The course conveys a solid understanding of the use of modern semiconductor technologies in power electronic applications. Based on the relevant figures of merit of Si, GaN and SiC based power semiconductors, aspects of power device characterization and modeling, circuit design, mounting and packaging and reliability will be covered. An additional focus is on the current front of research and development and the challenges of high power density and fast-switching power converter applications.

Ingmar Kallfass received the Dipl.-Ing. degree in Electrical Engineering from University of Stuttgart in 2000, and the Dr.-Ing. degree from University of Ulm in 2005. In 2001, he worked as a visiting researcher at the National University of Ireland, Dublin. In 2002, he joined the department of Electron Devices and Circuits of University of Ulm as a teaching and research assistant. In 2005, he joined the Fraunhofer Institute for Applied Solid-State Physics with a focus on nonlinear millimeter-wave integrated circuit design. From 2009 to 2012, he was a professor at the Karlsruhe Institute of Technology in the field of high-speed integrated circuits in a shared professorship with the Fraunhofer IAF in the frame of the German Excellence Initiative. Since 2013, he holds the chair for Robust Power Semiconductor Systems at the University of Stuttgart as part of the Robert Bosch Center for Power Electronics, where his major fields of research are compound semiconductor based circuits and systems for micro-wave and power electronics.
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The course is an elective faculty course, providing 2 academic points.

**Instructor:** Prof. Ingmar Kallfass.

Teaching assistant: Aleksey Dyskin

**Prerequisite:** Linear Electronic Circuits – 044142 (Integrated Power Devices 046235 is recommended but not necessary).

**Lectures:** 26 Hours

**Tutorials/HW/Workshops:** 13 Hours

**Academic points:** 2pts

For any course related questions please contact Aleks: aleksd@campus.technion.ac.il
Course Syllabus and Schedule:

Framework:

- 5 day course
- 4 blocks of 1.5h lectures per day
- 2 blocks in the morning, 2 blocks in the afternoon
- 2X5 Hours Tutorials/ Exercise Sessions/HW preparation (option for one of them)

Day 1

9:00 – 12:00  **Power Semiconductor Devices in Power Electronics Applications**

Application areas

Recent Trends and Developments

13:00 – 16:00  **Power Semiconductor Figures of Merit**

Baliga, Johnson FOM

Switching Loss FOM and Intrinsic Semiconductor Limits

Power Semiconductor Benchmarking

Link budget calculations

Day 2

9:00 – 12:00  **Power Semiconductor Devices**

Si MOSFET, IGBT

SiC MOSFET, IGBT

GaN HEMT, MISFET

13:00 – 16:00  **Static Device Characterization**

IV, CV, gate charge

Advanced concepts: on-state capacitance, S-parameter

Day 3

9:00 – 12:00  **Dynamic Device Characterisation**

Double Pulse Test

Nominal switching waveforms

Parasitic inductance and ringing

Current and voltage measurement
13:00 – 16:00 **Switching Loss**

- Turn-on loss
- Turn-off loss
- Switch node capacitance

**Day 4**

9:00 – 12:00 **Thermal Analysis**

- Thermal material properties
- Thermal modeling
- Thermal FEM simulation

13:00 – 16:00 **Multi-Physics Simulation**

- Electro-magnetic and thermal coupled simulations
- Multi-domain optimization
- Thermo-mechanic coupling
- Accelerated lifetime tests
- Lifetime prediction

**Day 5**

9:00 – 12:00 **GaN Monolithic Integrated Power Circuits**

- Driver integration
- Quasi normally-off concept
- Temperature Sensors
- Free-wheeling diode
- Integrated half-bridge

13:00 – 16:00 **Fast Switching with GaN power transistors**

- Driver concepts
- Double pulse tests with up to 1000 V/ns slew rate
Final Examination: March 09, 09:00-11:00. Room 165. Written examination on the academic paper on the course material.

Course Registration:

Undergraduate students: Please contact Ruthi/Rina at EE secretary to register.

Graduate students: Please contact Danit danitc@ef.technion.ac.il to register.