TARGET
TOP AMPLIFIER RESEARCH GROUPS IN A EUROPEAN TEAM

Course description: **RF Semiconductor Materials and Devices**

Modules:

1. Semiconductor Materials I – Structure and Physical Properties
2. Semiconductor Materials II – Alloys and Heterostructures
3. RF Devices I – Figures of Merit and Basic Transistor Concepts
4. RF Devices II - Transistor Concepts for High Frequency and High Power Applications
5. Si- and SiGe-based RF Transistors
6. GaAs and InP based RF Transistors
7. GaN based RF Transistors
8. SiC based Microwave Diodes

Audience:

This course is designed for engineers working on semiconductor process technologies and/or on device and circuit design.

Preliminary Knowledge:

- Physics of semiconductors
- Semiconductor process technology

Our presenters:

Frank Schwierz (Technical University Ilmenau, Germany)
Wolfgang Richter (University of Jena, Germany)
Joachim Würfl (Ferdinand-Braun-Institut Berlin, Germany)
Konstantinos Zekentes (Foundation for Research and Technology-HELLAS, Greece)

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Module 1 - Semiconductor Materials I – Structure and Physical Properties

The basic physical properties of semiconductor materials determine to a large extent their applicability for electronic devices. The module discusses the basic physical properties of important semiconductor materials and the connection between them. The main topics are:

- Crystal structures
- Physical properties
- Brillouin zone
- Band structure
- Effective mass
- Doping, carrier concentration
- Electrical conductivity

Presenter: Wolfgang Richter
Duration: 2 hours
Please note: It is recommended to book Module 1 in combination with Module 2.

Module 2 – Semiconductor Materials II – Alloys and Heterostructures

In advanced semiconductor devices, frequently different materials and material combinations are used. Besides the basic material properties, the characteristics of such devices depend heavily on the properties of material combinations like alloys and on the interfaces between different semiconductors, i.e., heterostructures.
The main module topics are:

- Semiconductor alloys
- Heterostructures
- Heteroepitaxy
- Size quantization
- Carrier transport
- Spontaneous polarization

Presenter: Wolfgang Richter
Duration: 2 hours
Please note: It is recommended to book Module 2 in combination with Module 1.

Module 3 - RF Devices I – Figures of Merit and Basic Transistor Concepts

This module provides important basics of RF devices. The most important RF transistor figures of merit are introduced. Basic RF transistor concepts and issues related to the suitability of different semiconductors for RF devices are discussed. The topics of this module are:

- Mainstream electronics versus RF electronics
- Transistor concepts I
- RF transistor figures of merit
- Material issues – special needs for RF
- History and evolution of RF Transistors

Presenter: Frank Schwierz
Duration: 2 hours
Please note: It is recommended to book Module 3 in combination with Module 4.

Module 4 – RF Devices II - Transistor Concepts for High Frequency and High Power Applications

The module provides an overview of all advanced RF transistor concepts currently in use or under development. The basic device structures, operation principles and state-of-the-art performance of transistors are discussed and design rules for RF low-noise and high-power transistors are explained.

- Transistor Concepts II
  - FETs (MESFET, HEMT, MOSFET)
  - Bipolar Transistors (BJTs, HBTs)
- Special needs for RF low-noise and high-power devices
- ITRS for RF transistors

Presenter: Frank Schwierz
Duration: 2 hours
Please note: It is recommended to book Module 4 in combination with Module 3.

Module 5 – Si- and SiGe-based RF Transistors

Si-based RF transistors become more and more popular and make inroads in frequency ranges that have been the domain of III-V transistors in the past. Especially in high volume markets where reasonable performance at low cost is crucial, Si and SiGe RF transistors successfully replace GaAs transistors. The basics and the performance of the most important Si-based RF transistor types is discussed. The module is divided in the following parts:

- Si RF MOSFETs
- SiGe HBTs
- Si LDMOS transistors
- Future trends

Presenter: Frank Schwierz
Duration: 2 hours

Module 6 – GaAs and InP based RF Transistors

GaAs PHEMT and InP HEMT are the premier millimetre wave (MMW) power devices in production. InP HEMTs and MHEMTs are for low noise/front end applications and power devices above 40 GHz. The module is divided in the following parts:

- GaAs- und InP-based HBTs
- GaAs- und InP-based HEMTs
- GaAs PHEMTs
- InP MHEMTs
- Future developments

Presenter: Joachim Würfl
Duration: 2 hours

Module 7 – GaN based RF Transistors

At lower frequencies, GaN may prove to be a disruptive technology, with up to 10x higher power density than GaAs or InP based technologies. While relatively immature, much remains to be done in this evolving technology, particularly in materials quality and device reliability. The module is divided in the following parts:

- GaN HFET
- GaN/AlGaN HEMT
- AlGaN/GaN HBT
- Future developments

Presenter: Joachim Würfl
Duration: 2 hours

Module 8 – SiC based Microwave Diodes

SiC is the ideal material for high power/ high frequency/ high temperature applications due to the outstanding materials parameters like thermal conductivity and breakdown voltage. The content of the teaching module comprises:

- IMPATT diode
- Schottky diode
- PIN diode
- Future developments

Presenter: Konstantinos Zekentes
Duration: 2 hours