Approval:11th Senate Meeting

Course Name: VLSI Fabrication Practicum

Course number: EE 611P

Credit: 0-0-3-2 (L-T-P-C)

Prerequisite: Device modeling and microelectronics (EE 519)

Students intended for: **M.Tech. in EE (VLSI)**

Elective or Core: Core

Semester: Even

Preamble: This course designed to build up the in depth understanding among the PG students (VLSI specialization) about the VLSI state of art technology. The major goal of this course is to make the students familiarized with device fabrications and characterizations to demonstrate the basic concepts of different device operations and their characteristics for certain real world applications. Clean room, vacuum technology, thin films or nanostructures deposition by physically and chemically are integral part of the course. Additionally, it will illustrate the students the concepts discussed in the class room teaching and give an opportunity to build, feel and test real systems in the lab. Moreover, the application orientated devices such as MOS capacitor diode, photo-detector, bio or gas sensors will also be fabricated by the students in the lab. As summarized, the objective of this course is to provide an understanding of the state of the art microelectronics fabrication processing technologies.

Course content:

Module: 1 Basic clean room training and introduction to instruments [3 hours]

- Clean room: do's and don'ts
- Identification of wafers and its type
- Wafer dicing techniques
- Standard wafer cleaning procedures (RCA)
- Instruments: oxidation furnace, pulsed layer deposition, plasma enhance chemical vapor deposition and RF sputtering, spin coater, thermal evaporator, mask aligner, electron beam lithography (EBL), reactive ion itching (RIE), mask less lithography, atomic force microscopy, parametric analyzer, probe station.
- Wet bench demonstration

***Experiment 1*:**

Draw a comprehensive wafer clean process flow/cleaning of wafer and validate the hydrophobic and hydrophilic nature through contact angle measurements.

Module: 2 Metal-Semiconductor contact fabrications and characterizations [3 hours]

- Design and fabricate metal semiconductor junction

- Characterize it to determine its nature (Ohmic / Schottky)
- If Schottky, deduce the Schottky barrier height and built-in potential from both I-V and C-V characteristics. Discuss the results.

***Experiment 2*:**

a) Ag/p-type Si based Schottky barriers fabrication and characterization

b) Al/n-type Si based Schottky barriers fabrication and characterization.

Module: 3 MOS capacitor fabrications and characterizations [3+3+3 hours]

- Design and fabricate a MOS based diode using a standard deposition and lithography techniques.
- Observe the current voltage (I-V) characteristics.
- Determine the On resistance, ideality factor, reverse saturation current, breakdown voltage and explain the result with respect to material quality.
- Observe capacitance voltage (C-V) characteristics at different frequency.

***Experiment 3*:**

a) Basic process flow for NMOS device fabrication having constant transistor channel width W=10 micron and L=5 to 12 micron

b) Photolithography process flow.

c) Fabrication and characterization of $Si/SiO_2/Al$ based MOS device

Module: 4 Transistor fabrications and characterizations [3+3+3 hours]

- Design and fabricate a MOSFET/MESFET device using standard thin film and lithography techniques.
- Characterize material compositions; observe topography, measure thickness of films.
- Measure drains current, transfer and gate leakage current characteristics.
- Comment on linearity and gain of the transistor
- Determine threshold voltage, breakdown voltage and sub-threshold slope.
- Discuss the application areas of the fabricated FET depending on the obtained results.

***Experiment 4*:**

a) Diffusion process flow with subsequent steps for dry diffusion, implantation and wet diffusion.

b) Fabrication and characterization of SiO_2 and High-k based n/p-MOSFET and characterization.

Module: 5 Sensor device fabrications and characterizations [3+3+3 hours]

- Design and fabricate a sensor device for gas or pressure.
- Characterize physical properties.
- Characterize sensitivity (response magnitude), stability, reproducibility, baseline recovery, selectivity.
- Determine response time, recovery time.

***Experiment 5*:**

a) Fabrication and characterization of thin film based acoustic/ gas/chemical/ biological sensors: e.g Palladium/ Si based hydrogen gas sensors.

b) Fabrication and characterization of ID/comb/accelerometer structure based gas/chemical/biological sensors.

Module: 6 Photo detector fabrications and characterizations [3+3+3 hours]

- Design and fabricate a photo-detector using metal-semiconductor-metal configuration.
- Characterize photo-responsivity, time domain response, repeatability and stability.
- Determine quantum efficiency, sensitivity, linearity, time constant, and leakage current.

***Experiments 6*:**

Synthesis and characterization of CuCl or CuBr deposition on Si for blue light emission or electroluminescence or ultraviolet applications.

[**Note**: Different types of quantum structures (heterojunction, nanowire, quantum dots) based on different types of materials such as oxides, compound semiconductor, polycrystalline or two dimensional may be further used to realize the above applications]

Text book:

1. S. M. Sze, VLSI Technology, 2nd Edition.
2. Sorab K. Ghandhi, VLSI Fabrication Principles: Silicon and Gallium Arsenide, 2nd Edition.
3. Dieter K. Schroder, Semiconductor Material and Device Characterization, 3rd Edition.

Reference books:

1. James D. Plummer, M. D. Deal and P. B. Griffin, Silicon VLSI Technology: Fundamentals, Practice and Modeling
2. E. H. Nicollian, J. R. Brews, MOS (metal oxide semiconductor) physics and technology.