Dept. of Nano Science & Technology

❑ Nano-material Major

The graduate school of Advanced Materials Engineering Department in Kookmin University was established in November 1974 after the authorization of Ministry of Education. The goal of our graduate course is to educate students who will become pro-active leaders with creative mind in the field of materials related industry by utilizing knowledge of materials engineering. Until now, more than 200 students with master and doctor degrees have been produced and they play a critical role in the field of industry, academia, and education. 19 faculty members in the graduate school of Advanced Materials Engineering Department are actively doing research works in the field of metals, ceramics, polymers, semiconductors, displays, energy/ environment. Also, the department possesses many up-to-date experimental equipments for various materials-related researches.

❑ Nano-electron Major

Nano-Electronics Major offers one of the most comprehensive research and instructional programs with Master's degree. In this Major, 1 Nano-electronic semiconductor devices including extremely scaled conventional devices, quantum effect devices, and nano-structured volatile and nonvolatile memory devices, 2 Nano-electronic analog integrated circuit design, 3 Nano-electronic low-voltage-low-power integrated circuits, 4 Nano-electronic mixed-mode integrated circuits will be intensively taught and investigated.

❑ Nano-physics Major

The goal of the Department of Nano Science and Technology (Nano-Physics Major) at Kookmin University is to educate the scientists and researchers in the emerging field of nanoscience and nanotechnology, and to carry out the innovative research in multidisciplinary environment. The courses offered in our department covers various topics with an emphasis on Physics and research activities includes the fabrication and measurement at nanometer scale as well as the physical analysis.

❑ Nano-chemistry Major

Nanochemistry is a subject dealing with the chemistry of making, analyzing, and applying substances that are active in the nanoscopic world in which substances are measured in one billionths of a meter. Nanochemistry, while serving as the basis for various sciences and technologies, is a very broad field involving the life sciences, energy, electronics, environment, and materials. So, the new discipline of nanochemistry has already made it possible for us to step into the world of superfine substances, make first-hand observations of and work with molecules and atoms on a nano-meter scale, including biomolecules and other functionally advanced materials.

☐ **Courses**

❑ **Nano‑material Major**

· **Advanced Semiconductor Physics and Technology (3)**

Behaviors of electrons and holes in semiconductor are discussed and their relevant p‑n junction, Schottky junction, MOS capacitors and MOSFET are studied.

· **Thin Film Science and Processing (3)**

The object of "Thin Film Science and Engineering" class is not only to document what is known about thin films including multilayers, but also to promote the potential of these versatile thin films and to facilitate the adsorption of the technology by others. The field introduced in this class is new. This class will show that thin films including multilayers represent a model platform for promoting modern research and furthermore, the intellectual distance between concept and application is minimal.

· **Nanotechnology (3)**

This course will introduce students to the relevant concepts related to the synthesis, science, characterization, and engineering of nanomaterials. Special applications in nanotechnology will also be reviewed, including bio‑medical, environmental, energy, defense, and telecommunication areas.

· **Electrochemical Engineering (3)**

Electrochemical Engineering is the course to understand the electrochemical principles and how to apply those theories to the relevant industries such as corrosion, surface finishing, battery and fuel cell and hydrometallurgy. This course covers the fundamental concept of electrochemistry, the equilibrium and the kinetics of electrochemical reactions, the corrosion of materials, the surface‑treatment, and the energy conversion methods such as battery and fuel cell.

· **Mechanical Properties of Thin Films (3)**

This course covers the mechanical properties of the thin films deposited on various substrates with an emphasis on thin film dynamics, process‑related stresses, and the measurement of thin film stresses. In addition, effects of the microstructure of thin film depending on the process variables such as substrate temperature and pressure, on its plastic deformation and elastic behavior will be discussed.

· **Multilevel Interconnect Technology(3)**

This course covers the integration process for multilevel metallizations in an advanced semiconductor device fabrication. The process includes the formation of metals, diffusion barrier metals and compounds, the insulators over a complex structure, and the planarization process as well. In addition, the dependence of device characteristics and reliability on the metallixation process will be discussed.

· **Plasma Physics and Processing (3)**

The goal of this course if to provide the student with a sound, scientific understanding of plasma physics and plasma chemistry through which he can better use plasma processes for microelectronic fabrication. The introduction of various plasma processes for sputtering, etching, plasma‑enhanced chemical deposition of thin films helps him to know the main factors affecting each plasma process. In addition, vacuum technology and surface measurement is to be provided to improve his practical ability to control the processes.

