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# KOKUSHIKAN University

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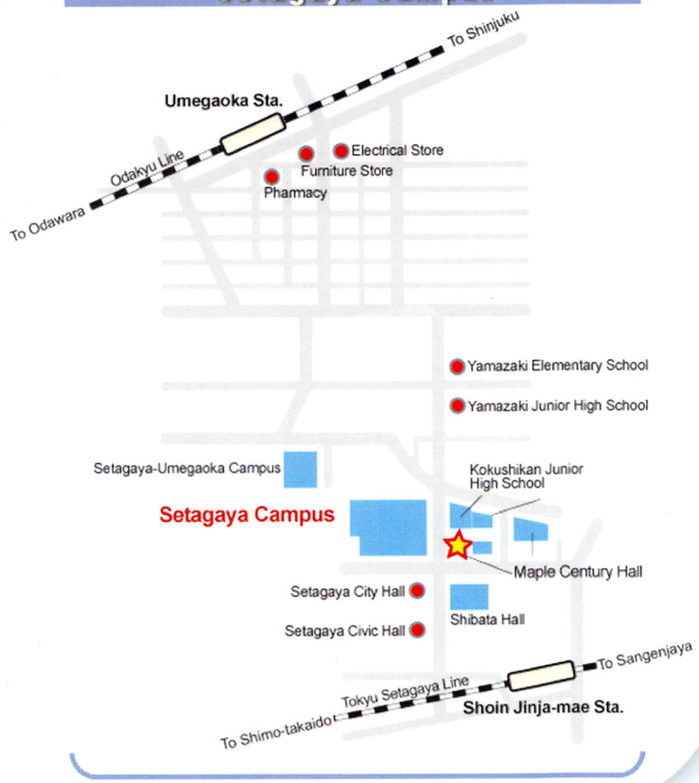


# APCOM 2014

## Asia-Pacific Conference on Fundamental Problems of Opto- and Microelectronics 2014

APCOM 2014

Kokushikan 100th

**Period:** Aug 24(sun)~27(wed), 2014(4days)

**Place:** Kokushikan University (Setagaya-ku,Tokyo)

Sponsored by Kokushikan University

Co-sponsored by Japan Society of Electromagnetic Wave Energy Applications

# APCOM 2014

*August 24 – 27, 2014, Kokushikan University, Tokyo, Japan*

## Abstract Book of
## The 14th Asia-Pacific Conference on Fundamental Problems of Opto- and Microelectronics

**Sponsored by Kokushikan University**

**Co-sponsored by Japan Society of Electromagnetic Wave Energy Applications**

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# APCOM2014 Program

August 24th

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August 25th

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# Light polarization singularities in nonlinear optics

**V.A. Makarov[1,2], K.S. Grigoriev[1], I.A. Perezhogin[2]**

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*Leninskie Gory, Moscow, 119991, Russia, E-mail: vamakarov@phys.msu.ru*

Inhomogeneously polarized beams may contain lines where electromagnetic field is circularly polarized. The intersections of these lines with the plane transversal to the beam propagation direction are treated as *C*-points or points of polarization singularity. The *C*-point is characterized by its topological index, which is the number of full rotations of the polarization ellipse on a counterclockwise loop around the *C*-point. It could be 1/2 (180°-rotation), -1/2, or higher numbers, divisible by 1/2.

We report about our theoretically study of polarization singularities formation in sum-frequency generation (SFG) and second harmonic generation (SHG) at the surface and in the bulk of isotropic gyrotropic medium. We established the conditions of appearance of the *C*-lines in symmetric sum-frequency and second harmonic beams obtained in case of SFG by coaxially propagating beams in medium bulk or by normally incident beams from medium surface. We have found the conditions of appearance of the *C*-points in SHG from the surface in case of oblique incident beam at fundamental frequency. We analyzed in details the symmetry breaking of the beam and the transformation of polarization singularities when proceeding from the normal incidence geometry to the oblique one.

We also numerically studied in the first time the interaction of two collinear specific-kind monochromatic beams with different topological charge of polarization singularities in the nonlinear isotropic gyrotropic medium. The relations between the components of local and nonlocal cubic optical susceptibility tensors determine possible scenario of the interaction of circularly polarized components of the light field. The processes of pairwise creation and annihilation of the *C*-points with opposite topological charges in the bulk of the nonlinear medium were observed.

# An Implementation of Smart Network Suitable for Context-based Content Delivery

Young-Do Joo*
Division of Computer and Media Information Engineering, Kangnam University,
40 Kangnam Street, Yongin-si, Gyeonggi-do, Rep. of Korea 446-702

***Abstract:*** *An explosively increasing number of multimedia contents including video, music, pictures will be the main driver for data explosion in the next decade. Video traffic will continue to gain Internet traffic share gradually because of the comprehensive usage of various connected devices like smartphones, tablet PCs and smart TVs. Accordingly, network providers are faced with rapidly more demanding network-related investments against the traffic explosion. But the challenging issue in the network providers is that the network investments do not contribute to revenue growth. This paper introduces a methodology to realize netwroks with a reasonable level of investment to support the traffic growth and to keep high-quality of service in a smart way. We propose the concept of smart netwrok to revolve around the technologies to use available network/service resources efficiently in order to optimize the context-based content delivery. In this paper, an architecture and fundamental functions to implement the smart network are presented with improved experimental results verified from an testbed network.*

***Keywords:*** *Smart Network, Context-based Content Delivery, Content Routing,*

# Imaging of the relative phase of blood pulsations *in-vivo*

**A. A. Kamshilin***

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Imaging and monitoring of blood microcirculation in living tissues is of major importance in both biomedical research and clinical practice. Currently, two optical methods, Laser Doppler Flowmetry and Laser Speckle Contrast techniques are very popular for blood perfusion imaging. Recently new optical technique, Blood Pulsation Imaging, was proposed in our laboratory. Important novelty is that, apart from the amplitude of blood pulsations, our approach allows 2D mapping of their relative phase. Non-zero phase of blood pulsations indicates presence of a delay in the blood delivery to different parts of the body, i.e. asynchronous blood perfusion. This parameter and its spatial distribution were not assessed by known techniques of blood perfusion imaging. In this lecture I will present experimental results which show that the relative phase of blood pulsations is very important channel of biomedical information. Particularly, it can be used as a biomarker of dysfunction of the autonomic vascular control which may occur in such neurological diseases as migraine. Our observations show that the method can be used for studying of the multicomponent regulation of peripheral blood circulation. The proposed technique is technologically simple and cost-effective, which makes it applicable for monitoring the peripheral microcirculation in clinical settings for example, in diagnostics or testing the efficiency of new medicines.

