[Title]			[Instructor]		
Advanced Condensed Matter Physics			Kiyoshi Kobayashi / Akira Ishikawa		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ501	2	Advanced Material Science	1st Semester	Mon.／II	Japanese/English

[Outline and purpose]

This course, which is based on electrodynamics, quantum mechanics, statistical mechanics, and condensed matter physics, deals with quantum field theory of electromagnetic and matter fields, focusing on elementary excitations, optical linear and nonlinear responses, and their dependence on matter dimension. It also covers electronic properties and confinement effects of quantum nanostructures from the fundamental viewpoint, as well as the fabrication processes and measurement methods from the application viewpoint. The essence of the theories and experiments will be systematically lectured for deeper understanding of solid state materials.

[Objectives]

1. to understand quantization of matter and electromagnetic fields
2. to understand concepts of field interaction and elementary excitation
3. to understand linear and nonlinear response theories
4. to understand quantum optical response and its dependence on matter dimension
5. to understand confinement effects, optical spectra, and optical nonlinearity of quantum dots
6. to understand fabrication, measurement, and utilities of quantum dots from application viewpoints

[Requirements]

electrodynamics, quantum mechanics, solid state physics, statistical mechanics

[Evaluation]

homework/examination : 100 %

[Textbooks]

[References]

J. J. Sakurai, Advanced Quantum Mechanics, Addison-Wesley
J. D. Bjorken and S. D. Drell, Relativistic Quantum Fields, McGraw-Hill
Y. R. Shen, The Principles of Nonlinear Optics, Wiley
D. F. Walls and G. J. Milburn, Quantum Optics, Springer
R. Turton, The Quantum Dot: Journey into the Future of Microelectronics, Oxford Univ. Press
E. L. Wolf, Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience, Wiley

[Schedule]

1. Classical electromagnetic field, Fourier decomposition
2. Canonical quantization of electromagnetic fields, photon states
3. Electronic field, relativistic field equation
4. Quantization of electronic fields
5. Description of matter and interaction in field theory, elementary excitation in solid state materials
6. Linear and nonlinear response theories
7. Dependence of optical response on matter dimension
8. Optical response of nanostructures
9. Quantum effects on optical response
10. Superradiance and superfluorescence
11. Quantum confinement effects in zero-dimensional systems
12. Optical spectra in quantum dots
13. Fabrication of quantum dots
14. Characterization of quantum dots
15. Application of quantum confinement structures

[Title]			[Instructor]		
Advanced Quantum Devices			Hirokazu Hori/ Keisuke Arimoto/Kzuharu Uchiyama		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ502	2	Advanced Material Science	2st Semester	Tue.／II	Japanese

[Outline and purpose]

In this program, bases of quantum mechanics and solid state physics are summarized, and then principles of devices which utilize quantum effects (e.g. semiconductor heterostructure devices) are lectured. The physical and engineering bases are provided for analysis and design of functionalities in novel devices and systems based on the interdisciplinary sciences of electronic and electromagnetic dynamics including quantum mechanical features through transport of signal and information in non-equilibrium open system as well as the underlying fundamental processes.

[Objectives]

Obtaining knowledge of the following items is the objective of this program.
(1) Fundamentals of quantum mechanics (e.g. states of electrons confined in quantum wells)
(2) Principles of functionality based on interaction in nanostructured devices including local environment

[Requirements]

Basic knowledges about quantum mechanics and solid-state physics are desirable.

[Evaluation]

Level of understanding is evaluated by small tests, reports and term-end examination.

[Textbooks]

[References]

Jasprit Singh, “Electronic and Optoelectronic Properties of Semiconductor Structures” (Cambridge University Press)

[Schedule]

1 Basics of quantum mechanics and classical/quantum statistical mechanics
2 Electronic states in solids
3 Quantum size effect
4 Band structure
5 Electron and current densities in nano-structures
6 Effective mass approximation
7 Transition probability and optical properties (absorption/emission) of materials
8 Phenomena and observations as the basis of functionality
9 Construction of quantum mechanical functionality
10 Thermodynamics basis for transport processes in non-equilibrium open system
11 Dynamics of environment as the basis of functionality
12 Phenomenology and mathematics for functionalities
13 Quantum optical devices based on laser and optical processes
14 Optoelectronics devices and quantum mechanical features
15 Summary and assessment

[Title]			[Instructor]		
Advanced Photonics			Tetsuo Harimoto / Masaru Sakai / Atsushi Syouji		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ503	2	Advanced Material Science	1st Semester	Fri.／II	Japanese

[Outline and purpose]

To pursue understanding of optics and related basic principles investigated with optoelectronics and optical devices.

