

친환경소재학과

1. 교육목표

친환경소재학과는 현재 산업사회의 근간을 담당하는 철강 산업 분야의 전문 인력을 양성하기 위하여 설립된 교육기관으로 철강 신합금 및 수소환원제철 신공정 개발, 그리고 미래 에너지원으로 주목받고 있는 수소 생산, 저장, 활용 분야 전문 인력을 공급함으로써 국내 철강 산업과 미래 에너지 관련 발전에 기여할 계획이다.

2. 설치과정

가. 설치과정 및 과정별 이수학점

설치과정	교과학점	연구학점	총 이수학점
석사과정	18	10	28
박사과정	12	20	32
통합과정	30	30	60

※ 교과학점 이수 시 유의사항: 대학원 교과학점 과목은 다음 과목들을 포함한다.

- 1) 친환경소재학과 교과목
- 2) 타 학과 대학원 교과목 (지도교수와 상의 하에 한 학기 6학점 이수가능)
- 3) 학부 400단위 교과목 (6학점까지 인정)

※ 연구학점 이수 시 유의사항: 대학원 연구학점 과목은 다음 과목들을 포함한다.

석사과정은 세미나 과목을 2학기 이상 이수해야 한다.

- 1) 석·박사 논문연구
- 2) 친환경소재학과 세미나, 타 학과 세미나

※ 대학원 공통 교과목 이수 시 유의 사항

- 1) GEDU501(대학원 영어논문작성법)
 - 2026학년도 이후 입학생: 의무수강 과목이며, 졸업학점(연구학점)으로 인정함
 - 단, 석사-박사 연계진학자의 경우 석사과정의 이수 사항을 인정하여, 박사과정의 의무수강을 면제함
- 2) ICEC501(연구윤리)
 - 2026학년도 이후 입학생: 의무수강 과목이며, 졸업학점으로 불인정함
 - 단, 석사-박사 연계진학자의 경우 석사과정의 이수 사항을 인정하여, 박사과정의 의무수강을 면제함

나. 과정별 졸업 요강

[석사과정-학위논문 심사 요강]

응시 요건	교과 18학점, 연구 10학점 이수, 평균평점 3.0/4.3 이상
평가방법	구술시험 및 학위논문심사
신청/심사 기간	3~4학기 중
심사위원	지도교수 포함 3인의 심사위원 선정
심사내용	논문제출 및 발표
합격기준 및 판정	심사위원의 심의에 따라 합격 또는 불합격으로 판정 함

※ 학위논문 작성 방법은 포항공과대학교 요람 [대학원학위논문작성지침]을 참고.

[박사 및 통합과정-박사자격시험 요강]

응시요건	박사과정: 4학기까지 교과 12학점 이수 시 박사자격시험 면제 통합과정: 3학기 이상 재학, 응시 전 교과학점 12학점 이수 평균평점 3.0/4.3 이상
평가방법	박사과정: 과목이수 통합과정: 구술시험(연구과제 수행내용, 전공 기초 지식)
시기	통합과정 3~4학기 중 수시
소요시간	2시간 내외
심사위원	통합과정: 지도교수 제외 2인의 심사위원 선정
합격기준 및 판정	심사위원의 심의에 따라 합격 또는 불합격으로 판정함
재시험	첫 시험에 불합격한 자는 입학 후 4학기 이내 1회에 한해 재시험 기회부여

[박사 및 통합과정-연구계획서심사 요강]

응시요건	박사자격시험 통과
평가방법	연구계획서심사 & 구술시험
시기	박사자격시험 합격 다음학기부터 수시 학위논문심사(본심사)신청 한학기 전까지 완료
소요시간	2시간 내외
심사위원	지도교수 포함 5인의 심사위원 선정, 심사위원 중 최소한 1명은 과외에서 선정, 친환경소재대학원 교수가 과반수 이상 이어야 함
합격기준 및 판정	심사위원의 심의에 따라 합격 또는 불합격으로 판정함
재시험	불합격 시, 통과될때까지 심사 진행

[박사 및 통합과정-학위논문심사 요강]

구분	본심사	종합심사
응시요건	박사과정: 교과 12학점, 연구 20학점 이수 통합과정: 교과 30학점, 연구 30학점 이수 학과에서 정한 연구계획서 심사 합격 학과에서 정한 국제학술지(SCIE)에 1편 이상의 논문 게재	본심사 합격 후
평가방법	구술시험 및 학위논문심사	서류심사(구술시험 가능)
신청/심사 기간	연구계획서 심사 완료 다음 학기부터 신청 심사 신청 학기 수업일수 ¼선 이내	본심사 완료 후 최소 4주 이후 실시
심사위원	지도교수 포함 5인의 심사위원 선정, 심사위원 중 최소한 1명은 과외에서 선정, 친환경소재대학원 교수가 과반수 이상 이어야 함	
심사내용	논문제출 및 발표 후 보완이 필요한 부분을 파악하여 수정	최종 논문 수정본 제출
합격기준 및 판정	심사위원의 심의에 따라 합격 또는 불합격으로 판정 함	

※ 학위논문 작성 방법은 포항공과대학교 요람 [대학원학위논문작성지침]을 참고.

