

# Lab of Technology Computer Aided Design M

## Laboratorio di Progettazione Tecnologica Assistita dal Calcolatore (AY 14–15)

### Massimo Rudan

These slides are available in pdf format at the link entitled *Teaching Activity* of the website

<http://www.micro.deis.unibo.it/cgi-bin/user?rudan>

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✓ IEEE.



## TO WHOM IS THIS COURSE ADDRESSED?

- ❑ In the Academic year 2014–2015 the Students attending the course belong to the **Electronics and Communication Science and Technology**, **Ingegneria elettronica (LM)**, and **Ingegneria elettronica e telecomunicazioni** program.
- ❑ The course may be attended by Students different from the above who choose it on a case-by-case basis.



## MORE DETAILS ABOUT THE ABOVE

- ❑ The lessons in the agenda will be given in the period February 23 through June 5, 2015. The weekly hours shown in the Faculty's schedule are a little more than those necessary to complete the maximum of 30 hours.

### Note:

- In many cases the lessons in class are replaced by laboratory work, whose agenda is given separately.
- The agenda may also be changed if necessary. Hours may be swapped with those of other teachers.
- Changes in the agenda may be sought in order to balance the needs of the different groups of Students.





## SCHEDULE

- ❑ The initial schedule is: Wednesdays 15–17 in classroom 5-2 or in the Laboratory, depending on the subject.
- ❑ The Laboratory sessions are held in the old building: take the main stairs up to the third floor, walk along the aisle, enter the third door on the left.
- ❑ It may happen that a few hours are added to the schedule if a need of recovery arises. In any case the total number of hours will not exceed 30.
- ❑ Due to national holidays there will be no lessons on
  - Easter vacations, April 2 through April 8.
  - Saturday, April 25.
  - Friday, May 1.
  - Tuesday, June 2.

## AIMS OF THE COURSE

- ❑ The Technology Computer-Aided Design (TCAD) represents a branch of the electronic-design automation that models the semiconductor-device fabrication and the behaviour of semiconductor devices. The student is taught to set and perform numerical simulations of semiconductor structures by means of commercial TCAD tools, with the main purpose of understanding the connections between the microscopic physical behaviour and the macroscopic properties of the electronic devices.
- ❑ La progettazione tecnologica assistita dal calcolatore costituisce un ramo dell'automazione della progettazione elettronica che modella la fabbricazione dei semiconduttori e il funzionamento dei dispositivi a semiconduttore. Lo studente è messo in grado di impostare ed eseguire simulazioni numeriche di strutture a semiconduttore utilizzando strumenti commerciali di progettazione assistita dal calcolatore per comprendere le connessioni tra il comportamento fisico microscopico e le proprietà macroscopiche dei dispositivi elettronici.





## PREREQUISITES

- ❑ Basic concepts of mathematics and physics acquired from earlier courses.
- ❑ Basic concepts about the electron devices.
- ❖ In this course further mathematical and physical concepts, not necessarily elementary, will be used. They will be explained as necessary during the lessons in class. The use of such concepts can not be disposed of, they actually constitute the cultural basis of the course itself.



## EXAMS

- ❑ The exam consists in a written examination on the theoretical part and, for those who pass the written examination, in the discussion of a project carried out by the student on one of the class' topics. The students who fail the written examination must repeat it.
- ❑ To register for the exam it is necessary to use the electronic lists that will be made available on the website

***<https://almaesami.unibo.it>***

**The Students that have access to the e-lists are kindly asked to use this method only**

- ❑ The electronic lists will carry the indication of the meeting point for the examinations' scheduling.



## REFERENCES (I)

### □ Solid-State Electronics

- 1-1. D. A. Neamen, *Semiconductor Physics and Devices*, IRWIN, 1992.
- 1-2. M. Rudan, *Tavole di Microelettronica*, Pitagora Tecnoprint, 3<sup>a</sup> Ed., 2001 (in English).
- 1-3. M. Rudan, *Physics of Semiconductor Devices*, Springer, 2015.
- 1-4. S. M. Sze, *Semiconductor Devices — Physics and Technology*, Wiley, 1985.
- 1-5. E. De Castro, *Fondamenti di Elettronica — Fisica elettronica ed elementi di teoria dei dispositivi*, UTET, 1975.
- 1-6. E. De Castro, *Teoria dei dispositivi a semiconduttore*, Pàtron, 1983.
- 1-7. N. Ashcroft, N. Mermin, *Solid State Physics*, Saunders, 1976.
- 1-8. Synopsys Sentaurus Handbook.





## REFERENCES (II)

- ❑ The textbooks listed above are given as references.
- ❑ The book *Tavole di Microelettronica* is written in English and is the collection of most of the transparencies used by M. Rudan in his courses. It is meant as a teaching aid providing drawings, schemes, and calculations, not as a “replacement” of the lessons. Richer explanations are in the 2015 textbook *Physics of Semiconductor Devices* published by Springer.
- ❑ During the lessons further transparencies not included in the collection may be used. Those that are not subject to copyright will be posted on M. Rudan’s website (many are actually posted there already).



# TENTATIVE AGENDA

Lesson no.	Teacher	Subject
01	GBB	Introduction to TCAD
02	GBB	Introduction to the Sentaurus code
03	MR	Fundamentals of Semiconductor modeling and numerical techniques
04	MR	Fundamentals of the pn junction
05	GBB	pn junction --- Static behavior I
06	GBB	pn junction --- Static behavior II
07	GBB	pn junction --- Static behavior III
08	GBB	pn junction --- Static behavior IV
09	GBB	pn junction --- Static behavior V
10	GBB	pn junction --- Static behavior VI
11	GBB	pn junction --- Process simulation I
12	GBB	pn junction --- Process simulation II
13	MR	Fundamentals of the MOS capacitor
14	MR	Fundamentals of MOSFET
15	GBB	MOS capacitor I
16	GBB	MOS capacitor II
17	GBB	MOS capacitor III
18	GBB	MOSFET I
19	GBB	MOS FET II
20	GBB	MOSFET III
21	GBB	MOSFET IV
22	GBB	Project
23	GBB	Project
24	GBB	Project
25	GBB	Project
26	GBB	Project
27	GBB	Project

## CONTACTING THE TEACHER/TUTOR

- ❑ The official agenda for contacting the teacher is:
  - Thursdays 11:30–13:30
  - Fridays 11:30–13:30
  
- ❑ However, it is advisable to ask for an appointment (not limited to the above agenda) during a class, or by calling 051-209-3016 (93016 when using the internal telephones of the Faculty), or by sending a message to

***mrudan@arces.unibo.it***

- ❑ The tutor is Dr. Giovanni Betti Beneventi, 051-209-3773, whose e-mail address is

***giobettibeneventi@gmail.com***





## THESIS (I)

- ❑ Possible subjects for a thesis in the area of semiconductor devices or materials are:
  - Advanced physical models for carrier transport in solids: through the BTE or the Schrödinger equation (coupled with the Poisson eq.), using different solution methods, among which the NEGF (Non-Equilibrium Green Function).
  - Quantum computation.
  - Carbon nanotubes, silicon nanowires.
  - Electronic nose (design and characterization of integrated sensors for volatile compounds using polymers).
  - MEMS for applications to radio-frequency circuits.
  - Advanced memory architectures, e.g., Phase-change memories (chalcogenide materials).
- ❑ Depending on the time left, some of the above research activities may be illustrated in seminars held within the course's schedule.



## THESIS (II)

- All the thesis subjects shown above are carried out by M. Rudan, or by Colleagues of his, working at the (\*)

### ***Advanced Research Center on Electronic Systems (ARCES)***

- The Professors of Electronics of the Faculty of Engineering belonging to ARCES are: G. Baccarani, G. Masetti, M. Rudan, R. Guerrieri, A. Gnudi, E. Franchi, R. Rovatti, C. Metra, S. Reggiani, N. Speciale.

**ARCES is a Research Center of the University of Bologna, not a private Company.**

(\*) In Italian: *Centro di Ricerca sui Sistemi Elettronici per l'Ingegneria dell'Informazione e delle Telecomunicazioni "Ercole De Castro" (ARCES).*



## IEEE

- ❑ IEEE means *Institute of Electrical and Electronic Engineers* (pron. “I triple E”).
- ❑ IEEE is an international Institute made of a large number of Technical Societies: *Electron Devices, Circuits and Systems, Quantum Electronics, Antennas, Telecommunications, Computers, Power Electronics*, and so on.
- ❑ Becoming an IEEE member gives access to one or more Societies and to the related Journals.
- ❑ In the University sites where IEEE is present, a Student Branch is present as well. Registration fees for Students are lower than the regular ones.

**The information provided here about IEEE has no relation with the official teaching activity. It is only meant to inform the Students about the existence of the Student membership.**