Course name:	**Course code:**
Solid State Physics	CE512

Location in curricular map:
Specialization Axis

Course description:
This is an introductory course for students interested in physics, electrical, computer and materials engineering. The course covers classic an quantum theory of conductors, insulators and semiconductors. Elastic properties of crystals, vibrations and thermal characteristics are studied, as well as crystalline structure, x-ray and electron diffraction and relationships between energy bands in metals, insulators and semiconductors.

Course learning outcomes:
At the end of the course, the student will: Know, comprehend and apply at an introductory level, the properties of crystalline materials, diffraction, photons, vibrations, etc. Know the principles of quantum mechanics with regards to the electron, its impact in the physical properties of metals, isolators and semiconductors.

Course content:	Hours
1. Crystalline structure of solids	6
2. Introduction to quantum mechanics	6
3. Introduction to quantum theory of solids	6
4. The semiconductor in equilibrium	6
5. Carrier transport phenomena	6
6. Carrier excess in semiconductors	6

Learning activities:	Hours
• **In-class activities:** - Presentation of topic by professor. - Presentations by guest speakers. - Case and topic discussions. - Final project presentations.	**36**
• **Independent activities:** - Reading of applied research case studies. - Research. - Research reports. - Problem analysis. - Solution design.	**60**

Evaluation criteria and procedures:

The evaluation instruments are as follows:

- Research homework.
- Final research project.
- Participation.

The weight in points for each of these instruments will be established between the group and the professor in the first class session.

Bibliography:

	Type	Title	Author	Publisher	Year
	Text	Semiconductor Physics and Devices 3rd Edition	Donald Neamen	McGraw-Hill	2002
	Reference	Solid-State Physics for Engineering and Materials Science	John Philip McKelvey	Krieger Publishing Company	1993

Course name:	Course code:
Semiconductor Fabrication Engineering	CE513

Location in curricular map:
Specialization Axis

Course description:
The rapid growth of the integrated circuit industry has given impulse to the semiconductor fabrication engineering as a new discipline. This course is focused on students without prior knowledge or experience in the fabrication of solid state or integrated circuits. The course presents the basic principles of semiconductor materials, their arrangement, and individual processes common to all integrated circuit technologies, such as preparation of substrate, oxidation, diffusion, implants and thin layer deposition. The course focuses on silicon processing at a basic level and applications of this processing to fabrication technologies for integrated circuits.

Course learning outcomes:
At the end of the course, the student will: Know and comprehend the basic information regarding the fabrication processes used in the semiconductor and microelectronics industry.

Course content:	Hours
1. General Introduction	6
1.1 Introduction	
1.2 Introduction to the semiconductor industry, history, and future tendencies.	
1.3 Basic electronic components and semiconductor devices.	
2. Semiconductor substrate	
2.1 Why silicon?	3
2.2 Electrical properties of silicon.	
2.3 Crystalline structure, diamond structure, Miller indices and crystalline defects.	
3. Preparation of the semiconductor wafer.	
3.1 Preparation of electronic grade silicon.	3
3.2 Crystal growth.	
3.3 Preparation of the wafer. Doping type, crystalline orientation and measure of resistivity.	
3.4 Clean rooms and wafer cleaning.	
4. Silicon oxidation	
4.1 Properties and applications of silicon-dioxide.	3
4.2 SiO_2-Si interface.	
4.3 Oxidation technology and characterization.	
4.4 Factors affecting oxidation.	
5. Oxidation, Cont.	
5.1 Selective oxidation.	
5.2 Simulation	3
6. Diffusion	
6.1 Diffusion process	
6.2 Mathematical model	
7. Diffusion, Cont.	3
7.1 Union forming.	
7.2 Depth of union. Irvin curves.	
7.3 Successive diffusions.	3
7.4 Diffusion and SiO_2.	
7.5 Characterization of diffusions.	
8. Ion implantation.	
8.1 Implantation technology.	
8.2 Applications.	
9. Metal deposition.	3
9.1 Metallization of integrated circuits	
9.2 Deposition techniques	
10. Micro-photolithography	
10.1 Design rules.	3
10.2 Mask fabrication.	
10.3 basic lithography.	

Learning activities:	Hours
• **In-class activities:** - Presentation of topic by professor. - Presentations by guest speakers. - Case and topic discussions. - Final project presentations.	**36**
• **Independent activities:** - Reading of applied research case studies. - Research. - Research reports. - Problem analysis. - Solution design.	**60**

Evaluation criteria and procedures:

The evaluation instruments are as follows:

- Research homework.
- Final research project.
- Participation.

