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C H R O N I C L E

35th Winter School on Wave and Quantum Acoustics

Ustroń, 27th February – 3rd March, 2006

I have a great pleasure to give the "Archives of Acoustics" Readers possibility acquaint with topics presented at 35th Winter School on Wave and Quantum Acoustics. This School, organized by Upper Silesian Division of the Polish Acoustical Society and Institute of Physics at Silesian University of Technology, is planned at February/March 2006 in beautiful scenery of Silesian Beskidy Mountains.

As always, the School has been a place where achievements of various sections of acoustics (especially molecular acoustics, quantum acoustics, acousto-optics, magnetoacoustics, acoustoelectronics, photoacoustics, acoustics of solids etc.) are being exchanged. Moreover, some similar and related topics, for example optoelectronics and thermal wave methods, will be presented too.

For the second time the School will be divided on three different, but complementary, parts – Winter Workshops (WW). Chronologically it will be: 2nd WW on Acoustoelectronics and Optoelectronics (chairman – Prof. Tadeusz Pustelny), 2nd WW on Molecular and Quantum Acoustics (chairwoman Dr. Marzena Dzida) and 11th WW on Photoacoustics and Thermal Waves Methods (chairman Prof. Jerzy Bodzenta). This dividing was very well accepted by Participants.

After acceptation by revivers the School lectures will be published in one of two journals – in Journal de Physique IV – Proceedings (which is published by EDP Sciences and covered in the ISI database) or in Journal of Molecular and Quantum Acoustics (annual journal published by Upper Silesian Division of the Polish Acoustical Society). Moreover, all Participants will obtain a folder with Program of the School and full set of the one page abstracts obtained by organizers.

Once again we have taken pains to organize this conference taking into account the fact that it is an important event for acousticians, opticians and other Polish and foreign scientists. We hope that this reach conference program will gain acceptance and respect among its potential participants. We count on your numerous response and active participation.

In behalf of Organizers: *Roman Bukowski*, coordinator of the School

Abstracts

2^{nd} WW on AE&OE

1. Feedback in acousto-optic systems

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Study of systems with feedback represents a very interesting and perspective line of investigations in modern acousto-optics because it enables extending the range of problems in optical information processing that can be solved by acousto-optic methods. In these systems, diverse oscillations, including harmonic, self-modulation and chaotic ones, can be excited; bistable and multistable regimes of operation with stable states distinguished by amplitude, frequency and propagation direction of diffracted waves can also be achieved.

Acousto-optic systems with feedback have two important peculiarities. First, such systems are basically distributed because the time of acoustic wave propagation in the cell is compared with the period of oscillations. Second, these systems are principally nonlinear and the character of nonlinearities affects fundamentally the system behavior. The nonlinearities concerned in the first place with the acousto-optic cell give rise to diversity of regimes, but, at the same time, they complicate essentially theoretical analysis of the systems.

The given lecture represents a brief overview on theoretical and experimental investigations of feedback acousto-optic systems carried out in Moscow State University.

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2. Domain wall motion effect in the phase transition area in lead zirconate titanate piezoelectric ceramics

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In this work, the results of investigations of the PZT ceramics, received on the base of two-component solid solutions $Pb(Zr_xTi_{1-x})O_3$ are presented. The samples were obtained by conventional ceramic sintering method with nanopowders received in the sol-gel method. The temperature dependencies of the electric conductivity σ for all samples, with different content Zr/Ti ($0.35 \leq x \leq 0.65$), in the range temperatures of 300–750 K, were performed. On the base of the $\ln(\sigma T) = f(1/T)$ dependencies, the activation energy E_a was calculated. The determined values of the E_a were limited in the range 0.53–0.71 eV for ferroelectric phase as well as 0.75–0.80 eV for paraelectric phase.

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3. Selection of the first stage of a photoreceiver

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In this paper, the first stages of receivers of optical radiation are described. Special attention was paid to the selection of a detector adequate for a range of radiation to be detected. Detectors of optical

radiation, including the detectors of X and g radiation, visible range detectors, and IR detectors have been characterised. The selection of the first stage of a photoreceiver is a difficult task because a large number of factors should be considered. The most significant are: spectral range, level of detected signal, required signal-to-noise ratio, response time of a photoreceiver and its price. Response time of the first stage of a photoreceiver and signal-to-noise ratio should be determined on the basis of an equivalent scheme that consists of a detector with bias system and signal preamplifier.

The main purpose of our research was to analyse the input stage of photoreceiver to optimise them providing maximal voltage of signal to noise ratio. The analysis of operating conditions affecting signal to noise ratio has been conducted. Three categories of preamplifiers i.e. voltage, I/V converter and Q/V converter are described. Each preamplifier was carefully optimised to work with a particular type of the detector. An analysis of noise models of photodetector preamplifier systems was carried out.

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4. Objectivization of the electrical discharge measurement results taken by the acoustic emission method

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During partial discharges (PDs) measurement taking by using the acoustic emission (AE) method there occur objective difficulties connected with the interpretation of the results obtained because their evaluation depends, to a large extent, on the experience of the persons taking the measurements. This, in turn, increases their cost, introduces the factor of uncertainty connected with the subjective evaluation of the results obtained and makes it impossible to compare them in various research and technical centers. Moreover, the up-to-date issue is the identification of basic PD forms measured by the AE method, which is significant in the evaluation of the condition of the insulation measured. These two issues constituted the origin of the research work the results of which are presented in this paper.

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5. The influence of the momentum coefficient and the number of the averaging points of the power spectrum density on the recognition effectiveness of the AE signals generated by basic PD forms by the neuron network

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The paper presents research results referring to the application of neuron networks (ANN) in recognizing basic PD forms, which can occur in paper-oil insulation weakened by aging processes. The authors suggested to use of a single-track, multi-layer ANN structure, the so-called Feed–Forward Backpropagation Network. The research results presented show the recognition effectiveness of basic PD forms depending on the momentum coefficient imposed, the number of PD forms given simultaneously at the network input and the size of the teaching series. Power spectrum density was assumed as the parameter of the AE signal generated by the PD forms adopted. The paper also presents the results of the network recognition effectiveness analysis depending on the number of the averaging points of the power spectrum density, the number of the hidden layer neurons and the size of the teaching series.