3. 개설과목

가. 개설교과목

학수번호	교과목명	강의-실습(실험)-학점
GIFT501	Seminars in Ferrous & Eco Metallurgy I	1-0-1
GIFT502	Seminars in Ferrous & Eco Metallurgy II	1-0-1
GIFT505	Seminars in Ferrous & Eco Metallurgy III	1-0-1
GIFT504	Seminars in Ferrous & Eco Metallurgy IV	1-0-1
GIFT50201	Masters Thesis Research	1-0-1
GIFT50203	Masters Thesis Research	3-0-3
GIFT50206	Masters Thesis Research	6-0-6
GIFT50301	Doctoral Dissertation Research	1-0-1
GIFT50303	Doctoral Dissertation Research	3-0-3
GIFT50305	Doctoral Dissertation Research	5-0-5
GIFT600	Materials Thermodynamics	3-0-3
GIFT601	Metallurgical kinetics	3-0-3
GIFT602	Principles of Steelmaking Process	3-0-3
GIFT603	Principles of Ironmaking Process	3-0-3
GIFT606	Computational Thermodynamics	3-0-3
GIFT610	Solid State Physics for Ferrous Technology	3-0-3
GIFT611	Transmission Electron Microscopy	3-0-3
GIFT611	TEM Laboratory	1-0-1
GIFT613	Theory of Dislocations	3-0-3
GIFT619	Special Topics on Physical Metallurgy	1-0-1
GIFT620	Phase Transformation in Steels	3-0-3
GIFT624	Crystallography and crystal diffraction	3-0-3
GIFT655	FEM for Crystalline Solid	3-0-3
GIFT661	Electrical Steels	3-0-3
GIFT671	Corrosion Science and Engineering	3-0-3
GIFT678	Special Topics on Chemical Metallurgy	3-0-3
GIFT694	Structure and Properties of Slags and Glasses	3-0-3
GIFT695	Advanced Alloys and Metal Forming	3-0-3
GIFT700	Introduction to Metallurgical Engineering	3-0-3
GIFT701	Characterization and Microanalysis	3-0-3
GIFT702	Solidification	3-0-3
GIFT703	Steel Production Technology	3-0-3
GIFT704	Computational Materials Science	3-0-3
GIFT706	Phase-Field Model	3-0-3
GIFT707	Material Degradation and Surface Engineering	3-0-3
GIFT708	Special Topics on Mechanical Behavior of Advanced Metallic Materials	3-0-3
GIFT713	Project Financing & Eng Economics	3-0-3

학수번호	교과목명	강의-실습(실험)-학점
GIFT714	Engineering Project Management Guideline	3-0-3
GIFT715	Cost Control: Estimation & Control	3-0-3
GIFT716	Contracts & Disputes Management	3-0-3
GIFT771	Multiscale Characterization of Microstructure-Property Relationships	3-0-3

나. 교과과정 및 교과내용

GIFT501, 502, 504, 505 Seminars in Ferrous & Eco Metallurgy

The purpose of this course is to give students the opportunity to obtain information about important issues and recent progress in the steel industry from invited specialists in each field. This course is required of all full-time PhD candidates in each semester for which they are registered.

GIFT50201~50203 Masters Thesis Research

These courses are required to perform research projects for the M.S. degree under the supervision of a faculty advisor.

GIFT50301~50305 Doctoral Dissertation Research

These courses are required to perform PhD research projects under the supervision of a faculty advisor.

GIFT600 Materials Thermodynamics

The objective of this course is to understand the fundamental principles of thermodynamics and to apply them to various phenomena relevant to metallurgy and materials processing. The laws of thermodynamics will be applied to gaseous, liquid, and solid systems, with special emphasis on thermochemistry and phase diagrams. Basic solution theory, energy requirements, and the relationships between Gibbs energy, phase equilibrium, and phase stability will be examined. By the end of the course, students will be able to confidently apply computational thermodynamics software to real materials processing problems.

GIFT601 Metallurgical Reaction Kinetics & mech.

This course deals with reaction mechanisms and kinetics of metallurgical systems and discussion on reaction processes. In particular, this course addresses the important rate controlling processes in high-temperature reactions, including gas phase mass transfer, free vaporization, liquid phase mass transfer and heat transfer. On completion of this course, students are expected to be confident of dealing with heterogeneous reactions occurring in steelmaking, refining, casting, reheating and hot rolling.

GIFT602 Principles of Steelmaking Process

The objective of this course is to introduce basic principles of steelmaking process and associated various phenomena. Fundamentals of steelmaking process are reviewed, followed by brief introduction of each process of steelmaking. A number of interesting phenomena observed during the process are selected, and relevant physico-chemical properties are reviewed, which play key roles in various phenomena occurring during high temperature metallurgical processes. Students shall understand these phenomena by learning and reviewing the various physico-chemical properties of liquid metal and the acting mechanism of the phenomena. The physico-chemical properties include structure, density, surface tension, viscosity etc.

GIFT603 Principles of Ironmaking Process

The course will be directed towards systematically understanding the underlying principles of ironmaking by focusing on the basic interactions between various components and phases. The

class will also drive the students to adapt themselves to the real ironmaking processes by making them understanding the ways and means of increasing blast furnace productivity, which depends upon the fuel efficiency and flow of materials and gases through the dry and wet zones of the furnace. The course is also required to be aware of the important treatment of raw iron ores and coals, which is one of the hot issues in the field of ironmaking since the efficient pretreatment of raw materials dominantly occupies the competitiveness of the entire steel production process.

GIFT606 Computational Thermodynamics

This course will provide 1) an introduction on recent advances on computational thermodynamics, 2) solid back ground on the principles lying behind the computational thermodynamics. Students are expected to use such computations in their own researches after the course is completed. Among various possible applications using the computational thermodynamics, topics related to metallurgy will be discussed.

GIFT610 Solid State Physics for Ferrous Technology

The objective of this course is modern understanding of materials relies upon atomic-scale description of material properties. This course will provide fundamental Concepts in solid state physics from quantum mechanical point of view. Starting with chemical bonding in solids, crystallography, electronic theory, lattice dynamics, and phase transition are covered.