· **Powder Processing (3)**

Topics include fabrication, properties, components of powder and fundamentals of sintering. Industrial application examples of powder metallurgy are also examined.

· **Electronic Materials Fabrication Processing (3)**

The goal of this course is to provide the student with a fundamental understanding of each process for the fabrication of microelectronic and electronic devices. The processes of oxidation, diffusion, iron implantation, etching, photolithography, metallization and packaging will be discussed with an emphasis on the principle of each process and its equipment, and the process-related issues.

· **Process Integrate Circuits (3)**

This course is to provide the student with an understanding of each process for the fabrication of semiconductor devices and the process integration of Integrated Circuits. In addition, the process for 1㎛, 0.8㎛, and 0.5㎛ CMOS will be introduced, and then discussing its device characteristics. Based on the technology roadmap, the progress for the process development required for the future devices will be predicted and discussed.

· **Electronic Ceramic (3)**

Principles of various electronic ceramics are introduced and semiconducting, insulating, high dielectric, magnetic, superconducting ceramics are discussed. Applications, such as sensors, actuators, solid oxide fuel cells and MEMS are also discussed.

Fracture Mechanics of Engineering Materials.

Based on fracture mechanics, characterization and design applications of fracture, fatigue, creep of metals are studied.

· **Electronic Materials (3)**

This course is designed to achieve knowledge of principles, properties and applications of electronic materials. Topics include conductor, semiconductors, superconductors, dielectrics and ferroelectrics.

· **Advanced Process Design of Metallic Materials (3)**

Recent advanced technology in processing and design of metallic materials is presented and studied along with their applications, such as processing of nano-materials, multi-phase materials, and shape-memory alloys.

· **Advanced Computational Materials Science(3)**

This course introduces advanced computer modeling methods in materials science and engineering using discrete particle systems and continuum fields. It covers techniques and software for statistical sampling, simulation, and uses statistical, quantum chemical, molecular dynamics, Monte Carlo, mesoscale and continuum methods to study fundamental physical phenomena encountered in the fields of computational physics, chemistry, mechanics, materials science, biology, and applied mathematics. A term project allows development of individual interests. Students are mentored by members of CMS Lab. in KMU.

· **Surface and Interface Science(3)**

This course surveys the basic concepts of surface and interface free energy, various phase transitions on the surface and interface such as surface roughening, surface reconstruction, etc.. Goals of the course also include the understanding of reation rate on the surface and interface, physi- or chemi-sorption, the role of stress in thin film growth, etc..

· **Advanced Ceramic Materials (3)**

Definition and crystal structures of ceramic materials are fundamental topics and different kinds of bonding and defect structures are advanced subject in this course. In addition it includes effect of crystal structures and defect structures on their physical properties.

· **Materials for Information Technology (3)**

This course will present to students information storage, transmission, and related materials and technology with special emphasis on materials technologies in the areas of optical information processing, memory semiconductors, and large-scale information storage.

· **Electronic Display Engineering (3)**

The purpose of this course is to gain an understanding of the principles and techniques of materials and process for flat panel displays EL, LCD, PDP, FED.... fabrication. Topics also include the characterization and evaluation of display materials and related technologies. Emphasis on materials design in relation to fundamental device characteristics.

· **Nano-material Chemistry & Technology (3)**

In this course, students will learn critical knowledge of chemistry and technology in the areas of advanced metals, polymers, and ceramics. Course modules will cover the fundamental scientific principles of molecular structure, chemical bonding, and structural measurement and analysis of materials at nano-scale level as well as related basic theories and mechanisms.

· **Advanced Polymer Materials(3)**

Overview of the problems associated with the selection, design, and function of advanced polymers is presented in this course. Particular emphasis is placed on discussion of the advanced application areas of polymer materials, which may include display, semiconductor, and energy technologies.

❑ **Nano-electron Major**

· **Semiconductor Physics (3)**

In this lecture, semiconductor physics, including crystal lattice structures, properties of semiconductors, wave phenomena and magnetic properties, electron emission, carrier generation and recombination property in the semiconductors, will be discussed.