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6. The influence of the propagation path length on the results of the time-frequency analysis of the acoustic emission generated by partial discharges in insulation oil

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The paper presents the measurement results of the acoustic emission (AE) signals generated by partial discharges (PDs) at various thickness of the oil insulation layer. For the AE signals registered the time-frequency analysis was carried out based on the use of the short-time Fourier transform (STFT). Two- and three-dimensional spectrograms of the power spectrum density and the amplitude spectrum were determined. The evaluation of the influence of the propagation path length of the AE signal on the results of the time–frequency analysis was performed through the analysis of the spectrograms determined.

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7. Non-reciprocal effects of acousto-optic interaction in birefringent media

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It is known that in acousto-optic (AO) interaction the frequency of light is changed on the value of the frequency of ultrasound. At the high acoustic frequencies (about 1 GHz and more) this effect is quite essential. If we exchange the directions of the incident and diffracted beams, the shift in the optic frequency will be opposite to the previous case. It results in the fact that the value of the acoustic frequency satisfying strict condition of Bragg matching is different in these two cases. The inequality of the frequencies is usually defined as non-reciprocity of AO interaction. The non-reciprocal effects are applied in electrically switchable optic devices such as valves and directional couplers.

In this paper, calculations of the phenomenon have been carried out for the most commonly used AO materials such as paratellurite, lithium niobate, α-quartz, calomel and other crystals and for various geometries of AO interaction. The main point of the research has been to evaluate the frequency shift conditioned by non-reciprocity in comparison with the frequency bandwidth of the AO interaction itself.

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8. Acousto-optic lens based on interaction of narrow laser beam with cylindrical ultrasound

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The investigations performed over seventy years of acousto-optics were confined to the interaction: a plane light wave – a plane ultrasonic wave (or a system of plane ultrasonic waves of different frequencies). Due to the access to the laser sources, there was an increased interest in diffraction of light beams of various widths or profiles by ultrasound.

Recently, attention has been paid on more complex cases of ultrasonic field. The first report on light diffraction by standing cylindrical ultrasound was given by Grulkowski and Kwiek, whose theory revealed a very good agreement with experiment.

In this paper, the experimental studies of the interaction of narrow Gaussian light beam with cylindrical standing ultrasonic wave are presented. The proposed arrangement appears to be an acousto-optic lens, and also serves as an efficient laser light modulator with the rise time of 100 ns. The parameters of both considered modalities can be easily controlled. Finally, possible applications of proposed system are suggested.

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9. The multielement probes for Ultrasound Transmission Tomography (UTT)

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Two models of the multielement ultrasonic probes: linear probe and ring-shaped probe, working at frequency of 1.7 MHz are presented. The probes are appropriated as a part of research set-up for UTT.

The model of linear probe is made up of 128 rectangular piezoelectric transducers of dimensions 0.5 mm $\times$ 18 mm and thickness 1 mm, made by incising a piezoceramic plate with diamond saw to the depth of 0.9 mm. Due to applying the multielement linear probes it is possible to eliminate the probes line shift, necessary for the image reconstruction using the pair of one-element probe in parallel ray projection geometry.

The model of ring shape probe is made up of 1024 rectangular separate piezoceramic plates of dimensions 0.5 mm $\times$ 18 mm $\times$ 1 mm placed inside a ring with diameter $D = 300$ mm. This probe is appropriated for examining objects in divergent ray projection geometry.

The elaborated models of probes can work as well as transmitter and receiver in cooperation with transmitter-receiver systems, containing the multiplexer and demultiplexer set-up and analog switches.

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10. Shaping of coherence function of sources used in low-coherent measurement techniques

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In low-coherent measurement techniques the coherence length of the source is one of the critical parameters of the designed system because it effects the resolution of the measurement system. The most popular low-coherent sources have the coherence length at the range of 20–40mm. In many applications it is too little to get the required resolution of the measurement. Hence, it is necessary to use some techniques to change the coherence length of the source. One of the most effective methods of changing it is using a synthesizing multiwavelength sources.

In this article, the author analyses the dependence between the spectral characteristic of the synthesized source and the equivalent coherence length. The result of theoretical investigation and simulations will show that the use of synthesized source can greatly reduce the equivalent coherence length. Additionally, it will be presented that it is possible to reduce the source equivalent coherence length by changing its spectral shape. It can be performed by using optical filters with properly chosen spectral parameters.

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11. Aircraft positioning with INS/GNSS integrated system

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Contemporary positioning systems are expected to provide for precise information about the parameters of motion of the vehicle. There exist numerous applications where a single navigational device would not be capable of fulfilling stringent requirements with respect to accuracy, reliability, continuity and integrity. In such cases, integrated positioning systems can be used.

In aircraft positioning, INS/GNSS systems are frequently applied. Integration of INS and GNSS receivers via the Kalman filter presents one of the best achievements in positioning technology and one of the most successful applications of the Kalman filter. Advantages and disadvantages of INS and GNSS are complementary, thus the integration can eliminate their drawbacks and make optimal use of their strengths.

The paper describes methods of INS/GNSS integration and rules of designing Kalman filters. An example of INS/GPS positioning system is presented. The designed system employs a complementary linearized Kalman filter, estimating INS position, velocity and attitude errors, as well as GPS clock bias and drift. Chosen simulation results, comparing accuracy of INS, GPS and INS/GPS are included in the paper.

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12. A variational treatment of SAW propagation in a system of periodically distributed surface flaws

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The purpose of the paper is to outline a systematic way for treating the coherent bulk wave excitation produced by a Rayleigh type wave propagating along a periodically modified surface, composed of 2D pseudo-array of altered phase inclusions.