The weight in points for each of these instruments will be established between the group and the professor in the first class session.

Bibliography:

	Type	Title	Author	Publisher	Year
	Text	Introduction to Microelectronic Fabrication, II Edition, Vol. V of Modular Series on Solid State Devices,	Richard C. Jaeger	Prentice Hall	2002
	Reference	Silicon VLSI Technology, Fundamentals, Practice and Modeling	by J D Plummer, Deal M D, and P B Griffin	, Prentice Hall	2000
	Reference	Silicon Processing for the VLSI Era, Vol. I, Process Technology, II Ed	S. Wolf and R.N. Tauber	Lattice Press	2000
	Reference	The Science and Engineering of Microelectronic Fabrication, II Ed	Stephan Campbell	Oxford University Press	2001
	Reference	Semiconductor Manufacturing Technology	Michael Quirk and Julian Serda	Prentice Hall	2001

Course name:	**Course code:**
Advanced Semiconductor Fabrication Engineering	CE514

Location in curricular map:
Specialization Axis

Course description:
This course follows the Semiconductor Fabrication Engineering course, with a more profound analysis and topics relating to application specific processes for certain materials. The course covers advanced topics in semiconductor materials, insulation techniques, packaging and specific materials such as GaAs and SiGe. The course focuses on processing, simulation, lab experience and applications for modern integrated circuit technologies.

Course learning outcomes:
At the end of the course, the student will: Apply advanced knowledge in processing and fabrication techniques for semiconductors and microelectronic devices. Know advanced techniques for simulation, measurement in devices and interaction between material properties and processes in the semiconductor and microelectronic industries.

Course content:	Hours
1. General introduction	6
2. Advanced CMOS technology	3
3. Insulation techniques	3
4. CVD and RTP	3
5. Plasma technologies	3
6. Processing of GaAs and SiGe	3
7. "Back End" processes	3
8. Packaging	3
9. TSUPREM simulation	3
10. Lab experience	6

Learning activities:	Hours
• **In-class activities:** - Presentation of topic by professor. - Presentations by guest speakers. - Case and topic discussions. - Final project presentations.	**36**
• **Independent activities:** - Reading of applied research case studies. - Research. - Research reports. - Problem analysis. - Solution design.	**60**

Evaluation criteria and procedures:

The evaluation instruments are as follows:

- Research homework.
- Final research project.
- Participation.

The weight in points for each of these instruments will be established between the group and the professor in the first class session.

Bibliography:

	Type	Title	Author	Publisher	Year
	Text	Microchip Manufacturing,	Stanley Wolf	Lattice Press	2004
	Reference	Introduction to Microelectronic Fabrication, II Edition, Vol. V of Modular Series on Solid State Devices,	Richard C. Jaeger	Prentice Hall	2002
	Text	Silicon VLSI Technology, Fundamentals, Practice and Modeling	by J D Plummer, Deal M D, and P B Griffin	, Prentice Hall	2000
	Reference	Silicon Processing for the VLSI Era, Vol. I, Process Technology, II Ed	S. Wolf and R.N. Tauber	Lattice Press	2000
	Reference	The Science and Engineering of Microelectronic Fabrication, II Ed	Stephan Campbell	Oxford University Press	2001
	Reference	Semiconductor Manufacturing Technology	Michael Quirk and Julian Serda	Prentice Hall	2001

Course name:	Course code:
Semiconductor Metrology and Characterization	CE515

Location in curricular map:
Specialization Axis

Course description:
This course provides an introduction as well as a report on the state of the art in semiconductor characterizations, in measurement as well as reading interpretation. These characterization techniques are the basis for the development of new techniques that support the advancement of the semiconductor industry. Due to the tendencies in size reduction of devices, metrology becomes an even more crucial element for its applications.

Course learning outcomes:
At the end of the course, the student will: Achieve an understanding of the majority of techniques used in industry, with major emphasis in the electric characterization because it is the most used. Also, optical techniques, such as electron, ion and X rays will be discussed.