[Objectives]

To acquire following basic knowledge of optics and photonics as they relate to forefront research of novel opto- and photo-electronic devices.
(1) Wave-particle duality of light
(2) Propagation, interference, and diffraction of light
(3) Coherent state and entanglement state
(4) Rabi oscillation
(5) Nonlinear optics
(6) Basic principles of the laser

[Requirements]

Wave theory, Electromagnetics, Elementary quantum mechanics, Mathematics.

[Evaluation]

Homework / Examination : 80%
Audit attitude : 20%

[Textbooks]

[References]

1. A. Yariv, Photonics: Optical Electronics in Modern Communication, Oxford Univ. Pr., ISBN: 0195179463
2. A. Furusawa, Quantum optics and quantum information science, Saiensu-sha Co., Ltd. Publishers, ISBN:4901683233 (in Japanese)
3. M. Matsuoka, Quantum Optics, Shokabo Co., Ltd., ISBN:4785320935 (in Japanese)

[Schedule]

1. Wave-particle duality of light
2. Polarization of light and polarization conversion
3. Gaussian beam optics
4. Total internal reflection and evanescent field
5. Numerical calculations in optics
6. Quantization of the electromagnetic field
7. Single-photon state and coherent state
8. Wavelength conversion and optical parametric conversion based on second order optical nonlinearity
9. Interference and entanglement state of photons
10. Rabi oscillation
11. Basic laser principles
12. Generation of ultrashort laser pulses
13. Control and detection of ultrashort and high intensity laser beams
14. Lasers devices: laser diode, all-solid-state lasers, and high-power lasers
15. Applied laser technologies: high-accuracy measurement, fine processing, nanotechnology, and nuclear fusion

[Title]			[Instructor]		
Advanced Quantum Material Science			Eiichi Kondoh / Tetsuya Sato/ Kazuya Ogawa		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ505	2	Advanced Material Science	1st Semester	Thu.／II	Japanese/English

[Outline and purpose]

This course deals with fabrication of thin films and nanomaterials, properties and characteristics of organic electronic/photonic materials, and gas-based microfabrication technologies including lithography as well as property changes upon miniaturization. The contents cover dye sensitized solar cell and organic nonlinear optical materials, organic - chemistry theories for synthesizing these materials and photochemistry as the basis for material characterization, and fabrication and testing for electronic/photoelectronic devices.

[Objectives]

1. to understand the fundamentals for microfabrication
2. to understand the fundamental principles of plasma discharges
3. to understand the gas- and surface-phase chemical reactions
4. to understand the principles of dye sensitized solar cell and organic NLO materials

[Requirements]

Physical Chemistry, Quantum Chemistry, Electromagnetism

[Evaluation]

examination : 25 %
homework : 25 %
audit attitude : 25 %
presentation : 25 %

[Textbooks]

[References]

1) The science and engineering of microelectronic fabrication, S. A. Campbell, Oxford, ISBN-10: 0195136055
2) Michael A. Lieberman, *Principles of Plasma Discharges and Materials Processing, 2nd Edition,* Wiley-Inter science , ISBN: 978-0-471-72001-0

[Schedule]

1. Microfabrication using gases
2. Gas kinetics
3. Thin film and evaporation
4. Etching
5. Lithography
6. What is discharges and plasma?
7. Principles of plasma discharges
8. Interaction of the plasma and the solid surface
9. Fabrication of thin films and nanostructure using plasma processes
10. Characterization of thin films and nanostructure
11. Introduction to organic functional materials
12. Organic nonlinear optics 1 Optical Kerr effect
13. Organic nonlinear optics 2 two-photon absorption
14. Dye sensitized solar cell
15. Assessment and explanation

[Title]			[Instructor]		
Advanced Functional Materials			Nobuhiro Kumada / Isao Tanaka / Takahiro Takei		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ506	2	Advanced Material Science	1st Semester	Tue.／II	English／Japanese

[Outline and purpose]

Synthesis and crystal growth techniques for solid state materials are acquired on the base of phase equilibrium in this course. Also crystal chemistry, X-ray crystal structure analysis, characterization for solid state materials are acquired. For various synthesis processes, the mechanism and their theories are acquired.

