Title Virtual Semiconductor Device Fabrication and Characterisation

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Students

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Abstract

In this project, students will be exposed to the state-of-the-art technology-CAD (TCAD) tools used by all wafer fab industries. Specifically, students will learn major wafer processing steps, such as diffusion, oxidation, ion implantation, as well as device electrical characterisation through a simple (but real) example by virtually “fabricating” and “characterizing” a PN junction diode. Students will have a chance to visualize cross-sectional views of the device at various processing steps as well as device operations in terms of internal charge, field, current distributions and terminal I−V characteristics. The project will serve as a first-hand and a first-step towards the entrance to the fascinating world of deep-submicron semiconductor technology.

Objectives

- Exposure to modern semiconductor fabrication processes and devices through a simple example
- Practical experience in the state-of-the-art computer simulation tools to emulate simplified physical phenomena
- Knowledge in design of experiment (DOE), modeling, and data analysis
- Creativity and innovative ideas to nurture technopreneurship
- Motivation and interest in the fascinating field of Microelectronics

Scope

- Reading on general semiconductor processes and device characterization
- Familiarization with the TCAD tools (such as DOE tool, process and device simulators)

- Virtual Wafer Fabrication (VWF) — simulate the fabrication process of a simple junction diode

- Virtual Device Characterization (VDC) — simulate the electrical (I–V) characteristics of the “fabricated” diode

- Modeling — study on the target–variable dependency through numerical data interpolation and analytical equation (parameter extraction)

**Methodology**

- Problem specification — decompose the complex electronic “system” to various levels of “abstraction” (or model, “mental image of reality”)

- Design conceptualization — identify the major target parameters and process variables

- Design implementation — implement the design to obtain the required target–variable dependency

- Numerical simulation — run process and device simulation

- Data analysis — analyze and understand the simulated data

- Physical modeling — extract physical model parameters from the simulated device

- Application — extend the idea (simple diode example) to large scale integrated circuit design and fabrication

- Documentation — summarize what has been achieved and demonstrate what could be done

**Tasks**

- Study the basic diode equation and its I–V characteristics

- Understand the basic process steps to fabricate the diode (such as implantation, diffusion, etc.)

- Identify the design targets (turn-on voltage, leakage current, ideality factor) and variables (implant dose and energy, diffusion time and temperature, substrate doping)

- Design and implement the experiment through DOE and numerical simulation

- Obtain the target–variable relationship by graphical plots
- Model the numerical data by physical equations through parameter extraction and nonlinear regression
- Predict diode characteristics of new process conditions through numerical data interpolation and the analytical model
- Generalize the approach to ULSI chip design and fabrication and demonstrate the potential impact (economical and technological) of the “virtual wafer fab” technology
- Document the project and summarize the experience

Management
- Self-motivated exploration through guided supervision
- Team work through cooperation and healthy competition
- Five groups, three students per group. Rotating group leaders of the week, each student serving as the group leader for two weeks (for weeks 2~7)
- Group leader is responsible for organisation and coordination of the group activities for the week, as well as liaison with the supervisors
- Weekly oral presentations (Friday afternoons for the weeks 2~7, 20 min. plus 10 min. Q&A per group), headed by the group leader of the week. Each student is expected to present (on average) 1 hour during IHPT.
- Wining team will represent the class for Technopreneurship Competition (22 June)
- Individual oral presentation of 5~10 min. (last week).
- Written report (per group) at the end of the IHPT session (Due: 24 June)

Assessment
- *Attitude*: motivation and enthusiasm
- *Aptitude*: approach and participation
- *Altitude*: understanding and creativity

References
- Website: http://www.ntu.edu.sg/home/exzhou/Teaching/IHPT-00.htm
- Online manuals: TMA WorkBench TSUPREM-4 MEDICI
- Handouts