Course content:	Hours
1. Electrical characterization. 1.1 Four point mapping of the wafer. 1.2 Doping profile 1.3 Vt, characteristics.	4
2. Optic microscopy 2.1 Optic microscopy 2.2 Elypsometry	8
3. Electron beam microscopy (high resolution images) 3.1 Scanning electronic microscopy (SEM) 3.2 Transmission electronic microscopy (TEM)	8
4. Particle beam analysis (doping and impurities) 4.1 Secondary Ion Mass Spectrometry (SIMS)	8
5. X-ray techniques 5.1 X-ray diffraction (XRD)	8

Learning activities:	Hours
• **In-class activities:** - Presentation of topic by professor. - Presentations by guest speakers. - Case and topic discussions. - Final project presentations.	**36**
• **Independent activities:** - Reading of applied research case studies. - Research. - Research reports. - Problem analysis. - Solution design.	**60**

Evaluation criteria and procedures:

The evaluation instruments are as follows:

- Research homework.
- Final research project.
- Participation.

The weight in points for each of these instruments will be established between the group and the professor in the first class session.

Bibliography:

	Type	Title	Author	Publisher	Year
	Text	Semiconductor Material and Device Characterization Third Edition	D. K. Schroder	Wiley-Interscience/IEEE New York	2006
	Reference	Semiconductor Measurements and Instrumentation Second Edition	W. R. Runyan and T. J. Shaffner	McGraw-Hill New York	1998

Course name:	**Course code:**
Analog and Digital VLSI Design	CE516

Location in curricular map:
Specialization Axis

Course description:
This course focuses on categorizing the styles of analog and digital VLSI design evaluating their merits and limitations, analyzing the rules of design and scale of operation of CMOS systems, explaining the operation of analog and digital subsystems, characterizing CMOS technology, modeling various simulations used in real applications in electronic systems. Implementation of typical implementations in bipolar and CMOS technologies.

Course learning outcomes:
At the end of the course, the student will: Achieve knowledge and experience in analog and digital VLSI design, being the primary goal that the student learns the basic building blocks for analog and digital VLSI design, as well as understanding the characteristics and limitations of the design of integrated analog and digital circuits.

Course content:	Hours
1 VLSI technology	4
2 Analog and digital circuit design	6
3 Memories and logic	6
4 Sigma-delta modulation	6
5 Low poser techniques	6
6 Dynamic techniques	4
7 Final projects	4

Learning activities:	Hours
• **In-class activities:** - Presentation of topic by professor. - Presentations by guest speakers. - Case and topic discussions. - Final project presentations.	**36**
• **Independent activities:** - Reading of applied research case studies. - Research. - Research reports. - Problem analysis. - Solution design.	**60**

Evaluation criteria and procedures:

The evaluation instruments are as follows:

- Research homework.
- Final research project.
- Participation.

The weight in points for each of these instruments will be established between the group and the professor in the first class session.

Bibliography:

	Type	Title	Author	Publisher	Year
	Text	Design of Analog CMOS Integrated Circuits	Behzad Razavi	McGraw-Hill	2001
	Reference	Digital Systems Engineering	William J. Dally and John W. Poulton	Cambridge University Press	1998

Course name:	Course code:
Structure and Properties of Materials	CE517

Location in curricular map:
Specialization Axis

Course description:
This course covers the fundamentals of structure and modification of structure and properties of materials, with emphasis on the structure-property relationship and modern solids theory. Concepts on electromagnetic and mechanical properties of materials are reviewed, and the concepts of micro structure engineering as well as synthesis and characterizations of materials, are introduced. The basic phenomena of materials are presented and the necessary knowledge is given so the engineering student may analyze problems relating to materials technology.

Course learning outcomes:
At the end of the course, the student will: Comprehend the production, processing, behavior and selection processes and the use of six materials: metals, ceramic, polymers, compounds, semiconductors and biomaterials.

Course content:	Hours
1 Introduction.	6
2 Structure of materials	3
3 Diffusion	3
4 Properties of metals	3
5 Phase diagrams	3
6 Alloys	3
7 Ceramics	3
8 Polymers	3
9 Corrosion	3
10 Compounds	3
11 Economic, environmental and social aspects of materials	3

Learning activities:	Hours
• **In-class activities:** - Presentation of topic by professor. - Presentations by guest speakers. - Case and topic discussions. - Final project presentations.	**36**
• **Independent activities:** - Reading of applied research case studies. - Research. - Research reports. - Problem analysis. - Solution design.	**60**

Evaluation criteria and procedures:

The evaluation instruments are as follows:

- Research homework.
- Final research project.
- Participation.

The weight in points for each of these instruments will be established between the group and the professor in the first class session.