[Objectives]

1. to understand phase equilibrium and the application of the phase equilibrium for synthesis techniques of solid state materials
2. to understand techniques of crystal structure analysis
3. to understand formation mechanism in various synthesis processes for solid state materials

[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, Solid State Chemistry and Its Applications, Second Edition, JOHN WILEY & SONS, LTD, ISBN:978-1-119-94294-8

[References]

[Schedule]

1. Rule about phase equilibrium
2. Understanding and application of monocomponent systems
3. Understanding and application of two component systems
4. Thermal analysis for preparation of phase diagrams
5. Fundamentals and applications of crystal growth
6. Synthesis techniques for materials
7. Inorganic chemistry and basis of solid state chemistry 1
8. Inorganic chemistry and basis of solid state chemistry 2
9. Fundamentals of crystal chemistry
10. Sol-gel synthesis of inorganic materials
11. Synthesis by hydrothermal reactions
12. Soft chemical reaction
13. Thin film preparation by gas phase reaction
14. Synthesis by electrochemical reactions
15. Summary

[Title]			[Instructor]		
Structure and Chemistry of Crystalline Solids			Junji Yamanaka / Satoshi Watauchi / Yonezaki Yoshinori		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ507	2	Advanced Material Science	2st Semester	Thu.／II	Japanese/English

[Outline and purpose]

There are three important purposes in this lecture:
1. For a better understanding of physical properties of crystals, the concepts of symmetry operations are lectured from the viewpoint of group theory.
2. To investigate physical properties of crystals, a bulk crystal is very useful. The concepts of nucleation mechanism are also lectured.
3. We will also learn reciprocal space, electron diffraction, and transmission electron microscopy.

[Objectives]

To image structural features from point group notations
To understand the nucleation mechanism based on the thermodynamics
Comprehension of electron diffraction.

[Requirements]

Basic knowledge on physical chemistry and solid state chemistry.
Completion of undergraduate course covering basic physics.
Completion of undergraduate course covering basic chemistry.

[Evaluation]

Examinations: 80%
Reports (homework) & mini-exam. : 20%

[Textbooks]

[References]

Basic Solid State Chemistry Second Edition, WILEY (ISBN: 0471987565)
Transmission Electron Microscopy, A Textbook for Materials Science, Springer Science+Business Media, 2009, (ISBN: 978-0-387-76502-0)

[Schedule]

1 Application of group theory to crystallography, Sets
2 Groups
3 Symmetry elements and Symmetry operations
4 Lattice, space groups
5 Phase equilibria
6 Nucleation
7 Surface energy
8 Equilibrium shape of crystal
9 Principle of growth
10 X-ray diffraction and electron diffraction
11 Reciprocal space and electron diffraction
12 Basic Mechanical Structure of TEM
13 Practical use of TEM for inorganic materials
14 Recent topics about TEM
15 Examinations and commentaries

[Title]			[Instructor]		
Advanced Special Lectures I					
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ601	1	Advanced Material Science	Intensive	／	Japanese

[Outline and purpose]

The lecture indicates the state of the art of material science.

[Objectives]

To acquire the interdisciplinary knowledge on material science based on the knowledge of science in the undergraduate level

[Requirements]

The basic knowledge of material science for the undergraduate level

[Evaluation]

Presentation or report 100%

[Textbooks]

Not specify

[References]

Introduce or distribute it, if necessary

[Schedule]

The lecture contents will be announced through the Campus Networking System (CNS).

[Title]			[Instructor]		
Advanced Special Lectures II					
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ602	1	Advanced Material Science	Intensive	／	Japanese

[Outline and purpose]

The lecture indicates the state of the art of material science.

[Objectives]

To acquire the interdisciplinary knowledge on material science based on the knowledge of science in the undergraduate level

[Requirements]

The basic knowledge of material science for the undergraduate level

[Evaluation]

Presentation or report 100%

[Textbooks]

Not specify

[References]

Introduce or distribute it, if necessary

[Schedule]

The lecture contents will be announced through the Campus Networking System (CNS).

[Title]			[Instructor]		
Seminar in Advanced Material Science IA			all academic supervisors		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ603	1	Advanced Material Science	1st Semester		Japanese

[Outline and purpose]

It is necessary to review the related literatures, to consider the theme of research, including foreign journals of the related field. This program provides information on approaching those literatures. Other than that, the way of communication and collaboration on research group is also studied through the seminar.

