Name: Physics of dielectric and ferroelectric materials - 34074

Type: elective **Semester:** 2nd

ECTS: 5

Periodicity: annual

Basic unity responsible: Department of Applied Physics (UPC)
Department of Physics and Nuclear Engineering (UPC)

Coordinator: Rafel Pérez Pérez

Professors: José E. García García, Vicente Gomis Arbonès, Miguel Mudarra Lopez, Rafel Pérez Pérez

Language classes: Catalan / Spanish

Prerequisite:

Aims:

To give the fundamentals of linear and nonlinear dielectric materials and their applications. The study of the different polarization mechanisms, the response to a harmonic signal and its dependence on the frequency, and the transport and trapping of electrical charge are included. In addition, materials behaving permanent polarization and their piezoelectrical properties are also studied,

Syllabus:

I. DIELECTRICS IN A CONSTANT ELECTRIC FIELD.
Introduction: Electric field and electric potential; Potential of an electric charge distribution. Electrostatic energy of a charge distribution inside an electric field. Interaction between electrical dipoles. Polarization mechanisms. Induced polarization: electronic and ionic. Orientational polarization. Relation between microscopic and macroscopic properties. Glass and polymer polarization.

II. DIELECTRICS IN AC ELECTRIC FIELD.

Material Response to a variable electric field : temporal and frequential response. Dielectric relaxation. Debye model. Other relaxation models. Ressonance phenomena. Dielectric measurements. Applications.

III. CHARGE TRANSPORT AND TRAPPING

Electrical conduction and breakdown in dielectrics . Dielectric devices. Electrets . Material types and properties of electrets. Space charge electrets. Charge distribution. Depolarization. Thermally Stimulated Depolarization currents.

IV. FERROELECTRICITY.
Polar dielectrics. Pyroelectrics, piezoelectrics and ferroelectrics. Material properties as a function of their symmetry . Ferroelectric phase transition. Ferroelectric materials: crystals, ceramics and polymers.

V. PIEZOELECTRICITY.
Interrelation between electric, mechanical and thermal properties. Constitutive equations: piezoelectric coefficients and electromechanical coupling factor. Tensor character of material properties. Coefficient reduction by symmetry. Reduced notation. Matricial description. Piezoelectric resonator analysis: contour conditions. Vibration modes. Resonator electrical admittance. Equivalent circuit. Transducer analysis . Analysis of an acoustical transmission line: matricial method and electrical equivalent network method. Active element analysis : Mason model.

VI. APLICATIONS .
Applications of dielectric, ferroelectric and piezoelectric materials.

Method:

In parallel with this course, complementary experimental and practical tools may be obtained in the course "Experimental techniques in physics of materials"

The student must have elemental knowledge about crystallography and phase transitions

Evaluation:

Attendance and participation in the course.(20%)
To carry out the exercises during the course (30%)
Final work. (50%)

Learning resources:

Bibliography:

- Física de dieléctricos. Albella, J. M.; Martínez, J. M. Barcelona, Marcombo-Boixareu. 1984.
- Theory of electric polarization. Böttcher, C.J.F. Amsterdam: Elsevier, 1996. 2 vols. 1996.
- Polar dielectrics and their applications. Burfoot, J.C.; Taylor, G.W. London: Mac Millan Press Ltd. 1979.
- An introduction to the physics of ferroelectrics. Mitsui, T; Tatsuzaki, I; Nakamura, E. New York: Gordon and Breach. 1976.
- Physical properties of crystals. J.F. Nye. Oxford Univ. Press. 1957
- Dielectrics . P. J. Harrop , New York : Wiley, cop. 1972
- Electrets R. Gerhard – Multhaupt (2 volúmenes) Laplacian Press .1999
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- Electrets in Engineering . V.Kestelman , L Pinchuk , V.Goldade. Kluwer Acad. Publishers. 2000
- Analisys of thermally stimulated processes. R.Chen , Y. Kirsh. Pergamon Press Oxford 1981
- Fundamentals of piezoelectricity. T. Ikeda. Oxford Univ. Press. 1990
- Bulk acoustic wave theory and devices. J.F.Rosenbaum. Artech House, inc. 1988
- Piezoelectric actuators and ultrasonic motors. K. Uchino. Kluver Academic Publishers. 1997
- Ondes elastiques dans les solides. D Royer, E. Dieulesaint. Masson et cie. 1996