Course guides
230355 - GRACNIF - Graphene and Carbon Nanotubes Introduction and Fundamentals

Last modified: 24/03/2017

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 710 - EEL - Department of Electronic Engineering.

Degree: DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 1992). (Optional subject).
DEGREE IN ELECTRONIC ENGINEERING (Syllabus 1992). (Optional subject).
MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Optional subject).
MASTER'S DEGREE IN ELECTRONIC ENGINEERING (Syllabus 2013). (Optional subject).

Academic year: 2017 **ECTS Credits:** 2.5 **Languages:** English

LECTURER

Coordinating lecturer: Juan Miguel López-González

Others: Juan Miguel López-González

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEE12. Ability to use semiconductor devices taking into account their physical characteristics and limitations.
CEE13. Ability to analyze and evaluate the performance at the physical level of the main devices and sensors, the relations between magnitudes in their terminals and their equivalent circuits.
CEE14. Ability to establish a relationship between an electronic device and its fabrication technology, and to understand its design process.
CE13. Ability to apply advanced knowledge in photonics, optoelectronics and high-frequency electronic

TEACHING METHODOLOGY

- Lectures
- Application classes
- Individual work (distance)
- Exercises to strengthen the theoretical knowledge.

LEARNING OBJECTIVES OF THE SUBJECT

Learning objectives of the subject:
The aim of Graphene and Carbon Nanotubes Introduction and Fundamentals course is to introduce the basic device physics of carbon nanotubes (CNTs) and graphene necessary to understand the performance of modern electronic devices based on these materials. First, we study basic quantum mechanic of solids. Then we describe the physical and electronic structure and properties of graphene and CNTs. Finally we explained graphene and CNTs applications for: transistors, solar cells, sensors and NEMS.

Learning results of the subject:
- Ability to understand energy bands of solids.
- Ability to understand electrical properties of Graphene.
- Ability to analyse electrical properties of Carbon Nanotubes.
- Ability to understand electrical performance of modern electronic devices based on graphene and CNTs.

STUDY LOAD

Type	Hours	Percentage
Self study	42,5	68.00
Hours large group	20,0	32.00

Total learning time: 62.5 h

CONTENTS

1. Introduction of Graphene and CNT

Description:
? Course introduction
? Synthesis and characterization techniques
? Graphene

Full-or-part-time: 9h 30m
Theory classes: 3h
Self study : 6h 30m

2. Quantum mechanics

Description:
? Introduction Quantum Mechanics
? E(k) dispersion equation
? Solids crystallography

Full-or-part-time: 9h
Theory classes: 3h
Self study : 6h

3. Graphene

Description:
- Lattice of Graphene
- Graphene energy dispersion bands
- Carrier densities
- Nanoribbons

Full-or-part-time: 9h
Theory classes: 3h
Self study : 6h

4. Carbon Nanotubes

Description:
- Chirality and configuration of CNTs
- Metallic and semiconductor CNTs
- CNT energy bands, carrier velocities and density

Full-or-part-time: 9h
Theory classes: 3h
Self study : 6h

5. Quantum electrical properties of Graphene and CNT

Description:
? Conductance, capacitance and inductance
? CNT resistance and transmission line models

Full-or-part-time: 9h
Theory classes: 3h
Self study : 6h

6. Applications of Carbon Nanotubes

Description:
? CNT applications
? CNT Field Effect Transistors, CNTFET

Full-or-part-time: 9h
Theory classes: 3h
Self study : 6h

7. Applications of Graphene

Description:
? Graphene FET
? Graphene electronics
? Graphene optoelectronics
? Graphene transistors review

Full-or-part-time: 8h
Theory classes: 2h
Self study : 6h

GRADING SYSTEM

Exercises: 100 %

BIBLIOGRAPHY

Basic:
- Xia, F.; Yan, H.; Avouris, P. "The interaction of Light and Graphene: Basics, Devices, and Applications". Proceedings of the IEEE [on line]. Vol. 101, No. 7, July 2013 [Consultation: 07/03/2016]. Available on: http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6514893.
- Wong, Hon-Sum Philip; Akinwande, Deji. Carbon nanotube and graphene device physics. Cambridge: Cambridge University Press, 2011. ISBN 9780521519052.
- Wu,Y ... [et al.]. "Graphene Electronics: Materials, Devices, and Circuits". Proceedings of the IEEE [on line]. Vol. 101, No. 7, July 2013 [Consultation: 07/03/2016]. Available on: http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6519298.

Complementary:
- Ferrari, A.C. "Science and technology roadmap for graphene, related two-dimensional crystals, and hybrid systems". Nanoscale [on line]. 2015, núm 7, p. 4598-4810 [Consultation: 07/03/2016]. Available on: http://pubs.rsc.org/en/results?searchtext=Title%3AScience%20and%20technology%20roadmap%20for%20graphene%2C%20related%20two-dimensional%20crystals%2C%20and%20hybrid%20systems.

RESOURCES

Other resources:

G.N. Dash, S.R. Pattanaik, S. Behera, ?Graphene for Electron Devices: The Panorama of a Decade?, Journal of the Electron Devices Society, vol. 2 no. 5, September 2014. DOI: 10.1109/JEDS.2014.2328032.

F. Schwierz, ?Graphene Transistors: Status, Prospects, and Problems?, Proceedings of the IEEE, vol. 101, no. 7, July 2013.