GIFT611 TEM Laboratory

Transmission electron microscope (TEM) is a powerful tool for the analysis on the sub-micron or nanometer scale microstructure. However, actual operation of TEM is so complicated that beginner needs to understand the structure of TEM and the analytical technique. In this course, the actual skill for TEM operation and the explanation of TEM structure will be treated for the beginner of TEM operation.

GIFT613 Theory of Dislocations

This course will cover the basic theory of dislocation including fundamental concept of dislocation, basic linear elasticity, stress-strain fields and associated self-energies of dislocation. Dislocation in various crystal structures and its interactions with other defect structures will also be given. The essential object of this course is to provide the students with the relationship between strengthening mechanism and dislocation motion in the crystalline structures in a comprehensive way.

GIFT620 Phase Transformation in Steels

This course will give an overview on the principles of phase transformation of steels and related issues, which is very essential to understand the diverse and versatile properties of modern steel products. The objective of this course is to provide the students with the fundamentals on equilibrium and non-equilibrium phase transformation in ferrous alloy, which contains basic solution thermodynamics, diffusion, and reconstructive and displacive transformation behavior in steel. Strengthening mechanism available for ferrous alloys and the concept of microstructure control by heat treatment and thermo-mechanical treatment will also be given.

GIFT624 Crystallography and crystal diffraction

Students analyze various crystalline materials for their researches. Most of the analytical equipment uses the simulation software which is based on crystallography. To evaluate exactly on the phase and crystallographic orientation, the background on the crystallography is necessary. This class introduces the key concept to understand crystallography and crystal diffraction.

GIFT655 FEM for Crystalline Solid

This course provides fundamentals of finite element methods for solids. The class covers the finite element formulations of linear static analysis, displacement-based finite element procedures, formulation of nonlinear static finite element methods, and elementary theory of single and polycrystalline solids. Especially, this course will discuss how to implement the constitutive material models into the finite element methods. Every student is required to be involved in a term project by which he or she can obtain hands-on experience in solving problems by using a commercial FE software (through the user material subroutines).

GIFT661 Electrical Steels

This course introduces fundamental theory of electric and magnetic fields applied to materials. It discusses microstructure and electrical/magnetic properties of grain-oriented silicon steels. This course explains the effect of hot rolling on microstructure and properties of silicon steels. It addresses the effect of cold rolling on secondary re-crystallization in silicon steels and high temperature deformation of silicon steels. The course covers the structure and texture of electrical steels. Examples of various kinds of electrical steels will be cited together with current and future electrical steel technology.

GIFT671 Corrosion Science and Engineering

The basic theory of electrochemistry will be studied since it controls the main reaction mechanism of aqueous corrosion. Various forms of corrosion will be discussed in terms of reaction between the material and environment. Corrosion prevention methods will be introduced depending on the specific corrosion system, including alloy design, organic painting, and cathodic protection.

GIFT678 Special Topics on Chemical Metallurgy

This course is to deliver a thorough review on the state-of-the-art development of high-temperature interfacial reaction kinetics involving the Fe-C-O system, which is of critical importance in ferrous metallurgical process. Students will understand the fundamental theory of reaction kinetics, various experimental techniques for reaction rate measurements, and practical application to Fe-C-O system encompassing metallic Fe to Fe oxide.

GIFT694 Structure and Properties of Slags and Glasses

To understand the basic of polymerized silicate-based glass structure, which will govern the various thermo-physical properties of ferrous slag system such as viscosity, thermal conductivity, electric conductivity, and refining capacities. Other glass systems based on CaO-Al₂O₃ will also be dealt with.

GIFT695 Advanced Alloys and Metal Forming

The object of this course is to introduce basic concepts and advanced techniques of

heterostructured metallics materials, high entropy alloys, and metal additive manufacturing (3-D printing) for understanding the future and extreme material, structure, and processing. The course will cover the topics of stress, strain, elastic constants, plasticity, dislocations, strengthening mechanisms, fracture, fatigue, high temperature deformation and hydrogen embrittlement. Selected topics including the role of various microstructural factors on the mechanical properties of steels will be discussed in the class.

GIFT700 Introduction to Metallurgical Engineering

This course is offered to those students who have not taken any course related to the materials science and engineering during their undergraduate studies. The course is designed to provide the basic understanding of the metallurgy of irons and steels, including their structure, property and performance. Practical applications of ferrous materials are discussed with respect to the control of composition and microstructure by various thermal, mechanical and surface treatments.

GIFT701 Characterizations and Microanalysis

This course begins with an overview of fundamental physical and electronic theories underlying chemical and instrumental analysis for the determination of composition and structure of materials. The class will be directed towards systematically understanding the approximate principles of each instrument operation by combining the results of practical analysis, measurement, and testing and their application methods. Each student in the course is required to submit a modular report on a special experiment closely related to metallurgical processes and research with a special emphasis on how to interpret and utilize experimental results.

GIFT702 Solidification

The goal of this course is to enable the student to solve practical solidification processing problems through the application of solidification theory. The objectives of this course are to: (1) Develop solidification theory so that the student can understand solidification structure; (2) Develop a strong understanding of the role of heat transfer in castings; (3) Develop an appreciation for the strengths and weaknesses of a variety of casting processes. The first half of the course will be theoretical, covering nucleation, growth, instability, and solidification microstructure: cells, dendrite, eutectic and peritectic structures, solute redistribution, inclusion formation and separation, and defects and heat transfer problems. The second part of the course will be process oriented and will include conventional and near-net-shape casting, rapid solidification and spray casting with emphasis on process design to avoid defects.