· **High-Speed and High-Frequency Semiconductor Devices (3)**
In this lecture, high-speed and high frequency characteristics of microwave- and millimeter-wave devices, which include compound semiconductor devices such as HEMTs high-electron mobility transistor and HBTs heterojunction bipolar transistors, will be discussed in detail. Design, implementation, and characterization techniques will be discussed for better electrical performances.
· **Quantum Electronics (3)**
In this lecture, properties of the quantum mechanical electronic systems, basic concepts of the quantum mechanics, crystal structure in the quantum-mechanical scale, spins and energy band diagram theory in the lattice semiconductors will be discussed.
· **Application Specific Integrated Circuit Design (3)**
Analog and digital IC designs for a single-chip implementation of the application-specific integrated systems with signal processing, automatic control, artificial intelligence, and image processing.
· **Semiconductor Device Physics and Characteristics (3)**
Secondary effects and non-ideal device characteristics in semiconductor materials and devices will be discussed. Hot carrier effects and reliability-related physical mechanisms will be also discussed in this lecture.
· **Advanced Topics on Semiconductor Device Physics and Characteristics (3)**
Electrical characteristics of unipolar-type IC devices JFET, MOSFET, MESFET, as analog or digital IC components, will be taught in detail.
· **Characterization of Semiconductor Materials and Devices (3)**
In this lecture, analysis, modeling, parameter extraction method of the characterization parameters and their applications for the electrical and optical characteristics of the semiconductor devices will be discussed in detail.
· **Analog Integrated Circuit Design (3)**
Analog signal-processing chip design based on a standard CMOS process will be discussed in this lecture. In the first, the basic concept of analog signal-processing with various transformation techniques including the z-transform and the op-amp, which is a basic building block in the analog signal processing circuits, will be taught in detail. The concept of the switched-capacitor filter for accurate analog signal-processing and its application analog filters will be also considered in the lecture.
· **VLSI Process Technology (3)**
Modern CMOS VLSI technology is covered in depth in this course to understand the physical phenomena in the fabrication process and characterize the VLSI circuit. In this course, the individual process steps including epitaxial growth, lithography, oxidation, metallization, etching, and so on are discussed in details. Moreover, the integrated manufacturing processes using many individual steps are covered.
· **Digital VLSI Design (3)**
Based on the knowledge on the fundamental digital logic and CMOS technology, this course aims to convey knowledge of advanced concepts of circuit design for digital LSI

and VLSI components in state of the art CMOS technologies. Emphasis in this course is on the circuit design, optimization, and layout of CPU, ALU, register file, digital filter, RAM, ROM, and so on.

· **Low-Power Integrated Circuit Design (3)**

Low power circuit technology is strongly required to enhance battery lifetime especially in portable devices such as mobile phone and notebook. This power consumption can be divided into two categories of the dynamic and static consumption. Recently developed logic families and clocking strategy to reduce the dynamic power consumption are discussed in this course. In addition, static-power reduction techniques using dynamic threshold-voltage scheme, power cut-off switch, and so on are covered.

· **Memory Circuit Design (3)**

Memory devices as a core semiconductor industry, specifically, a circuit design of DRAM will be discussed in the lecture. The principle of the memory cells, cell-arrays, circuit technologies of various peripheral circuits incorporated in the row path, column path, and the performance enhancement strategy of the overall chip in the high-speed DRAMs, including SDRAM synchronous DRAM or DDR dual-data rate SDRAM, will be considered in detail.

· **Optical Semiconductor Devices (3)**

Operation principle, design method, characterization and its applications of optical-electrical / electrical-optical semiconductor devices for the absorption and emission of the light will be discussed in this lecture.

· **Advanced Topics in Integrated Circuit Design (3)**

The current research trends and problems in modern CMOS VLSI design are discussed in this course. In modern very deep-submicron VLSI design, high-speed signaling and low power issues such as signal integrity, interconnect, power distribution, power consumption, and timing becomes important, as devices go scaled further down. This course aims to introduce the recent design techniques, the optimization algorithms, and the layout methodologies to solve the signaling and low power issues in modern very deep-submicron VLSI design.

· **Nanostructure Semiconductor Device Technology (3)**

The principle, characterization, analysis, and applications of nano-structure electrical and optical devices, which focus on the quantum effects in the semiconductor, will be discussed in this lecture.

· **VLSI System Design (3)**

Digital circuit technology based on the standard CMOS process will be discussed in this lecture. The delta-sigma data converters adopting digital signal-processing theory, in order to achieve a very high resolution, will be intensively considered. For this purpose, a digital signal-processing, especially the multi-rate sampling frequency system, will be taught in depth. Various types of delta-sigma architectures, digital behavioral blocks and VLSI implementation will be also treated in the lecture.

