The University Of Sheffield.

Electronic & Electrical Engineering.

EEE6206 POWER SEMICONDUCTOR DEVICES

Credits: 15

Course Description including Aims

1. Introduce and develop an understanding of power semiconductor devices - physics, technologies, design, fabrication and characterization.
2. Evaluate suitability of various semiconductor device concepts for specific power electronic applications.
3. Device integration concepts such as device assembly, packaging and thermal constraints.

Outline Syllabus

Introduction to power semiconductor devices. Review of basic semiconductor device physics, structures, design and fabrication technologies and moving towards power semiconductor architectures. **Scaling effects of breakdown voltage**, material limits of breakdown voltage, on-state resistance and switching; techniques to overcome these physical limits (electric field shaping / wide band gap device materials (SiC, GaN)), where do bipolar device technologies sit, etc) **Power device packaging techniques.** Current packaging techniques for power semiconductor devices, thermal constraints and how it affects power device ratings, wire bonding and press-pack packaging techniques and reliability. **How to read datasheets.** Linking between semiconductor device parameters and the datasheet to choose the correct device technology. **Power device measurement techniques**. Practical experience of common measurement techniques used for un-packaged/packaged power devices. The practical experience will illustrate the difficulties in measuring device characteristics, capacitance voltage characteristics of power diodes and MOSFET/IGBT structures to illustrate input/output and reverse transfer capacitance and their physical processes. Transient device characterisation will be covered showing the influence of test circuitry upon measured energy loss and the considerations for voltage and current measurement probes. **TCAD modelling techniques for power semiconductor devices**. Practical experience of TCAD modelling of power semiconductor devices. This unit will use worked examples to explain TCAD techniques for process, device and mixed mode simulations. The practical experience will illustrate fundamental device physics such as depletion enhancement, electric field crowding and junction recovery processes. Advanced modeling techniques will also be discussed such a three-dimensional device modeling and illustrate the difficulties in building simulations of wide band gap power device technologies.

Time Allocation
36 lectures plus 12 hours of additional support including laboratories and tutorials.

Assessment
2 hour examination: Candidates must choose any three out of four questions; 70% final mark
Course work to assess practical aspects of course; 30% of final mark

Recommended books
B. G. Streetman	Solid state electronic devices
S. M. Sze	Semiconductor devices: physics and technology
B. J. Baliga	Power semiconductor devices
D. K. Schroder	Semiconductor material and device characterisation
V. Benda	Power semiconductor devices: theory and application
N. Mohan	Power electronics converters, applications and design
B. J. Baliga	Silicon carbide power devices
V. Khanna	Insulated gate bipolar transistor: theory and design

Objectives
By the end of this module successful students will be able to:

1. Demonstrate understanding of voltage/current/switching related issues in power device technologies and fundamental physical limits to these devices.
2. Show an awareness of power ICs, discrete and intelligent power modules.
3. Describe a range of new power device technologies are being used to increase power density ratings.
4. Demonstrate knowledge of non-silicon based technologies and how these can improve on silicon power semiconductor technologies.
5. Show an awareness of future device technologies which would overcome current limitations.
6. Demonstrate an understanding of TCAD modelling techniques.
7. Link datasheet parameters to physical device performance with measurements and understand ratings for specific applications.
8. Show an awareness of measurement techniques used to populate datasheets and to extract specific parameters and see how they link to specific power electronics applications.