GIFT703 Steel Production Technology

This course begins with an overview of process routes of an integrated steel works such as POSCO. The class will be directed towards systematically understanding the underlying principles of each process by positively using the e-learning web site of steel-university-org. The class will also drive the students to adapt themselves to the real processes by making them exercising the simulation programs of specific processes. Each student in the course is required to submit a modular report on a special topic closely related to metallurgical processes and research with a special emphasis on how to interpret and apply simulation results.

GIFT704 Computational Materials Science

This class covers a tour through the world of modern computational materials science. Main objective is to give you a feel of how simulations work. What is possible, and what is not? Understand how things work in computational materials science.

GIFT706 Phase-Field Model

This class covers a tour through the world of the-state-of-art phase-field modeling for describing microstructure evolutions in materials. Main objective is to give you a feel of how phase-field modeling works. What is possible, and what are limitations? Understand how things work in phase-field modeling for microstructure predictions.

GIFT707 Material Degradation and Surface Engineering

This lecture provides a basic knowledge of the properties of metal surfaces, electrochemical theories, corrosion phenomena, high-temperature oxidation, and friction/wear characteristics, relevant to commercial structural materials. It also introduces surface engineering technologies that are widely used in various industries. The lecture covers theories ranging from the properties of metal surfaces, electrochemistry, high-temperature oxidation, and corrosion modes, to practical surface treatment technologies such as surface diffusion treatment, deposition treatment, implantation treatment, and electroplating.

GIFT708 Special Topics on Mechanical Behavior of Advanced Metallic Materials

This graduate-level course explores the mechanical behavior of emerging metallic systems—including high-entropy alloys (HEAs), heterostructured materials, and other advanced alloys—through the lens of dislocation theory and microstructural design. Students will gain a theoretical foundation in dislocation mechanics and apply these principles to understand strengthening mechanisms, deformation behavior, and design strategies in cutting-edge metallic materials.

GIFT713 Project Financing & Eng Economics

This subject covers financial analysis and financing structure for successful plant projects. This subject will cover the case studies related with the actual financing models.

GIFT714 Engineering Project Management Guideline

This subject covers the critical PM issues at the stage of construction and operation. This subject will cover the case studies and practices with the probable plant projects. It's required to take the PM practice & case study I, as the pre-requisite subject. This subject shall be the pre-requisite subject to take the PM practice & case study III.

GIFT715 Cost Control: Estimation & Control

This course deals with overall system reliability addressing how well a system could provide functionalities and satisfy system requirements under pre-defined conditions. Student will study defining reliability of various systems and system functions, and also study establishing mathematical model to express quantitative reliability. By analyzing certain complex system, reliability model will be established for each consisting subsystems, and integrated reliability model will be developed and applied to whole complex system. Reliability test planning and procedure will be studied, as well as reliability program and standards.

GIFT716 Contracts & Disputes Management

This subject covers the integrated project management for the whole stage of project planning, construction and operation. This subject will cover the case studies and practices with the probable plant projects. It's required to take the PM practice & case study I & II as pre-requisite subjects.

GIFT771 Multiscale Characterization of Microstructure-Property Relationships

This course introduces the principles, limitations, and correlative use of EBSD, TEM/STEM, and APT for understanding microstructure-property relationships in metallic materials. After establishing the physical-metallurgical basis of strengthening and ordering, the course develops technique-specific and correlative workflows for crystallographic, defect-structural, and chemical characterization across length scales. Emphasis is placed on selecting the right technique for a physical-metallurgical question, linking the same region or defect across multiple methods, assessing artifacts and uncertainty, and integrating complementary evidence. Mechanical properties provide an important application context, but the central subject is the design and interpretation of multiscale characterization strategies used to understand why a given microstructure produces a given response

배터리공학과

1. 교육목표

친환경소재대학원 배터리공학과는 미래의 지속 가능한 친환경 사회를 선도할 첨단 에너지 소재 및 시스템 분야의 전문가를 양성하는데 있습니다. 본 학과는 이차전지용 양극, 음극, 전해액, 분리막과 같은 핵심 소재부터 차세대 에너지저장 시스템까지 기초 및 응용연구를 수행함으로써 이차전지 분야에 적합한 융합적 사고를 가진 인재를 배출하고자 합니다. 이를 통해, 급변하는 국내외 에너지 산업에서 요구되는 혁신적 기술을 제공하고, 국내 이차전지 산업 발전과 더불어 지속 가능한 사회 구현에 기여하고자 합니다.

2. 설치과정

가. 설치과정 및 과정별 이수학점

설치과정	교과학점	연구학점	총 이수학점
석사과정	18	10	28
박사과정	12	20	32
통합과정	30	30	60

※ 교과학점 이수 시 유의사항: 대학원 교과학점 과목은 다음 과목들을 포함한다.

- 1) 배터리공학과 교과목
- 2) 타 학과 대학원 교과목 (지도교수와 상의 하에 한 학기 6학점 이수가능)
- 3) 학부 400단위 교과목 (6학점까지 인정)

※ 연구학점 이수 시 유의사항: 대학원 연구학점 과목은 다음 과목들을 포함한다.

- 1) 석·박사 논문연구(반복이수 가능)
- 2) 배터리공학과 세미나, 타 학과 세미나

학과 세미나 과목은 석사과정은 2학기 이상, 박사과정은 2학기 이상, 통합과정은 4학기 이상 이수해야 한다.

