

# JEMNÁ MECHANIKA A OPTIKA

VĚDECKO-TECHNICKÝ ČASOPIS  
ROČNÍK 59 6 - 7/2014

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Cena čísla 40 Kč včetně DPH

# FINE MECHANICS AND OPTICS

SCIENTIFIC-TECHNICAL JOURNAL  
VOLUME 59 6 - 7/2014

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Price for single copy: 40 Kč incl. VAT

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**Learning by doing concept used at the Institute of Physical Engineering** (P. Dub, J. Spousta, T. Šíkola)..... 159

Teaching and learning approaches in the fields of light and charged-particle optics and fabrication and analysis of nanostructures used at the Institute of Physical Engineering, Brno University of Technology, are described.

**Multimodal holographic microscope – a joint project of VUT and TESCAN** (J. Čolláková, A. Křížová, