MICRO-435 Quantum and Nanocomputing

Edoardo Charbon
Mariagrazia Graziano

Instructors

Prof. Mariagrazia Graziano
Politecnico di Torino
Torino, Italy

Email: mariagrazia.graziano@polito.it
URL: https://www.swas.polito.it/rubrica/scheda_pers.asp?matricola=004318
Office hours: by appointment

Prof. Edoardo Charbon
EPFL
INF 135

Email: edoardo.charbon@epfl.ch
URL: https://people.epfl.ch/edoardo.charbon
Office hours: Wednesdays 17-18 and by appointment

Syllabus, etc.

- Quantum computing (Week 1-7)
- Nano computing (Week 8-14)

- Prerequisites
  - Basic mathematics/physics

- Recommended courses
  - Basic quantum mechanics
  - Solid-state devices
  - CMOS circuit design

Logistics

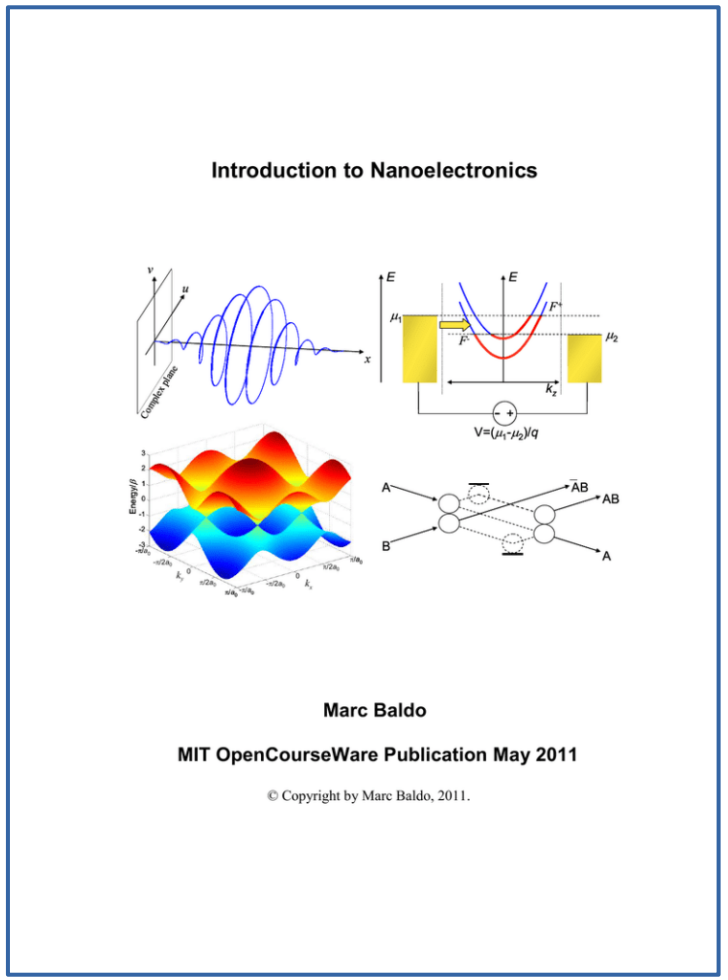
- Tuesday: 3h lectures with breaks
- Wednesday: 1h lecture/testimonial
  2h homework/questions
- Evaluation
  - Weekly homework (50%)
  - Final oral exam (50%)