※ 대학원 공통 교과목 이수 시 유의 사항

- 1) GEDU501(대학원 영어논문작성법)
 - 2026학년도 이후 입학생: 의무수강 과목이며, 졸업학점(연구학점)으로 인정함
 - 단, 석사-박사 연계진학자의 경우 석사과정의 이수 사항을 인정하여, 박사과정의 의무수강을 면제함
- 2) ICEC501(연구윤리)
 - 2026학년도 이후 입학생: 의무수강 과목이며, 졸업학점으로 불인정함
 - 단, 석사-박사 연계진학자의 경우 석사과정의 이수 사항을 인정하여, 박사과정의 의무수강을 면제함

나. 과정별 졸업 요건

[학위논문 심사 요강 - 석사과정]

응시 요건	교과 18학점, 연구 10학점 이수, 평균평점 3.0/4.3 이상
평가방법	구술시험 및 학위논문심사
신청/심사 기간	3~4학기 중
심사위원	지도교수 포함 3인의 심사위원 선정
심사내용	논문제출 및 발표
합격기준 및 판정	심사위원의 심의에 따라 합격 또는 불합격으로 판정 함

[박사 및 통합과정-박사자격시험 요강]

응시요건	박사과정: 4학기까지 교과 12학점 이수 시 박사자격시험 면제 통합과정: 3학기 이상 재학, 응시 전 교과학점 12학점 이수 평균평점 3.0/4.3 이상
평가방법	박사과정: 과목이수 통합과정: 구술시험(연구과제 수행내용, 전공 기초 지식)
시기	통합과정: 3~4학기 중 수시
소요시간	2시간 내외
심사위원	통합과정: 지도교수 제외 2인의 심사위원 선정
합격기준 및 판정	심사위원의 심의에 따라 합격 또는 불합격으로 판정함
재시험	첫 시험에 불합격한 자는 입학 후 4학기 이내 1회에 한해 재시험 기회부여

[박사 및 통합과정-연구계획서심사 요강]

응시요건	박사자격시험 통과
평가방법	연구계획서심사 & 구술시험
시기	박사자격시험 합격 다음학기부터 수시 학위논문심사(본심사)신청 한학기 전까지 완료
소요시간	2시간 내외
심사위원	지도교수 포함 5인의 심사위원 선정, 심사위원 중 최소한 1명은 과외에서 선정, 친환경소재대학원 교수가 과반수 이상 이어야 함
합격기준 및 판정	심사위원의 심의에 따라 합격 또는 불합격으로 판정함
재시험	불합격 시, 통과될때까지 심사 진행

[박사 및 통합과정-학위논문 심사 요강]

구분	본심사	종합심사
응시 요건	박사과정: 교과 12학점, 연구 20학점 이수 통합과정: 교과 30학점, 연구 30학점 이수 학과에서 정한 연구계획서 심사 합격 학과에서 정한 국제학술지(SCIE)에 1편 이상의 논문 게재	본심사 합격 후
평가방법	구술시험 및 학위논문심사	서류심사(구술시험 가능)
신청/심사 기간	연구계획서 심사 완료 다음 학기부터 신청 심사 신청 학기 수업일수 ¼선 이내	본심사 완료 후 최소 4주 이후 실시
심사위원	지도교수 포함 5인의 심사위원 선정, 심사위원 중 최소한 1명은 과외에서 선정, 친환경소재대학원 교수가 과반수 이상 이어야 함	
심사내용	논문제출 및 발표 후 보완이 필요한 부분을 파악하여 수정	최종 논문 수정본 제출
합격기준 및 판정	심사위원의 심의에 따라 합격 또는 불합격으로 판정 함	

※ 학위논문 작성 방법은 포항공과대학교 요람 [대학원학위논문작성지침]을 참고.

3. 개설과목

가. 개설교과목

구분			학수번호	교과목명	강의-실습(실험)-학점
필수이수			BATT501	Seminars for Energy Storage Materials & Systems I	1-0-1
필수이수			BATT502	Seminars for Energy Storage Materials & Systems II	1-0-1
필수이수			BATT503	Seminars for Energy Storage Materials & Systems III	1-0-1
필수이수			BATT504	Seminars for Energy Storage Materials & Systems IV	1-0-1
필수이수			BATT50201	석사논문연구(PBL)	1-0-1
필수이수			BATT50203	석사논문연구(PBL)	3-0-3
필수이수			BATT50205	석사논문연구(PBL)	5-0-5
필수이수			BATT50301	박사논문연구(PBL)	1-0-1
필수이수			BATT50303	박사논문연구(PBL)	3-0-3
필수이수			BATT50305	박사논문연구(PBL)	5-0-5
-			BATT505	산업체인턴십 I (Industry Internship I)	1-0-1
-			BATT506	산업체인턴십 II (Industry Internship II)	1-0-1
선수과목	기초공통		BATT519	Intro. to Battery systems	3-0-3
선수과목	기초공통		BATT524	에너지전기화학	3-0-3
전공	소재	기초과정	BATT525	반응공학특론	3-0-3
전공	소재	기초과정	BATT529	나노화학	3-0-3
전공	분석	기초과정	BATT531	고체화학	3-0-3
선수과목	기초공통		BATT532	Active materials for lithium-ion batteries	3-0-3
전공	소재	응용과정	BATT533	Energy Material Chemistry for Battery	3-0-3
전공	분석	응용과정	BATT534	Computational materials science	3-0-3
전공	분석	응용과정	BATT535	Phase-Field Model	3-0-3
전공	소재	응용과정	BATT536	Organic energy materials	3-0-3
전공	분석	기초과정	BATT537	Introduction to energy materials characterization	3-0-3
전공	융합	응용과정	BATT538	Scientific Communication in Battery	3-0-3
전공	소재	응용과정	BATT601	Materials Thermodynamics	3-0-3
전공	소재	응용과정	BATT608	고분자젤	3-0-3
전공	소재	응용과정	BATT614	중합반응 및 분석	3-0-3
전공	분석	응용과정	BATT618	Energy Storage System and Design	3-0-3
전공	소재	심화과정	BATT620	Carbon-based materials	3-0-3
전공	소재	심화과정	BATT622	Organic chemistry for batteries	3-0-3
전공	분석	응용과정	BATT623	Thermodynamics and Phase Transformations in Battery Materials	3-0-3
전공	분석	심화과정	BATT624	Density Functional Theory for Battery Research	3-0-3
전공	분석	심화과정	BATT701	Transmission Electron Microscopy	3-0-3
전공	소재	심화과정	BATT708	고등무기화학 I	3-0-3
전공	소재	심화과정	BATT709	고등무기화학II	3-0-3
전공	분석	심화과정	BATT713	X-ray diffraction for energy materials	3-0-3
전공	융합	응용과정	BATT714	Advanced Battery Science and Engineering	3-0-3
전공	분석	응용과정	BATT715	Analysis techniques for nano & energy materials	3-0-3

나. 교과목 이수 로드맵

분류		1단계 (Intro) / 석사 1년차		2단계 (Core) / 석사 2년차 & 박사 1년차		3단계 (Advanced) / 박사 2년차
		기초	응용	기초	응용	심화
전수과목	공통	Intro. to Battery Systems				
		에너지전기화학				
		Active Materials for LIB				
		소재열역학 (AMSE205)				
		열역학 Thermodynamics (MECH250)				
전공: 전기화학/고도분석	분석 실험	에너지소재 Energy Materials (AMSE414)				
		Characterization and micro analysis (GIFT701)		Intro. to energy materials characterization	Analysis techniques for nano & energy materials	Transmission Electron Microscopy
					Energy Storage System and Design	X-ray diffraction for energy materials
	분석 이론	고등분석화학 (CHEM541)			Phase Field Model	Density Functional Theory for Battery
		고체화학			Computational materials science	
전공: 무기재료 심화	유기소재		Thermodynamics and Phase Transformations in Battery Materials			
		특론: 유무기소재의 단성과 파괴 (AMSE721R)			고분자결	Organic chemistry for batteries
		고분자화학 (CHEM451)			중합반응 및 분석	
	무기소재		Organic energy materials			
		세라믹소재개론 (AMSE341)			고등 무기화학 I	고등 무기화학 II
		전자 세라믹스 (AMSE441)			Energy Material Chemistry for Battery	특강: 고급 촉매 에너지 기술특론 (CHEB801G)
	나노 및 카본소재		Materials Thermodynamics			
		나노화학		전달현상특론 (CHEB642)		Carbon-based Materials
		반응공학특론		반응공학 (CHEB305)		
전공: 필수 이수		Project-based learning (PBL)				
Recycling			Seminars for Energy Storage Materials and Systems I-III		Seminars for Energy Storage Materials and Systems II-IV	
		(기초 소재 과목) 이수		분리공정, 화질 TEM 분석	Materials Thermodynamics	
융합	기타	이차전지 소재 및 시스템 (CITE700K)			Scientific Communication in Battery	
		특론: 배터리카장화학 (CITE700G)			Advanced Battery Science and Engineering	
		스마트제조 (IMEN529)				
		시스템분석 및 설계 (IMEN483)				

다. 교과과정 및 교과내용

BATT501, 502, 503, 504 Seminars for Energy Storage Materials

The purpose of this course is to give students the opportunity to obtain information about important issues and recent progress in the steel industry from invited specialists in each field. This course is required of all full-time PhD candidates in each semester for which they are registered.

BATT50201~50205 석사논문연구(PBL)

These courses are required to perform research projects for the M.S. degree under the supervision of a faculty advisor.

BATT50301~50305 박사논문연구(PBL)

These courses are required to perform PhD research projects under the supervision of a faculty advisor.

BATT505 Industry Internship I

This course aims to help students accumulate experience via on the job training in the engineering industry, and to apply theories on an actual site.

BATT506 Industry Internship II

This course aims to help students accumulate experience via on the job training in the engineering industry, and to apply theories on an actual site.

BATT519 Intro. to Battery systems

[This course is designed for new graduate students. Students who are already conducting research on secondary batteries are advised to take a different course]. This course provides a comprehensive overview of key materials processing methods used in the fabrication of cathodes, anodes, and separators for lithium-ion batteries. To cultivate specialized professionals in the field of secondary batteries and reflect the needs of industry, the curriculum goes beyond basic principles to include instruction on battery materials, synthesis strategies, and cell assembly. In line with the goals of the Graduate Program for Battery-Specialized Universities, the course is designed to foster highly trained battery professionals by covering topics ranging from the fundamentals of secondary batteries to seminar programs delivered by experts actively working in academia and industry. Additionally, guest lectures (in Korean) by leading experts from academia and industry will offer insights into current issues and real-world practices in Korea's secondary battery sector.

BATT524 에너지전기화학

본 과목에서는 에너지 저장 및 변환에 필요한 다양한 전기화학적 기초 지식뿐만 아니라 실제 대학원생들이 전기화학 실험을 진행하면서 주의를 기울여야 하는 부분까지 상세히 다루어 에너지 관련 연구를 진행하기 위한 이론적/실험적 기초를 제공한다.

BATT525 반응공학특론

실제 반응계에서 대두되는 여러 가지 문제를 대상으로 하여 그 현상을 체계적으로 검토하고 적절한 모델을 설정하여 해석하는 방법을 논의하며 그 결과의 응용에 관하여 강의한다. 먼저 체류시간분포(RTD) 기법을 소개하고

이를 이용하여 비이상형 반응기를 해석하는 방법을 학습한 다음 비균질촉매 반응계에서 표면흡착, 외부물질전달 및 내부확산의 영향을 체계적으로 학습한다. 또한 비촉매 반응계로서 기·고 반응계, 액·액 및 기·액 반응계 그리고 3상 반응계에 관한 문제를 취급하고. 이어서 비등온 반응계의 이해와 해석 및 설계에 대하여 학습한다.

