| 3．電気電子情報工学系　Electrical, Electronics and Computer Engineering Field | | | **EEC-F1** |
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| 授業科目名<br>Course Title | Semiconductor Physics | 単位数<br>Credit | **2** |
| 担当教員<br>Instructor | Joel T. Asubar | 開講学期<br>Semester | Fall |
| キーワード<br>Keywords | material science, quantum theory, electrical conduction, band theory, carrier density, drift, diffusion, mobility, quantum mechanical tunneling, continuity equations of carriers, lattice scattering, Einstein's relation | 曜日/時限<br>Day & Time | TBD |

## 授業概要　Course summary

The purpose of this class is to give a series of lectures for understanding carrier transport in semiconductors. After brief review of basic Quantum Theory and Statistical Mechanics, the lectures cover those subjects, including fundamentals of band theory, carrier densities, carrier generation and recombination, and basic carrier transport equations. This class is a prerequisite for taking the class of “Electron Devices”.

## 到達目標　Course goal

1. Understand basic quantum theory and explain particle-wave dualism of electrons in solids.
2. Understand and explain the difference between phase velocity and group velocity using their basic formulas.
3. Understand the concept of quantum states in solids and describe the equation of density of states.
4. Understand the band theory and explain the difference between insulator, semiconductor, and conductor.
5. Calculate densities of electrons and holes in semiconductors using the concept of effective density of states.
6. Understand the diffusion and drift of carriers in semiconductors and explain the Einstein's relation.

## 授業内容　Course description

Lecture 1: Overview; Application of semiconductor devices
Lecture 2: Quantum theory; Schrödinger’s equation, Fermi energy
Lecture 3: Quantum theory; Derivation of density of states in semiconductors
Lecture 4: Quantum theory; Quantum well, quantum mechanical tunneling
Lecture 5: Band theory; Hydrogen atom, periodic potential, allowed and forbidden bands
Lecture 6: Band theory; Description of Kronig-Penney model
Lecture 7: Band theory; Solution of Kronig-Penney model, E-k relation
Lecture 8: Band theory; Effective mass, hole concept
Lecture 9: Basics of statistical mechanics; Fermi-Dirac statistics
Lecture 10: Conduction mechanism in semiconductors; Electron transport in semiconductors
Lecture 11: Conduction mechanism in semiconductors; Intrinsic carrier concentration
Lecture 12: Conduction mechanism in semiconductors; Extrinsic carrier concentration
Lecture 13: Conduction mechanism in semiconductors; Carrier scattering and continuity equation
Lecture 14: Conduction mechanism in semiconductors; Carrier mobility
Lecture 15: Conduction mechanism in semiconductors; Phonon scattering, Einstein’s relation
Final examination

## 準備学習（予習・復習）等　Preparation / Review

Before each lecture, students are encouraged to do advance reading about the topic using not only textbook and listed reference books but also relevant materials available online. Reading beforehand gives the student an idea of what to expect, preliminary understanding, and advance recognition of important points of discussion. It is advised to allot a minimum of an hour of advance reading for every hour of lecture. In addition, review of the

previous topic using the handouts previously given is a must for smooth continuity of understanding especially for related topics held in succession. A minimum of 15 minutes of review for every hour of lecture is advised. Occasionally, for self-check, home works will be assigned, and solution will be discussed the following meeting.

授業形式　Class style

Lectures will be delivered in English using PowerPoint slides. However, from time to time, if the need arises, traditional chalk and board method will also be used. As much as possible, all the equations will be derived step-by-step, filling the gaps left by the text book. In addition, intuitive meaning of mathematical equations and graphs will be highlighted. Asking questions is highly encouraged even during the middle of the class.

成績評価の方法・基準　Method of evaluation

Percentage of Grade based on Final Exam: 100%
Passing Grade: 60% and above

教科書・参考書等　Textbook and reference books

Semiconductor Engineering (Kiyoshi Takahashi)
Semiconductor Device Fundamentals (Robert F. Pierret)
Physics of Semiconductor Devices (Simon M. Sze and Kwok K. Ng)
Integrated Microelectronic Devices (Jesus A. Del Alamo)
Semiconductor Physics and Devices (Donald A. Neamen)
Supplementary handouts will be also be distributed

受講要件・予備知識　Prerequisite

College Physics, Differential Equations

その他の注意事項　Note