Reference week

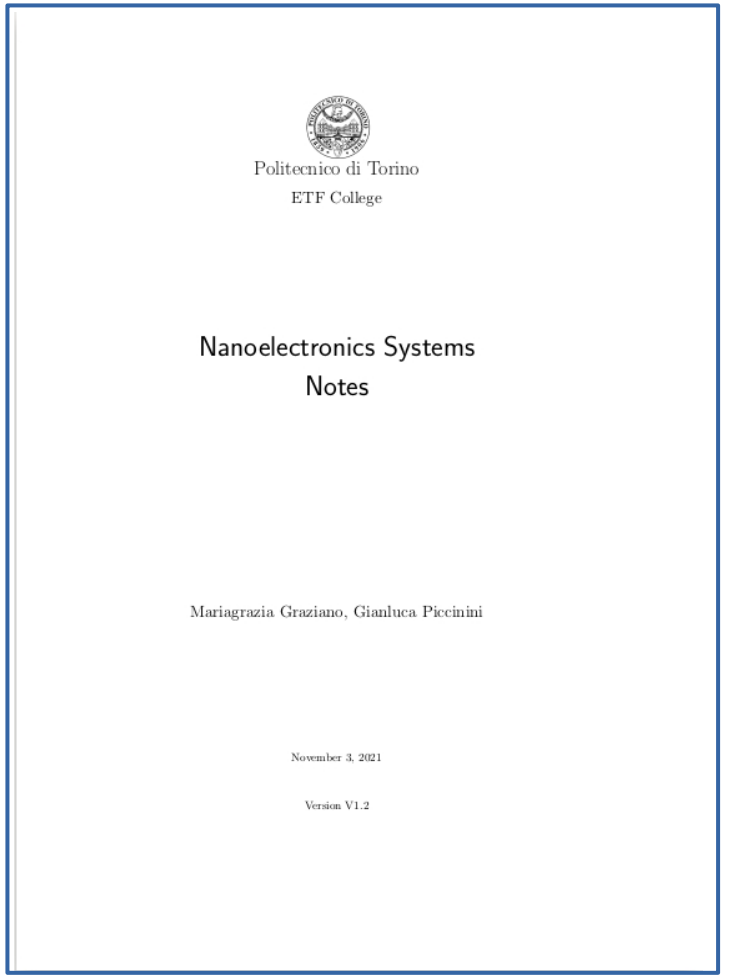
	Mo	Tu	We	Th	Fr
8-9					
9-10					
10-11					
11-12					
12-13					
13-14			AAC132		
14-15			AAC132		
15-16					
16-17		AAC132			
17-18					
18-19					
19-20					
20-21					
21-22					

Recommended textbooks

- Marc Baldo, Introduction to Nanoelectronics, MIT OpenCourseWare, 2011.



- M.Graziano, G.Piccinini "Nanoelectronics Systems, Notes" Politecnico di Torino, 2023, Version 1.3



Nanocomputing - Collaborations VLSI Nanocomputing Lab @Polito

- Lectures are given by:
  - Prof. Mariagrazia Graziano

    mariagrazia.graziano@epfl.ch mariagrazia.graziano@polito.it

- Credits:

  Prof. G. Piccinini, Y.Ardesi, C. Elfi Spano, G. Beretta, F. Mo, F. Riente, M. Vacca, G.Turvani, L. Gnoli

Nanocomputing - syllabus

- **Molecules as conductive elements for computing**
  - Molecular transistors characteristics and fabrication
  - Theory on conduction for molecular transistors
  - Molecular wires/transistors parameters
  - MT logic behavior and circuits design
- **Molecules and Nanomagnets as Field Coupling elements for computing**
  - General concepts on Field Coupling Nanocoputing
  - Molecular FCN characteristics, computational models, circuits
  - Nanomagnetic FCN: NML, PNML, Racetrack PNML logic, LIM
  - Skyrmions, Logic in Memory, LIM architectures

Nanocomputing - organization

- Molecules as conductive elements for computing **(W8-10)**
  - Molecular transistors characteristics and fabrication **(T+Hw)** – M.Graziano
  - Theory on conduction for molecular transistors **(T+Ex+Hw)** – Graziano
  - Molecular wires/transistors parameters **(T+Ex/Lab+Hw)** – M.Graziano &TA
  - MT logic behavior and circuits design **(T+Ex/Lab+Hw)** – M. Graziano &TA
- Molecules and Nanomagnets as Field Coupling elements for computing (**W11-14)**
  - General concepts on Field Coupling Nanocoputing **(T)** – M.Graziano
  - Molecular FCN characteristics, computational models, circuits **(T+Ex/Lab+Hw)** – M.Graziano &TA
  - Nanomagnetic FCN: NML, PNML, Racetrack PNML logic, LIM **(T+Ex/Lab+Hw)** – M.Graziano & TA
  - Skyrmions, Logic in Memory, Magn Molecules for QC **(T+Ex/Lab)**