To circumvent the technological difficulties in a multi-element piezoelectric device fabrication, associated mainly with the number of microelements required, it has been previously proposed in an alternative method, employing an array composed of periodic system of regions (clusters of impurity defects) with varying material parameters or, alternatively, altered phase inclusions, located at the surface of a SAW substrate.

An analytical model scheme is constructed, using a variational method combined with the T-matrix approach, appropriate for the 2D periodic array treated.

The technique can be used to describe 3D beam-forming waves, coherently scattered into the depth, for anticipated use in non-destructive evaluation of the bulk or opposite face of the material used.

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13. Spectral sensitivity of optopneumatic and optoacoustic gas detectors

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Detection and measurements of concentration of basic air pollutants are often conducted by applying NDIR analysers (Non-Dispersive InfraRed). These instruments are characterised by high sensitivity, selectivity and credibility.

The main part of NDIR analyser is an infrared detector. Its parameters determine a relationship between signal and concentration as well as measuring range and selectivity. The gas filled detectors used for infrared measurements possess very interesting properties. Their principle of operation is based on the absorption of radiation in a gas and conversion of its energy into changes of pressure or flow.

In this paper mathematical models describing optoacoustic and optopneumatic detectors are presented. These models base on energy balance of radiation absorbed in the detector. Spectral characteristics and the relationships between the response signal and concentration of analysed gas are the most important results of the calculation.

Theoretical results were verified by measurements of calibration curves for detectors with various filling. It was shown that the sensitivity of detection could be adjusted in a wide range by selection of gas filling.

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14. Acousto-optic properties of materials transparent in the infrared

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The report is devoted to investigation of acousto-optic properties of materials transparent in the long infrared range of wavelengths. At present, acousto-optic instruments operate in the visible light as well as in the ultraviolet and near infrared regions of spectrum. On the other hand, the instruments intended for processing of radiation in the long infrared have not so far been perfectly developed.

Birefringent materials transparent in the infrared and used in Acousto-optics are calomel, TAS and mercury bromide. Unfortunately, these crystals do not provide high diffraction efficiency in the long infrared though they demonstrate good performance in the near and middle infrared regions of spectrum.

In this paper, a single crystal of tellurium is considered as a candidate for the application. The material possesses an extremely high acousto-optic figure of merit value that is about 200 times better than in calomel. Hence, driving power in a tellurium based instrument may be sufficiently decreased in comparison with similar cells using calomel, TAS and other known infrared crystals.

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15. Two-interferometers sensor for detection and localization of disturbance

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This paper presents a fiber optic perimeter sensor based on Sagnac and Michelson interferometers. This sensor can detect a mechanical disturbance along the protected zone.

The output of the Sagnac interferometer is proportional to the product of two factors: firstly the rate of time derivate phase change and secondly the distance which is described by the disturbance point. So, to localize the disturbance a knowledge of the rate of time derivate phase change is needed. The output from the Michelson interferometer gives an output proportional to the phase change. If both outputs will be demodulated, the desired distance will be given from simple division of demodulated interferometers outputs.

A laboratory arrangement of the sensor and its experimental research are shown.

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16. Visualization of phase objects in geometry of tangential acousto-optic interaction

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Acousto-optic processing of optical images is a relatively new line of investigations in acousto-optics. This paper presents results of theoretical research of an acousto-optic method of phase object visualization in the tangential geometry of acousto-optic interaction. The acousto-optic method of phase object visualization is based on angular selectivity of Bragg diffraction. The law of conversion of the phase spatial modulation into the amplitude one depends on a cut of the crystal used in the acousto-optic cell and on parameters of the acoustic wave. The two-dimensional transfer function of the acousto-optic cell describes these dependencies. The usage of the tangential geometry of acousto-optic interaction for the phase object visualization is of particular interest because the transfer function in this case has an axially symmetric structure. In this work, most attention is focused on calculation of the limiting resolution and the contrast of the visualized image in accordance with acoustic wave parameters. Examples of computer simulation illustrating potentialities of this method are presented as well.

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17. Tuning of optic and electron properties of laser heterostructures by the ultrasonic strain

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Frequency modulation of diode lasers is the basis of the most of interferometric measurement systems. Recently tuning of a radiation frequency, realized in multisectional diode lasers, with the help of an operating current change, and also by heat effects, have a main defect consisting in rather inaccurate reproducibility of the frequency at the tuning.

On the other hand, an alternating strain in laser heterostructures may lead to change in time of spectral characteristics, such as the frequency and the polarization of generated radiation. A new approach to the problem of the frequency tuning of diode laser radiation is presented in our paper. It consists in action of the alternate strain, stipulated by ultrasonic (both bulk and surface) waves, on an active region of a laser. The interaction models are offered and the theoretical analysis of the obtained experimental data has been carried out. Is shown that mainly acousto-electron interaction determines surface acoustic wave effect on spectral parameters of InGaAsP/InP laser radiation.

The authors are grateful to the RFBR (Gr. No. 04-02-16205).

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18. Optimization of dual-core fiber optic for localization sensor

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We presented some calculation of a dual-core fiber optic specially designed for a sensor with localization of a disturbance point. Distribution of the refractive index causes that two groups of modes can propagate with different velocities. In the presence of the microbendings, we can observed the time delays between the pulse trains and on this basis the disturbance point can be localized.

In our calculations we make use of the software FiberCad by OptiWave. We took into considerations the geometrical parameters as well as refractive indices. First, we calculated the effective refractive indices

of the modes. Next, we were seeking the higher order mode that can propagate in the outer core with the effective refractive index close to the effective refractive index of the fundamental mode localized in the inner core. The difference between the indices should be less than 0.002 in order to assure high coupling efficiency in the presence of the microbendings.

We obtained the time difference equals to 43.5 ns/km and the difference between the indices equals to 0.0015.

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19. Photonic Crystal Fibers for detection and localization of disturbance

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We presented some calculation of a photonic crystal fiber specially designed for a sensor with localization of a disturbance point. Distribution of the refractive index causes that two groups of modes can propagate with different velocities. In the presence of the microbendings, we can observed the time delays between the pulse trains and on this basis the disturbance point can be localized.