BATT529 나노화학

나노 크기의 여러 물질의 합성과 특성을 규명하는 과학에 대한 기초적인 개념들을 학생들이 이해하도록 하며, 이를 바탕으로 최근 연구 결과들을 통해 밝혀진 새로운 유기물, 금속, 그리고 반도체로 이루어져 있는 다양한 나노물질들에 대한 지식을 전달한다. 현대 과학 및 기술의 주요 과제 중의 하나인 나노 연구에 대한 고등 지식을 전달함으로써 학생들이 향후 학계 산업계 및 연구소에서 나노 관련 연구를 주도적으로 수행할 수 있도록 하고자 한다.

BATT531 고체화학

This course aims to provide a general introduction to solid state chemistry that covers various topics ranging from traditional subjects like crystal & symmetry, defects, synthesis, characterization, electrical/optical/magnetic properties of materials, to modern subjects that have been issued in more recent years, such as, low-dimensional materials, organic solids, coordinated molecular networks.

BATT532 Active materials for lithium-ion batteries

The purpose of this class is to learn the basic principles of batteries and talk about the active materials used in lithium-ion batteries. Also, we will develop an eye for researching lithium rechargeable battery systems. We will talk about which characteristics should be emphasized and considered in the actual battery system. Afterward, we take a more in-depth approach to what equipment is actually used in battery research. Finally, we cover conventional active materials as well as post-lithium-ion battery systems. This class allows students to advance their research levels.

BATT533 Energy Material Chemistry for Battery Devices

The purpose of this course is to understand material engineering concepts for advanced material design for secondary batteries. It will, also, cover the details of case studies, the material design logic of the system based on various battery technologies from the battery material to the system operation. Through this course, you will gain insight into the design of battery materials to be applied to battery systems.

BATT534 Computational Materials Science

This course provides students with foundational knowledge of computational materials science, along with practical hands-on experience in applications related to structural metals and battery materials.

BATT535 Phase-Field Model

강의 목표는 상장 모델(Phase-Field Model) 이론을 학습하고, 이를 바탕으로 컴퓨터 시뮬레이션을 수행하여 시간에 따른 미세 조직의 동역학적 상변화를 도모하는 데 있음.

BATT536 Organic energy materials

Rechargeable batteries encompass complex, interrelated phenomena that span multiple areas of

chemistry and physics, requiring a multidimensional learning approach. This course offers a comprehensive exploration of electrochemical theories related to electrolytes and their interactions with electrodes. It will cover the fundamentals of ionics, ion interactions, ion transport, and various interfacial phenomena. The primary goal is to provide a practical understanding of electrolyte behavior, grounded in a strong grasp of their fundamental properties.

BATT537 Intro. to energy materials characterization

This course introduces the fundamental principles and applications of synchrotron-based X-ray characterization techniques for battery materials research. Emphasis is placed on understanding the generation and properties of synchrotron X-rays, their interaction with matter, and the spectroscopic methods used to probe the structural, chemical, and electronic states of battery materials. Building on the crystal and electronic structures of electrode and electrolyte materials, the course focuses on X-ray absorption spectroscopy (XAS), X-ray photoelectron spectroscopy (XPS), X-ray fluorescence (XRF), and related synchrotron-based analytical techniques. Through lectures, case studies, and invited seminars, students will learn how advanced X-ray spectroscopy can be used to reveal redox mechanisms, interfacial chemistry, local structural evolution, and degradation pathways in rechargeable batteries.

BATT538 Scientific Communication in Battery

This course aims to develop the scientific thinking, academic writing, presentation, and discussion skills required for graduate students in battery research. Students will learn how to formulate clear research questions, construct logical scientific arguments based on experimental and computational data, and communicate their ideas effectively through manuscripts, presentations, research proposals, and academic discussions.

The course will particularly emphasize claim-evidence-reasoning structures, figure-based storytelling, abstract and introduction writing, and oral presentation skills. In addition, students will read and discuss recent high-impact papers in battery science and engineering to understand how important scientific questions are framed, how data are logically organized, and how persuasive scientific narratives are constructed. Through these activities, students will strengthen their ability to communicate research outcomes clearly and convincingly in the international scientific community.

BATT601 Materials Thermodynamics

The objective of this course is to understand the basic principles of thermodynamics, and to apply the principles in various phenomena relevant to ferrous metallurgy and general materials production. The laws of thermodynamics will be applied to gas, liquid, solid systems. Basic solution theory, energy requirements, relations between Gibbs energy and phase equilibria and phase stability will be examined.

BATT608 고분자젤

This class deals with the fundamentals of the static and dynamic properties of polymer networks and gels. And it covers the synthesis and characterization of novel polymeric networks and gels such as hydrogels, ion gels, and gels of amphiphilic block copolymers. Also, the applications of gels such as the use of the gel medium for controlled drug delivery, encapsulation of proteins and enzymes, and biomimetic soft actuators will be introduced.

BATT614 중합반응 및 분석

This course aims to provide introductory polymer chemistry, in particular (i) polymer synthesis methods, (ii) polymerization kinetics and thermodynamics, and (iii) characterization methods.

BATT618 Energy Storage System and Design

The purpose of this course is to understand various energy storage system based on electrochemical principle and learn the battery design and related electrochemical analysis method. It will, also, cover the details of case studies, the design logic of the system based on various battery technologies from the battery material to the system operation. Through this course, you will gain insight into the design of battery materials to be applied to battery systems.

