
MA3204 Metallurgical Thermodynamics II 3(3) 2-2
MA3310 Phase Transformation in Metals and Alloys 3(3) 3-1

MA3211 Introductory Laboratory in Materials 3(3) 2-1
MA3212 Experiments in Materials Engineering Ⅰ 4(3) 2-2
MA3212 Experiments in Materials Engineering Ⅱ 4(3) 3-1
MA3212 Experiments in Materials Engineering Ⅲ 4(3) 3-2
MA3401 Project Ⅰ 3(3) 4-1
MA3401 Project Ⅱ 3(3) 4-2

Elective Courses

MA4219 Test Methods in Materials Engineering 3(3) 2-2
MA4318 Semiconductor Materials 3(3) 3-1
MA3201 Mechanics of Materials 3(3) 3-1
MA4307 Metallography 3(3) 3-1
MA4320 Introduction to Ceramics 3(3) 3-1
MA4319 Introduction to Composite Materials 3(3) 3-1
MA4314 Semiconductor Processing Technology 3(3) 3-2
MA4393 Surface and Thin Film Science 3(3) 3-2
MA4440 Optical Materials 3(3) 3-2
MA3304 Mechanical Behaviors of Materials 3(3) 3-2
MA4323 Introduction Flat Panel Displays 3(3) 3-2
MA4305 X-Ray Diffraction 3(3) 3-2
MA3302 Non-ferrous Materials 3(3) 3-2
MA4442 Instrumental Materials Characterization 3(3) 3-2
MA4313 Transfer Phenomena 3(3) 3-2
MA4331 Material for Energy Device Applications 3(3) 3-2
MA4455 Steel Smelting 3(3) 3-2
MA4421 Display Manufacturing Technology 3(3) 4-1
MA4422 Ferrous Materials 3(3) 4-1
MA4409 Introduction to Polymers 3(3) 4-1
MA4423 Materials and Design 3(3) 4-1
MA4329 Bio-Materials 3(3) 4-1
MA4308 Corrosion and Protection 3(3) 4-1
MA4426 Design of Composite Manufacturing Process 3(3) 4-2
MA4427 Powder Metallurgy and Materials 3(3) 4-2
MA4328 Manufacturing Processes for Engineering Materials 3(3) 4-2
MA4412 Magnetic Materials 3(3) 4-2
MA4450 Joining Technology 3(3) 4-2
MA4430 Ceramic Processings 3(3) 4-2
MA4443 Ceramic Devices and Applications 3(3) 4-2

■ Course Descriptions

MA3103 **Introduction to Materials for Aerospace Vehicles 3(3)**
This course deals with the chronological development of materials for aircraft, manufacturing techniques and characteristics of metallic and non-metallic materials, and examples of their practical applications as well as recent topics relevant to advanced materials for aircraft application.

MA3213 **Elementary Materials Science I 3(3)**
This course provides knowledge on structure-property relationships, deformation, fracture and dislocation behavior of metal alloys, and magnetic, electronic and optical properties of metals and ceramics.

MA3203 **Metallurgical Thermodynamics I**
This course deals with basic concepts and definitions of matter, properties, processes and ideal gases and their applications. The course also includes essential features of first, second, and third laws of thermodynamics and their application to materials, thermodynamics of solutions, phase diagrams and homogeneous and heterogeneous reactions.

MA3207 **Material Physics 3(3)**
This course is an introduction to the physical principles of modern semiconductor devices and their advanced fabrication technology. It describes the basic properties of semiconductors and their conduction processes, with special emphasis on the physics and characteristics of all major semiconductor devices.

MA3204 **Elementary Materials Science Ⅱ 3(3)**
This course focuses on structure-property relationships, deformation, fracture and dislocation behavior of metal alloys, and magnetic, electronic and optical properties of metals and ceramics.

MA3204 **Metallurgical Thermodynamics Ⅱ 3(3)**
The topics of this course are basic thermodynamic principles, which include energy, entropy, and free energy, macroscopic properties of various materials systems such as equilibrium states, phases, and phase transitions, thermodynamics of solutions, phase diagrams, and the application of phase diagrams.

MA3310 **Phase Transformation in Metals and Alloys 3(3)**
This course deals with the studies of phase transformations, nucleation, crystallization, displacives, spinodal decomposition, examination of surface and interface phenomena, sintering, grain growth, recovery and recrystallization, kinetics of chemical reactions, rate equations, reaction mechanisms, transport processes, diffusion equations, and atomic and molecular diffusion.

MA3211 **Introductory Laboratory in Materials 3(3)**
This is a lab course whose goal is to provide an integrated approach to materials science

and engineering. This class is open to junior students in the materials engineering program. The lab is intended to provide students with a broad appreciation of the range and contrast of material structures, processing, and property characterizations, in order that students more fully appreciate the breadth of material science and engineering.

MA3212 **Experiments in Materials Engineering Ⅰ 4(3)**
This course includes laboratory studies of micro-structural characteristics of equilibrium and non-equilibrium phases in metallic materials and the effects of prior treatments or methods of manufacture.