# Mapping the refractive index of dielectric samples by means of optical nanoantenna

Alexander A. Kuchmizhak,[*] Oleg B. Vitrik,[**] and Yuri N. Kulchin[***]

***Abstract:*** *We demonstrate analytically and numerically that the detection of the spectral response of a single spherical Au nanoantenna allows one to map very small (down to 5•10-4 RIU) variations of the refractive index of an optically transparent sample. Spectral shift of the dipole local plasmon resonance wavelength of the nanoantenna and the spectral sensitivity of the method developed was estimated by using simple analytical quasi-static model. A pointed scanning probe based on fiber microaxicon with the Au spherical nanoantenna attached to its tip was proposed to realize the RI mapping method. Finite-difference time-domain numerical simulations of the spectral properties of the proposed probe are in good agreement with the theoretical quasi-electrostatic estimations for a radius of the nanoantenna not exceeding the skin depth of Au.*

***Keywords:*** *Optical nanoantenna, local plasmon resonance, refractive index mapping.*

# Study of cortical spreading depression in rat by blood pulsation imaging

**E. Nippolainen*, V. Teplov*, A. Shatillo**, R. Giniatullin**, *** and A. A. Kamshilin***

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Cortical spreading depression (CSD) is a self-propagating wave of cellular depolarization in the cerebral cortex. CSD is involved in the mechanism of migraine, stroke, subarachnoid hemorrhage and traumatic brain injury. Optical methods are among most powerful tools to detect the temporal and spatial changes of an experimentally evoked CSD. In this work, we aimed to evaluate the applicability of blood pulsation imaging (BPI) technique for detection of vascular component of CSDs in rat's brain and to characterize its properties in comparison with concurrently applied optical intrinsic signal (OIS) imaging technique. The trajectories and the speed of CSD propagation were estimated from obtained images by using both techniques. Our study shows that the wave components measured by these techniques propagate across the cortex along the different trajectory. Moreover, the speed of wave measured by BPI technique is 40% faster in compare with OIS measurements. These findings indicate that the blood pulsation amplitude measured by BPI and slower change of the cerebral blood volume measured by OIS are not directly related with each other even though both characterize the same vascular system. Our study demonstrates that the BPI technique could be widely used for characterization of the new pulsatile vascular component of CSDs and perhaps for other models of brain disorders.

# Fiber microaxicons for generation of Bessel-like beams and laser-assisted materials processing

Alexander A. Kuchmizhak,[*] Oleg B. Vitrik,[**] and Yuri N. Kulchin[***]

***Abstract:*** *The fabrication method of the high-quality fiber microaxicons (FMA) on the endface of the optical fiber was developed. Using several types of the commercially available optical fibers we experimentally demonstrated the fabrication of the high-quality FMAs focusing the laser beam into a tiny spot with the FWHM ≈0.6λ and Bessel-like field distribution. It was also demonstrated that choosing the appropriate chemical composition of the etching solution makes it possible to change the shape of the FMA tip from conical to hemispherical. This allows one to change the spatial distribution of the output laser beam, which can represents both the Bessel-like beam with the depth of focus of up to 49λ and the very tiny focal spot with close to diffraction limit size. Experimentally measured focusing characteristics of the fabricated FMAs obtained using home-made collection-mode SNOM setup demonstrate good agreement with numerical simulations based on the 3D-FDTD simulations. We also utilized the fabricated FMAs for laser-assisted material processing by nano- and femtosecond laser pulses.*

***Keywords:*** *Fiber microaxicon, Bessel-like beams, Laser materials processing, nano- and femtosecond laser pulses.*

# Application of cascaded long period fiber gratings to measurement of strain and temperature

Osamu Tsukida, Thanh Tung Ngo, Satoshi Tanaka, Ryotaro Uchimura,
Atsushi Wada and Nobuaki Takahashi
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**ABSTRACT**

Cascaded long period fiber gratings (LPG) are fabricated and investigated for use in fiber-optic strain and/or temperature sensors. The cascaded LPGs are inscribed in photosensitive fiber by means of point-by-point technique with UV KrF excimer laser and examined their strain and temperature response. Since the channeled spectrum of the cascaded LPGs have much narrower spectral width than spectral attenuation dips of the normal LPGs, more precise measurements can be provided. In the experiment, several kinds of cascaded LPGs are devised and compared in terms of strain and thermal sensitivity. From the obtaoned results it is found that the more sensitive measurement can be achieved by adopting higher order cladding modes.

# The effectiveness of correlation method for non-destructive rough surface testing by means of vortex laser beams

Pavel V. Pavlov[*], Nikolay V. Petrov[**] and Alexander N. Malov[***]

*The process of reflection of laser vortex beams from rough surfaces with different roughness values of is discussed. Basing on the results of numerical experiments the applicability of the correlation analysis method of speckle-structures for surface defect detection with different roughness parameters was evaluated. The optimal ratios between the rough surface parameters and the optical system parameters, which provide the best efficiency of the method, were determined. It was established that in case of the increase in the number of topological charges the sensitivity of the optical system to changes of parameters of surface roughness increases.*

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# Holographic formation of the polarization gratings in PDLCs under light-induced absorption

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Currently, polarization gratings holographically formed in polymer-dispersed liquid crystals (PDLCs) by the polarization holography methods are of great interest due to possibility of managing their optical properties. Experimentally obtained polarization holographic gratings in composite materials based on nematic liquid crystals (NLC).

This paper presents an analytical model of the holographic polarization gratings (HPGs) formation in PDLCs taking into account the light-induced absorption coefficient changing. Holographic formation by two orthogonally polarized beams is considered.

HPGs formation in PDLCs is possible due to the light-induced periodic spatial inhomogeneity of the optical anisotropy of the material caused by the superposition of two plane coherent orthogonally polarized waves on the sample plane, and stabilized as a result of phase separation of PDLC components during photopolymerization process. In this case, the phase difference between the interfering waves only leads to a polarization state changing of the resulting field, intensity modulation is absent. Because NLC is able to orient in the direction of the electric field vector of the light field under the influence of the photo-induced Fredericks effect, then gratings with periodically repeated NLC molecules orientations in polymer droplets are formed in PDLC after exposure.

According to the obtained relations, numerical simulation of the spatial changing of the dielectric tensor was made. Light-induced absorption coefficient changes are taken into account.

The resulting mathematical model describes the holographic formation of polarization gratings in PDLC under the influence of the light-induced absorption. Obtained results can be used to develop a model of light beams diffraction on the spatially inhomogeneous HPGs.

