PROGRAMMES OF STUDY

Institute of Applied Physics and Materials Engineering

Doctoral Degree Programme

AREA OF STUDY

- Applied Physics and Materials Engineering

Doctoral Degree Programme

Doctor of Philosophy

- **Applied Physics and Materials Engineering**

Compulsory Courses:		Credits
APME8003	Advanced Instrumentation for Materials Characterization	3
APME8025	Advanced Quantum Mechanics	3
APME8027	Research Ethics	0
APME8028	Research Writing	0
1 Required Elective from the list of Required Electives		3
APME8999	Doctoral Thesis	18
Total Credits:		**27**

List of Requiredl Electives:

APME8001	Solid State Physics	3
APME8007	Thin Film Physics	3
APME8014	Advanced Electrochemical Energy Conversion and Storage	3
APME8020	Advanced Optoelectronics	3
APME8021	Advanced Laser Spectroscopy Technology	3
APME8022	Transmission Electron Microscopy	3
APME8024	Special Topics in Applied Physics and Materials Engineering	3
APME8029	Advanced Inorganic Chemical Synthesis	3
APME8030	Advanced Mechanics of Materials	3
APME8031	Advanced Micro and Nano-systems: from Fundamentals to Applications	3
APME8032	Advanced Organic-Inorganic Engineering Materials	3
APME8033	Nanomaterials and Nanochemistry	3
APME8034	Semiconductor Physics	3
APME8035	Advanced Materials Science and Engineering	3
APME8036	Advanced Electromagnetism and Modern Scattering Techniques	3

Course Description

APME8001 SOLID STATE PHYSICS
In this course, the behavior of atoms and shared electrons in solids will be described by classical physics and quantum mechanics. The discussion of solid with crystalline structure will be one of the emphases. Some properties of crystal such as defects, disorder and thermal vibration will be studied. Then, band theory will be investigated. The physics of p-n junction semiconductor will also be introduced. Materials will be classified by models of magnetism as well as electric properties.
Pre-requisite: None

APME8003 ADVANCED INSTRUMENTATION FOR MATERIALS CHARACTERIZATION
Introduction of commonly used materials characterization methods (XPS, SEM, AFM, XRD, XRF, Raman, XPS), including their theory of operation and hands-on experience. Includes a discussion of the measurement process and instrumental analysis of samples.
Pre-requisite: None

APME8007 THIN FILM PHYSICS
Definition of thin films. Environment and molecular and plasma processes in thin film deposition. Cold and thermal plasma. Requirement for substrate, substrate cleaning. Formation of thin films. Properties of thin films. Mechanical, electrical, thermal, chemical, and optical properties of thin films. Thermal evaporation. Laser ablation, synthesis of nanomaterials. Electrical discharges used in thin film deposition. Practical electric discharge configuration for deposition of thin films, direct current electric discharges, radio-frequency discharges, microwave discharges, electron cyclotron resonance plasma, matching units, floating potential, bias potential, plasma potential, effective bias, self-bias. Physical deposition techniques. Chemical vapor deposition techniques (CVD). Other processing technologies.
Pre-requisite: None

APME8014 ADVANCED ELECTROCHEMICAL ENERGY CONVERSION AND STORAGE
This advanced course introduces principles, mathematical models and implementation of electrochemical energy conversion and storage. The principle of electrochemistry is introduced, including components of an electrolytic cell, Nernst's equation, thermodynamics and electrokinetics. The basic of power conversion is also introduced, including power electronics switches, converters and their control. The applications to batteries, solar cells, fuel cells and other emerging energy generation technologies are explored.
Pre-requisite: None

APME8020 ADVANCED OPTOELECTRONICS
Brief introduction of semiconductor physics and condensed matter physics. Theory of the interaction between light and matter. Optical gain, light transmission and absorption in media. Applications of light emission device and photo-electric transfer device. Principle and structure of selected photoelectric device.
Pre-requisite: None

APME8021 ADVANCED LASER SPECTROSCOPY TECHNOLOGY
Provide essential knowledge for the research frontiers in ultrafast laser spectroscopy and novel optical materials. Topics include: laser fundamentals, linear and nonlinear optical spectroscopy, time-resolved spectroscopy, single molecule spectroscopy, fluorescence and Raman microscopy, optical manipulation, optical properties of novel materials and some optoelectronic applications.
Pre-requisite: None

APME8022 TRANSMISSION ELECTRON MICROSCOPY
Introduction to imaging and diffraction analysis with transmission electron microscopy. Common sample preparation techniques. Basic diffraction theory and imaging principles using different imaging techniques, including bright field, dark field, high resolution and z-contrast imaging.