The structure of the fiber consists of 9 rings of the holes with different diameters and spacing. We took into considerations the geometrical parameters as well as refractive indices. First, we calculated the effective refractive indices of the modes. Next, we were seeking the higher order mode that can propagate in the outer core with the effective refractive index close to the effective refractive index of the fundamental mode localized in the inner core. The difference between the indices should be less than 0.002.

For the spacing equals to 3 mm, we obtained the time difference equals to 144 ns/km and the difference between the indices equals to 0.0013.

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20. UHF oscillators for SAW chemical compounds sensors

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Although chemisensitive coatings play the key role in the surface acoustic wave (SAW) chemical sensors, nearly as important as the coatings are electronic circuits cooperating with SAW elements. The results of theoretical calculations show that an increase in the SAW sensors operating frequency is profitable from the sensitivity and miniaturisation point of view.

Unfortunately, the values of parasitic elements increase when the frequency raise and an oscillator gradually begin to work as a distributed element circuit. In UHF range it should be designed more carefully than its lower frequency equivalent and needs much more precise elements to right tune. It is well known that oscillator designing, especially in high frequency range, is rather an art than a science. Calculation or simulation results give a starting point for the working circuit only. Such process requires as much experience as a theoretical knowledge.

This paper presents practical remarks concerning UHF SAW stabilised oscillators for chemical sensors design as well as a few useful applications.

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21. PLZT ceramics as the material for the electronic and electro-optic applications

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For many years the PLZT ceramics have been known as a ferroelectric material, which has various electro-optic and piezoelectric properties. The solid-state nature and majority properties of lead lanthanum zirconate titanate are function of the La concentration, and also the Zr/Ti ratio. Unfortunately, receiving of transparent PLZT ceramics is a very complexes process, because in such materials are a lot of light diffusions and absorption centers. Those phenomena decide about transparency of $(Pb,La)(Zr,Ti)O_3$.

The aim of this work was to design technology of transparent x/65/35 PLZT ceramics, with a different amount of La ions (x). The conventional ceramic sintering method and the sol-gel method were applied to obtain such materials. The relationships between stoichiometry, microstructure and piezoelectric properties were studied for all samples. The investigations have revealed that obtained PLZT ceramics have a few of particularities, which increase substantially possibilities of its application in electronic devices.

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22. Inclined incidence of acoustic waves on a free boundary in acousto-optic crystal paratellurite

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The main goal of the research consists in investigation of unusual cases of propagation and reflection of bulk acoustic waves in the acousto-optic crystal tellurium dioxide.

It is proved that, during a reflection form the plane facet of a sample, as much as two reflected acoustic waves propagate from a boundary at both sides with respect to an incident wave. Relative intensities of the two waves, in the case of inclined incidence, were calculated. In this way, evaluation of reflection coefficients for each of the reflected waves was carried out. The calculations were executed for a wide variety of cuts of the crystal.

Problems of development of a generalized theory describing the unusual reflection of waves in media with strong anisotropy of elastic properties are discussed in the report. It is expected that it will be possible to apply the proposed theoretical approach to the wide class of physical phenomena existing in acoustic and optic media. Various applications of the investigated effects in new acousto-optic devices are also considered in the paper.

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23. Application of wavelet transform for monitoring of operation of high-power Diesel engine

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The possibilities of the application of the wavelet decomposition of Acoustic Emission (AE) signal of frequency range of 1.2–10 kHz for diagnosing of common faults of the fuel injection system of a high-

power Diesel engine is presented. AE signal was recorded in two locations: on the stub inlet to the injector and on the stub outlet of the fuel pump.

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24. Polymer piezoelectric transducers made from polyhydroxybutyrate (PHB)

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The objective of this work was to investigate the piezoelectric properties of different samples of PHB prepared either from powder, films or spun filaments. All samples were analysed regarding their piezoelectricity in the thickness mode and in its bending mode. For the latter the samples were glued onto brass plate and then deflected by means of a piezoelectric stack.

Whereas the piezoelectric effect in the thickness mode is negligible, there is clear evidence that in the bending mode a piezoelectric effect occurs. The strength of the effect varies depending on the degree of the elongation of the material and the angle between the direction of elongation and mechanical load. A quantitative consideration based on the measurement of the charge generation due to the bending of the brass substrate as function of the strain delivers $e_{14} = 1.57$ mC/m^2. The effect was also analysed when a piece of fabric made from PHB filaments was used instead of the thin film material.

As an application a PHB airborne transducer has been produced and its operation has been studied using a scanning laser Doppler vibrometer.

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25. Theoretical and experimental investigation of Optical Coherent Tomography topologies

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Optical Coherent Tomography is a measurement technique, which enables us to visualize the internal structure of the investigated object with very high resolution. In OCT systems to detect the measured signal the measurement techniques such as: optical frequency domain reflectometry (OFDR) and optical low-coherent reflectometry (OLCR), are employed. In both these methods it is necessary to use at least one interferometer.

Up today a few topologies for Optical Coherent Tomography have been employed. Still, the most popular is configuration with Michelson interferometer, but Fizeau and Fabry-Perot are performed as well. Furthermore, it is known that using balanced configuration of interferometer topologies is possible to effectively reduce noise-to-signal ratio. Hence, the use of the second interferometer is necessary. In this situation a few of interferometer topologies can be used.

In this article the theoretical and experimental investigation of interferometer topologies for Optical Coherent Tomography will be analyzed. The optimal configuration of the designed system has been presented. By use of the special configuration, our OCT system is sensitive to change of polarization of measured signals.

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26. Planar polymer photonic crystal waveguide

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In the last years, Photonic Crystals (PhC) became objects of intensive studies by many groups. It is possible today to design optical elements controlled and read optically. This study presents a broad

review of application of the Polymer Photonic Crystals to manufacture many optical waveguide devices like couplers, splitters, switches, modulators, amplifiers, generators, logical units etc. We described the basic properties of Photonic Crystals and phenomena observed in the PhCs. The manufacture technologies are also presented.