# Real-time Measurement of Pectin Particles Diameter During their Jellification by Optical Correlation Technique

Natalia P. Kraeva*, Oleg B. Vitrik** and Yuri N. Kulchin***

***Abstract:*** *Organic colloids based on pectin particles are widely used in modern chemical, pharmaceutical and food industry. Steady tendency of pectin particles to be resized during their jellification is sufficiently known and studied. Depending on the percentage of dry matter and sugar, the pH of the product and the type of buffer salts in the product and ambient conditions, this process takes from several to tens of minutes. Technology, prescription standards and the production of various drugs on the basis of pectin require precision dimensional control of pectin particles at various stages of the gelling process. This paper presents the possibility of real-time measurement of pectin particles diameter during their jellification by optical correlation method based on spatial averaging of data.*

***Keywords:*** *pectin particles, jellification, dynamic light scattering, spatial averaging*

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# Relation between linkage structure and dynamical properties of Lotka-Volterra type food-webs with adaptive foraging behavior

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Abstract: The local and global stability of fixed points of Lotka-Volterra population dynamics combined with adaptive foraging are studied. The so called community matrix of Lotka-Volaterra population dynamics determines the potential linkage structure of food webs and the (element-wise) product of community matrix and foraging matrix describes the effective linkage structure. A sufficient condition on the linkage structure is presented under which positive fixed points of the dynamics are stable. In terms of the local stability, this condition applies to the effective link structure of food-webs, while in terms of the global stability the condition applies to the potential link structure. Further the effect of intraspecific competition on the stability of fixed points is investigated, which shows that the intraspecific competition stabilizes the fixed point. Finally the simplest food-web whose linkage structure does not satisfy the above mentioned condition is analyzed. Even this simplest food-web can be unstable and turns out to show diverse dynamical behaviors like chaos.

# The speckle image analysis by means of «chessboard» method

Anna V. Neupokoeva[*] and Alexander N. Malov[**]

*Efficiencies of correlation methods for speckle-pictures processing and wavelet-analysis of separate image fragments processing for definition of characteristic spatial scales of speckle-pictures are discussed. For primary speckle-picture spatial scale estimation the wavelet-analysis of one or two image lines (or diagonals) well approaches. The most informative is use as base function Morle wavelet. Method lack is information loss in connection with use of a speckle-picture fragment, advantage – speed and clear interpretation. For speckle-picture processing as a whole, and also at the decision of changes in speckle-pictures under the any factor influence monitoring problems, it is expedient to use a correlation field between regular «chessboard» structure with an investigated picture calculation. This method is very sensitive – speckle size change on some pixels leads to essential correlation peaks deformation.*

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# Intensity-based fiber-optic ultrasonic sensors using fiber gratings

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**ABSTRACT**

Intensity modulation technique is an attractive interrogation method for fiber-optic ultrasonic sensors using fiber Bragg gratings (FBGs), in which the FBG modulates intensity of reflected (or transmitted) narrowband light with a wavelength tuned to the slope of the FBG reflection (or transmission) spectrum curve if the vibration or acoustic wave is applied to the FBG and the intensity detection enables an direct observation of their waveforms. In this paper, principles of the intensity-based FBG vibration and underwater acoustic sensors, and their multiplexing techniques are presented. In addition, intensity-based ultrasonic sensors using long period fiber gratings (LPGs) are described.

**All-Fiber Adaptive Two-Wave Mixing Demodulator and Adaptive Fiber Ring Laser Source for Fiber Bragg Grating Dynamic Strain Sensors**

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Abstract:
The emerging concept of structural health management relies on extensive onboard diagnostic sensors that can provide near real-time information about the state of a structure so that informed prognostic assessment can be made of the continuing reliability of the structure. In previous work at NU, we have demonstrated that Fiber Bragg Grating (FBG) sensors can be used to monitor not only quasistatic and low frequency parameters such as strain, temperature, and vibration, but also high frequency dynamic strains such as due to impact or acoustic emission. These systems were based on a novel two-wave mixing demodulator that provided adaptivity to low frequency drift of the sensor as well as multipexibility to demodulate dynamic signals from multiple sensors in one single demodulation system. However, one major limitation of this system was the necessity for an erbium-doped optical amplifier which increases the cost of the demodulator and limits the number of FBG channels that can be processed. To overcome this, we have previously attempted an adaptive ring laser source that has optical power only at the wavelengths of the FBG sensors. However, with Er-doped fibers at the C-band, the relaxation times are not fast enough to avoid system instability. In this paper, we discuss our current effort to move the adaptive source to the ~1064nm range where the Yb-doped ring laser systems are expected to have an order of magnitude faster relaxation time, thereby avoiding system instability. We propose to integrate this adaptive source with a fiber-based TWM adaptive demodulator to provide a low-cost high frequency multipexable FBG demodulation system.

**Multi-channel adaptive interferometers with photorefractive crystals**

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Use of dynamic photorefractive holograms in optical and fiber-optical measurement systems makes them adaptive, capable to operate in unstable environment and reliably detect ultra-small physical quantities [1, 2]. At the same time development of multidimensional measurement systems consisted of large number of sensors requires appropriate number of photorefractive crystals as well as reference optical beams for recording a set of holograms. This leads to undesirable complexification of the measurement system, reducing its reliability, increase cost and energy consuming.

Different approaches based on spatial, spectral and angular multiplexing of dynamic holograms in a photorefractive crystal were proposed by researches for a development of multichannel adaptive interferometry measurement systems [3-7]. In this paper we report a review of recent achievements in a development of multichannel adaptive interferometry systems. We also report a novel geometry for dynamic holograms multiplexing in a photorefractive crystal of cubic symmetry which provide a formation of cross-talk-free holographic channels. The geometry supports multiplexing of both reflection and orthogonal holograms. The adaptive 26-channels fiber-optical sensory network based on the proposed geometry is developed. The system is applied for real-time reconstruction of weak acoustic field in elastic membrane.

The geometry of the dynamic hologram (DH) multiplexing is shown in Fig.1. It uses vectorial wave mixing in photorefractive crystal (PRC) of cubic symmetry (point groups 23 and $\bar{4}3m$ ). Both reflection and orthogonal types of DHs are supported. When being multiplexed several object waves (only two of them, $S_1$ and $S_2$, are shown in Fig.1) propagate in PRC at small angle to its principal crystallographic axis [001]. In its turn, a common reference wave, R, propagates orthogonally (for orthogonal DH) or toward (for reflection DH) to the object waves. In both cases any pair of waves "object-reference" forms the main holograms (with grating vectors $\mathbf{K_1}$ and $\mathbf{K_2}$) or holographic demodulation channel. At the same time an interference of any pair of two object waves can lead to appearance of holographic grating $\mathbf{K_{12}}$ which may be interpreted as a cross hologram. It is rigorously shown that in the proposed multiplexing geometry, there is no interaction between two object waves. In other words, dynamic hologram multiplexing does not lead to appearance of cross-talk between holographic channels. It opens opportunity for building of highly-effective adaptive measurement system with a large number of channels.

