APROOVED
DEAN OF FACULTY OF ADVANCED TECHNOLOGIES
AND CHEMISTRY

2 up.

Professor Stanisław Cudziło PhD, DSc, Eng

Subject's name: ***Dielectric spectroscopy***

w języku polskim: ***Spektroskopia dielektryczna***

in English:

Subject's code: WTCNTCSM-SD

Subject's information:

Faculty responsible for the subject: Advanced Technologies and Chemistry

Subject for faculty: Advanced Technologies and Chemistry

Valid from: October 2016

Default protocol type for the subject:
Credit on a grade
Course language:
English
Short description:
Course introduces dielectric spectroscopy as an experimental method in materials science and chemistry. It presents the the theoretical basis of relaxation phenomena. Introduces with the experimental setups - impedance analyzers, experiment procedures, parasitic effects and data analysis. The analysis of the experimental data relates to the results obtained for liquid crystals.
Description:
The course consists of: lectures (14h), exercises (8h=4×2h), laboratories (8h=2×4h). The subject requires the significant student involvement. Topics presented in lectures: - Empty capacitor in constant and harmonic electric field. - Solving of ordinary differential equations with right side (forced) and without (free). - Analysis of RC, LC and RLC circuit (without dielectric inside capacitor). - Vectors describing electric field in the medium: * electric field E (depended on free and bound charges) * polarization vector P (depended on bound charges) * electric displacement vector D (depended on free charges) - Multipole expansion of charge distribution in molecules. - Multipole (monopole, dipole, quadrupole) interaction with external electric field. - Parasitic effects related to: * finite value of electrode conductivity, * non-zero value of inductivity of connecting wires. - Debye, Cole-Cole, Cole-Davidson, Havriliak-Negami models of relaxations. - Molecular and collective modes in liquid crystals. - Arrhenius law in dielectric spectroscopy. - Ion impurities influence on dielectric response. Topics presented in exercises: - Electric field of monopole, dipole and quadrupole. - interaction between different poles (monopoles, diploes, etc.). - Behavior of empty capacitor under constant and harmonic external electric field. - Solving of homogeneous and inhomogeneous ODE. - Analysis of RC, LC and RLC circuit (without dielectric inside capacitor). Topics implemented in laboratories (choice of two - depending on the course): * analysis of the molecular modes observed in dual-frequency nematics, * analysis of the collective modes at the phase transition SmA* - SmC*, * analysis of the collective modes in SmCa*.
Sources:
Obligatory: W. Haase, S. Wróbel (Eds.), "Relaxation Phenomena", Springer 2003 C. Böttcher, P. Bordewijk, "Theory of electric polarization", Elsevier 1978 F. Kremer, A. Schonhals, W. Luck, "Broadband Dielectric Spectroscopy", Springer 2002

J. Lagerwall, tutorial „ Dielectric Spectroscopy of Liquid Crystals", ILCC, Keystone USA, 2006: http://www.exicone.com/Exicone/Dielectric_Spectroscopy.html
Z. Galewski, L. Sobczyk (Eds.), "Dielectric properties of liquid crystals", Transworld Research Network, 2007
Complementary:
P. Perkowski, D. Łada, K. Ogrodnik, J. Rutkowska, W. Piecek, Z. Raszewski, "Technical aspects of liquid crystal dielectric spectroscopy measurements", Opto-Electronics Rev., 16(3), 271-276, 2008
P. Perkowski, "Dielectric spectroscopy of liquid crystals. Theoretical model of ITO electrodes influ-ence on dielectric measurements", Opto-Electronics Rev., 17(2), 180-186, 2009
P. Perkowski, "Numerical elimination methods of ITO cell contribution to dielectric spectra of ferroelectric liquid crystals", Opto-electronics Rev., 19(2), 1-7, 2011
P. Perkowski, "How to determine parameters of soft mode from dielectric spectroscopy performed in ITO cells?", Opto-electronics Rev., 19(1), 76-82, 2011
P. Perkowski, "How to determine the limits of using Afn function for extracting of ITO cell contribution to dielectric spectra?", Phase Transitions, 83(10-11), 836-843, 2010
P. Perkowski, "Dielectric spectroscopy of liquid crystals. Electrodes resistivity and connecting wires inductance influence on dielectric measurements", Opto-electronic Rev., 20(1), 1-8, 2012
P. Perkowski, M. Mrukiewicz, K. Garbat, M. Laska, U. Chodorow, W. Piecek, R. Dąbrowski, J. Parka, "Precise dielectric spectroscopy of dual-frequency nematic mixture in a broad temperature range", Liquid Crystals, 39(10),1237–1242, 2012
P. Perkowski, K. Ogrodnik, M. Żurowska, W. Piecek, R. Dąbrowski, Z. Raszewski, L. Jaroszewicz, "Antiferroelectric SmC_A* and ferroelectric SmC* phases in racemic mixture", Phase Transitions, 86, 138–146, 2013
P. Perkowski, M. Mrukiewicz, M. Laska, K. Garbat, W. Piecek, R. Dąbrowski, "Dielectric behavior of dual-frequency nematic at extra low temperatures", Phase Transitions, 86, 113-122, 2013

