Chapter 57
Teaching Technology Computer Aided Design (TCAD) Online

Chinmay K Maiti
Indian Institute of Technology, India

Ananda Maiti
Indian Institute of Technology, India

ABSTRACT

Since Technology Computer Aided Design (TCAD) is an important component of modern semiconductor manufacturing, a new framework is needed for microelectronics education. An integrated measurement-based microelectronics and VLSI engineering laboratory with simulation-based technology CAD laboratory is described. An Internet-based laboratory management system for monitoring and control of a real-time measurement system interfaced via a dedicated local computer is discussed. The management system allows the remote students to conduct remote experiments, perform monitoring and control of the experimental setup, and collect data from the experiment through the network link as if the student is physically in a conventional laboratory. The management system is also capable of evaluating of a student's performance and grading laboratory courses that involve preliminary quiz and viva-voce examinations, checking of experimental data and submitted online laboratory reports. The proposed online TCAD teaching methodology will provide an opportunity for expanding microelectronics education.

INTRODUCTION

The field of microelectronics technology is recognized as a driving force for the Information Age. Micro- and nanoelectronics device and circuit design and fabrication are specialized fields in electrical engineering. The main goal of undergraduate and/or postgraduate level microelectronics teaching is to produce high-quality engineers who are able to make contributions in the context of the rapid change that characterizes integrated circuit (IC) fabrication. For microelectronics courses, laboratory should include a clean room infrastructure, semiconductor equipment operation procedures, process and metrology, device testing, and process integration and manufacturing learning as hands-on fabrication as well as characterization of devices that enhance the educational

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experience. However, due to the high cost of a microelectronic fabrication laboratory, teaching microelectronic circuit fabrication is very much driven by the availability of resources at the institution providing such courses and is primarily taught at universities where an actual fabrication facility is available and, currently, it is mostly taught via demonstration mode. Microelectronics engineering education is in transition. New thought is being given to topics such as what constitutes microelectronics process design fundamentals, how to shrink the gap between industrial and academic perspectives on process design, and how to help students gain more experience and knowledge.

Currently, in most final year undergraduate and virtually all master's level programs, there are courses on device physics and processing technology (usually as one single course) based on standard text books on MOS and bipolar device physics that often do not include a laboratory component. Integrated circuit fabrication courses are offered as an elective in some Electrical and/or Electronic Engineering programs that cover fabrication theory of integrated circuits and process modeling. The introduction of process and device simulations in undergraduate teaching is also considered a difficult task. This is mainly due to the complicated user interaction with most of the available process and device simulators; usually the input information is prepared in the form of files written in a specific input language for each simulator. In general, professional Technology CAD (TCAD) simulation tools are difficult to use and are considerably more complex. The users need dedicated training sessions to successfully use the tools.

Also, during the last three decades, a new generation of semiconductor processing involving new material systems such as strained-Si and Silicon-Germanium (SiGe) have appeared, and integration of Group III-V compound semiconductors with Si technology is evolving (Maiti, Chattopadhyay, & Bera, 2007). With these advancements in semiconductor manufacturing, it is becoming difficult for the VLSI designers to optimize circuit design without considering the effects of advanced ULSI/GSI integration processes. The International Technology Roadmap for Semiconductors (ITRS, 2007) predicts the use of TCAD may provide as much as 40% reduction in technology development costs. TCAD has grown in both sophistication and maturity and is now an essential engineering tool for new technology development in industrial environments. Recent industry trends have given rise to major development opportunities for TCAD, and the virtual wafer fabrication has now become an integral part of semiconductor fabrication.

THE NEED

Semiconductor device theory and IC processing courses are becoming more important in electrical engineering curricula due to the fast changing semiconductor technologies and the challenges faced by the semiconductor industry. Process/device simulation tools are being introduced to students taking graduate courses in device physics and SPICE for circuit simulation. Semiconductor CAD originated in the early 1960s with efforts to understand and optimize bipolar transistors (Dutton, & Yu, 1993). TCAD is now a proven approach for developing process technologies, and a comprehensive set of TCAD tools is available from universities and from TCAD vendors. Advanced TCAD tools are capable of modeling the entire semiconductor manufacturing process. Also, the most challenging issue in the context of IC design and manufacturing now is product yield because the main causes for yield loss have changed over the years. Technology development in the semiconductor industry is a very complex task and requires a deep understanding of different physical and mathematical techniques. Next generation semiconductor engineers will need to be competent in the use of advanced process and

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