Annexe A: New/Revised Course Content in OBTL+ Format

Course Overview

The sections shown on this interface are based on the templates UG OBTL+ or PG OBTL+
If you are revising/duplicating an existing course and do not see the pre-filled contents you expect in the subsequent sections e.g. Course Aims, Intended Learning Outcomes etc. please refer to Data Transformation Status for more information.

Expected Implementation in Academic Year	AY2025-2026
Semester/Trimester/Others (specify approx. Start/End date)	Semester 2
Course Author * Faculty proposing/revising the course	Lew Wen Siang
Course Author Email	wensiang@ntu.edu.sg
Course Title	Physics of Semiconductor and Devices
Course Code	PH4601
Academic Units	3
Contact Hours	39
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	PH3102 Condensed Matter Physics I or PH3103 Technological Applications of Quantum Mechanics
Co-requisites	
Pre-requisite to	
Mutually exclusive to	
Replacement course to	
Remarks (if any)	

Course Aims

This course aims to provide comprehensive introduction to you on the physics of semiconductor and devices. It covers essential topics including principles and design, in order to provide foundation knowledge of the functionality and applications of the devices. You will be taught to design experiment that uses these devices, and linking theory and practice so that concept learned in the course can be implemented. Widely used semiconductor devices, be it logic, such as diode and transistor, or memory, such as, SRAM, DRAM, NAND Flash, will be explained in detail. It is also the aim of this course to familiarise you with the common semiconductor devices in advanced manufacturing industry so that you can have relevant background before embarking you engineering career in semiconductor industry.

Course's Intended Learning Outcomes (ILOs)

Upon the successful completion of this course, you (student) would be able to:

ILO 1	Explain the fundamentals of semiconductor physics.
ILO 2	Use extrinsic semiconductor concepts to analyse carrier concentrations in semiconductor device.
ILO 3	Explain the carrier transport phenomena in semiconductor, and apply the relevant concept in experimental measurement to calculate the transport properties, such as, carrier type and concentration, mobility, conductivity and total current density in semiconductor device.
ILO 4	Describe the concepts of generation and recombination of excess carriers in non-equilibrium state of semiconductor, and apply the concept of ambipolar transport model to determine the excess carrier dynamics behaviour when device is under external stimuli.
ILO 5	Explain the working principles of pn junction diode, and use the concept to design device current-voltage characteristics.
ILO 6	Explain the working principles of metal-semiconductor-oxide field effect transistor (MOSFET), and use the concept to design the device current-voltage characteristics.
ILO 7	Identify the physics limitations of MOSFET and understand the engineering approach in making transistor advancement, such as FinFET and GAA.
ILO 8	Explain the concepts of semiconductor memory devices, such as SRAM, DRAM and NAND Flash.
ILO 9	Explain the concepts of metal-semiconductor device, such as Schottky device, and use the concept to design device current-voltage characteristics.
ILO 10	Explain the concepts of bipolar transistor, heterostructure bipolar transistor.
ILO 11	Explain the concepts other types of semiconductor devices in microwave and power applications, such MESFET, HEMT, RTD, GaN, and SiC.

Course Content

Lecture 1: Introduction to Semiconductors

Lecture 2: Carrier Transport Phenomena in Semiconductors

Lecture 3: Non-Equilibrium Excess Carriers in Semiconductors

Lecture 4: The pn Junction Diodes

Lecture 5: The Metal-Oxide-Semiconductor Field-Effect Transistors

Lecture 6: Semiconductor Memory Devices

Lecture 7: Bipolar Transistor

Lecture 8: Other Semiconductor Devices

Reading and References (if applicable)

1. Semiconductor Physics and Devices: Basic Principles, 4th edition, Donald A. Neamen, McGraw-Hill, 978-0073529585, 2011.
2. Physics of Semiconductor Devices, 3rd edition, Simon M. Sze and Kwok K. Ng, Wiley-Interscience, 978-0471143239, 2007.
3. Fundamentals of Semiconductor Devices, Betty L. Anderson and Richard L. Anderson, McGraw-Hill College, 978-0072369779, 2004.
4. Modern Semiconductor Devices for Integrated Circuits, Chenming Calvin Hu, 978-0137006687, 2009.

NOTE: The above readings comprise the foundational readings for the course and more up-to-date relevant readings will be provided when they are available.

Planned Schedule

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
1	Course Introduction and Lecture 1 (Introduction to Semiconductors)	1-2	Lecture note 1	In-person	
2	Lecture 1	1-2	Lecture note 1	In-person	
3	Lecture 2 (Carrier Transport Phenomena in Semiconductors)	3	Lecture note 2	In-person	
4	Lecture 3 (Non-Equilibrium Excess Carriers in Semiconductors)	4	Lecture note 3	In-person	
5	Lectures 4 (The pn Junction Diodes)	5	Lecture note 4	In-person	
6	Lectures 4 and 5 (The Metal-Oxide-Semiconductor Field-Effect Transistors)	5-6	Lecture notes 4 and 5	In-person	
7	Lectures 5 and midterm test 1	6	Lecture note 5	In-person	
8	Lecture 5 and 6 (Semiconductor Memory Devices)	7-8	Lecture notes 5 and 6	In-person	
9	Lecture 6	8	Lecture note 6	In-person	

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
10	Lecture 7 (Bipolar Transistor)	9	Lecture note 7	In-person	
11	Lectures 7-8 (Other Semiconductor Devices)	9-10	Lecture notes 7- 8	In-person	
12	Lecture 8 and midterm test 2	10-11	Lecture note 8	In-person	
13	Lecture 8 and assignment presentation	11	Lecture note 98	In-person	

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Lectures	In the lecture, you will be first motivated with the relevant technology and processing techniques of electronic devices, followed by lectures that further explains the working principles and physics. Wrap up questions will also be provided.
Tutorials	Discussion on tutorial questions will help to improve the understanding of the main concepts learned in lectures.
Device Simulation	You will be introduced TCAD (Technology Computer-Aided Design) tools for simulating and optimizing semiconductor devices. Lab tutors will conduct sessions of software simulations so that you have the understanding to design and simulate semiconductor device.
Technology-enhanced Learning	Extended learning will be facilitated by online learning video and other materials. This includes recorded lecture and video of animated device working principles.

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Team/Individual	Rubrics	Level of Understanding
1	Summative Assessment (EXAM): Final exam(Final Examination)	All		50	Individual	Analytic	Multistructural
2	Continuous Assessment (CA): Report/Case study(CA1: Assignment of Device Simulation: Report and Presentation)	All		20	Individual	Holistic	Relational
3	Continuous Assessment (CA): Test/Quiz(CA2: Midterm Test 1)	Lectures 1-5		15	Individual	Analytic	Multistructural
4	Continuous Assessment (CA): Test/Quiz(CA3: Midterm Test 2)	Lectures 5-9		15	Individual	Analytic	Multistructural

Description of Assessment Components (if applicable)

Assignment (CA1): The course also requires you to do a Technology Computer-Aided Design (TCAD) assignment of semiconductor device simulations. A list of assignment topics will be available for you to choose. A group of 2 students can work together on a chosen topic for the simulation assignment. Tutors will guide you on the learning of TCAD software during tutorial. Manual of each simulation topic will be provided, which contain instructions to access the simulation program, problems to be solved and questions to be answered. Upon completion of the simulations, you are required to write an assignment report. Each student in the group must submit his/her own report and the report from each group member cannot be identical. After report submission, you are required to give a 20 min oral presentation. A joint presentation of a group two students working together on the same topic is allowed and the given time is 30 min. The rubrics for assignment assessment, both report and presentation, are clearly described in the attached appendix.

Midterm Test 1 (CA2): Restricted open book test covering the lectures taught since the semester start, typically lectures 1-4.

Midterm Test 1 (CA3): Restricted open book test covering the remaining lectures taught, typically lecture 5-8.

Final Exam: Restricted open book exam covering all lectures taught.

Formative Feedback

You will receive formative feedback through discussion within tutorial lessons.

You will receive both oral feedback on your report and presentation performance during the Q and A session in your assignment oral presentation.

Feedback is also given after each term test on the common mistakes and level of difficulty of the problems. Past exam questions and content of previous examiner's report will be discussed in lecture.

NTU Graduate Attributes/Competency Mapping

This course intends to develop the following graduate attributes and competencies (maximum 5 most relevant)

Attributes/Competency	Level
Communication	Intermediate
Curiosity	Advanced
Problem Solving	Advanced
Project Management	Advanced
Critical Thinking	Advanced

Course Policy

Policy (Academic Integrity)

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values. As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. On the use of technological tools (such as Generative AI tools), different courses / assignments have different intended learning outcomes. Students should refer to the specific assignment instructions on their use and requirements and/or consult your instructors on how you can use these tools to help your learning. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Policy (General)

Students are encouraged to attend the lecture from the start of the course though lectures are recorded. Subsequent lecture is largely dependent on the understanding of the course content taught earlier hence it is helpful for student to attend the lecture and lab demo regularly.

Policy (Absenteeism)

Absence Due to Medical or Other Reasons
If you are sick and unable to attend your class (particularly the mid-terms), you must:
1. Send an email to the instructor regarding the absence.
2. Submit the Medical Certificate* to administrator.

* The medical certificate mentioned above should be issued in Singapore by a medical practitioner registered with the Singapore Medical Association.
A make-up test will be conducted only for those absent in both midterm tests with valid reasons (as mentioned above).

Policy (Others, if applicable)

Diversity and inclusion policy

Integrating a diverse set of experiences is important for a more comprehensive understanding of science.

It is our goal to create an inclusive and collaborative learning environment that supports a diversity of perspectives and learning experiences, and that honours your identities; including ethnicity, gender, socioeconomic status, sexual orientation, religion or ability.

To help accomplish this:

- If you are neuroatypical or neurodiverse, have dyslexia or ADHD (for example), or have a social anxiety disorder or social phobia;
- If you feel like your performance in the class is being impacted by your experiences outside of class;

- If something was said in class (by anyone, including the instructor) that made you feel uncomfortable;

Please speak to your teaching team, our school pastoral officer or a peer or senior (either in-person or via email) about how we can help facilitate your learning experience.

