**BITS-Pilani, Hyderabad Campus**

**FIRST SEMESTER 2022-2023**

**Course Handout Part II**

Date: August 02nd, 2022

In addition to Part-I (General Handout for all courses appended to the timetable) this portion gives further specific details regarding the course.

CourseNo. : MELG611

CourseTitle : IC FabricationTechnology

Units : 5 (3 2 5)

Instructor-in-charge : Dr. Parikshit Sahatiya

Instructor :Dr. Parikshit Sahatiya

Lab Teaching Assistants : Mr. Venkatarao Selamneni and Mr. Gowtham Polumati

**Description**: Material properties; crystal growth and doping; diffusion; oxidation;

epitaxy; ion implantation; deposition of films using CVD, LPCVD and sputtering

techniques; wet and dry etching and cleaning; lithographic process; device and

circuit fabrication; process modeling and simulation

# COURSE DESCRIPTION:

The course describes both theoretical and practical aspects of Integrated Circuit (IC) fabrication technology. Conversion of a single crystal of silicon into an IC requires several fabrication steps such as epitaxy, oxidation, chemical vapor deposition, metallization, ion implantation, diffusion, etching, lithography etc. All these process steps will be discussed. Further, modelling of each processing step would be discussed in details.

# SCOPE ANDOBJECTIVE:

The objective of the course is not only to introduce the basic principles involved in IC fabricationbutalsotodiscussthe processingtechnology.Fabricationofintegratedcircuits is a joint venture by electrical engineers, chemical engineers, materials scientists and physicists. This interdisciplinary course builds bridges across variousdisciplines.

# TEXTBOOK:

T1: Plummer, James D. Silicon VLSI technology: Fundamentals, Practice and Modeling. Pearson Education India, 2009.

# REFERENCEBOOKS:

R1: Sze S. M., VLSI Technology, McGraw-Hill, 2nd ed., 1980.

R2:CampbellSA,ThescienceandEngineeringofmicroelectronicfabrication,Oxford 2001.

R3: Gandhi, Sorab K. VLSI fabrication principles: silicon and gallium arsenide. John Wiley, 1994.

# Schedule:

Lecture: Mon, Wed, Fri, 9 am – 9:50 am.

Labs: Tue, Thurs 11 am – 12:50 pm.

# COURSE PLAN

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Section** | **Lecture**  **#** | **Topic** | **Brief** | **Reference** |
| I | 1 - 2 | Introduction to IC Fabrication Technology | A brief overview of the course and basic fabrication steps. | Lect notes/slides |
| II | 3-5 | CMOS Technology | CMOS Process flow | Lecture Notes/Slides/Ch.2 Plummer |
| III | 6- 8 | Crystal structures,  defects, directions, planes | Basic Solid State Physics for understanding of Silicon fundamentals | Lect notes/  slides/Ch. 3, Plummer |
| IV | 9-11 | Single crystal growth to Waferpreparation, dopantdistribution | To learn the art of wafer preparation and some of the basic properties of these wafers. | Lect Notes/Slides/Ch.3, Plummer |
| V | 12 | Semiconductor Manufacturing | Introduction to Clean room and wafer cleaning process (RCA) | Lect Notes/Slides/Ch.4, Plummer |
| VI | 13-18 | Oxidation and Si/SiO2 interface | Focus primarily on the thermal oxidation process and the properties at  the Si/SiO2interface. | Lect Notes/Slides  /Ch. 6, Plummer |
| VII | 19-24 | Lithography | Learn how to print the patterns on the wafer using optical exposure systems. Basics of Optical systems | Lect Notes/Slides  /Ch. 5, Plummer’s |
| VIII | 25-29 | Dopant Diffusion (Doping process) | Understand the doping concept by diffusion method. | Lect Notes/Slides  /Ch. 7, Plummer |
| IX | 30-34 | Ion Implantation (Doping process) | Understand the doping concept by Ion Implantation method | Lect Notes/Slides  /Ch. 8, Plummer |
| X | 35 | Annealing of damages and masking during  implantation | How annealing helps to recover damages and how the thickness of themasking  layer improves the maskingefficiency. | Ch. 8,  Plummer’s book |
| XI | 36-38 | Thin Film Deposition | Understand different techniques to deposit thin films (Chemical/Physical Vapor Deposition systems) | Lect Notes/Slides  /Ch. 9, Plummer |
| XII | 39-40 | Etching | Introducing various etching mechanism involved in CMOS device fabrication | Lect Notes/Slides  /Ch. 10, Plummer |
| XIII | 41-42 | Metallization and conclude the course | How devices are connected to the outside world. | Ch. 11  Plummer |

1. **EVALUATIONSCHEME:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Component** | **Duration (min)** | **Weightage** | | **Date &Time** | **Remarks** |
| **%** | **Marks** |
| Mid Semester | 90 | 20 | 60 | 31/10 3.30 - 5.00PM | CB |
| Research Project | - | 20 | 60 | Comment 1\* | OB |
| Assignment | - | 5 | 15 | To be announced | OB |
| Lab | - | 15 | 45 | Comment 2+ | OB |
| Quizzes | - | 10 | 30 | To be announced | OB |
| Comprehensive Exam | 180 | 30 | 90 | 19/12 AN | CB |
| **Total** |  | **100** | **300** |  |  |

* \*Comment 1: Details regarding the Project evaluation will be announced separately.
* +Comment 2: Regular labs will be as per schedule and details regarding the lab reports will be announced separately.
* OB 🡪Open Book
* CB 🡪 Closed Book

1. **LIST OF EXPERIMENTS**
   1. To study/observe clean room formation, various components, reliability.
   2. Study the poly-di-methyl-siloxane (PDMS) based fabrication and its testing
   3. To study the 3D printing based device fabrication and its testing
   4. Characterization Lab -1 (XRD and XPS)

a. Study the crystal structure using XRD

b. Study the chemical composition and oxidation state using XPS

* 1. Characterization Lab – 2 (UV-vis and FESEM)

a. Study the UV-visible spectroscopy and calculating the optical bandgap

b. Study the Surface Morphology using Scanning Electron Microscopy

* 1. Demonstration of the Thermal Oxidation Process
  2. Demonstration of the Positive/NegativePhotolithography process and wet-etching
  3. Demonstration of the Chemical Vapour Deposition (CVD Technique)
  4. Demonstration of the Metallization Process using E-Beam Evaporator/Thermal Evaporator
  5. Demonstration of the IV Characterization using Semiconductor Parameter Analyzer

1. **CHAMBER CONSULTATION HOUR:** To be announced in theclass.

# Makeup Policy: Make-up only to those who apply before start of an evaluation component (medical reason only).

# Academic Honesty and Integrity Policy: Academic honesty and integrity are to be maintained by all the students throughout the semester and any mode of academic dishonesty will not be acceptable

Instructor-in-charge

MEL G611