[Title]			[Instructor]		
Advanced Inorganic Materials Chemistry			Hideto Sakane／Naoya Miyajima		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
PTA701	2	Energy Materials Science Course	1st Semester	Mon.／IV	Japanese

[Outline and purpose]

As a local structural analysis method for inorganic materials XAFS is lectured from basic principles to applications.
As an example of inorganic materials and industrial design and structural control of them, carbon material is also lectured in its science and applications.
This lecture aims to learn research and development of characters and characterization for wide range of inorganic materials.

[Objectives]

Students are expected to apply the knowledges learned to characteristics design and analysis of a variety of inorganic materials.

[Requirements]

Expertise of solid state chemistry, molecular structure, and spectroscopies.

[Evaluation]

Report on the considerations of the lecture and student's own research problems.

[Textbooks]

none

[References]

Students are wanted to select proper references in their own.

[Schedule]

1. Interferences of X-ray and materials
2. Analytical methods for materials by X-ray
3. Core shell of atomic orbital
4. Absorptions of X-ray
5. Basic principles of XAFS (X-ray Absorption near-edge structures)
6. Analysis of XAFS
7. Measurements of XAFS
8. Applications of XAFS
9. Basic structures of carbon materials
10. Preparations of carbon materials (carbonizations and graphitization)
11. Chemical properties of carbon materials
12. Surface and spatial properties of carbon materials
13. Diversity of carbon materials
14. Applications of carbon materials
15. Reports

[Title]			[Instructor]		
Advanced Course of Inorganic Material Property			Satoshi Wada / Shintaro Ueno		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
PTA702	2	Energy Materials Science Course	2nd Semester	Mon.／II	Japanese

[Outline and purpose]

Students learn the basics and application of Inorganic Material Property

[Objectives]

To understand fundamental principle of electronic and optical properties of Inorganic Material

[Requirements]

A good grounding in Physical Chemistry, Inorganic Chemistry, and Quantum Chemistry.

[Evaluation]

1 Midterm examination　30%
2 homework　30%
3 class participation　40%

[Textbooks]

[References]

[Schedule]

1. Introduction
2. Crystal Structure
3. Chemical bonding and band structure
4. Spectroscopic methods
5. Other evaluation method
6. The essence of electronic structure
7. Material design based on electronic structure
8. Midterm examination
9. Mechanism of electric polarization
10. Complex dielectric constant and dielectric relaxation
11. Evaluation of dielectric properties
12. Ferroelectrics and ferroelectric domain configuration
13. Piezoelectricity
14. Application of dielectrics and ferroelectrics
15. Summative assessment for total score

[Title]			[Instructor]		
Advanced Course of Functional Organic Molecular Chemistry			Yuichirou Haramoto / Tetsuo Kuwabara / Naoki Yoneyama		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
PTA703	2	Energy Materials Science Course	1st Semester	Tue.／II	Japanese

[Outline and purpose]

Functional organic molecules with unconventional physical and chemical properties have been widely used in the field of electronic devices and medical treatments. They are one of the most important advanced technologies now and in the future. In the present lecture, the students will learn the basic acknowledgment and application of the functional organic molecules.

[Objectives]

The students will learn the leading edge to design the molecular structure of the functional organics and to measure the physical and chemical properties.

[Requirements]

The students will need to have a basic understanding of organic chemistry, crystal chemistry, and chemical bond theory. It is very fine to be interested in the supermolecular chemistry and/or solid state chemistry.

[Evaluation]

attitude 30%
documentary survey and presentation 70 %

[Textbooks]

[References]

[Schedule]

1. guidance: functional organic molecules from the view of material science
2. synthesis of small and polymeric liquid crystal
3. ferroelectric liquid crystal and ionic liquid crystal
4. conductive liquid crystal memory
5. ionic conductive liquid crystal and ionic liquid lubricant
6. supermolecule and molecular recognition
7. self-assembly and molecular aggregation
8. rotaxane and catenane; molecular machine
9. analysis and sensing of nanostructure
10. interim evaluation
11. molecular based organic conductors
12. synthesis, crystal structure, and electronic structure of organic conductors
13. physics and chemistry in strongly correlated electron system
14. physical properties of organic superconductors
15. summary and comprehensive evaluation

[Title]					
Advanced Chemical Analysis			Kazue Tani / Ikuo Ueta		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
PTA704	2	Energy Materials Science Course	1st Semester	Wed.／I	Japanese

[Instructor] heads the instructor column.