Working principles of related compositional analysis techniques, including energy dispersive X-ray spectroscopy (EDS) and electron energy loss spectroscopy (EELS). Hands-on operation of the microscope can be optional.
Pre-requisite: None

APME8024 SPECIAL TOPICS IN APPLIED PHYSICS AND MATERIALS ENGINEERING
Any specialized topic in Applied Physics and Materials Engineering chosen by the staff member who has experience in that particular field, but the topic is not covered by the other postgraduate courses in the PhD Programme.
Pre-requisite: None

APME8025 ADVANCED QUANTUM MECHANICS
History and philosophy of quantum mechanics will first be reviewed in this course. Wave function and its statistical interpretation will be investigated. Time-independent Schrodinger equation will be discussed with some examples of infinite square well, finite square well and harmonic oscillator, etc. Then, hydrogen atom will be studied by Schrodinger equations in three dimensions. Furthermore, wave function of two-particle systems, atoms and solids will be introduced. The parts of application cover contents of perturbation theory, variational principle, WKB approximation and adiabatic approximation.
Pre-requisite: None

APME8027 RESEARCH ETHICS
The course provides students with an understanding of the following issues:
- The need for research ethics and the responsibility of the researcher (the student)
- The most common types of academic dishonesty (such as fabrication and plagiarism)
- How to avoid committing acts of academic dishonesty (such as through using citations and references)

Pre-requisite: None

APME8028 RESEARCH WRITING
The course focuses on helping students to make academic presentations whether verbally (as in a conference) or in writing (as in a paper). Topics include:
- How to write a research proposal
- How to structure a presentation (on paper and in power point)
- Tenses used in various parts of a paper presentation
- How to structure clear logical paragraphs
- How to be concise
- How to avoid ambiguity and different writing styles (for example, conventions for use of numbers, abbreviations, etc.)

Pre-requisite: None

APME8029 ADVANCED INORGANIC CHEMICAL SYNTHESIS
Brief introduction of chemistry basics and main focus on classic and emerging inorganic chemical synthesis methods as well as some physical and mechanical approaches for comparison. Some characterization techniques and their chemical principles. Implications of the inorganic synthesis techniques to the research and development in applied physics and materials science.
Pre-requisite: None

APME8030 ADVANCED MECHANICS OF MATERIALS
Basic training for students to understand the advanced mechanics of materials such as elastic behavior, inelastic behavior, anisotropic behavior, fracture behavior, and fatigue. With these knowledge, students will be able to analyze the materials mechanical behavior and wisely use the materials. Students with the knowledge of different mechanical behavior of materials, both isotropic and anisotropic. Pre-requisite: None

APME8031 ADVANCED MICRO AND NANO-SYSTEMS: FROM FUNDAMENTALS TO APPLICATIONS

Overall introduction to miniaturization and microelectromechanical systems (MEMS); Fundamental physics of scaling in micro/nano-worlds; Overview of advanced micro/nano-fabrication materials & technologies & devices; Governing principle of physical phenomenon in micro/nano-scales, e.g. actuation, transduction, resonance, and manipulation, etc.; State-of-the-art applications of micro/nano-systems for interdisciplinary fields.
Pre-requisite: None

APME8032 ADVANCED ORGANIC-INORGANIC ENGINEERING MATERIALS

Briefly introducing basic knowledge of traditional engineering materials including polymer and cement. Mainly focus on: Introduction of organic/inorganic composite and nanocomposite materials; Introduction of polymeric admixtures for high-performance inorganic materials; Crystallization, surface and interface science of composite materials; Achievement of functionalization and ultimate mechanical properties for engineering composites; Design of advanced engineering composites; Industrial processing and application of engineering composites. Students will learn how to apply the basic knowledge of polymer, cement and composite into the design of advanced organic/inorganic engineering materials towards practical applications. They will also have a good impression for the real industrial use of engineering composites.
Pre-requisite: None

APME8033 NANOMATERIALS AND NANOCHEMISTRY

Introduction of low dimensional nanomaterials, e.g. carbon nanotube, graphene and transition metal dichalcogenides, and the corresponding methods of synthesis and characterization. Surface and interface modification of nanomaterials. Band-structure engineering of nanomaterials. Low-dimensional Van del Waals heterostructures. Applications of electronic devices, thermodynamics and fluid dynamics.
Pre-requisite: None

APME8034 SEMICONDUCTOR PHYSICS

Brief introduction of solid-state physics and crystallography. Mainly focus on the knowledge of semiconductor physics, condensed matter physics and semiconductor device physics: Intrinsic semiconductor, doped semiconductor and the carrier transportation in semiconductors will be introduced; the operating principles of some kinds of semiconductor devices will be introduced, such as pn junction, MS junction and FET, as well as the fabrication method and application in present. Also, some commercial semiconductor devices, such as LED and solar cells, will be introduced.
Pre-requisite: None

APME8035 ADVANCED MATERIALS SCIENCE AND ENGINEERING

A historical account of the discovery and development of materials science & engineering, including in-depth discussion of metals, ceramics, semiconductors, and other strongly-correlated electron systems. Fundamental knowledge in development of energy materials and single crystal growth, introduction of the modern neutron & synchrotron X-ray scattering techniques based on worldwide national large facilities, review of the most updated research achievements in the study of advanced functional materials such as spintronic, multiferroicity, superconductivity, spin frustration, spic ice, solar cell, battery, etc.
Pre-requisite: None

APME8036 ADVANCED ELECTROMAGNETISM AND MODERN SCATTERING TECHNIQUES

Magnetism is a very active and challenging subject since it represents a typical many-body problem and a complex application of quantum-mechanics, statistical physics and electromagnetism. During the last decades, new discoveries have emerged such as the high

temperature superconductors and the colossal magneto-resistance manganite compounds. Besides bulk materials, magnetism of thin films and surfaces became a topic of great current interest. A promising new field of application emerges, so-called magneto-electronics with spin transistors. This progress is largely due to new experimental methods and only neutron and synchrotron X-ray scattering would be mentioned.
Pre-requisite: None

APME8999 DOCTORAL THESIS
An independent investigation under the supervision of an institute staff member.
Pre-requisite: None