MA3212 **Experiments in Materials Engineering Ⅱ 4(3)**
This course includes laboratory work such as application techniques of strain gages, tensile testing, compression testing, hardness testing, flexural testing, impact testing and fractography using SEM.

MA3212 **Experiments in Materials Engineering Ⅲ 4(3)**
This course includes laboratory work including the processing and fabrication of ceramic composites, ceramic thermistors, and oxide ferro-electric thin films with appropriate techniques in a group of students, with emphasis on teamwork, communications skills, and so on. It also provides discussion on developing an understanding of the trade-offs between design, processing and performance and the fabrication of a deliverable prototype.

MA3401 **Project Ⅰ,Ⅱ 3(3)**
This course focuses on the advanced work of materials engineering in the field through lectures, conferences, assignments and laboratory work.

MA4219 **Test Methods in Materials Engineering 3(3)**
This course focuses on the engineering aspects of the common testing techniques of the mechanical failure of materials, and a wide variety of testing methods which includes tension, compression, hardness, fatigue, creep, and non-destructive testing

MA4318 **Semiconductor Materials 3(3)**
This course covers the electronic properties of semiconductors, P-N junctions, bipolarity, FET transistors, and the processing of Si-oriented IC devices.

MA3201 **Mechanics of Materials 3(3)**
This course provides such fundamental concepts as stress and strains, deformation and displacements, elasticity and inelasticity, and strain energy and load-carrying capacity. These concepts are the basis for the design and analysis of a wide variety of mechanical and structural systems.

MA4307 **Metallography 3(3)**

This course provides fundamental knowledge for understanding structures and their physical properties. Topics include the quantitative description of non-crystalline materials, fractals, the symmetry theory of atomic and molecular arrangements in crystals, principles of space groups and use of the international tables for crystallography used in specifying crystal structure, liquid crystals, point, line, and planar imperfection and it's influence on micro-structure, and structure-property relations.

MA4320 **Introduction to Ceramics 3(3)**
This course provides knowledge of structure-property relationships in ceramic materials, hierarchy of structures from the atomic to micro-structural levels, defects, atom mobility, solid-state electrochemical processes, and phase equilibria of controlling properties for structural and electronic applications of ceramics.

MA4319 **Introduction to Composite Materials 3(3)**
This course provides the concepts the underlying formation, characteristics and behavior of FRP, MMC and CMC, methods of fabrication, testing, and failure mechanisms of mechanical types.

MA4314 **Semiconductor Processing Technology 3(3)**
This course covers theoretical study as well as practical lab training for the relevant processing of semiconductor devices.

MA4393 **Surface and Thin Film Science 3(3)**
This course focuses on the processing of bulk and thin film electronic materials for device and circuit applications, thin films for magnetic, mechanical, and photonic devices, techniques and theory for growth of device quality crystals, integrated circuit fabrication including oxidation, junction formation, and film deposition, relationships among processing, structures, and properties.

MA4440 **Optical Materials 3(3)**
Fundamentals of optical phenomena associated with light-matter interaction are dealt with at an introductory level. In addition, some key photonics materials including metals, semiconductors and dielectrics are discussed along with corresponding commercial optical devices.

MA3304 **Mechanical Behaviors of Materials 3(3)**
This course focuses on defect mechanisms of the flow and fracture of metals, the dislocation theory of plastic deformation, strengthening mechanisms and the testing techniques of the mechanical failure of metals.

MA4323 **Introduction Flat Panel Displays 3(3)**
This course offers students the chance to gain a basic understanding of various flat panel displays such as CRT, LCD, ELD, FED and PDP.

MA4305 **X-ray Diffraction 3(3)**
This course provides knowledge on x-ray and neutron diffraction using Laue's equations, Bragg's law, and reciprocal lattice. Fourier transformation and a series of relations between intensity and distribution of scattering density, applications in identifying materials, texture, and small angle scattering and analysis, and structure determination through diffraction effects are all covered during the course.

MA3302 **Non-ferrous Materials 3(3)**
This course deals with structure-property relationships of nonferrous alloys such as Ni, Al, Cu, Ti, Mg, Zn, etc, and their properties and applications.

MA4442 **Instrumental Materials Characterization**
This course offers students the chance to study the basic operation principles and practical analysis methods of essential instruments widely used for materials characterization. Instruments discussed are optical microscopes, SEM, TEM, DSC, DTA, XPS, SPM, some analytical tools based on synchrotron radiation sources, and so on.

MA4313 **Transfer Phenomena 3(3)**
This course provides knowledge on the definition of viscosity, balances on simple overall mechanical energy balances, elements of laminar flow and turbulent flow, thermal conductivity, steady and unsteady conduction problems, forced and natural convection, heat transfer coefficients, and radiative heat transfer. It also includes the definition of binary diffusivity, convection mass transfer, and mass transfer coefficients.

