The Hebrew University of Jerusalem

Syllabus

THE PHYSICS OF DIELECTRICS - 83887

Last update 09-10-2016

HU Credits: 3

Degree/Cycle: 2nd degree (Master)

Responsible Department: applied physics

Academic year: 0

Semester: 1st Semester

Teaching Languages: English

Campus: E. Safra

Course/Module Coordinator: Prof. Yuri Feldman

Coordinator Email: Yurif@mail.huji.ac.il

Coordinator Office Hours: coordinate in advance

Teaching Staff:

Prof Yuri Feldman

Course/Module description:

The course is devoted to the study of dielectric polarization and relaxation phenomena in condensed matter. A basic theory of dielectrics is given. Different experimental technique of dielectric spectroscopy is presented. The application of dielectric spectroscopy to different systems is considered.

Course/Module aims:

NA

Learning outcomes - On successful completion of this module, students should be able to:

NA

Attendance requirements(%):

0

Teaching arrangement and method of instruction: Frontal lecture

Course/Module Content:

Lecture 1. Introduction into the physics of dielectrics. Permanent dipole moment. Induced dipole moment. Polarization and dielectric constant. Types of polarization, Electron polarization, Atomic polarization, Orientation polarization. Ionic polarization.

*Lecture 2. Dipole moments and electrostatic problems. Polarizability *. Polarization and energy. Internal field Langeven function. Non-polar dielectrics. Lorentz's field. Clausius-Massotti formula.*

Lecture 3. Reaction field. Polarization in gases, Debye's Theories, Polar molecules in nonpolar solvent. Onsager's theory. The dielectric properties of polar non-associative liquids.

Lecture 4. Kirkwood-Frelich's theory, the dipole-dipole interaction, the correlation factor of Kirkwood. The static dielectric permittivity of strong polar associative liquids. The modern theories of the static dielectric permittivity (Böttcher, Nienhuis and Deutch, Ramshaw, Wertheim etc).

Lecture 5. The theory of linear response. The time dependent fields. The dielectric *response function. The dielectric relaxation theory. Frequency and Time Domain.*

Lecture 6. The complex dielectric permittivity. Dielectric losses and dispersion. The distribution functions of the relaxation times. Cole-Cole distribution. Cole-Davidson distribution. Havriliak-Nehamy and Johnsher distributions.

Lecture 7. The dipole correlation function. The relationship between the complex dielectric permittivity and the dipole correlation function. Short-range and long range correlation functions. Fulton's Theory. The memory function. Kohlrausch-Williams-Watts (KWW) non-exponential behavior in complex systems.

Lecture 8. Models of dielectric relaxation. Rotational diffusion; Dielectric friction.Forced diffusion of molecules with internal rotation. Reorientation by discrete jumpsMemory-Function Formalism. The fractal nature of dielectric behavior.

Lecture 9. Dielectric Spectroscopy. Classification of the experimental methods. Frequency methods: Bridges, Resonance methods, Coaxial lines, Waveguides, Transient methods, Strip lines, Slot lines, etc. Broad Band Dielectric Spectroscopy. A frequency response analyzer (10-5 Hz - 106 Hz), automatic radio - frequency bridge (10 Hz - 107 Hz) coaxial line reflectometer (106 Hz - 109 Hz) and coaxial vector network analyzer (107 Hz - 1011 Hz). Time Domain Dielectric Spectroscopy. The single reflection and transition methods. Multiple reflection, transition, lumped capacitance methods. Nonuniform sampling. Furier transform and the time domain treatment

Lecture 10. The applications of dielectric spectroscopy. Pure liquids and Solutions. Glass forming liquids. Dielectric relaxation of water. Dielectric relaxation of ice.

Lecture 11. The dielectric properties of heterogeneous substances. Emulsions and Micro emulsions. Polarization of Double Lay, Polarization of Maxwell Wagner. Nonionic Microemulsions. Zwiterionic Microemulsions. Ionic Microemulsions. Dielectrics with conductive paths. Percolation Phenomena.

Lecture 12. Dielectric response in Porous systems. Porous Glasses and Sole-Gel glasses. Porous silicon. Clays. Percolation. Fractal dimension. Porosity determination. Confinement.

Lecture 13. Dielectric properties of biological materials I. Amino acids. Peptides. Proteins in solutions. Membrane Proteins. Liposomes.

Lecture 14. Dielectric properties of biological materials II. RBC and the dielectric response. Lymphocytes. Non Invasive Glucose Monitoring, Water is a marker of the cells vitality.

Required Reading:
NA

Additional Reading Material:

1. C.J.F. Böetcher Theory of Electric Polarization 2D ED. 2 volumes 19731978.

2. H. Fröehlich, Theory of Dielectrics ,1950, reprinted 1992.

3. Dielectric and Related Molecular Processes 19721977 (3 v)

4. J.B. Hasted Aqueous Dielectrics 1973

5. N.E. Hill Dielectric properties and Molecular Behaviour 1969.

6. C.H. L. Goodman, Physics of Dielectrics Solids, 1980

7. S. Takashima Electrical Properties of Biopolymers and Membranes 1989.

8. E.H. Grant, R.J. Sheppard and G.P.South Dielectric Behaviour of Biological Molecules in Solutions , 1978.

9. S.Bone and B.Zaba, Bioelectronics, 1992.

10. V. Raicu and Yu. Feldman, "Dielectric Relaxation in Biological Systems: Physical Principles, Methods, and Applications", (2015) Publisher: OXFORD UNIVERSITY PRESS, Oxford UK

Course/Module evaluation:
End of year written/oral examination 0 %
Presentation 30 %
Participation in Tutorials 0 %
Project work 70 %
Assignments 0 %
Reports 0 %
Research project 0 %
Quizzes 0 %
Other 0 %

Additional information:
NA