· **SoC Design (3)**

The methodology for the IP-based SoC system-on a chip design will be discussed in detail. The hardware-description languages of VHDL or Verilog-HDL as a basic design tool for the SoC design will be studied, and the synthesis of digital circuits, verification methods, an auto-placement and routing technique in the layout design will be taught in hand. Some standards for the coding guideline and mixed-mode specs will be also introduced.

· **Mixed-Mode Integrated Circuits (3)**

Main subsystems of the mixed-mode integrated circuits, based on a standard CMOS process, will be discussed. Issues on the design of analog filters adopting switched-capacitor circuits, A/D converters, D/A converters, PLL phase-locked loop and DLL delay-locked loop will be studied in depth.

❑ **Nano-physics Major**

· **Classical Mechanics (3)**

This course on the classical mechanics presents Lagrangian and Hamilton mechanics using Hamiltonian theory. Various aspects of mechanics such as small oscillation, collision of two particles and relativistic theory will be discussed.

· **Electrodynamics (3)**

This course covers the advanced topics in electromagnitism such as electrostatic fields in vacuum and in dielectrics, magnetic fields associated with constant and variable currents, magnetic materials, and Maxwell's equations.

· **Quantum Mechanics (3)**

This course introduces the advanced concepts in Quantum Mechanics: Schroedinger equation, operators, angular momentum, harmonic oscillator, atomic hydrogen, perturbation theory, scattering theory, identical particles, and radiation.

· **Solid State Physics (3)**

This course discusses various physical phenomena in solid. The topics covered in the course are atomic, molecular and crystal structure, energy levels of electrons, and binding energies in molecules and solids.

· **Statistical Mechanics (3)**

This course discusses the concepts and application of statistical mechanics in varous fields of physics. The topics include introduction to equilibrium thermodynamics and elementary statistical mechanics.

· **Mechanics Physics (3)**

This course introduces the various aspects of mathematical physics including ordinary differential equation, complex variable, and calculus of variation. The course also presents the methods of the numerical solution.

· **Semiconductor Physics (3)**

This course discusses the physical properties of semiconductor physics such as lattice vibration, band structure and conductivity of semiconductor.

· **Material Physics (3)**

This course presents the topics in modern material physics. This course also discusses the current theoretical and experimental works in the field of material physics in addition to the introduction of the basics of magnetic, superconducting and dielectric materials.

· **Magnetism (3)**

This course discusses the advanced topics on modern physics of magnetism and magnetic materials such as spintronics and multiferroic materials as well as their applications in addition to the basics of magnetic, electronic properties and applications of magnetic materials.

· **Physics of Thin Films (3)**

This course is intended to serve as an advanced course onthin films and their properties as well as their applications. In addition, the growth mechanism of thin films and various film growth techniques such as PECVD, LPCVD, and MOCVD will be discussed. Especially, this course focuses on various physical properties of superconducting, metallic, semiconducting, magnetic thin films.

· **Research in Solid State Physics (3)**

This course presents the current topics in the field of solid state physics. This course introduces current theories in solid state physics and offers chances to review some of solid state physics experiments. This course is intended for a small group of students involved in various research projects to discuss the current topics in solid state physics, which are actively pursed in the field of solid state physics.

· **Research in Magnetism (3)**

This course presents the current topics in physics of magnetism. This course introduces current theories in the field of magnetism and offers chances to review some of experiments such as spintronics and dilute magnetic semiconductors. This course is intended for a small group of students involved in various research projects to discuss the current topics in magnetism, which are actively pursed in the field of magnetism and their applications.

· **Surface Physics (3)**

This course is intended to serve as a graduate level course on the surface physics. This course describes the fundamental physical processes on surfaces. Also, this course covers the basic theories of surface physics and their applications. In addition, this course describes the various analysis methods on the solid surface using ARS, SIMS, XPS, AFM, SEM, TEM and RBS.

· **Semiconductor Process (3)**

This course provides technological aspects of the semiconductor process such as crystal growing, vacuum technology, diffusion barrier and amorphous process, in addition to the introduction of the basics of the semiconductor physics.

❑ **Nano-chemistry Major**

· **Advanced Analytical Chemistry (3)**

Treatment of the basic issues of importance in modern analytical chemistry. Topics include basic chemical and measurement concepts, measurement instrumentation and techniques, and principles, tools, and applications in spectroscopy, electrochemistry, separations, sensors, mass spectroscopy and surface characterization.