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27. Influence of birefringence on parameters of imaging acousto-optic filters

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The report is devoted to analysis of light diffraction by ultrasound propagating in optically anisotropic crystals. In particular, regular trends of wide angle regime of light diffraction by acoustic waves in crystals possessing different grade of birefringence is examined in the presentation.

The anisotropic diffraction is investigated with the goals of application in the imaging acousto-optic filters. As found and proved experimentally, basic characteristics of the acousto-optic filtering depend on the birefringence value of a crystal. In the majority of crystals, the relative birefringence is limited to the magnitude 0.1. On the other hand, in such materials as calomel (Hg_2Cl_2) and tellurium (Te), the optic anisotropy is as large as 0.3–0.4.

Analysis demonstrates that basic parameters of the wide angle interaction, such as the angle of spatial separation of incident and diffracted beams, the spectral bandwidth of filtering and the maximal number of resolvable spots in a processed image, are improved with growth of the birefringence value.

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28. Analysis of Bragg diffraction of light in periodically inhomogeneous acoustic field

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The paper presents results of theoretical investigations of acousto-optic interaction in cells where amplitude or phase of an acoustic wave varies periodically along the direction of optical wave propagation. Such an acoustic field creates a two-dimensional grating for light: the first grating has a period equal to the acoustic wavelength and the period of the second grating is defined by the period of spatial modulation. Most attention is concentrated on the case of sinusoidal law of spatial modulation because this case makes it possible to realize more complicated variants of the modulation.

The diffraction problem has been solved for the regime of Bragg diffraction in both isotropic and anisotropic medium. Amplitude, frequency and angular characteristics of the diffraction spectrum have been calculated for the case of strong acousto-optic interaction. It has been found that the spatial modulation of the acoustic field can essentially change the optimal geometry of acousto-optic interaction, which provides the most effective scattering of light. The diffraction efficiency in the Bragg regime can attain, as usual, 100%, but it requires more acoustic power than in case of the homogeneous transducer.

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29. Modelling of optical components made of liquid crystals and liquid crystalline polymers

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Interferometric sensors are often implemented as polarization interferometers since they attain high resolution and accuracy by maintaining stable and well-defined states of polarization of interfering beams. Since parts of birefringent optical components, such as waveplates and polarizing prisms, are usually manufactured from crystalline materials and aligned with high precision, their cost is high.

By manufacturing some of the aforementioned components from Liquid Crystals (LCs) or Liquid Crystalline Polymers (LCPs), their cost can be substantially reduced. Moreover, better integration of optical setups can be obtained, e.g. by creating an LCP waveplate directly on a beamsplitter face, reducing at the same time the number of surfaces on which antireflection coating must be applied.

In the case of polarizing prisms the difference between traditional crystalline designs and their LC/LCP counterparts are great, so they merit closes examination. In the paper we compare the two classes of Wollaston prisms and discuss the limitations of the latter group. Moreover, we present results of modelling of light propagation through Wollaston and Nomarski prisms made from LCPs.

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30. Optoelectronic monitoring of plasma discharge optimized for thin diamond film synthesis

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We used Optical Emission Spectroscopy (OES) as a non-invasive optoelectronic tool of plasma discharge on-line monitoring. The low-temperature plasma, based on mixture of methane and hydrogen, was produced during Microwave Plasma Assisted Chemical Vapour Deposition process of thin diamond and DLC films synthesis. Quality of the synthesized thin films is determined by total amount as well composition ratio of ions H^+ and CH^{3+}, produced in an area of Electron Cyclotron Resonance (ECR).

The excitation and ionization of H_2 particles was an object of OES monitoring. Due to partial return of the excited and ionized atoms to lower energy levels, emission spectrum can be observed. Intensity of the hydrogen bands is determined by efficiency of molecules dissociation as well as on excitation and ionization in ECR area. Developed monitoring system used the spectrograph Mechelle 900, coupled with the reaction chamber by a dedicated optical probe and waveguide. Argon-plasma was used for test measurements. Intensities of hydrogen Lyman and Paschen series were investigated as a function of main CVD process parameters.

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31. Acousto-optic imaging by means of wide angle tunable acousto-optic filter

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The paper is devoted to the investigation of wide angle acousto-optic tunable filters, which can provide a high rate filtration from near-infrared to near-ultraviolet range of optical wavelengths with a good spectral resolution. The factors which decrease the quality of processed images were studied.

The research proved that tuning of the filtered wavelength by the wide angle AOTF is accompanied by the defocusing of the processed image in whole. Consideration of this effect in order to compensate the disadvantage resulted in an appreciable enhancement of the image sharpness over the wide range of the filtered optical wavelengths.

The examined type of an image processing spectrograph is promising for applications in verification systems of protected documents (e.g. bank notes, passports), in non-destructive analysis of biological and artificial objects, in medicine, in environmental monitoring, etc. Spectral measurement of a thermal damage of a leaf was carried out in order to demonstrate the operation capability of the instrument.

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32. Parameters of ceramics obtained on the base PZT used to build electroacoustic converters

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Modifying the basic chemical compositions of converters, obtained on the base of two – component solid solutions of the PZT type, is possible by the use of suitable dopants. In the work the complex of electric parameters, such as: k_p, ε, tanδ, d_{31}, S_{11}^E, E_C, P_r was determined for five different compositions of ceramics of the PZT type, used to product electroacoustic converters. The samples to research were condensed by conventional ceramic sintering method, replacing partly the ions Pb^{2+} with ions Ba^{2+} or Sr^{2+}. To basic chemical compositions of ceramic samples, hard: Mn^{2+} and Cr^{2+} or soft: Nb^{5+} dopants were introduced, too.