BATT620 Carbon-based materials

In order to design functional carbon-based materials for energy storage applications, it is important to understand the intrinsic properties of carbon and the strategies to make better materials. In this course, we will study the basic structural features of carbon and electrochemical energy storage systems which utilize various carbon materials. In particular, to foster research personnel specialized in secondary battery research, the course content related to secondary batteries has been further strengthened. Students will study general electrochemistry and various techniques for nanomaterials' preparation, characterization, and their energy storage applications.

Electrochemical energy storage systems use various carbonaceous materials. In lithium-ion batteries and supercapacitor systems, carbon materials can be applied not only as active materials (for energy storage) and additives (as conductive electrodes), but also as support materials for next-generation battery systems. Therefore, these materials are being studied intensively, leading to impressive improvements in energy storage systems. In this course, students will study (i) a general introduction to energy storage systems and (ii) the intrinsic properties of carbon materials and strategies to tailor their structures for energy storage applications. In detail, we will cover materials' precursors, properties of carbon, types of carbon materials, characterization tools, and performance in energy storage applications.

BATT622 Organic chemistry for batteries

This course equips graduate students with core organic chemistry principles—such as acid-base behavior, nucleophilic/electrophilic substitution, and radical reactions—relevant to battery materials. Emphasis is placed on understanding functional groups (ethers, esters, fluorinated compounds, polymers) and their reactivity under electrochemical environments, fostering the ability to evaluate and design stable organic components for battery systems.

BATT623 Thermodynamics and Phase Transformations in Battery Materials

This course develops a fundamental understanding of thermodynamics and phase transformations in solid-state materials. Students will learn how to analyze electrochemical profiles and redox mechanisms in battery materials based on thermodynamic and phase behavior, and build intuition for both equilibrium and non-equilibrium electrochemical reaction mechanisms in solid-state electrodes.

BATT624 Density Functional Theory for Battery Research

This class will cover hand-on experience on first-principles density functional calculations (e.g.,

formation energy, convex hull, voltage profile, density of states) to understand thermodynamics of battery systems during charge and discharge process. This class will also cover how to accelerate new battery materials discovery with artificial intelligence (e.g., regression, classification).

BATT701 Transmission Electron Microscopy

The purpose of this course is to introduce students the basic principles and applications of transmission electron microscopy (TEM) for the study of ferrous and battery materials. The lecture is composed of theoretical study and practice. After study of each topic, TEM laboratory will be followed. The first part of lecture will cover the basics of electron optics, structure of TEM, and principles of electron diffraction. Geometry of electron diffraction and Kikuchi lines to the structure analysis will be emphasized. The basics of TEM alignment and electron diffraction, and the application of Kikuchi line will be treated in the TEM laboratory. In the second part, theory of image contrast in TEM will be presented. Kinematical theory of diffraction contrast will be discussed with examples of crystalline defects such as dislocations, stacking faults and inclusions. The principles of other commonly used methods will also be presented. These include High Resolution TEM (HRTEM), Scanning TEM (STEM), and Spectrometry (EDS, EELS). Students will have a chance to practice above topics in TEM laboratory and final team project. This course offers only the basic principles of TEM.

BATT708 고등무기화학 I

The purpose of this course is to predict a molecule's electronic structure and spectroscopic properties from knowledge of its atomic composition and geometric structure, and to predict the electronic structure and physical properties of an extended solid from knowledge of the geometric structure of a building unit.

BATT709 고등무기화학 II

Students will learn both organometallic chemistry and DFT calculation.

BATT713 X-ray diffraction for energy materials

This class is focusing on the fine crystal structural analysis for Li-ion battery materials, specifically using synchrotron, lab scale X-ray, and neutron diffraction source. We are learning about basis of crystallographic theory in terms of materials science aspect, and then move to the practice of refinement or XANES analysis using programs.

Most of incumbent materials for lithium-ion batteries are based on the crystalline. Therefore, various crystal structural properties being on the atomic level significantly affect the electrochemical properties of lithium-ion batteries. For example, atomic defects present in the lithium diffusion pathway eventually lowered the diffusion coefficient of particle, resulting in a sluggish electrochemical reaction. Therefore, it is critical to accurately analyze the properties of the material and design the electrode according to the crystallographic information. In this class, we are going to study the in-depth crystal structure analysis for lithium rechargeable batteries.

BATT714 Advanced Battery Science and Engineering

This course will cover the inorganic material chemistry and related In-depth study of electrochemical (scientific) principles for rechargeable batteries. Through this course, you will gain insight into the design of battery materials to be applied to battery systems

BATT715 Analysis techniques for nano & energy materials

Electrochemical energy conversion/storage systems consist of various materials including electrodes (anode/cathode active materials with binder and carbon additive), separator, and electrolytes. The reaction behavior mainly depends on these materials. Therefore, materials' structures before/after reaction are being studied intensively, resulting in impressive improvements in analysis techniques. In this course, we will study battery materials' structural changes (crystal, nanometer scale structure, surface, etc.) in electrochemical energy conversion/storage systems. In detail, we will look at nano-structuring methods and characterization tools for understanding reaction mechanisms and performance for various materials including electrodes, separators, and electrolytes.

In order to develop advanced materials for electrochemical energy conversion/storage applications, it is important to understand and adjust materials' structural properties. In addition, in/ex situ analysis techniques of various electrode materials have been regarded as core techniques for state-of-art research. In this course, we will focus on the characterization techniques for battery materials and nanomaterials, which require precise analysis methods. Students will study various strategies for nanomaterials' synthesis & prove of fine structure by various characterization methods, and analysis techniques to investigate reaction mechanisms of electrochemical energy conversion/storage systems.