· **Advanced Physical Chemistry (3)**

The principles of physical chemistry are studied from the standpoint of the laws of thermodynamics, kinetic theory, statistical mechanics, quantum chemistry and molecular spectroscopy.

· **Biochemistry (3)**

This subject gives an opportunity to understand the life science by dealing with Enzyme structure and mechanism, protein modification, signal transduction in sensory systems, DNA and RNA biochemistry, and biochemistry of disease.

· **Material Chemistry (3)**

Chemistry has a vital role to play in materials processing and in the development of new materials. This course is concerned with the basic underlying principles and the technological relevance of major topics in advanced material chemistry. This course includes organic, inorganic, solid-state, and surface chemistry as well as polymer and materials science.

· **Chemical Instrumentation (3)**

Principles of instrumental analysis. Application of separation techniques and instrumental analysis.

· **Thin Films (3)**

This course includes the developments in the physical and chemical sciences that have changed the design, manufacture, and analysis of thin films, and their application, especially in communications and information processing, storage, and display.

· **Solid State Chemistry (3)**

Solid state chemistry has emerged as a very important element of mainstream chemistry and modern materials science. This course is concerned with the synthesis, structure, and properties and applications of solid materials, and plays a crucial role in determining the properties of materials. An understanding of solid state chemistry is also essential in materials design.

· **X-Ray Diffractometry (3)**

The principles and practice of the determination of structures by single crystal x-ray diffraction techniques. Crystal symmetry, diffraction, structure solution and refinement. Opportunities for hands-on experience in structure determination.

· **Nanochemistry (3)**

Nano chemistry is related with chemical methods to build nano structures with atoms and molecules. This course presents nano chemistry with the most up to date survey of current applications, research, and technical challenges.

· **Molecular Spectroscopy (3)**
The course will explore the interaction of light with matter. We will start with the quantum mechanical foundations of spectroscopy and follow with a detailed treatment of a variety of different spectroscopies, including the study of rotation, rotation and vibration, and electronic spectra for simple molecules as well as polyatomics.
As time and interest allow, we will cover special topics such as magnetic resonance, nonlinear and molecular beam spectroscopies.
· **Surface Nano Chemistry (3)**
Introduction to the behavior of molecules adsorbed on solid surfaces: the structure of surfaces and adsorbate layers. The bonding of molecules to surfaces: adsorbate phase transitions: trapping and sticking of molecules on surfaces. An introduction to surface reactions: kinetics of surface reactions. A review of principles of chemical reactivity: reactivity trends on surfaces: prediction of rates and mechanisms of reactions on metals, semiconductors, and insulators.
· **Solid State Physical Chemistry (3)**
Introduction to the theory of electrons in solids: bands and zones. Absorption of light and excitons. Vacancies, interstitials, electronic defects and dislocations and their roles in chemical reactivity.
· **Research in Physical Chemistry (3)**
An upper-division student in good standing is urged to pursue an experimental research in physical chemistry with the guidance of any member of the chemistry faculty chosen.
· **Research in Organic Chemistry (3)**
An upper-division student in good standing is urged to pursue an experimental research in organic chemistry with the guidance of any member of the chemistry faculty chosen.
· **Research in Inorganic Chemistry (3)**
An upper-division student in good standing is urged to pursue an experimental research in inorganic chemistry with the guidance of any member of the chemistry faculty chosen.
· **Research in Nano Chemistry (3)**
An upper-division student in good standing is urged to pursue an experimental research in nanochemistry with the guidance of any member of the chemistry faculty chosen.
· **Research in Biochemistry (3)**
An upper-division student in good standing is urged to pursue an experimental research in biochemistry with the guidance of any member of the chemistry faculty chosen.
· **Seminar in Physical . Analytical Chemistry (3)**
To aid students in learning to speak well publicly. The focus is on discussing in physical and analytical chemistry topics from journal articles appearing in recent year.

· **Seminar in Organic Chemistry (3)**
To aid students in learning to speak well publicly. The focus is on discussing in organic chemistry topics from journal articles appearing in recent year.
· **Seminar in Inorganic Chemistry (3)**
To aid students in learning to present well publicly, the class is focused on discussing in inorganic chemistry topics from journal articles appearing in recent years.
· **Seminar in Nano Chemistry (3)**
To aid students in learning to speak well publicly. The focus is on discussing in nano-chemistry topics from journal articles appearing in recent year.
· **Seminar in Biochemistry (3)**
To aid students in learning to speak well publicly. The focus is on discussing in biochemistry topics from journal articles appearing in recent year.

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