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Power Semiconductor Devices and Physics

Instructor

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Department: DESE

Course Time: Tue., Thu., 11:30 AM - 1 PM

Lecture venue: Classroom, First Floor, DESE

Detailed Course Page: http://www.ee.iisc.ac.in/SOI_2016-17.pdf

Announcements

Brief description of the course

Although, power semiconductor devices have a big market share, fundamental course on the basics of Power semiconductor devices is still not common across academia. This course covers the fundamentals about physics of power semiconductor devices. Power devices handle high voltage and high current and process power instead of information unlike devices in VLSI circuits. So, the power device design guidelines are different from those used in VLSI applications. Tthe knowledge about these design essentials is very important to realize power semiconductor devices with desired specifications. This course focuses on this.

Prerequisites

Semiconductor Physics

Syllabus

1) Power device applications:

Power electronic applications, High voltage and high-power circuits, RF power circuits and applications, On-chip circuits and power management system, high switching speed requirements for power system scaling.

2) Semiconductor Physics under extreme conditions:

Basics of semiconductor device physics, p-n junction, carrier transport under extreme conditions, avalanche breakdown, and thermal transport.

3) Power Diodes:

Various types of power diodes: Si diodes, Schottky diodes and P-i-N diodes; Physics of power diodes, power diode design essentials, breakdown voltage and ON-resistance trade-off, high current and ultra-fast transient behavior.

4) Si High Power MOS devices, design and Technology:

VMOS, VDMOS, UMOS, DMOS, LDMOS, DeMOS and Dual trench MOS; Process flow, discrete and On-chip device manufacturing technology; High power MOS design essentials, breakdown voltage and on-resistance trade-off, parasitic capacitance and resistances, DC, RF and switching characteristics; quasi saturation behavior, high current effects, Negative differential resistance (NDR), self-heating, filament formation and safe operating area (SOA).

5) GaN and SiC Power MOS devices:

Advantage of high bandgap materials, High bandgap material physics, various GaN/SiC devices, device physics and design essentials, GaN/SiC device manufacturing technology; breakdown voltage and on-resistance trade-off, parasitic capacitance and resistances, DC, RF and switching characteristics; quasi saturation behavior, self-heating effects and safe operating area (SOA), State-of-the-art GaN/SiC devices and ongoing research.

6) IGBTs and SCR: IGBTs and SCR device physics and device design essentials, breakdown voltage and on-resistance trade-off, self-heating effects and filament formation.

Course outcomes

Very less power semiconductor device expertise is

available in industry and numerous research options are available. This course will provide insight into physics of power semiconductor devices under extreme operation conditions like high voltage, high current and high temperature which are encountered under typical power electronic environment. The knowledge developed from this, will help in designing power devices with desired specifications.

Grading policy

15% for Assignment

15% for Quiz (Mid Term)

20% for Term Paper

50% for End Semester Exam

Assignments

Assignment-1: Course Module 1 - 3

Assignment-2: Course Module 4

Assignment-3: Course Module 5 - 6

Resources

Semiconductor power devices: Physics of operation and fabrication technology, Sorab Khushro Ghandhi, Wiley, 1977

Advanced Power MOSFET Concepts, B. Jayant Baliga, 2010

High Voltage Devices and Circuits in Standard CMOS Technologies, Hussein Ballan, Michel Declercq

Fundamentals of Power Semiconductor Devices, B. Jayant Baliga, 2010

Smart Power ICs: Technologies and Applications, edited by Bruno Murari, Franco Bertotti, Guiovanni A. Vignola

Silicon Carbide Power Devices, B. Jayant Baliga, World Scientific, 2005

Integrated Power Devices and TCAD Simulation, Yue Fu, Zhanming Li, Wai Tung Ng, Johnny K.O. Sin

Advanced High Voltage Power Device Concepts, B. Jayant Baliga, 2011