Bibliography:

	Type	Title	Author	Publisher	Year
	Text	Materials Science and Engineering. An Introduction. Fifth Edition	William D. Callister, Jr.	Wiley	2000
	Reference	Semiconductor Manufacturing Technology	Michael Quirk and Julian Serda	Prentice Hall	2001

Course name:	**Course code:**
Rapid Prototype Synthesis	CE518

Location in curricular map:
Specialization Axis

Course description:
Rapid prototypes using VHDL and FPGAs allow for the implementation of complex digital architectures, that previously had a long development cycle. The course familiarizes the student with the methods and tools necessary to develop these systems, including criteria for design, as well as function verification.

Course learning outcomes:
At the end of the course, the student will: Know and apply the VHDL language, its characteristics, integral development systems, as well as its limitations. Learn techniques for rapid prototyping via VHDL synthesis in hardware.

Course content:	Hours
1. Introduction to Logic Design	4
2. VHDL	6
3. Synthesis with VHDL, simulation and hardware implementation	6
4. Architecture of FPGAs and CPLDs	6
5. Rapid prototypes for development	6
6. Tendencies in the FPGA industry	4
7. Application development	4

Learning activities:	Hours
• **In-class activities:** - Presentation of topic by professor. - Presentations by guest speakers. - Case and topic discussions. - Final project presentations.	**36**
• **Independent activities:** - Reading of applied research case studies. - Research. - Research reports. - Problem analysis. - Solution design.	**60**

Evaluation criteria and procedures:

The evaluation instruments are as follows:

- Research homework.
- Final research project.
- Participation.

The weight in points for each of these instruments will be established between the group and the professor in the first class session.

Bibliography:

	Type	Title	Author	Publisher	Year
	Text	Digital Signal Processing with Field Programmable Gate Arrays (With CD-ROM)	Uwe Meyer-Baese	Prentice Hall	2004
	Text	Design of Analog CMOS Integrated Circuits	Behzad Razavi	McGraw-Hill	2001
	Reference	Digital Systems Engineering	William J. Dally and John W. Poulton	Cambridge University Press	1998

Course name:	Course code:
Principles of Electronic Microscopy	CE519

Location in curricular map:
Specialization Axis

Course description:
This course provides an introduction to Scanning Electron Microscopes, including the preparation of the simple, instrumentation, interpretation of results and applications. Various materials will be selected for this study. Emphasis will be made on applications of research done individually.

Course learning outcomes:
At the end of the course, the student will: Achieve abilities and knowledge relating to acquisition, display and interpretation of various digital images obtained from an SEM microscope. Know the aspects related to an SEM, from the generation of the signal, the interaction of the electron beam with the sample on the surface, to perception and interpretation of this information. Understand the characteristics and limitations of an SEM, as well as all the operational aspects of the instrument.

Course content:	Hours
1. Introduction	4
2. Principles of an SEM	6
3. Design of an SEM microscope	6
4. Contrast and image formation	6
5. Causes that affect the operation of an SEM	6
6. Operation of an SEM	4
7. Preparation of the sample	4

Learning activities:	Hours
• **In-class activities:** - Presentation of topic by professor. - Presentations by guest speakers. - Case and topic discussions. - Final project presentations.	**36**
• **Independent activities:** - Reading of applied research case studies. - Research. - Research reports. - Problem analysis. - Solution design.	**60**

Evaluation criteria and procedures:

The evaluation instruments are as follows:

- Research homework.
- Final research project.
- Participation.

The weight in points for each of these instruments will be established between the group and the professor in the first class session.

Bibliography:

	Type	Title	Author	Publisher	Year
	Text	Scanning Electron Microscopy and X-Ray Microanalysis, 2nd. Edition	Goldstein	Springer-Verlag New York	2002
	Reference	Image Formation in Low-Voltage Scanning Electron Microscopy	Ludwig Reimer	S P I E-International Society for Optical Engineering	1993
	Reference	Digital Systems Engineering	William J. Dally and John W. Poulton	Cambridge University Press	1998

Course name:	**Course code:**
MEMS Design and Fabrication	CE520

Location in curricular map:
Specialization Axis

Course description:
This course provides the student the opportunity to have familiarization with the technology used to fabricate MEMS as well as to applications involving MEMS. This is an area of major development in semiconductors in this day and age. MEMS fabrication techniques as well as applications will be discussed.

Course learning outcomes:
At the end of the course, the student will: Know MEMS technologies. Comprehend the fabrication techniques, as well as the various opportunities in the market regarding this technology. Comprehend the mathematical models that govern the behavior of these systems, as well as their design and fabrication processes.

