MICRO-432 **Microelectronics**

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| Cursus | Sem. | Type |
|---|---|---|
| Microtechnics | MA1, MA3 | Opt. |
| Mineur STAS Chine | H | Opt. |

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|---|---|
| Language of teaching | English |
| Credits | 2 |
| Session | Winter |
| Semester | Fall |
| Exam | Oral |
| Workload | 60h |
| Weeks | 14 |
| **Hours** | **2 weekly** |
| Courses | 2 weekly |
| **Number of positions** | |


## Summary

Analysis of the relationship between the structure of the main microelectronic devices and their electrical characteristics and explanation of the role and behavior of the systems studied in an integrated circuit. Evolution of technology and microelectronic components.


## Content

- Summary of semiconductor physics: Energy band diagrams, drift and diffusion currents, mobility, temperature effects.
- MOS transistor advanced topics: Weak inversion, down scaling, high electric field, bipolar transistor mode of operation.
- Compound semiconductors, hetero-junctions and devices: Equilibrium, current-voltage characteristics, capacitance; FETs, HEMT, heterojonction bipolar transistor, electrical models.
- Bipolar junction transistors: scaling down, ballistic transport, high frequency structures.
- Noise in integrated circuits: thermal noise, shot noise, generation-recombination noise, 1/f noise and noise in circuits.
- Parasitic and limiting effects in devices and circuits: Parasitic resistances, capacitances and inductances, leakage currents, hot carrier effects, breakdown.
- CMOS digital and analog integrated circuits: Principal building blocks and functions; Example: integrated Hall magnetic field sensors.
- Memories: Working principles and structures of ROM, PROM, EPROM, DRAM, SRAM, FLASH.
- Yield and reliability: Defect density, relation with design rules, yield statistics; Reliability, failure rate, failure mechanisms due to high electric field effects, electro-migration, heat dissipation, and packaging stress.
- Design of integrated circuits: Project outline, schematic, layout, design rules, numerical modelling and simulation.
- Integrated sensor microsystem: Example: Integrated optical detector.
- Current trends in microelectronics: State of the art and scaling down.

## Keywords

Semiconductors, silicium, III-V compounds, GAAs, diode, bipolar transistor, MOS transistor, HEMT, CMOS, Memories, ROM, RAM, Flash, reliability, yield, design, integrated circuit, IC, schematic, layout, design, model, simulation.

## Learning Prerequisites

### Required courses

Composants semiconducteurs MICRO-312

### Recommended courses

Composants semiconducteurs MICRO-312

### Important concepts to start the course

Energy band diagram, semiconductor device modellisation

## Learning Outcomes

By the end of the course, the student must be able to:

- Develop electronic properties of devices and circuits.
- Explain basic microelectronic devices such aas FET, BJT, CMOS, Memories.
- Discuss main electronic circuits, including digital and analogue components.
- Formulate fundamental equations of the mains components and circuits.
- Model microelectronics devices.
- Illustrate design tools for intergrated circuits

## Transversal skills

- Access and evaluate appropriate sources of information.

## Teaching methods

Ex-cathedra course with exercises.

## Expected student activities

Attend to the lectures.
Exercises solved with personal work.
Associated thinking for every topic.

## Assessment methods

20% exercises
80% oral examination (2 questions)

## Resources

### Bibliography

Notes polycopiées :
1. S.M. Sze: "Semiconductor Devices", J. Wiley & Sons, 2002
2. S.M. Sze, Kwok K. Ng:  "Physics of semiconductor devices", 3rd Edition, J. Wiley& Sons, 2007
3. H. Mathieu, H. Fanet: "Physique des semi-conducteurs et des composants électroniques", 6e édition, Dunod, Paris, 2009
4. R. Jacob Baker: "CMOS, Circuit Design, Layout and Simulation", 3rd Edition, Wiley, 2010
5. H. Veendrick: "Deep-submicron CMOS ICs", Kluwer, 2000

### Ressources en bibliothèque

- Semiconductor Devices / Sze
- Physique des semi-conducteurs / Mathieu
- Physics of semiconductor devices / Sze
- Deep-submicron CMOS ICs / Veendrick
- CMOS / Baker

### Notes/Handbook

Distributed handsout at each lecture

**Prerequisite for**

Microelectronics and microsystems, Semester work in microelectronics laboratory