BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI

**FIRST SEMESTER 2020-21**

**Course Handout (Part II)**

Date: 17 August 2020

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

*Course No.* : BITS F415

*Course Title* : Introduction to MEMS

*Instructor‑in‑charge* : Prof. Sanket Goel

*Teaching Assistants* : Mr. Avinash Kothuru, Mr. Sohan Dudala and Ms. Jayapiriya U S

*Schedule* : Lec (Tues, Thu, Sat: 11 am – 12 nn) || Lab (Mon: 9 am – 11 am & Fri: 1 pm – 3 pm)

1. **Scope and Objective of the Course:**

The course introduces the basic concepts in MEMS (Micro Electromechanical Systems) with a view to address a class of students from science and engineering disciplines. The discussion on topics like MEMS design, Microfabrication, Microfluidics, Microsensors and Diverse applications have been structured in the course plan. The objective of the course is to equip the students from various aspects and with basic knowledge of the area of MEMS.

1. **Text Book:**

Tai-Ran Hsu, *MEMS and Micro systems Design and Manufacture*, Tata McGraw Hill, 2002

**Reference Books:**

1. G.K. Ananthsuresh et al ,’Micro and Smart Systems’, Wiley, India, 2010.
2. Nitaigour P. Mahalik, *MEMS*, Tata McGraw Hill, 2007
3. Marc Madou, *Fundamentals of Microfabrication*, CRC Press, 2002.
4. Chang Liu, *Foundation of MEMS*, Pearson Education Inc., NJ, 2006
5. Nadim Maluf, *Introduction to Microelectromechanical Systems Engineering*, Artech House, 2000.
6. Stephen D. Senturia, *Microsystem Design* , Kluwer Academic Publishers, 2001
7. Gad- el-Hak, *Introduction to MEMS*, CRC Press, 2010.
8. **Course Plan:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **#** | **Learning Objectives** | **Topic** | **Lectures** | **Chap. Sec.** |
| 1 | Introduction – history, fundamentals, components, landmark interventions, career opportunities, research areas in MEMS | | 2 | Ch. 1(T), Ref (b) |
| 2 | To understand MEMS fundamentals and components | Basic Concepts of MEMS Design and Fabrication | 2 | Ch. 3 Ref (a) |
| 3 | To understand basic MEMS governing laws | Scaling Laws – geometry, various forces, fluid mechanics etc | 3 | Ch. 9(T) |
| 4 | To understand Microsensors & Microactuatars | Microsensors & Microactuatars: working principles, design, applications | 4 | Ch. 2, (T) |
| 5 | To understand MEMS fabrication processes | Microfabrication Processes I - lithography | 4 | Ch. 7 (T), Ch.7 Ref. (a) |
| 6 | To understand MEMS fabrication processes | Microfabrication Processes II - soft-lithography, 3D printing | 6 | Ch. 3(T), Ch 8 7Ref. (a) |
| 7 | To understand how MEMS can be harnessed for micromanufactering | Micromanufacturing – fundamental design principles, MEMS integration, applications | 4 | C8h. 3 (T) Ch. 9 Re9f. (a) |
| 8 | To understand Microfluidics | Microfluidics – fundamentals, design parameters, fabrication aspects, characterization, applications | 5 | Ch. 5 Ref (a), Class Notes |
| 9 | To understand Biomedical applications for MEMS | MEMS devices used for various Biomedical applications, such as biosensing, medical devices, diagnostics etc | 2 | Class-notes |
| 10 | To understand Biochemical applications for MEMS | MEMS devices used for various Biochemical applications, environmental, mining, monitoring adulteration, Soil parameters etc. | 2 | Chapter 7 (T) |
| 11 | To understand Energy applications in MEMS | MEMS devices used for various Energy applications, Solar, Fuel cells, Supercapacitors etc | 2 | Ch.8 Ref (b), Class notes |
| 12 | To understand Automotive and Defense applications in MEMS | MEMS devices for automobiles, aerospace, defence and military applications | 2 | Ch.7 Ref (b), Class notes |
| 13 | To understand Microsystem design considerations | Microsystem design – integration constraints, industrial applications, troubleshooting | 2 | Ch.10 Ref. (a) |
| 14 | To understand MEMS packaging | MEMS Packaging – function of packaging, requirements, integration aspects, advantages, applications | Self-study | Ch. 11 Ref (a) |
|  |  | Total | 40 |  |

1. **Evaluation Scheme:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Component** | **Duration** | **Weightage** | | **Date &Time** | **Nature** |
| **%** | **Marks** |
| Test 1 | 30 mins | 10 | 30 | September 10 –September 20 (During scheduled class hour) | OB |
| Test 2 | 30 mins | 15 | 30 | October 09 –October 20 (During scheduled class hour) | OB |
| Test 3 | 30 mins | 10 | 30 | November 10 – November 20 (During scheduled class hour) | OB |
| Comprehensive Exam | 2 hours. | 35 | 90 | To be announced | OB |
| Quizzes[[1]](#footnote-1) |  | 5 | 30 | During Lecture | OB |
| Lab[[2]](#footnote-2) |  | 12.5 | 37.5 |  |  |
| Project[[3]](#footnote-3) |  | 12.5 | 37.5 | To be announced |  |
| **Total** |  | **100** | **300** |  |  |

1. **Lab Experiments**
2. Introduction to the software COMSOL and its application in MEMS/Microfluidics.
3. Simulation of MEMS Sensors/Actuators using COMSOL
4. Microfluidic simulations using COMSOL: Laminar Flow; Convection diffusion; Conjugate heat transfer.
5. Development of Micro-device using FDM based 3D printing.
6. Development of electrically conductive polymers using CO2 Laser.
7. Development of PCB/µ-devices using dry film resist based photolithography.
8. Development of Micro-device using poly-di-methyl-siloxane (PDMS) based Soft-lithography.
9. Development of micro-devices using liquid photoresist based Direct Laser Writing (DLW).
10. Fundamentals of Clean room and demonstration of Electron Beam Vapour Deposition.
11. Study of Scanning Electron Microscopy

6. **Chamber Consultation Hour:** To be announced in the class.

7. Make-up Policy: There will no make-ups unless for genuine reasons. Prior Permission of the Instructor-in-Charge is required to take a make-up for any component.

**8.Notices:** CMS

**9.Academic Honesty and Integrity Policy:** Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

**Instructor‑In‑Charge**

1. Total 4 quizzes will be taken and the best 3 will be considered for the final evaluation. No makeup will be allowed for quizzes. [↑](#footnote-ref-1)
2. The marks will be based on the lab reports and lab performance [↑](#footnote-ref-2)
3. Evaluation: Project Outline - 20%, Project Report - 30%, Presentation and Demo - 50% [↑](#footnote-ref-3)