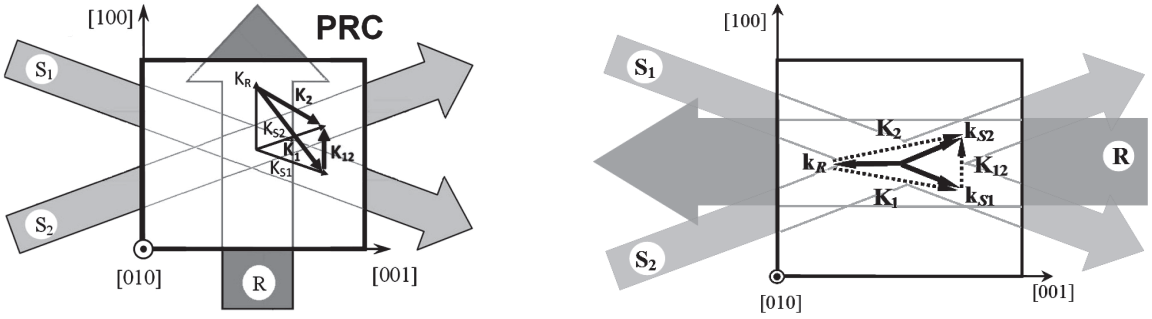
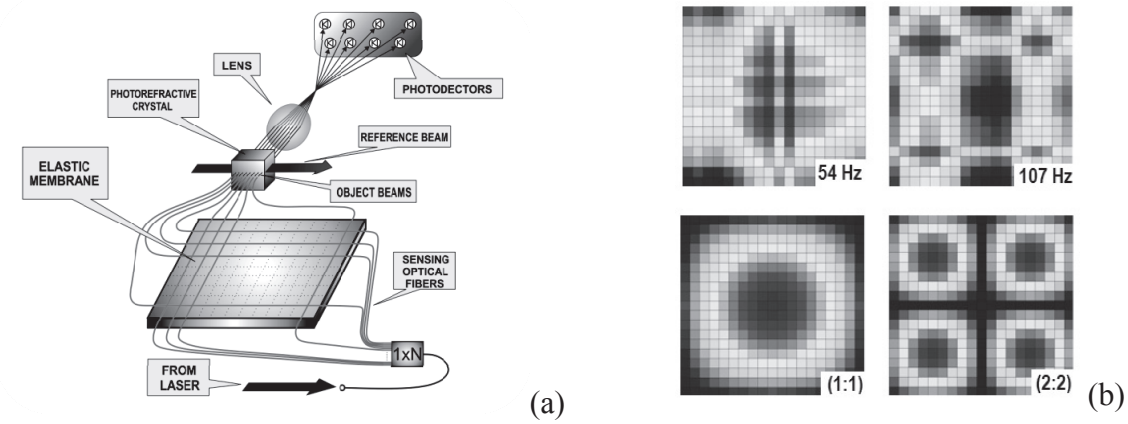



Fig.1. Geometry of orthogonal (left) and reflection (right) holograms multiplexing

On the base of the proposed geometry, the 26-channel adaptive interferometer was developed and its performance was studied. Sensing part of the system was implemented by a net of 26 fiber-optical measuring lines arranged according to a tomographic principle of data gathering (Fig.2,a). Each fiber was attached to an elastic membrane which acoustic field is under investigation. Phase demodulation of each of 26 signals coming from fibers was simultaneously performed by means of orthogonal DHs multiplexed in the photorefractive crystal CdTe:V.




(a) (b)

Fig.2. (a) Multichannel adaptive interferometer applied for detection of acoustic field in a membrane; (b) Experimental reconstruction of acoustic field amplitude (upper row) in comparison with 2D-map of membrane oscillation eigenmodes (1:1) and (2:2) (lower row)

The adaptive tomographic measurement system was applied for reconstruction of 2D distribution of acoustic field (AF) caused by transverse vibrations of elastic membrane having rectangular shape with dimensions 20×20 $cm^2$. The result of tomographic reconstruction of 2D-map of the AF amplitude is presented on Fig.2,b. As seen there is a good agreement between experimental data obtained at 54Hz and 107Hz and theoretically calculated eigenmodes (1:1) and (2:2) with correlation coefficients 0.87 and 0.75, respectively. Our recent results [7] show that number of measuring lines can be increase up to 100 (and more) without noticeable worsening of the measurement system sensitivity and inter-channel cross-talk. It opens possibility for realization of the single-shot measurement mode with high spatial resolution. The research is supported by Russian Scientific Foundation and Russian Foundation for Basic Research.

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# Study on Noninvasive Measurement of Temperature Distribution in Human Leg Using MRI

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[Abstract] Various heating treatments are performed in the medical field throughout the world. To monitor the temperature distribution in the treatment area, it is strongly required to develop a noninvasive temperature measuring technique in deep human tissue. The noninvasive temperature distribution measurement is an innovative methodology for research in not only the western medicine but also the traditional oriental medicine. Due to the fact that the temperature change can generate minute difference in the physical parameter in tissues, it becomes very difficult to measure the temperature change noninvasively against the deep target tissues. Recent development of electromagnetic wave technique enables noninvasive temperature measurement inside the material using Magnetic Resonance Imaging (MRI). In this paper, the temperature distribution in human leg is obtained using MRI by measuring the phase of longitudinal relaxation time of proton. Furthermore, carbonized moxa-needle treatment which is one of the techniques of acupuncture and moxibustion therapy was selected to heat the target. The result of noninvasively measured temperature distribution agrees well to that obtained by the simulation.

**Novel SPR-sensor concept for precision refractometric applications**

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We present a numerical study of a novel SPR-sensor concept for precision refractometry applications. The proposed technique is based on a standard SMF 28–type bent single-mode optical fiber with a thin metal film applied to its optical cladding. It was shown that by adjusting the curvature radius and the metal film thickness one can achieve effective coupling between the fundamental mode of the fiber and the surface plasmon mode supported by metal / surrounding medium interface through the meditation of whispering gallery modes propagating along the bent inner surface of the fiber cladding. This effect is demonstrated to allow for refractometric measurement both in wavelength and intensity-modulated regimes with a resolution of up to $10^{-8}$ RIU (refractive index units). Usage of standard noise reduction techniques for intensity-modulated optical signals promises further increase in accuracy.