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33. The influence of the Zr/Ti content of the PZT ceramics obtained by sol-gel method on the electric conductivity

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In this work, the results of investigations of the PZT ceramics, received on the base of two-component solid solutions $Pb(Zr_xTi_{1-x})O_3$ are presented. The samples were obtained by conventional ceramic sintering method with nanopowders received in the sol-gel method. The temperature dependencies of the electric conductivity σ for all samples, with different content Zr/Ti ($0.35 \leq x \leq 0.65$), in the range temperatures of 300–750 K, were performed. On the base of the $\ln(\sigma T) = f(1/T)$ dependencies, the activation energy E_a was calculated. The determined values of the E_a were limited in the range 0.53–0.71 eV for ferroelectric phase as well as 0.75–0.80 eV for paraelectric phase.

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34. Brillouin scattering in single mode fiber optic in construction of localization sensor

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For the purpose of protection against intruders, infrared sensors, magnetic sensors buried under ground and leakage coaxial cable sensors are widely used. Fiber optic sensors were developed for intrusion detection of the surroundings, such as the outskirts of an airport and the buildings.

Stimulated Brillouin scattering fiber optic sensor employs a pumping pulse and a continuous wave probe beam running along a single mode optical fiber in opposite direction and detects the stimulated Brillouin back scattering signal amplified by two light beam and acoustic wave mixing. In this method, the frequency of continuous wave probe beam differs from the pump beam by the amount of Brillouin frequency of optical fiber to enable the amplification and high intensity Brillouin scattering signal can be obtained.

In this study we propose a Brillouin sensor system, which has possibility of detecting and locating intrusion attempts over several tens of kilometers long paths.

11th WW on PA&TWM

35. FT-IR/PAS studies of silver modified manganese catalysts

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Manganese oxides have found wide interests in catalysis. Their peculiar structural and redox properties arise from different spatial arrangement of MnO_6 octahedral units and labile oxidation state of manganese. It was noticed that catalysts modified by silver can oxidized CO at room temperature.

The aim of the present studies was an attempt to characterize bulk and surface properties of silver manganese catalysts by FT-IR and FT-IR/PAS. The catalysts were prepared by the redox precipitation technique followed by hydrothermal processing. Silver was introduced directly to the synthesis mixture or after calcination by the wetness impregnation. FT-IR and FT-IR/PAS studies of the catalysts after different pretreatment conditions were performed by means of Bio-Rad Excalibur 3000MX spectrometer equipped with MCT and PA detector MTEC300.

The application of both techniques offered a complementary picture of the surface and bulk properties of the examined catalysts. Studies evidenced the influence of preparation method and different treatment conditions on their properties.

This work was supported by the Polish Ministry of Education and Science as research project 3T09B11429.

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36. Thermal stability of chemically bonded phases on silica gel by photoacoustic FT-IR spectroscopy

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The main feature of silica gel prepared using sol-gel method is the presence of silanol groups and siloxane bridges on internal and external surface. For many practical applications silica gel is chemically modified and various organic ligands are bonded for partial or total elimination of surface silanols. Most popular modified silica contain on the surface hydrocarbon species of different number of carbon atoms e.g. C2, C8 and C18. Silica gels with $-NH_2$ or – diol groups are also used as a specific sorbents. These materials are widely used as a column packings in chromatography. In the present paper we report the results investigations of surface species for commercial silica's Lichrosorb RP2, RP8, RP18 and RP-NH_2

obtained by FT-IR/PAS technique. The surface characterization for these materials was performed after treatment at different temperatures from 298 K to 573 K in air and in inert gas. The FT-IR/PAS spectra were recorded by means of a Bio-Rad Excalibur 3000MX spectrometer equipped with photoacoustic detector MTEC300 (in the helium atmosphere).

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37. Speciation of functional groups formed on the surface of carbonaceous materials modified by NO

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This report concerns the catalytic applications of two types of coal – brown coal (KWB Konin) and subbituminous coal (KWK Sośnica) refined and modified by exposition to nitrogen (II) oxide at two temperatures 270°C or 300°C. These materials used as catalysts' supports were also subjected to carbonisation (at 700°C) and activation in steam (at 800°C). The species of the functional groups formed on the surface of these support materials as a result of their reaction with NO were determined by the photoacoustic IR spectroscopy (FT-IR/PAS).

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38. Structuralization induced by photothermal effect in magnetic fluid film

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The formation of the magnetite nanoparticle structuralization in the magnetic fluids is observed as a consequence of the nanoparticle thermo-diffusion. The temperature gradients can arise due to light-absorption on the accidental concentration fluctuations of particles or on the well defined geometric structure such as the concentration – diffraction grating.

The structuralization of the magnetic particles after illumination was experimentally observed in two types of magnetic fluid based on mineral oil with magnetite particles covered by mono-layer surfactant and kerosene based magnetic fluid sterically stabilized by double layer consisting of oleic acid and dodecylbenzensulphonic acid. During illumination in kerosene based magnetic fluid structure with "islands" has developed what confirms the supposed negative value of the Soret constant.

This paper presents the detailed theoretical description of the thermodiffusion process in magnetic fluids, to simulate the structuralization in magnetic fluid with negative Soret constant and to confirm the negative value of this constant for kerosene-based magnetic fluid.

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39. The hyperthermia effect in biocompatible magnetic fluids

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Application of magnetic materials for hyperthermia of biological tissue with the goal of tumour therapy is known in principle for more than four decades. For biomedical purposes magnetic particles must be coated with substance ensured their stability and biocompatibility. Biocompatible water based magnetic fluid with magnetite nanoparticles coated by additional biocompatible layer of polysaccharide dextran was prepared. The successful adsorption of the dextran to the magnetite nanoparticles and structural stability was confirmed by infrared spectrophotometry and ultrasound study, respectively. Calorimetric measurements were performed at some frequencies (in the range from 250 kHz up to 2.94 MHz) in dependence on the AC-magnetic field amplitude and values for specific absorption rate (SAR) calculated from experimental results were in range up to 150 W/g. This paper presents the experimental results of calorimetric study in biocompatible magnetic fluid. The obtained results show that observed heating effect may be applied in hyperthermia treatments especially in preferable region 500–800 kHz.

