

Department of Physics College of Science

University of Salahaddin-Erbil Subject: Semiconductor Physics

Course Book – (Year 4, General Branch)

Lecturer's name: Jala Muhamed

 Academic Year: 2022/2023

**Course Book**

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| **1. Course name** | **Semiconductor Physics** |
| **2. Lecturer in charge** | **Jala Muhamed Ahmed** |
| **3. Department/ College** | **Physics / Science** |
| **4. Contact** | **e-mail:** **jala.ahmed@su.edu.krd** |
| **5. Time (in hours) per week** | **Theory: 2** |
| **6. Office hours** | **To be Return to the schedule on the office door** |
| **7. Course code** |  |
| **8. Teacher's academic profile** | I graduate from Salahaddin University in 1991. I worked as assistant physicist for many years and assist in different labs: solid state physics lab., atomic lab., mechanics physics lab., properties of matter lab., thermodynamics lab., general physics lab., electricity and magnetism lab. And optics lab.In 2010 I finished my MSc degree in solid state physics and start as Assistant Lecturer Teaching different subjects as: general physics, mechanics physics, Academic Debate, Practical solid state physics and practical medical imaging. For 2 years I worked as a member of the examination committee for college of science. |
| **9. Keywords** | Semiconductor physics, Fundamental concepts of Semiconductors, Semiconductor devices. semiconductor, n- type, p-type, silicon, germanium, carrier mobility, band gap, intrinsic semiconductor, extrinsic semiconductor, dopant, conductivity, photoexcitation, thermal excitation, valence band, conduction band, pair generation |

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| **10. Course overview:**This is an introductory course at the undergraduate level in semiconductor physics. Semiconducting materials and semiconductor devices play a very important role in modern technology. Semiconductor devices are not only indispensable parts of systems, such as computers, biomedical equipment, which are important in our daily life, but also from the basis for development of novel technology through their operational principles.This course will introduce students to the foundations of semiconductor physics, therefore the course is intended to cover some of the standard concepts in semiconductor physics namely, Energy bands in solids, Elemental and compound semiconductors, Intrinsic and extrinsic semiconductors, n-type and p-type semiconductors, electrical resistivity and conductivity of semiconductors, p-n junction diode and their characteristics, Zener and Avalanche breakdown.The lectures are easy to understand with simple language and lucid style, the mathematical treatment is clear and explanatory and the student will experience no difficulty in understanding the subject. The lectures also contain a moderate number of clearly illustrated diagrams and solved problems wherever necessary.The course aims to lay the foundational concepts for students who would take up more advancedand specialized topics in later years |
| 1. **Course objective:**
	* To give insight into the structure of semiconductors
	* To give insight into the physics of semiconductor diodes and transistors.
	* To give models of device behavior that can be used as a basis for understanding the functioning of other/new semiconductor devices.

Students should become familiar with the principles and basic equations of the theory of semiconductors and their applications in various fields of physics, for example; solid-state physics.  |
| **12. Student's obligation**To get the best of the course, it is suggested that you attend classes as much as possible for all the material discussed in class. Come to class prepared physically and mentally. Before class, read the required lecture for that day, and then read the material again after class discussion of the topics. Lecture's notes are for supporting and not for submitting the reading material including the handouts. It is your responsibility to review the lecture notes and work on the problems at the end of every chapter in addition to the solved examples. Do not miss class; get notes from someone if you have an unavoidable absence and completion of all tests, exams, assignments. |

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| **13. Forms of teaching**Different teaching rules and manners will be used to fulfil the objectives of the course teaching subject: power point presentation for the head titles and definitions and summary of conclusions, classification of materials and any other illustration, solving problems on the white board, besides worksheet will be designed to let the chance for practicing on several aspects of the course.To get the best of the course, it is suggested that you attend classes as much as possible, read the required lectures, teacher’s notes regularly as all of them are foundation for the course. Try as much as possible to participate in classroom discussions and preparing the assignments given in the course. |
| **14. Assessment scheme**The students are required to do two closed book examinations, one at the beginning of the course and others at the end. The examination has 30 marks besides other assignments including one quiz (short examine), the attendance, classroom activities all count 10 marks. There will be final exam on 60 marks so that the final grade will be based upon the following criteria:Mean of the two exams: 30%The quiz with classroom activities 10% Final exam: 60% |
| 1. **Student learning outcome:**

Upon the successful completion of this course, the student should be able to* + Understand and explain the principle concepts in physics of semiconductor; Discuss the characteristics of semiconductors, in particular Si, that make the material suitable for electronic devices, the importance of electrons and holes in semiconductors and the charge transport mechanisms.
	+ Understand the physics of a p-n junction; Estimate and discuss the importance of space- charge region currents in a P-N junction.
	+ Explain the concept of breakdown voltage in relation with Avalanche and Zener breakdown.