Educational outcomes:

No.	Description	the reference to the course effects
W1	**Knows about mathematical description of relaxation and vibration processes in dielectric spectroscopy**	K2_W04, K2_W11, K2_W12
W2	**Knows how the impedance analyzers work and what we can measure with them**	K2_W06
U1	**Is able to solve simple problems related to measurements be means of dielectric spectroscopy**	K2_U07
U2	**Is able to solve the simple theoretical problems how electric field playse with matter**	K2_W08
U3	**Is able to prepare samples and measure dielectric properties of liquid crystals by means of dielectric spectroscopy**	K2_U09
K1	**Is able to organize work in laboratory and how to play different role in laboratory group**	K2_K03
K2	**Understand that learning process it the long term process and knowledge level should be higher after every step of learning**	K2_K01

Methods and criteria for evaluation:

Subject is evaluated as a whole on grade. Exercises are evaluated on 'pass' or 'fail'. The same system is for laboratory.
Subject is an optional subject for the diploma semester, so the assumption is that it is designed for students who will use this measuring technique in their thesis. A prerequisite for receiving credit is the assessment of exercises and laboratory and passing the test of the theory on the last lecture.
The grade **NDST** (unsatisfactory) receives a student who has not confirmed the intended learning outcomes.
The grade **DST** (satisfactory) receives a student who has in satisfactory way confirmed knowledge and skills required in the curse. Who indecently solves problems with a low degree of difficulty. His knowledge and skills show noticeable gaps that can complement, but under the guidance of a teacher. Who can make (under supervision) measurements. Who can compile experimental results. Who needs help to interpreter the results. Who can, with the help of teacher, solve the theoretical problems associated with the influence of the electric field on the different medium.
The grade **DB** (good) receives a student who has in a good level way confirmed knowledge and skills required in the curse. Who is able to solve tasks and problems associated with dielectric spectroscopy. Who must use the help at work the consultation. Who cannot provide the knowledge in this area. Who is able to learn about dielectric spectroscopy using the external sources. Who copes with the measuring equipment but must use the consultation.
The grade **BDB** (very good) receives a student who has in a very good level confirmed knowledge and skills required in the curse. Who can independently carry out the measurements and is able to analyze the results. Who can without any help solve theoretical problems associated with the electric field influence on the different medium. Can independently acquire knowledge from the extensive literature of the subject. Who can spread out the knowledge in this field.

The effect W1, is evaluated as part of a test of the theory and during exercises.
The effect W2 is evaluated as part of a test of the theory and during laboratory exercises.
Effects U1 and U3 are evaluated during laboratory exercises.
The effect of U2 is evaluated during exercises.
The effects K1 and K2 are evaluated during laboratory exercises and during exercises.

Apprenticeship:

no

Condition of study:

full time studies

Grade of studies:

graduale course

Type of subject:

optional

Introducing subjects from under- and graduate courses:

physics, mathematics, electrotechnic and electronics

Program:

semester: III
field: material engineering
specialization: new materials and technologies

Form of classes, credit:

semester	x- exam, + credit with a grade, # project						ECTS
	sum	lectures	exercises	laboratories	project	semminar	
III	30	14 / +	8 / +	8 / +			2

Author:

Paweł Perkowski

ETCS effect:

No.	student activity	Workload
1	Participation in lectures	14
2	Self studying of lectures' topics	10
3	Participation in exercises	8
4	Self preparation for exercises	8
5	Participation in laboratories	8
6	Self preparation for laboratories	8
7	Participation in seminars	
8	Self preparation for seminars	
9	Project's realization	
10	Participation in consultation	4
11	Self preparation for exam	
12	Participations in exam	

	Hours	ECTS
Effective student's workload	60	2
Work with tutor: 1+3+5+7+9+10+12	34	1
Practical classes: 5+6+9	16	0,5
Classes related to science: 1+2+3+4+7+8	40	1,5

THE SUBJECT'S AUTHOR

Paweł PERKOWSKI PhD DSc Eng

HEAD OF THE UNIT RESPONSIBLE FOR THE SUBJECT

Professor Leszek JAROSZEWICZ PhD, DSC Eng