# Control under pharmacological media activity with the laser liquid nanoclusterization

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*Influence of a nutrient medium laser irradiation on microorganism's population development dynamics and on nystatin activity is experimentally established. On the basis of the received results the microbiological quantitative analysis technique of bioorganic solutions laser nanoclusterization processes can be developed. In the practical plan similar technologies presume to lower a therapeutic dose of preparations, having reduced by-effects, not reducing medical result and not changing a medicine chemical compound.*

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# Spiral light beams and contour image processing

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***Abstract:*** *Spiral beams of light are characterized by their ability to remain structurally unchanged at propagation. They may have the shape of any closed curve. In the present paper a new approach is proposed within the framework of contour analysis, based on close cooperation of modern coherent optics, theory of functions, and numerical methods. An algorithm for comparing contours is presented and theoretically justified, which allows determination of whether two contours are similar or not to a scale factor and or rotation. The advantages and disadvantages of the proposed approach are evaluated; the results of numerical modeling are presented.*

# Laser-based technology for creating of metal nanoantennas

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**Abstract**
Laser-based technology for creating of metal nanoantennas was created. The technology consists of two stages. At the first stage, nanostructuring of metal films by nano-and femtosecond laser pulses is performed to form nanobumps, nanojets and nanoholes. The second step is the removal of residual film around the nanostructures obtained by polishing of accelerated argon ions. The possibility of creating of spherical nanoparticles with diameters from 50nm up to 400nm, nanospikes with height up to 500nm and nanorings with diameters from 200nm up to 1μm and a wall thickness up to 50 nm, as well as creating of their spatially ordered arrays was demonstrated. The study of the spectral response of the obtained structures using dark field microscopy techniques was conducted.

## Features of recording holograms in polymethylmethacrylate doped by boron difluoride anthraceneacetonates

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Holographic gratings formation in polymethylmethacrylate doped with boron difluoride anthraceneacetonates was studied. It was shown, that the time dependence of refractive index (RI) modulation amplitude for recorded holographic gratings demonstrates M-shaped character, with the first (up to $0.5 \times 10^{-4}$ RI units) and the second (up to $0.2 \times 10^{-4}$ RI units) maxima of this dependence being caused by photodimerizability and postexposure diffusion of photoactive additive molecules. It was found that the material's resolution determined by competition of diffusion and photochemical processes for recorded gratings is about 1000 lines/mm. However, due to diffusion this value raises with time after the recording process end reaching 2500 lines/mm. It was shown that the optimal exposure time is inversely proportional to the grating spatial frequency and can be reduced by more than an order of magnitude by material heating from 25 °C to 75 °C.

# Exciton and Biexciton States in Quasi-Zero-Dimensional Nanostructures

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***Abstract***. *We developed within the modified effective mass method the theory of an excitons and biexcitons formed from spatially separated electrons and holes (the hole is in the semiconductor spherical quantum dot (QD) volume, and the electron is localized at the outer spherical surface of the QD–dielectric matrix interface. The use of semiconductor nanosystems as the active region of nanolasers is prevented by the low binding energy of the quantum dot (QD) exciton [1, 2]. Therefore, studies directed toward the search for nanostructures in which a significant increase in the binding energy of QD excitons would be observed are of importance. Currently, the theory of exciton states in quasi- zero- dimensional semiconductor nanosystems has not been adequately studied, in particular, no theory exists for an exciton with a spatially separated electron and* hole in quasi- zero- *dimensional nanosystems. The review analyzes the results of theoretical investigations of excitons states (electron - hole pairs states) in a quasi - zero - dimensional nanosystems consisting of spherical semiconductor nanocrystals (quantum dots) placed in transparent dielectric matrice [1 – 11].*

**Key words:** *excitons, biexcitons, semiconductor (dielectric) quantum dots, binding energy of excitons, nanolaser*

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# Electric polarizability of $Fe_3O_4$ nanoparticles in weak laser optical fields

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***Abstract***

*Magnetite ($FeO*Fe_2O_3$, or $Fe_3O_4$) nanoparticles, and materials based on them, have been successfully used to solve applied problems in biology and magneto-optics. Pronounced superparamagnetic and ferromagnetic properties at room temperature enable the use of these nanoparticles in magnetic resonance imaging (MRI) and biosensing as well in drug delivery and drug uptake applications. In fact, $Fe_3O_4$ nanoparticles have been examined for the presence of unique magnetic properties, because magnetite is a narrow-gap semiconductor, and the optical properties of other semiconductor nanoparticles have been thoroughly studied. Currently, there are several experimental and theoretical works dedicated to studying the optical properties of both bulk magnetite and its nanoparticles. Using a developed co-precipitation method, we synthesized spherical $Fe_3O_4$ nanoparticles with a wide nonlinear absorption band of visible radiation. The optical properties of the synthesized nanoparticles dispersed in an optically transparent copolymer of methylmethacrylate with styrene were studied by optical spectroscopy and z-scan techniques. We found that the electric polarizability of $Fe_3O_4$ nanoparticles is altered by low-intensity visible radiation ($I \leq 0.2$ kW/cm$^2$, $\lambda$=442 and 561 nm) and reaches a value of $10^7$ $A^3$. The change in polarizability is induced by the intraband photo-transition of charge carriers. This optical effect may be employed to improve the drug uptake properties of $Fe_3O_4$ nanoparticles. In this report, we demonstrate that $Fe_3O_4$ nanoparticles exhibiting a wide nonlinear absorption band of visible radiation (1.7 ;3.7) eV, are able to significantly change their electric polarizability when exposed to low-intensity visible radiation ($I \leq 0.2$ kW/cm$^2$). The observed change in polarizability was induced by the intraband photo-transition of nanoparticle charge carriers, and the polarizability changes were orders of magnitude greater than those of semiconductor nanoparticles and molecules.*

**Keywords:** *magnetite nanoparticles, electric polarizability, low-intensity visible radiation*

# Signal Processing System of DFMN Segmental Type for Recognition of Dynamic Images Using Neural Networks

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***Abstract***. *Methods, techniques and algorithms for signal processing of distributed fiber-optic network (DFMN) segmental type and the formation of their models using images as a set of characteristic features or principal component collections for the states of moving object are considered. We have invited to receive sample examples for training and testing of neural networks using generated software modules (sensory data generator and data conversion module). Analysis of the results of research carried out for the development of intelligent distributed information-measurement system based on DFMN segmental type for recognition of dynamic images.*