[Outline and purpose]

This lecture presents the separation method for organic compounds, and the nature of ceramics and its application to HPLC packing materials. The knowledge of chemical analysis can be readily applied to evaluation of new materials.

[Objectives]

1. Understanding the theory and practice of modern chromatography in specially HPLC, Supercritical Fluid Chromatography and Capillary Electrophoresis
2. Mastering materials science from ceramics to HPLC new ceramics packing materials

[Requirements]

Basic knowledge of chromatography and spectrometric identification of organic compounds.
Basic understanding of inorganic, metallic and macromolecular materials.

[Evaluation]

By two Reports on the considerations of the lecture associated with Chromatography and Ceramics.

[Textbooks]

None

[References]

None

[Schedule]

1. Modern separation in HPLC (1)
2. Modern separation in HPLC (2)
3. Modern detection in HPLC (1)
4. Modern detection in HPLC (2)
5. Modern sample preparation method in chromatography
6. Ceramics treated as material
7. Genealogy and property of ceramics as inorganic material
8. Category of ceramics sensor
9. Electric properties of ceramics
10. Optical properties of ceramics
11. Explanation of ceramics sensor
12. Ceramics as HPLC packing materials
13. Separation properties of new ceramics packing materials
14. Chromatographic retention characteristic of new ceramics packing materials
15. Summarization

[Title]			[Instructor]		
Advanced Course of Polymer Materials Chemistry			Akihiro Suzuki/ Hidenori Okuzaki / Makoto Obata		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
PTA705	2	Energy Materials Science Course	2nd Semester	Thu.／II	Japanese

[Outline and purpose]

This course addresses the relation between structures and basis properties of various polymer materials, and their evaluation methods.

[Objectives]

To understand the relation between properties and structure of polymer materials.

[Requirements]

Basic knowledge of polymer synthesis and material properties.

[Evaluation]

Homework/Reports 70%
Class participation 30%

[Textbooks]

[References]

高分子化学序論，化学同人
高分子と複合材料の力学的性質
高分子のＸ線回折（上・下）

[Schedule]

1. Introduction
2. Polymer synthesis
3. Molecular weight and polydispersity
4. Glass transition
5. Conformation and configuration
6. Creep and relaxation
7. Theoretical model
8. Stress-strain curve, Young's modulus, strength, and elongation at break
9. Theoretical modulus and strength
10. Crystalline polymer
11. Amorphous polymer
12. Wide-angle X-ray diffraction and crystallinity
13. Dynamic mechanical properties and viscoelasticity
14. Drawing of polymer materials
15. Molecular orientation

[Title]			[Instructor]		
Advanced Course of Applied Electronic Chemistry			Masami Shibata/ Hiroshi Yanagi		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
PTA706	2	Energy Materials Science Course	1st Semester	Tue.／I	Japanese

[Outline and purpose]

Students learn the following topics:
1. Electronic structure of solids and devices in related chemistry of solid
2. Decorative and functional plating

[Objectives]

To understand basics and application of electronic chemistry of solids and its evaluation techniques

[Requirements]

A good grounding in Physical Chemistry, Inorganic Chemistry, and Quantum Chemistry.

[Evaluation]

Quizzes and Examinations 50%
Attendance and class participation 50%

[Textbooks]

[References]

[Schedule]

1.Introduction
2.The electronic structure in solids
3.Spectrophotometric analysis (Basic)
4.Spectrophotometric analysis (Advanced)
5.The basics of functional transparent oxides
6.Film preparation and evaluation techniques
7.Application in actual devices
8.Outline of electrochemistry and surface finishing
9.Electroless plating (Basic)
10.Electroless plating (Advanced)
11.Electroplating (Basic)
12.Electroplating (Advanced)
13.Anodizing (Basic)
14.Anodizing (Advanced)
15.Summarization and Examination

[Title]					
Material Chemistry of Solids			Satoshi Watauchi / Yoshinori Yonesaki		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
PTA707	2	Energy Materials Science Course	2nd Semester	Tue.／II	Japanese

[Outline and purpose]

For a better understanding of material properties, an elementary knowledge of group representation theory is lectured. For a better understanding of material preparation, crystal nucleation theory is lectured.

[Objectives]

To explain the influence of an electrostatic field symmetry on the energy shift of ion from the viewpoint of group representation theory. To understand the effects of thermodynamic parameters such as pressure and temperature on crystal nucleation phenomena.

[Requirements]

Basic knowledge on symmetry classification of molecular by sets of symmetry operations and on thermodynamics (lectured in Structure and Chemistry of Crystalline Solids).