Course content:	Hours
1. MEMS fabrication processes	4
2. Deposition, lithography	4
3. Micro machining of the surface	4
4. Micro machining the substrate	4
5. Plasma systems	4
6. MEMS design	6
7. Micro mechanics and micro electrostatics	4
8. MEMS applications	6

Learning activities:	Hours
• **In-class activities:** - Presentation of topic by professor. - Presentations by guest speakers. - Case and topic discussions. - Final project presentations.	**36**
• **Independent activities:** - Reading of applied research case studies. - Research. - Research reports. - Problem analysis. - Solution design.	**60**

Evaluation criteria and procedures:

The evaluation instruments are as follows:

- Research homework.
- Final research project.
- Participation.

The weight in points for each of these instruments will be established between the group and the professor in the first class session.

Bibliography:

	Type	Title	Author	Publisher	Year
	Text	Fundamentals of Micro fabrication	Marc Madou	CRC Press	1997
	Reference	Micro system Design	Stephen D. Senturia	Kluwer Academic Publishers	2001
	Reference	Digital Systems Engineering	William J. Dally and John W. Poulton	Cambridge University Press	1998

Course name: Introduction to Nanotechnology	**Course code:** CE521

Location in curricular map:
Specialization Axis

Course description:
Nanotechnology has become one of the most important fields in engineering, chemistry and biology state of the art. The use of technology that operates in these dimensions promises grand results for the advancement of areas such as electronics and medicine. The course provides initial practical knowledge on the subject, and shows the student potential applications in various areas.

Course learning outcomes:
At the end of the course, the student will: Comprehend the two methodologies of nanofabrication: top-down and bottom-up. Comprehend the scope of the bottom-up methodology for the fabrication of nanometric structures via the atom by atom array or auto assembly. Comprehend the scope of the top-down methodology for the development of nanometric structures via the use of nanometric lithography as well as electron or ion beam lithography. Apply the various analysis techniques such as SEM, TEM, XRD, etc. Know the latest technological developments in nanoelectronics, bionanotechnology, as well as the challenges and risks for society.

Course content:	Hours
1. Introduction	2
2. Property measurement methods	4
3. Individual nanoparticle properties	6
4. Carbon nanostructures	6
5. Nanomaterials	6
6. Abysses, cables and quantum points	4
7. Auto assembly and catalysis	4
8. Tools for nanotechnology processing	4

Learning activities:	Hours
• **In-class activities:** - Presentation of topic by professor. - Presentations by guest speakers. - Case and topic discussions. - Final project presentations.	**36**
• **Independent activities:** - Reading of applied research case studies. - Research. - Research reports. - Problem analysis. - Solution design.	**60**

Evaluation criteria and procedures:

The evaluation instruments are as follows:

- Research homework.
- Final research project.
- Participation.

The weight in points for each of these instruments will be established between the group and the professor in the first class session.

Bibliography:

	Type	Title	Author	Publisher	Year
	Text	Introduction to Nanotechnology	Charles P. Poole, Frank J. Owens	Wiley, John & Sons	2003
	Reference	Handbook of Nanomaterials	Yury Gogotsi (Editor), Gogotsi Gogotsi	CRC Press	2006
	Reference	Digital Systems Engineering	William J. Dally and John W. Poulton	Cambridge University Press	1998

Course name: Application Project	**Course code:** CS 501

Location in curricular map: Terminal Axis

Course description: Throughout the course, the student will develop pan application project that demonstrates the capacity for analysis, team work, interpretation and application of knowledge and tools acquired throughout the masters program

Course learning outcomes: The student will be capable of applying the knowledge and abilities acquired throughout the courses of the masters program, contributing to the development of practical solutions that benefit the community.

Course Content	Hours
1. **Definition of application pre-project.**	**16**
2. **Ethics in professional services.**	**4**
3. **Project presentation.**	**4**
4. **Follow up by professor.**	**4**
5. **Presentation of pre results.**	**4**
6. **Presentation of final results.**	**4**

Learning activities:	
• **Guided activities:** - Presentation of subject by professor. - Presentation by guest researchers. - Discussions of subjects and cases. - Final project presentation.	**36**
• **Independent activities:** - Applied research case reading. - Information gathering. - Research reports. - Problem analysis. - Solution design.	**60**

Evaluation criteria and procedures:
The evaluation instruments are the following: Homework and research work Final project research Participation The points distribution for each instrument will be established in accordance with the group in the first class session.

Bibliography

	Type	Title	Author	Publisher	Year
1	None				