***Keywords:*** *neural networks, intelligent information-measuring systems, expert systems, model images, recognition of dynamic images*

# Construction of Fuzzy Decision Tree Based on Experimental Data of Signal Processing of Distributed Fiber-Optic Measuring Network

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***Abstract***. *We developed and researched the algorithm for constructing a fuzzy system of production in the form of a fuzzy decision tree in the process of learning at multiple sample of experimental data pertaining to the issue of recognition of dynamic images for moving objects in the monitoring area distributed fiber-optic measuring network (DFMN) to protect the perimeter of the object.*

***Keywords***: *fuzzy system of production, expert system, fuzzy inference, fuzzy modeling.*

# Detecting Ultrasound Waves in Solids by Adaptive Fiber-optic Interferometer

Roman V. Romashko[*,**], Michail N. Bezruk[***] and Sergei A. Ermolaev[****]

***Abstract :*** *Adaptive fiber-optic interferometer for detection of ultrasound waves in solids is developed. Sensitive element of the system is fiber-optic sensor composed of coil with flat side and multimode optical fiber reeled on the coil. Ultrasound pulse with carrier frequency of 2 MHz excited in solid by a piezoelectric modulator strains optical fiber of the sensor and leads to phase modulation of light in the fiber. Phase demodulation of the signal coming from the sensor is performed by means of dynamic hologram continuously recorded in the photorefractive crystal CdTe. Developed system has dynamic range 21 dB and allows detecting ultrasound waves with acoustic pressure from 6 mPa. This research is supported by Russian Scientific Foundation (grant No. 14-12-01122).*

***Keywords :*** *dynamic hologram, ultrasound detecting multiplexing, adaptive interferometer*

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# Holographic interferometry system for ultra-small displacement measurement

Roman V. Romashko[*,**], Timofey A.Efimov[***] and Mariya A. Asalkhanova[***]

***Abstract :*** *In this work we present an adaptive holographic system for measurement of nanoscale displacements of micro and macro objects based on an adaptive interferometer. The system is based on using dynamic hologram recorded in photorefractive crystal. It is experimentally demonstrated that system is able to detect a macro object displacement from 0,5 nm, and from 9 nm for a micro object. Theoretical detection limit for displacement is found as 0,1 nm. It is shown that displacements with amplitude up to 266 nm can be detected in linear regime. We also present theoretical model of adaptive interferometer operation which take into account displacement speed. Due to its adaptive properties the measurement system can be used for inspection of sub micro objects with arbitrary shape and surface profiles.*

***Keywords :*** *dynamic hologram, adaptive interferometer, nanoscale displacement*

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# Study on Monitoring of Blood Sugar Level by Measuring Reflection Coefficient in Millimeter-Waves

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Abstract

To diagnose diabetic, the normal measurement method of blood sugar level is the method using the general enzyme electrode. It is necessary to collect blood for the measurement of blood sugar level. For the diabetics and subjects of measurement of repeated blood sugar level, it is burden on repeated collect blood. Therefore, a non-invasive technique to measure blood sugar level is one of the most demanding techniques. In this paper, as base research to measure blood sugar level by using millimeter-wave, the reflection coefficient of the human model is obtained in the frequency region from 35 to 40 GHz. From the above conditions, the possibility of non-invasive measurement has been performed.

# Study on Bowtie Antenna for Acquisition of Biological Data

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Abstract:

To obtain biological data noninvasively, applying microwaves which are widely used in various apparatuses including a cellular phone, a PC and the wireless LAN can be applicable. However, the antenna located nearby human body receives the change of characteristics by the high complex permittivity attached to the antenna. The purpose of this study is to examine a reflection coefficient when the antenna which is emitted microwave in neighbor of the human body to acquire biological data. In this technique, a reflection coefficient is obtained which is located or directly contacted to the antenna. The simulated result in the frequency in 1 ~ 30 GHz is shown using TLM method for electromagnetic field analysis. The result shows the developed bowtie antenna is very sensitive to receive the reflection microwaves from human body and can be applicable to obtain biological data.

# Comparison of Brain Activity evaluated by Blood Flow Measurements in Frontal Lobe

Kanako Mikami*,Kunihiko Oura (Kokushikan University)

**Abstract:** *The energy source of human brain activity is glucose and it is reported in some papers that brain activity tends to be activated after having taken in glucose. In this paper, we perform an examination for Kraepelin to subjects taking in glucose. Two kinds of experiments were carried out. The differences between them were the number of subjects attended the experiment. One experiment was performed by a subject while the other was performed by two subjects at the same time. We evaluate whether differences appear for brain activity by comparing the measurements. The data of oxidation hemoglobin concentration (HbO) in frontal lobe measured by near infrared spectroscopy (NIRS) are used for analysis. The difference in brain activity based on the active domain in frontal lobe as well as the subjects' emotion caused by competition is considered.*

# Characteristics in a Microwave Coaxial-Slot Antenna for Applied Thermal Therapy

Tetsuyuki Michiyama* Shuzo Kuwano*

***Abstract***

We previously proposed coaxial-slot antenna of not whole conductor needle but one sandwiched dielectric between conductors for cancer therapy. The heating of the antenna was possessed of suppressed extension in the direction of the tip compared with that of the antenna of whole conductor needle, as a result of the experiment of liver phantom. In this paper, we calculate the heating characteristics of the antenna in the liver model. It is shown that the heating pattern is similar to the measured one although the value is different. The difference between the calculated and experiment was about 60%, even considering the transmission loss up to the antenna; however, distributions were almost equal to each other.

In the future, we will study how to improve the analysis area and make it more appropriate, conduct more detailed experiments on phantoms by preparing a more precise antenna and compare the results with calculated values. We also intend to examine the impedance characteristics.