[Objectives]

To direct one's study through the knowledge from this seminar

[Requirements]

General knowledge of material science relating research at undergraduate course

[Evaluation]

Integrated evaluation : 100%

[Textbooks]

Not specify

[References]

Introduce or distribute it, if necessary

[Schedule]

Contents that advising teacher designates

[Title]			[Instructor]		
Seminar in Advanced Material Science IB			all academic supervisors		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ604	1	Advanced Material Science	2nd Semester		Japanese

[Outline and purpose]

It is necessary to review the related literatures, to consider the theme of research, including foreign journals of the related field. This program provides information on approaching those literatures. Other than that, the way of communication and collaboration on research group is also studied through the seminar.

[Objectives]

To direct one's study through the knowledge from this seminar

[Requirements]

General knowledge of material science relating research at undergraduate course

[Evaluation]

Integrated evaluation : 100%

[Textbooks]

Not specify

[References]

Introduce or distribute it, if necessary

[Schedule]

Contents that advising teacher designates

[Title]			[Instructor]		
Seminar in Advanced Material Science IIA			all academic supervisors		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ605	1	Advanced Material Science	1st Semester		Japanese

[Outline and purpose]

It is necessary to review the related literatures, to consider the theme of research, including foreign journals of the related field in addition to the Seminar I. This program provides information on approaching those literatures. Other than that, the way of communication and collaboration on research group is also studied through the seminar.

[Objectives]

To direct one's study through the knowledge from this seminar

[Requirements]

General knowledge of material science relating research at undergraduate course

[Evaluation]

Integrated evaluation : 100%

[Textbooks]

Not specify

[References]

Introduce or distribute it, if necessary

[Schedule]

Contents that advising teacher designates

[Title]			[Instructor]		
Seminar in Advanced Material Science IIB			all academic supervisors		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ606	1	Advanced Material Science	2nd Semester		Japanese

[Outline and purpose]

It is necessary to review the related literatures, to consider the theme of research, including foreign journals of the related field in addition to the Seminar I. This program provides information on approaching those literatures. Other than that, the way of communication and collaboration on research group is also studied through the seminar.

[Objectives]

To direct one's study through the knowledge from this seminar

[Requirements]

General knowledge of material science relating research at undergraduate course

[Evaluation]

Integrated evaluation : 100%

[Textbooks]

Not specify

[References]

Introduce or distribute it, if necessary

[Schedule]

Contents that advising teacher designates

[Title]			[Instructor]		
Research Work in Advanced Material Science IA			all academic supervisors		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ607	2	Advanced Material Science	1st Semester		Japanese

[Outline and purpose]

Research studies on advanced material science for master's thesis.

[Objectives]

To direct one's study through the knowledge from this seminar

[Requirements]

General knowledge of material science relating research at undergraduate course

[Evaluation]

Integrated evaluation : 100%

[Textbooks]

Not specify

[References]

References that advising teacher designates

[Schedule]

Contents that advising teacher designates

[Title]			[Instructor]		
Research Work in Advanced Material Science IB			all academic supervisors		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ608	2	Advanced Material Science	2nd Semester		Japanese

[Outline and purpose]

Research studies on advanced material science for master's thesis.

[Objectives]

To direct one's study through the knowledge from this seminar

[Requirements]

General knowledge of material science relating research at undergraduate course

[Evaluation]

Integrated evaluation : 100%

[Textbooks]

Not specify

[References]

References that advising teacher designates

[Schedule]

Contents that advising teacher designates

[Title]			[Instructor]		
Research Work in Advanced Material Science IIA			all academic supervisors		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ609	2	Advanced Material Science	1st Semester		English／Japanese

[Outline and purpose]

Research studies on advanced material science for master's thesis.

[Objectives]

To direct one's study through the knowledge from this seminar

[Requirements]

General knowledge of material science relating research at undergraduate course

[Evaluation]

Integrated evaluation : 100%

[Textbooks]

Not specify

[References]

References that advising teacher designates

[Schedule]

Contents that advising teacher designates

[Title]			[Instructor]		
Research Work in Advanced Material Science IIB			all academic supervisors		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTZ610	2	Advanced Material Science	2nd Semester		Japanese

[Outline and purpose]

Research studies on advanced material science for master's thesis.

[Objectives]

To direct one's study through the knowledge from this seminar

[Requirements]

General knowledge of material science relating research at undergraduate course

[Evaluation]

Integrated evaluation : 100%

[Textbooks]

Not specify

[References]

References that advising teacher designates

[Schedule]

Contents that advising teacher designates