[Evaluation]

Midterm examination: 50%
Term-end examination : 50%

[Textbooks]

[References]

[Schedule]

1 Application of group theory to crystallography
2 Sets, Group
3 Crystallographic point groups
4 Representation matrices
5 Irreducible representation
6 Crystal field theory
7 Midterm examination
8 Midterm summary
9 Phase equilibrium
10 Crystal structure and atomic arrangement on crystal surface
11 Nucleation
12 Surface energy
13 Equilibrium form of crystal
14 Principle of crystal growth
15 Total summary

[Title]			[Instructor]		
Advanced Quantum Materials Chemistry			Kazuya Ogawa/ Tetsuya Sato		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
PTA708	2	Energy Materials Science Course	1st Semester	Thu.／I	Japanese

[Outline and purpose]

Nano-level structure control technology combining nanoscience and nanotechnology is required for creation of high-definition and high-performance materials to be the basis of next-generation electronics and photonics. We will explain how to control chemical reaction at the atomic / molecular level and create quantum dots and extremely thin films. Lecture on characteristics and physical properties of devices and photonics materials making use of quantum effect. Learn the process theory to grasp the thin film · surface from a micro viewpoint of atoms / molecules and create a new organic / inorganic material by physical and chemical methods. In addition, we will acquire molecular element / quantum device design method based on numerical analysis.

[Objectives]

1. To understand the electronic excitation and chemical reaction of the solid surface.
2. To understand nanostructure creation method using plasma / process principle.
3. To understand how to create energy related materials using quantum effects.
4. To understand understanding quantum chemistry of molecules.
5. To understand the principles and preparation methods of organic semiconductors.

[Requirements]

Physical Chemistry, Quantum Chemistry, Electromagnetism

[Evaluation]

examination : 0 %
homework : 40 %
audit attitude : 40 %
presentation : 20 %

[Textbooks]

[References]

[Schedule]

1. Electronic excitation of the surface
2. Electron excitation of solid surface by slow electron / photo excitation
3. Collision of slow ion and solid
4. Surface chemical reactions involving hydrogen atoms and radicals
5. Quantum device fabrication I
6. Quantum device fabrication II
7. Quantum chemistry of molecules
8. Electron correlation
9. Transport phenomenon
10. Superconductivity
11. Charge transfer complex
12. Organic EL
13. Organic transistor
14. Organic solar cell, Conductive polymer
15. Assessment and explanation

[Title]			[Instructor]		
Physics for Solid State Materials			Junji　Yamanaka/ Keisuke Arimoto		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
PTB705	2	Energy Materials Science Course	2nd Semester	Mon.／II	Japanese

[Outline and purpose]

We will learn about the basics of crystal structures and experimental techniques for analyzing crystal structures. Then, we will focus on semiconductor physics which is a core field of electronics.

[Objectives]

Introduction for Structure Analysis of Solid State Materials
Introduction for Solid State Physics

[Requirements]

Completion of course covering Quantum Mechanics
Completion of course covering Electromagnetism

[Evaluation]

Activities, lectures, and discussions: 80%
Presentations: 20%

[Textbooks]

[References]

<References written in Japanese are shown in the Japanese syllabus.>
Transmission Electron Microscopy, David B. Williams and C. Barry Carter, ISBN-10: 030645324X, ISBN-13: 978-030645324
Electronic Structure and The Properties of Solids, Walter A. Harrison, ISBN-13: 978-0-486-66021-9, ISBN-10: 0-486-66021-4

[Schedule]

1. Introduction
2. Crystal Structure
3. Diffraction Theory I
4. Diffraction Theory II
5. Transmission Electron Microscopy I
6. Transmission Electron Microscopy II
7. Other Experimental Techniques of Crystal Structure Analyses
8. Band Theory
   8.1 Nearly Free Electron Model
   8.2 Tight Binding Model
9. Band Structure
10. Transport Properties of Solids
11. Optical Properties of of Solids
12. Physics for Semiconductor Devices
    12.1 pn Junction
    12.2 MOS Devices
    12.3 Heterostructure Devices

[Title]			[Instructor]		
Advanced Quantum Science of Light and Matter			Akira Ishikawa / Masaru Sakai/ Atsushi Syouji		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
PTB706	2	Energy Materials Science Course	1st Semester	Tue.／II	Japanese

[Outline and purpose]

In this course, we explain: (1) full-quantum theory describing the interaction between light and matter and its application to physical phenomena; (2) optical properties in interaction between light and nanosized materials; (3) optical responses in a semiconductor microstructure on the interaction through a radiation field performed by the coherent transition radiation function. In order to realize innovative nanodevices, it is essential to understand and apply those new aspects of interaction between light and matter.