# A search for stable and substable crystal structures of materials using Immune Algorithms

Takuya Satomi* ,Manabu Kawana ,Kazuhiro Shimada ,Michio Miyazaki
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***Abstract:*** *To solve crystal structure optimizations, many methods using evolutionary algorithms such as GA, ES, and PSO have been proposed. However there are many crystals which have similar total energies and similar crystal structures. When we treat such materials, it is necessary to repeat searches more than the number of possible crystal structures to search for a set of crystal structures. In this study, we propose a crystal structure search technique using the Immune Algorithms (IA) which can effectively search for crystal structures of materials even if they have a stable and many substable crystal structures. To confirm the effectiveness of our technique, we did a simulation experiment using hexagonal boron nitride (h-BN). As a result, we found a stable structure and two substable crystal structures of h-BN.*

# Biomechanical analysis of underwater lower limbs motion in competitive swimmers

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**INTRODUCTION:** Improvement in swimming performance is not only associated with stroke technique but also with the gliding and dolphin kick movement during the start and turn phases. The underwater gliding and dolphin kick movement during the start and turn phases is important for improving total race time in modern swimming. **PURPOSE:** The study was designed to biomechanical analyze the findings of underwater electromyography of lower limb muscles during the underwater gliding and dolphin kick movement in competitive collegiate swimmers. **METHODS:** Eight healthy male collegiate swimmers volunteered to participate in this study. The subjects performed underwater gliding movement at maximum speed after pushing off from the start wall. In addition, three types of underwater dolphin kick movement [Control (C): maximum effort kick; Build-up (BU): small-to-large kick; and Dynamic (D): large kick) were performed with maximum effort. The subjects were monitored through an underwater video camera with a sampling frequency of 60 Hz in the sagittal plane to measure the angular displacement of their different joints. A wireless electromyography system (Biolog DL-5000, S&ME, Japan) was used to collect the muscle activities from the vastus lateralis, hamstrings, tibialis anterior, and gastrocnemius. Speed Meter (Vine Co., Japan) was used to measure swimming speed, and a motion analysis system (Frame-DIAS4; DKH, Japan) was used to digitize body landmarks. **RESULTS:** Among the underwater dolphin kick movement types, the BU kick was the fastest (BU: 1.67 m/s; C: 1.65 m/s; and D: 1.65 m/s). The rectified EMG findings showed that gastrocnemius and hamstrings muscle activities of elite swimmers (International level) were higher than non-elite swimmers (Collegiate level) during these movements. However, elite swimmers had no muscle activity in the tibialis anterior. **CONCLUSIONS:** The present study results suggested that the angular displacement of the knee joints gradually increases during underwater dolphin kick movement. In addition, the muscle activity of the hamstrings and gastrocnemius increase during underwater dolphin kick movement. However, the muscle activity of tibialis anterior was inhibited during these movements. Our results also suggested that swimmers experienced a large propulsion force and a small resistance force with the help of these movements.

# Investigation of the environmental parameters influence on the phytoplankton condition by fiber optic spectrometer

Evgeniy L. Gamayunov[*], Alexander Yu. Popik[**]

***Abstract:*** *The concentration of phytoplankton often using to assess the ecological status of water bodies, concentration is determined by the intensity of chlorophyll-a fluorescence, located in microalgae cells. Investigators do not take into account the effect of the medium parameters on the fluorescence intensity in determining the concentration of fluorescent methods usually. In this article demonstrates the use of fiber-optic spectrometer developed by the authors to identify the relationship between the fluorescence of chlorophyll-a as part of phytoplankton cells and environment conditions, such as temperature and illumination. The mathematical model for calculating the chlorophyll-a concentration on the fluorescence measurements results, taking into account temperature and light. Using the resulting expressions for the proportionality coefficient can twice reduce the error in determining of the chlorophyll-a concentration by the fluorescence methods. In this article the authors show the results of the developed method in the performance monitoring in the waters of the Gulf of Peter the Great in the September-October 2013.*

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# Accelerating space-charge gratings in photorefractive crystals: novel approach for laser Doppler velocimetry

Mikhail Bryushinin* and Igor Sokolov**

***Abstract:*** *We study the excitation of the two-wave mixing and non-steady-state photoelectromotive force signals using uniformly accelerated motion of the recording light pattern. Such illumination is created by the linear frequency modulation of the interfering light beams. The pulse response is predicted theoretically and observed experimentally in $Bi_{12}TiO_{20}$ and GaAs crystals at $\lambda$=633 nm. We analyse both the diffusion and space-charge wave regimes of signal excitation. The evolution of the pulse shape versus the chirp rate is demonstrated and explained in the frames of the developed theory. The application of the effects in laser Doppler velocimeters and accelerometers is discussed as well.*

***Keywords:*** *non-steady-state photo-EMF, two-wave mixing, Doppler velocimetry.*

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# DEPENDENCE OF THE FLUORESCENCE OF THE PHYTOPLANKTON FROM EXTERNAL INFLUENCES

Evgeniy L. Gamayunov and Alexander Yu Popik
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**Abstract**: The concentration of phytoplankton often using to assess the ecological status of water bodies, concentration is determined by the intensity of chlorophyll-a fluorescence, located in microalgae cells. Investigators do not take into account the effect of the medium parameters on the fluorescence intensity in determining the concentration of fluorescent methods usually. In this article demonstrates the use of fiber-optic spectrometer developed by the authors to identify the relationship between the fluorescence of chlorophyll-a as part of phytoplankton cells and environment conditions, such as temperature and illumination. The mathematical model for calculating the chlorophyll-a concentration on the fluorescence measurements results, taking into account temperature and light. Using the resulting expressions for the proportionality coefficient can twice reduce the error in determining of the chlorophyll-a concentration by the fluorescence methods. In this article the authors show the results of the developed method in the performance monitoring in the waters of the Gulf of Peter the Great in the September-October 2013.

**Keywords:** chlorophyll-a fluorescence, chlorophyll-a concentration, phytoplankton influence of illuminating intensity, Influence of temperature

# Direct Microstructuring of Silicon by Laser Ablation of Tightly Focused Femtosecond Laser Pulses

Sergey S. Golik[*], Michail Yu. Babiy[**] , Yuliya S Biryukova[***] and Aleksandr V. Kolesnikov[**]

***Abstract:*** *The result of direct ablation of silicon by an tightly focused 800 nm Ti:Sa femtosecond laser pulses are presented. Direct laser processing of thin edges on silicon was systematically performed for to explore the effect of the process parameters such as pulse energy, translation speed, and the number of passes on the material removal and the surface morphology. The milled depth and the surface roughness have strong relations with the process parameters. The surface morphologies showed the evolution of periodic cone-shaped structures. The average size of the crater ablated by a single pulse on the silicon surface is 250 nm. This research is supported by the Scientific Foundation Program of Far Eastern Federal University.*

***Keywords:*** *laser ablation, femtosecond pulses, silicon*

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# Optical Sensor Array to Visualize Microwave Field for Medical Application

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**ABSTRACT**

Optical sensor array to visualize microwave field is developed especially for applying medical field. The optical sensor array is developed using schottly barrier diode connected with LED and forming very small loop. The sensor also can be driven by the directed microwave magnetic field, thus the activation direction can be separated in the three orthogonal directions. The sensor can emit red, green and blue colored light by using full color LED. It can visualize the microwave field distribution in application of medical field such as operating microwave coagulation devices. The sensor also can visualize microwave fields in the microwave sterilizers. Theoretical considerations with various device arrangements for realizing optical sensors which can visualize the microwave field are discussed in the paper.