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40. The investigations of radiative and nonradiative deexcitation of pigments of the oils

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The absorption, steady state photoacoustic and fluorescence spectra of unbleached oils obtained by pressing the following types of seeds: evening primrose, borage, rape and viper‘s bugloss were taken. Samples were measured under air and nitrogen atmosphere. The thermal deactivation in the absorption regions of carotenoids and the pheophytins were established at various frequencies of acting light modulations. The interactions between oil pigments are discussed. The generation of very photochemically active triplet states at various carotenoids and pheophytins contents were evaluated.

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41. Photoacoustic infrared analysis of nickel catalysts precursors

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IR spectroscopy provides data on the composition and structure of surface compounds, the nature of the bonds formed between adsorbed molecules and the surface, the existence of various types of surface

compounds and active surface centers. The most frequently used infrared transmission technique detects only the bulk of a sample. In the contrary, FT-IR/PAS method differentiate the near-surface region of a sample from its bulk.

The aim of this work was to investigate the adsorption of various nickel precursors on alumina surface during preparation procedure. Moreover, the influence of pH environment was taken into account. For this purpose five catalysts series were prepared. The FT-IR/PAS spectra were recorded by means of a Bio-Rad Excalibur 3000MX spectrometer equipped with photoacoustic detector MTEC300 (in the helium atmosphere). The spectra were normalized with reference to MTEC carbon black standard. Interferograms of 1024 scans were averaged for each spectrum.

Systematic and complex investigations allow to propose a general guideline related to the preparation conditions. Among the others, the FT-IR/PAS results give a strong premises for the formed conclusions.

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42. FT-IR/PAS characteristic of the Ni-NiO/Al_2O_3 catalyst

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In industrial conditions catalysts deactivation causes considerable economical losses related to necessity of catalyst's regeneration or new catalyst's costs (catalyst exchange in the reactor). The aim of this work was to examine the samples of the KUB-3 catalyst (Ni-NiO/Al_2O_3) taken from the industrial bed after three-year continuous work (applied for the hydrogenation of benzene).

Spectra of the catalyst samples taken from the bed and after extraction (Soxhlet extraction) were recorded by FT-IR/PAS utilizing a helium-purged MTEC 300 PA detector. Based on the conducted experiments the following conclusions can be done:

- analyzed KUB-3 samples by the FT-IR/PAS exhibit similar character of the surface species, independent from the position in the industrial bed,
- in all cases the carbon deposit was present,
- the spectra of extracts showed that the highest soluble carbon contents is present in the upper part of the industrial bed.

This work was partially supported (K. Stołecki) by the Polish Ministry of Education and Science as research project 3T09B 12527.

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43. Photoacoustic and photopyroelectric complementary investigations of thermal parameters in water mixtures with some nonelectrolyte liquids

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In this work, two photothermal techniques have been applied for complementary investigations of liquid mixtures. The photopyroelectric (PPE) technique in back configuration, has been used for thermal diffusivity measurement. For the same media, the thermal effusivity investigation has been performed using

photoacoustic open cell with microphone registration. A linear dependence of thermal effusivity on mass concentration of liquid admixture was observed in the case of non-interacting liquids. The plots obtained for such "inert" mixtures were compared with those obtained for strongly interacting liquids. In this latest case the mass concentration dependence of relative excess values of both thermal diffusivity and thermal effusivity revealed distinct minima, at a specific concentration. The results of the photothermal experiments have been analyzed based on theoretical considerations. Apart from the PT examination of the solutions, adiabatic compressibility variation versus mole fraction of the liquid admixture was determined using ultrasonic method. The conclusions drawn from the compressibility run, well support the PT results.

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44. The influence of the copolymerization conditions on the polymer structure. FT-IR/PAS studies

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Polymer beads have variety areas of practical applications. In our work we focused our attention on the copolymers synthesized by emulsion and polymerization method. In both polymerization techniques two phases are present. The first one, water phase is a dispersion medium for the organic one, while the second consists of monomers and diluent mixture.

In this work we report the preparation of spherical porous copolymer beads of methacrylic acid – MAA and ethylene glycol dimethacrylate – EGDMA. As a pore-forming diluent, the mixture of diluent system on the porous structure of the poly(MAA-EGDMA) has been examined.

The surface structure of the obtained copolymers was examined by FT-IR/PAS. Spectra were recorded by means of a Bio-Rad Excalibur 3000MX spectrometer equipped with PA detector MTEC300 (helium atmosphere in a detector). The spectra were normalized with reference to MTEC carbon black standard. Interferograms of 512 scans were averaged for each spectrum. Obtained results were compared with those coming from the traditional transmission technique.

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45. Investigation of platinum(IV) ions sorption on some anion exchangers by using Photoacoustic and DRS methods

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The high cost and increasing demand have prompted the recovery of platinum from low-grade ores and spent catalysts. Platinum exist in chloride solutions in the anionic form, therefore anion-exchanging is a better method than cation exchanging for sorption of platinum(IV) ions. Therefore applicability of four anion exchangers Duolite A 30 B, Lewatite MP 62, Lewatite MP 64 and Purolite A 520E were studied.

The FT-IR/PAS spectra were recorded by means of a Bio-Rad Excalibur 3000MX spectrometer equipped with photoacoustic detector MTEC300. The DRS spectra of three anion exchangers Lewatite MP 62, Lewatite MP 64 and Purolite A 520E are similar but spectra of anion exchangers Duolite A 30B is different. The differences in spectra can be result from skeletons of anion exchangers. Recorded FT-IR/PAS spectra allow to distinguish the differences between applied anion exchangers before and after sorption of platinum(IV) ions. In all spectra the biggest differences could be noticed in the OH and CH_2 stretching region.