The course provides an opportunity for students to continue education in undertaking advanced study and research in the variety of different branches of semiconductor device applications. |
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| 1. **Course Reading List and References:**
	1. ``Semiconductor Physics and Devices, Basic Principles’’, Donald A. Neamen, McGraw Hill, 3rd Edition (2003).
	2. ``Semiconductor Devices Physics and Technology’’, S. M. Sze, John Wiley & Son, Inc. 2nd Edition (2002).
	3. `` Physics of Semiconductor Devices’’, Jean-Pierre Colinge & Cynthia A. Colinge, Kluwer Academic Publishers, New Tork (2000).
	4. ``Device electronics for integrated circuits’’, Richard S. Muller, Theodor I. Kamins with Mansun Cha, (2000)
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| **17. The Topics:** | **Lecturer's name** |
| Theory of Semiconductor: Introduction to the theory of semiconductor, the energy-band theory of crystals, insulators, semiconductors, and metals, Definition of semiconductor, classification of semiconductors, elemental semiconductor materials, binary semiconductor, ternary compound semiconductor, intrinsic semiconductor. |  Jala M. Ahmed  (2 hrs)**Week 1** |
| Extrinsic semiconductor, N-type semiconductor, P-type semiconductor, explanation of the band theory of semiconductor types; intrinsic semiconductor, extrinsic semiconductor. | Jala M. Ahmed (2 hrs)**Week2** |
| Energy bands of semiconductor; energy bands of Silicon, energy band diagram of Silicon, donor and acceptor impurities in semiconductor; n-type semiconductor, p-type semiconductor, compensation, examples | Jala M. Ahmed (2 hrs)**Week3** |
| Conductivity of semiconductor, current density in metal and semiconductor; current density in metal, current density semiconductor, examples. | Jala M. Ahmed (2 hrs)**Week4** |

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| Thermal-Equilibrium statistics: thermal equilibrium, mass-action law, Fermi level, examples. | Jala M. Ahmed (2 hrs)**Week5** |
| P-N Junction Theory. P-N junction, forward and reverse bias of P- N junction; forward biased P-N junction, reverse biased P-N junction. | Jala M. Ahmed  (2 hrs)**Week6** |
| Forward current in P-N junction, Reverse current in P-N junction, general specification of P-N junction. | Jala M. Ahmed (2 hrs)**Week7** |
| I-V Characteristics of a P-N Junction, resistances of P-N junction, dynamic resistance of P-N junction, average AC resistance of P-N junction. Some important terms related to P-N junction: transition capacitance of P-N junction, diffusion capacitance of P- N junction, storge time of P-N junction, transition time of P-N junction, reverse recovery time of P-N junction. | Jala M. Ahmed (2 hrs)**Week8** |
| I-V Characteristics of a P-N Junction; Zener Breakdown, Avalanche Breakdown, Avalanche Breakdown voltage, the efficiency of Avalanche Breakdown (multiplication factor). | Jala M. Ahmed (2 hrs)**Week9** |
| Hall Effect. Hall effect applications. Hall effect as a useful phenomenon to determine the Type of Semiconductor, Hall Mobility, | Jala M. Ahmed (2 hrs)**Week10** |
| Silicon Semiconductor, Application of silicon semiconductor. | Jala M. Ahmed (2 hrs)**Week 11** |
| Binary semiconductor, Gallium Arsenide Semiconductor. Review. | Jala M. Ahmed (2 hrs)**Week 12** |

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| ***Note:*** This syllabus may be subject to changes, i.e. we may take either longer or shorter time to finish a topic, if any changes happened you will be notified well in advance. |  |
| **18. Examinations:**University of Salahaddin-ErbilCollege of Science Final Examination in:Department of Physics **“Semiconductor Physics”**4th Year / General-Branch A / …………Trial Time: 2 hours***Q.1)*** Choose the correct answer ***(18 marks )***1. In an intrinsic semiconductor, the number of free electrons………

**( equals the number of holes, is greater than the number of holes, is less than the number of holes, none of them. )**1. What type of material is obtained when intrinsic semiconductor is doped with pentavalent impurity?

**( Extrinsic semiconductor, Insulator, P-type semiconductor, N-type semiconductor )**1. At room temperature a semiconductor material is

**( Perfect insulator, Conductor, Slightly conducting, none of them )**1. Single–element semiconductors are characterized by atoms with valence electrons.

**( 3, 4, 5, 2, none of them )**1. Doping of a semiconductor material means

**( that a glue-type substance is added to hold the material together that impurities are added to increase the resistance of the material. that impurities are added to decrease the resistance of the material.****that all impurities are removed to get pure silicon. )**1. A semiconductor has temperature coefficient of resistance.

**( negative, positive, zero, none of them )**1. At any temperature, the total number of electrons in extrinsic semiconductor is

**( the thermally generated electrons.,** |



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| **the electrons donated by the donor atoms.,****the sum of thermally generated electrons and the electrons donated by the donor atoms., the sum of electrons and holes. )*****h)*** You have an unknown type of diode in a circuit. You measure the voltage across it and find it to be **0.3 V.** The diode might be**( a silicon diode, a germanium diode,****a forward-biased silicon diode, a reverse-biased germanium diode )*****i)*** The battery connections required to forward bias a p-n junction are ……………..**( +ve terminal to p and –ve terminal to n,****-ve terminal to p and +ve terminal to n,****-ve terminal to p and –ve terminal to n, None of the above )*** 1. Give two differences between n-type and p-type semiconductors. ***(8 marks)***
	2. A silicon crystal is known to contain ***10 - 4*** atomic percent of arsenic (As) as an impurity. It then receives a uniform doping of ***3 X 1016 cm-3*** phosphorus (P) atoms and a subsequent uniform doping of ***1018 cm-3*** boron (B) atoms. A thermal annealing treatment then completely

activates all impurities. If the atomic density of Si is ***5.00 X 1022 cm-3***, What is the conductivity type of this silicon sample? What is the density of the majority carriers?***(10 marks)**** 1. Explain briefly the concept of mass action law in semiconductors.

***(12 marks)***1. When a battery voltage is applied across the p-n junction in the forward bias, a current will flow through this junction. Write down the expression for forward biased current and define all the symbols used.
2. In a heavily doped semiconductor subjected to reverse bias condition, explain the mechanism by which Zener Breakdown phenomenon produced at highly intensified electric field.
3. Draw the V-I curve for a p-n junction depicting Zener Breakdown phenomenon.

***(12 marks)*** |

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| *Good luck* .  |
| **20. Extra notes:** |
| **21. Peer review** |