MA4331 **Materials for Energy Device Applications 3(3)**
This course introduces cutting-edge materials technologies for a variety of energy conversion and storage systems utilizing renewable energy sources. Fundamental mechanisms and structure-property-processing relations of various functional materials for electrical energy conversion/storage devices, such as photovoltaic cells, secondary batteries, capacitors, and fuel cells, are emphasized.

MA4421 **Display Manufacturing Technology 3(3)**
This course deals primarily with the principles and practices of film deposition formed in the vapor phase by physical and chemical methods related to the fabrication of hydrogenated amorphous silicon (a-Si:H) thin film transistors(TFTs) suitable for large-area high resolution active-matrix liquid crystal displays(AMLCDs). Fundamentals of plasma, thin film, and electrochemistry will be covered. Surface analytical techniques on thin films are briefly introduced.

MA4422 **Ferrous Materials 3(3)**
This course deals with structure-property relationships in ferrous alloys, as well as the properties of ferrous materials including irons, steels and cast irons.

MA4409 **Introduction to Polymers 3(3)**

This course covers studies on the types and structures of thermoplastics and thermosets, treatment of materials selection, mechanical characterization and principal fabrication methods.

MA4423 **Materials and Design 3(3)**
Course lectures focus on topics such as state-of-the-art materials and the science of material selection in product design and manufacturing.

MA4329 **Bio-Materials 3(3)**
The target is to understand the role and importance of metallic materials as bio-materials through the study on materials characteristics. In addition, the applications of such materials for real orthopedic and dental fields are studied through special lectures by an orthopedist and dentist who are invited during the semester.

MA4308 **Corrosion and Protection 3(3)**
This course provides principles of corrosion engineering that include the basis of electrochemistry, corrosion mechanisms, definitions, types of corrosive attack and methods of minimization and prevention.

MA **Design of Composite Materials 3(3)**
This course covers stress-strain relationships and the transformation of properties for isotropic materials and classical lamination theory, treatment methods and practices currently used for FRP including failure prediction methods, laminate design procedures and joint design considerations.

MA4427 **Powder Metallurgy and Materials 3(3)**
This course covers studies on powder preparation, characterization, compaction, and the theory of sintering, engineering considerations such as materials design, and processes and economic considerations with applications for automobiles and aerospace.

MA4328 **Manufacturing Process for Engineering Materials 3(3)**
This course deals with subjects in manufacturing which comprise mechanical and physical behaviors of materials in mechanical metallurgy. It also includes stress analysis, tribology, primary and secondary processing of these materials, computer controls, machine tools and economics.

MA4412 **Magnetic Materials 3(3)**
This course focuses on magnetostatics, the origin of magnetism in materials, magnetic domains and domain walls, magnetic anisotropy, reversible and magnetization processes, hard and soft magnetic materials and magnetic recording, and includes special topics including magnetism of thin films, surfaces and fine particles, transport in ferromagnets, magnetoresistive sensors, and amorphous magnetic materials.

MA4450 **Joining Technology 3(3)**

This course includes lectures on non-equilibrium solidification behaviors, microstructural development, residual stresses, and welding defects created during the welding process. In addition, various welding and joining processes including special welding methods will be elucidated.

MA4430 **Ceramic Processings 3(3)**
This course provides an in-depth study of unit operations in processing technical ceramics and its effect on the properties of sintered material, powder production and conditioning, drying, forming, sintering, and microstructure development, relevant aspects of transport phenomena, colloid science, and chemistry, ceramic composite processing, and also includes case studies involving both electronic and structural ceramics.

MA____ **Ceramics Processing**
This course covers the scientific and engineering principles of manufacturing of ceramic products. The course covers powder synthesis and characterization, surface and colloid chemistry, fabrication, and densification by sintering. There is an emphasis on the physical chemistry of particulate systems as relates to the various stages of processing. The course objectives are for the student to (1) become knowledgeable in all steps involved in ceramic manufacture from powder synthesis through final densification by sintering, (2) understand the rationale and compromises for selecting a given processing route, (3) understand and be able to apply the parametric relations for manufacture of a ceramic with a specified microstructure, and (4) understand the physical chemistry fundamentals responsible for the unique properties of fine powders.

MA4443 **Ceramic Devices and Applications 3(3)**
This course covers electrical properties of ceramic materials for passive electronic devices and their operation mechanisms. Materials and processing for various ceramic-based electronic devices are introduced. The role of materials engineering on the device performance improvement is explained by emphasizing structure-processing-property relations of the electroceramics.

■ Minor Courses

Required Courses
Elementary Materials Science I 3(3)
Elementary Materials Science II 3(3)
Mechanical Behaviors of Materials 3(3)

Elective Courses
Introduction to Materials for Aircraft and Aerospace Vehicles 3(3)
Ceramics 3(3)
Ferrous Materials 3(3)

Introduction to Composite Materials 3(3)
Phase Transformation in Metals and Alloys 3(3)
Physics of Materials 3(3)
Manufacturing Processes for Engineering Materials 3(3)