Nanocomputing - tools

- Labs based on:
  - EEBESD, for MT - Matlab based
  - SCERPA for MolFCN - Matlab based – TopoliNano Tech
  - OOMF for MagnFCN - micromagnetic simulator – free
  - MAGCAD for MagnCircuits – TopoliNano Tech
- All of them will be available with instructions

Nanocomputing - Ex/Labs/Hw

- W8 – Exercises NG fabrication/ conduction quantum dots – HW OPTIONAL
- W9 – Exercises conduction on Quantum wires for MT theory support – HW MAND
- W10 – EEBESD Labwork for MT, part 1 – HW MANDATORY
- W11 – EEBESD Labwork for MT, part 2 – HW MANDATORY
- W12 – SCERPA Labwork for MolFCN – HW MANDATORY
- W13 – OOMF Labwork for MagnFCN – HW MANDATORY
- W14 – MAGCAD for MagnCircuits – HW OPTIONAL

- A small shift:
  - W11 Lab on MT, Theory on FCN
  - W14 Lab on MagnCircuits, Theory on Skyrmions and Magn. Molecules for quantum computing

Molecules as conductive elements for computing

Nanocomputing - W8

- Molecules as conductive elements for computing
  - **Molecular transistors characteristics and fabrication (T+Hw)** – M.Graziano
  - **Theory on conduction for molecular transistors (T+Ex+Hw)** – M.Graziano &TA
  - Molecular wires/transistors parameters (T+Ex/Lab+Hw) – M.Graziano &TA
  - MT logic behavior and circuits design (T+Ex/Lab+Hw) –
  - M. Graziano &TA

Nanocomputing - W9

- Molecules as conductive elements for computing
  - Molecular transistors characteristics and fabrication (T+Hw) – M.Graziano
  - **Theory on conduction for molecular transistors (T+Ex+Hw)** – M.Graziano &TA
  - **Molecular wires/transistors parameters (T)** – M.Graziano
  - MT logic behavior and circuits design **(T+Ex/Lab+Hw)** –

    M. Graziano &TA

Nanocomputing - W10

- Molecules as conductive elements for computing
  - Molecular transistors characteristics and fabrication **(T+Hw)** – M.Graziano
  - Theory on conduction for molecular transistors **(T+Ex+Hw)** – M.Graziano
  - **Molecular wires/transistors parameters (Ex/Lab+HW EEBESD1)** M.Graziano & TA
  - **MT logic behavior and circuits design (T)** – M. Graziano &TA

Nanocomputing - W11

- Molecules as conductive elements for computing
  - Molecular transistors characteristics and fabrication **(T+Hw)** – M.Graziano
  - Theory on conduction for molecular transistors **(T+Ex+Hw)** – G. Piccinini
  - Molecular wires/transistors parameters **(Ex/Lab+HW EEBESD 1)** M.Graziano & TA
  - **MT logic behavior and circuits design (Ex/Lab+Hw EEBESD 2)** - M. Graziano &TA
- Molecules and Nanomagnets as Field Coupling elements for computing (**W11-14)**
  - **General concepts on Field Coupling Nanocoputing (T)** – M.Graziano

Speaker

Molecules as conductive elements for computing…..

….. let’s start

Nanocomputing - W8

- Molecules as conductive elements for computing
  - **Molecular transistors characteristics and fabrication (T+Hw)** – M.Graziano
  - **Theory on conduction for molecular transistors (T+Ex+Hw)** – M.Graziano
  - Molecular wires/transistors parameters (T+Ex/Lab+Hw) – M.Graziano &TA
  - MT logic behavior and circuits design (T+Ex/Lab+Hw) –
  - M. Graziano &TA

W8	HW5	OPTIONAL	- M.T. FABRICATION	(M THE OPT)
W9	HW6	MANDATORY	- M.T. MODEL, PEN & PAPER EXERCISES	M.
W10	HW7	//	- MT. CIRCUITS P&P +EEBESD	M.
W11	HW8	//	- MT CIRCUITS++ EEBESD ++	M.
W12	HW9	//	- SCERPA	M.
W13	HW10	//	- OOMMF	M.
W14	HW11	OPTIONAL	(- TOPOLINANO - MAGCAD)	