# A Study for Patch Length L of Microstrip Patch Antenna Excited By Coplanar Waveguide Edge Slot

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Microwave tunable components such as phase shifters and filters have attracted considerable attention for satellite broadcast application. We have started the research on the liquid crystal application to an adaptive antenna for the next generation satellite broadcasting. Nematic liquid crystal (NLC) is found to be useful in realizing such microwave phase shifters. Operation of these phase shifters is based on controlling the orientation of LC's anisotropy of dielectric permittivity with an applied electric field, which allows controlling the phase of microwave signal externally. And we have proposed and demonstrated the two-element array microstrip patch antenna incorporating an LC loaded Coplanar Waveguide with Floating Electrode (CPW-FE) phase shifter at 20 GHz. However, because the phase shifter is connected with the antenna, the converter is necessary, and the integration of the antenna and the phase shifter is difficult in this structure. Then the CPW power feeder is made for the one side of the substrate, and there is a slot in the tip of it. The microstrip patch antenna is arranged on the other side of the slot. It is a structure that the antenna works in the electric field that leaks from the slot.

In this paper, we consider for the design formula for the proposed structure. And we reports on the result of examining the design formula concerning L where the effective dielectric permittivity and the edge effect are included from the change in the center frequency into the change in L in the length of the patch.

# Exciton states of the optical electrons of $Al_2O_3$ nanoparticles in dielectric matrix

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*In recent years, experimental investigations of the nonlinear optical properties of dielectric nanocomposites containing small concentrations of dielectric nanoparticles showed that they [1–10 etc.] exhibit unique optical nonlinearity in low-intensity optical radiation fields. The anomalous nonlinear optical properties are as follows: (i) Great value of bandgap gave reason to think that the nonlinear response of nanocomposite media occurs under ultraviolet light but it is observed for visible and infrared light; (ii) Nonlinear response occurs at radiation intensities below 1 kW/cm2 and can be observed under pulsed and cw laser modes. It reaches a maximum and disappears with increasing intensity; (iii) It takes place if transmission spectra of nanoparticles array have the broad bands of light absorption that are absent for the bulk sample; (iiii) Nonlinear optical properties take place at frequencies lying within the absorption band of light.*

*The intensity threshold and nature of nonlinear response depend on characteristics of nanoparticles and matrix material as well as their size and shape. It was determined that dielectric nanoparticles have nonlinear response when the matrix has a static permittivity less than that of nanoparticles. This fact allows us to vary the parameters of response by changing nanocomposite components and nanoparticles concentration, size, and shape. The existence of nonlinear optical properties in dielectric nanocomposites points out that the electronic structure of nanoparticles dispersed in dielectric matrix differs significantly from the electronic structure of the bulk sample. Differences consist, first, of formation of the allowed energy levels for the charge carrier in the bandgap because the bandgap structure is connected with a complex form of nanoparticles and high density of surface defects in the crystal structure. Moreover, the electrons of nanoparticles should have broad band of exciton states. The report presents and analyzes the experimental results luminescence study alumina and theoretical results showing that the dielectric nanoparticles have the exciton states of electrons with binding energy of several electron volts, which are excited by the weak optical laser radiation. Such materials with a wide spectrum of exciton states are important for creation: exciton lasers and optical emitters; receiving and emitting optical nano-antennas; control and processing information and signals; generation low-power optical solitons; optical computers etc.*

***Keywords**: dielectric nanoparticles , exciton state, luminescence/*

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# Modelling technique of brain activity from the data measured by NIRS

Kunihiko Oura (Kokushikan University)
Izumi Hanazaki (Tokyo Denki University)

**Abstract:** *The energy source of human brain activity is glucose and it is reported in some papers that brain activity tends to be activated after having taken in glucose. In this paper, we perform an examination for Kraepelin to subjects taking in glucose. Two kinds of experiments were carried out. The differences between them were the number of subjects attended the experiment. One experiment was performed by a subject while the other was performed by two subjects at the same time. We evaluate whether differences appear for brain activity by comparing the measurements. The data of oxidation hemoglobin concentration (HbO) in frontal lobe measured by near infrared spectroscopy (NIRS) are used for analysis. The difference in brain activity based on the active domain in frontal lobe as well as the subjects' emotion caused by competition is considered.*

# Two-Channel Microweighing System Based on Adaptive Interferometer

Roman V. Romashko[*,**] and Timofey A. Efimov[***]

***Abstract :*** *Measurement of mass at the microscopic scale is very vital as it serves powerful tool that can provide information about the molecular and atomic composition of an object. Micromechanical resonators are widely used as inertial balances to detect small quantities of adsorbed mass through shifts in oscillation frequency. A system with two measuring channels for measuring the mass of micro- and nanoobjects based on resonance microweighing using the principles of adaptive holographic interferometry is proposed in this work. The sensitive element of the system is a microcantilever. Eigen oscillations of the microcantilever are excited with a laser pulse. Detection of oscillations is implemented by using adaptive holographic interferometer which key element is a dynamic hologram continuously recorded in a photorefractive crystal CdTe. It is experimentally demonstrated that system can provide independent operation of two measurement channels based on two dynamic holograms multiplexed in a single crystal. Specific geometry of vectorial wave interaction in a cubic crystal is used to preclude a cross-talk between holographic channels.*

***Keywords :*** *microweighing, adaptive interferometer, multichannel system, cantilever*

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# Laser radiation energy localization in biological tissues: waveguide mechanism role

Alexander N. Malov* and Andrey A. Vaichas**

*Possible laser radiation localization mechanisms at interaction with biological tissues are discussed. Excess of a reaction energy threshold at a laser beam propagation stage in biotissues probably, first, at the expense of Talbot effect – self-reproductions of radiation intensity distribution. Secondly, spatial laser radiation localization is connected with the in narrow channels – the tracks formed in liquid films (biological cellular membranes). The possible mechanism of thin tracks formation is connected with waveguide liquid film properties and radiation diffraction on its local defects is described. Results of modelling experiments on research of tracks distribution in flat films and in the three-dimensional spatial structures formed by liquid films are presented. It is established, that tracks possess mobility, can arise and extend simultaneously at once in several adjoining liquid films. It is registered, that tracks extending in films at hit on section border could initiate occurrence of new tracks in the next film structures.*

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