[Objectives]

1. to understand quantization of electromagnetic field and full-quantum theory of light-matter interaction
2. to understand interaction between light and nanosized materials.
3. to understand longwave approximation and limitation of that, and transition probability of nano-scale materials.

[Requirements]

Electromagnetics, quantum mechanics, and optics.

[Evaluation]

Report: 60%
Attendance: 40%

[Textbooks]

None

[References]

Cho, Kikuo, Optical Response of Nanostructures, Springer-Verlag Tokyo (ISBN:4431710752)

[Schedule]

1. Quantization of electromagnetic field (A. Ishikawa)
2. Full-quantum theory of light-matter interaction (A. Ishikawa)
3. Luminescence equations (A. Ishikawa)
4. Superradiance and superfluorescence (A. Ishikawa)
5. Cavity QED and nonlinear optical response of photons (A. Ishikawa)
6. Optical pulse propagation in exciton resonant region (M. Sakai)
7. Development of enhanced SNOM (M. Sakai)
8. Light localization in GaN nanocolumns (M. Sakai)
9. Random laser (M. Sakai)
10. WGM laser in GaN microdisk (M. Sakai)
11. Exciton polariton (A. Syouji)
12. Confined exciton (A. Syouji)
13. Longwave approximation (A. Syouji)
14. Exciton creation and annihilation (A. Syouji)
15. Radiation correction of confined exciton (A. Syouji)

[Title]			[Instructor]		
Advanced Photon Engineering			Tetuo Harimoto		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
PTB708	2	Energy Materials Science Course	2nd Semester	Mon.／Ⅳ	Japanese

[Outline and purpose]

Emphases of this course are on the development of ultrahigh intensity laser science and interaction of laser and materials. In addition, some numerical methods on the photon engineering, especially involving the UV laser generation using the second-harmonic generation and the optical chirped pulse parametric amplification. It meets the needs of many students with interests in the modern physics and provides students with a general feel for the subject of ultrahigh intensity laser science.

[Objectives]

To introduce students to the concept of photon and ultrahigh intensity laser science.
To introduce students to the generation mechanism of ultrashort laser pulses.
To allow students to learn the numerical method of the photon engineering.
To introduce students to the interaction of laser and materials.

[Requirements]

Electromagnetics, optics, and quantum mechanics.

[Evaluation]

Report: 80%
Attendance: 20%

[Textbooks]

[References]

Amnon Yariv, Optical Electronics, Saunders College Publishing, 1991, ISBN:0030474442
Amnon Yariv, Quantum Electronics, John Wiley & Sons Inc., 1989, ISBN:0471609978

[Schedule]

1. Generation of ultrashort and ultrahigh intensity laser pulses
2. Wavelength conversion of ultrahigh intensity laser pulses
3. Amplification of a cycle pulse
4. Measurement for ultra-broadband laser pulses
5. Design of photonics devices
6. Interaction of laser and materials
7. Simulation of photon engineering

[Title]			[Instructor]		
Advanced Course of Catalyst Design for Electrodes			Makoto Uchida / Katsuyoshi Kakinuma / Takao Tuneda / Hiroshi Yano/ Shinji Nohara		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
PTC702	2	Energy Materials Science Course	2nd Semester	Wed.／I	Japanese

[Outline and purpose]

Fuel cells have attracted much attention as key technologies of energy conversion to solve the energy and global environment issues. Especially, polymer electrolyte fuel cells (PEFCs) have been intensively developed for the extensive spread as residential cogeneration systems and automotive power sources. In this course, design guideline, preparation and evaluation methods and development trend of electrocatalysts and catalyst layers with important roles in the PEFCs will be studied. Furthermore, lectures on fuel cell systems will be given, accompanied with practical science based on progressive experience in companies.