As a participant in course discussions, you should also strive to honour the diversity of your classmates. You can do this by: using preferred pronouns and names; being respectful of others opinions and actively making sure all voices are being heard; and refraining from the use of derogatory or demeaning speech or actions.

All members of the class are expected to adhere to the NTU anti-harassment policy. if you witness something that goes against this or have any other concerns, please speak to your instructors or a faculty member.

Nanyang Technological University
Division of Physics and Applied Physics

Appendix 1: Assessment Rubrics for Assignment Report

Criteria Description	**Assessment**					**Score (Max)**
	Poor (0-2)	**Below Average (3-4)**	**Adequate (5-6)**	**Good (7-8)**	**Excellent (9-10)**	
QUALITY OF WRITE-UP Consider good effort have been made on the assignment work of semiconductor device simulation. Proper planning is shown and correct simulation results are demonstrated.	Work quality presented is questionable or severely poor.	Work presented is of subpar quality	Work quality presented is marginally acceptable.	Good quality of work presented.	Excellent Work Quality	10
STRUCTURE AND ORGANISATION Consider use of proper report structure, i.e., a clear and concise summary/abstract followed by logical sequences on the write up.	No or negligible effort in organizing the report is shown.	Report is poorly organized	Report is adequately organized.	Report is well organized.	Report is excellently organized	10
RESULTS PRESENTATION AND DISCUSSION Consider if interpretation and discussion of results are put into context, main points picked for discussion, understanding of underlying assumptions and limitation while being rationale to various approaches. Good English with minimal grammatical errors and spellings.	No or negligible effort of discussion is shown. Clear trace of paragraphs plagiarism.	Poor discussion	Only minimal discussion is presented.	Good discussion with in-depth analysis.	Excellent discussion and new ideas is presented	10
LOGICAL ANALYSIS AND CONCLUSION Consider clear and logical statements in the conclusions, and other implications. Acknowledge the rewards and drawbacks of the work (if any) with possible solutions.	No or negligible effort of logical analysis and conclusion is shown.	Poor analysis and conclusion	Only minimal analysis and conclusion is presented.	Good analysis and logical conclusion is presented.	Excellent analysis and new ideas is presented.	10
QUALITY OF INFORMATION GATHERING & REFERENCES Consider the degree of preparation on the information gathered related to the work and choices of references. Proper citations have been made to external statements, picture, table and plots.	No or negligible effort in information gathering is shown.	Insufficient information gathering, or substantial use info from unreliable sources	Only minimal effort of information gathering is shown.	Good effort of information gathering is presented.	Excellent information gathering is presented	10
					Total	**50**

Nanyang Technological University
Division of Physics and Applied Physics

Appendix 2: Assessment Rubrics for Assignment Presentation

Criteria Description	**Assessment**					**Score (Max)**
	Poor (0-2)	**Below Average (3-4)**	**Adequate (5-6)**	**Good (7-8)**	**Excellent (9-10)**	
QUALITY OF WORK PRESENTED Consider the originality, correctness and importance of the work presented.	Work quality presented is questionable or severely poor.	Work presented is of subpar quality.	Quality of work presented is marginally acceptable.	Good work quality is presented.	Excellent work quality is presented.	10
ABILITY OF GIVING EXPLANATION Consider the student's ability to explain the technical knowledge learnt, specifically from the physics viewpoint; consider the coherence between the presentation and the contents of the final report submitted.	Completely fails to demonstrate the relevant technical understanding.	Struggling to provide decent technical explanations of the work presented	Able to demonstrate the relevant technical understanding.	Demonstrate good understanding of the technical knowledge.	Demonstrate excellent understanding and strong command of the technical knowledge.	10
QUALITY OF PRESENTATION MATERIALS Consider the degree of preparation of the presentation materials – informative, and appropriateness on the topics discussed; consider the clarity and context of the slides.	No effort shown in preparing the presentation materials, or complete plagiarism without proper source citing.	Materials were poorly prepared and visuals were not helpful to audience.	Ideas were vaguely presented and visuals were marginally helpful to audience.	Ideas were presented clearly and visuals were helpful to audience.	Exceptional presentation skills with highly informative materials.	10
CLARITY, LANGUAGE USE AND ACCURACY Consider the student's ability to give a clear and concise presentation – appropriate choice of words, understandable, minimal stoppage, proper pace and good timing.	Very poor verbal and communication skills.	Reading from notes all the time during presentation.	Able to communicate ideas and relates to others.	Communicates and explains ideas clearly and concisely.	Communicates in a highly convincing and persuasive manner.	10
QUESTIONS AND ANSWERS Consider the student's ability to explain his/her work in the Q&A session – able to provide unambiguous and logical answers confidently.	Unable to provide logical answers to any of the questions raised.	Struggling in answering any of the questions raised.	Limited capability in answering some of the questions.	Able to answer most queries raised.	Confidently respond to all queries raised and able to provide new ideas.	10
					Total	**50**