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2^{nd} WW on M&QA

46. Acoustic and volumetric effects of self-association of 2-methyl-1-propanol in binary liquid mixtures at 293.15 K

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The speeds of ultrasound in and densities of binary solutions of 2-methyl-1-propanol in hexane and cyclohexane were measured on the whole concentration range at 293.15 K. Using the measurements results in connection with literature data, the isothermal compressibility coefficients and isochoric molar heat capacities for the pure components were calculated. The above values were used to estimate the free volumes and excess free volumes of the mixtures under test. Also, the excess molar volumes, adiabatic compressibility coefficients and adiabatic compressibilities, as well as the free intermolecular lengths were determined for the binaries. The dependence of the excess molar volumes, adiabatic compressibilities and excess free volumes on the mixture composition were compared and discussed in terms of the free intermolecular length and other factors affecting the self-association of 2-methyl-1-propanol and structural changes of the non-polar solvents. The differences between corresponding values of the excess molar volume and other thermodynamic quantities are related to the space filling ability, as well as to the entropy effects accompanied with the solvation processes.

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47. Modification of a high pressure device for speed of sound measurements in liquids

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In this work modifications of the measuring set for measurements of the speed of sound in liquids under pressures up to 100 MPa in the temperature range from 293 K to 318 K were described. The modifications include the acoustic path, geometry of reflector, transducer, damping layer, seal wire and sealing unit. These modifications resulted in the reduction of the volume of liquids needed for measurement (from 370 ml to 120 ml), higher stability of pressure during measurements (± 0.03 MPa) and more comfortable mounting the acoustic part in the high pressure chamber. The apparatus was tested using benzene, cyklohexane, n-heptane, n-hexane, carbon tetrachloride, hexan-1-ol, and ethylene glycol under atmospheric pressure and n-heptane at pressures up to 100 MPa and at temperatures from 293.15 K to 318.15 K. A good agreement with literature data was obtained.

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48. Acoustic and thermodynamic investigation of aqueous solutions of some carbohydrates

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The main aim of this work is the discussion of properties of aqueous solutions of D-fructose, D-glucose and D-saccharose. D-fructose and D-glucose are the monocarbohydrates that have the same molecular for-

mula, but because of the different molecular structure they may interact with water in two different ways. D-saccharose consists of D-fructose and D-glucose, so it may be anticipated that the properties of aqueous solutions of sucrose results from those of aqueous solutions of both monosaccharides. The properties compared are speeds of sound and adiabatic compressibilities as well as the other related thermodynamic properties. Additionally, some sound absorption results will be interpreted in terms of molecular processes that probably occur in the investigated solutions. All discussion will be made on results of our measurements and some values taken from the literature.

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49. Viscoelastic properties of tissue simulation phantoms obtained by the acoustic pulse technique

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In recent years several new approaches were proposed for determining mechanical properties of biological tissues pertaining to both, ultrasonic methods and magnetic resonance ones. Imaging of the Young modulus or shear modulus distribution has become an important medical diagnostic tool.

Mechanical properties of soft tissues play an important role in the detection and treatment of many solid tumours in those parts of the body which are accessible to the physician's hand. It means that standard palpation is a common indication of some cancers. However, this method is not a quantitative one. Therefore, sonoelastography and MR elastography has found numerous applications in medical diagnostics, e.g. for identification of the breast, prostate, brain or liver tumours the rigidity of which generally differs markedly from that of the surrounding healthy tissues.

In the present report, an acoustic pulse method is proposed to determine viscoelastic properties of soft tissue simulating phantoms.

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50. Effect of dilution on compressibility of naproxen in acetonitrile studied by ultrasonic method

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Numerous 2-arylpropionic acids (e.g. naproxen, ibuprofen, and ketoprofen) are used as non-steroidal anti-inflammatory drugs. All of them are chiral that can cause serious problems if one enantiomer has a favourable healing potential, while its antipode is toxic, because they may remain in a patient's body as the two antimers, even if administered as a single one, due to transenantiomerization. Chromatographic data suggest that solutions of S-(+)-naproxen in acetonitrile are stiffer than the pure solvent that favours oscillatory transenantiomerisation. Acoustic and volumetric studies of dilute solutions of naproxen in acetonitrile have been undertaken to verify that supposition. The molar adiabatic compressibility and volume depend linearly on the molar percent of naproxen at temperatures from 298.15 K to 313.15 K. Limiting partial compressibility of naproxen is close to zero and decreases slightly with increasing temperature. Thus, the compressibility of dilute solutions is mainly due to compressibility of acetonitrile, while naproxen is virtually incompressible. The hydrogen-bonded dimers of naproxen probably remain intact, even at infinite dilution.

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51. Ultrasonic absorption measurements by means a megahertz – range measuring set

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The goal of the paper is the description and comparison of the performance of two devices for the measurement of ultrasonic absorption. Both devices were designed and constructed in our laboratory.

The design of the apparatus is based on the standard pulse technique, i.e., the amplitude of the first transmitted pulse is measured as a function of distance. The first device allows the measurement the absolute absorption in the frequency range from 10 to 80 MHz. The construction details as well as the performance of the first apparatus were reported previously. The second apparatus allows the measurement in the extended frequency range. The apparatus is currently used in the laboratory at Wroclaw University. The results of some measurements were reported in literature. In the paper the comparison of the performance of the two devices will be based on the results obtained for the various test system.

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52. Acoustic studies of aqueous solutions of polyethylene glycol 400

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The absorption, velocity of ultrasound and the density have been measured in mixtures of water and polyethylene glycol (PEG) 400 in the temperature range from 291.15 to 309.15 K.

The investigation of ultrasonic attenuation spectra were carried out in the frequency range of 100 kHz – 1 GHz at 298.15 K.

The variations of ultrasonic velocities and adiabatic compressibility coefficient with concentration and temperature have been studied. Structural interactions and the formation of a compact pseudo-stable structure in the region of a very low polyethylene glycol 400 concentration have been observed.

The experimental values of ultrasonic velocities for the various concentration have been used to calculate the apparent excess speeds of sound. The excess properties presents the detailed knowledge about the deviation from ideality, and thus is responsible for assessing the structural variation and the type of molecular interactions.

Ultrasonic attenuation research allowed us to determine the relaxation time of the observed molecular process.

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