[Objectives]

To learn expert knowledge and advanced technology on electrocatalysts and catalyst layers in PEFCs, and fuel cell systems

[Requirements]

Basic knowledge on electrochemistry, physical chemistry, materials chemistry, and thermodynamics

[Evaluation]

Report and examination: 60%
Attendance: 40%

[Textbooks]

None

[References]

1.（監修）田村英雄、（編著）内田裕之、池田宏之助、岩倉千秋、高須芳雄，固体高分子形燃料電池のすべて，エヌティーエス（in Japanese)
2. 松田好晴、岩倉千秋共著，電気化学概論，丸善（in Japanese)

[Schedule]

1. Overview and significance of energy and global environmental issues
2. Electrochemistry of fuel cells (1)
3. Electrochemistry of fuel cells (2)
4. Principles and development status of various fuel cells (1)
5. Principles and development status of various fuel cells (2)
6. Design for electrocatalysts in PEFCs (1)
7. Design for electrocatalysts in PEFCs (2)
8. Design for practical electrocatalysts in PEFCs (1)
9. Design for practical electrocatalysts in PEFCs (2)
10. Design for pore structure and catalyst effectiveness of the catalyst layer in PEFCs (1)
11. Design for pore structure and catalyst effectiveness of the catalyst layer in PEFCs (2)
12. Design guideline and evaluation methods of the catalyst layer in PEFCs (1)
13. Design guideline and evaluation methods of the catalyst layer in PEFCs (2)
14. Current status and future prospects of PEFC systems
15. Summary

[Title]					
Advanced Course of Design for Advanced Inorganic Materials			[Instructor] Isao Tanaka / Nobuhiro Kumada /Takahiro Takei		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
PTC705	2	Energy Materials Science Course	2nd Semester	Tue.／I	Japanese

[Outline and purpose]

Crystal structure, crystal defects, functions and property of functional inorganic compounds are acquired as combined with scientific research fields of inorganic industrial chemistry, crystal engineering, materials engineering. Also recent topics about properties, characterization and crystal structures of functional inorganic compounds are discussed.

[Objectives]

1. to understand point group and non-stoichiometry of oxides
2. to understand drawing technique of crystal structure
3. to understand crystal chemistry
4. to understand X-ray diffraction analysis

[Requirements]

inorganic chemistry, solid state chemistry, materials engineering, physical chemistry, electronic physical properties

[Evaluation]

Homework/ examination: 70%
audit attitude: 10%
presentation: 20%

[Textbooks]

Anthony R. West, Basic Solid State Chemistry, Second Edition, John Wiley & Sons Ltd.,
ISBN: 978-1-119-94294-8

[References]

[Schedule]

1. Lattice defects and its effects on functions and properties in materials
2. Non-stoichiometry of oxides
3. Lattice defects in oxides
4. Defect concentration and defect equilibrium
5. Relationship between defect concentration and electrical conductivity
6. Basis of crystalline materials
7. Basis of crystal chemistry
8. Concept of ionic radius
9. Concept of tolerance factor of perovskite-type compounds
10. Drawing of crystal structures of inorganic compounds
11. Metallic conductivity and Superconductivity
12. Semiconductivity
13. Ionic conductivity
14. Recent topics
15. Summary

[Title]			[Instructor]		
Advanced Course of English for Green Energy Science and Technology, Advanced Level			D. A. Tryk / M. E. Brito		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
PTC707	2	Energy Materials Science Course	1st Semester	Wed.／III	English

[Outline and purpose]

This course will cover all aspects of scientific and engineering English, including reading, writing, speaking and listening. All are important for today's green energy scientist and engineer. Oral skills are particularly important, including presentation and discussion skills. Such skills will benefit you throughout your career. There will be an emphasis on learning general chemical and engineering vocabulary, in addition to specific terms for each student's own research. The course will complement the Green Program monthly presentations.

[Objectives]

The specific achievements or milestones will include: (1) ability to read a technical paper and summarize it briefly in English; (2) ability to write a short paper; (3) ability to confidently give a short technical presentation in English and understand and answer questions; (4) ability to listen to an oral technical presentation and ask questions.

[Requirements]

D1 status

[Evaluation]

Attendance: 20%; presentations: 40%; reports: 40%

[Textbooks]

None

[References]

None

[Schedule]

1. Introduction; overview; basic pronunciation; online software; short self-introductions;
2. Self-introductions by students; online software;
3. Brief oral introduction to your research field for non-specialists 1
4. Brief oral introduction to your research field for non-specialists 2
5. Brief oral introduction to your research field for non-specialists 3
6. Brief oral introduction to your research field for non-specialists 4
7. Oral presentation of student's research 1
8. Oral presentation of student's research 2
9. Oral presentation of student's research 3
10. Oral presentation of student's research 4
11. Brief written reports on student's own research 1
12. Brief written reports on student's own research 2
13. Brief written reports on student's own research 3
14. Brief written reports on student's own research 4
15. Brief written reports on student's own research 5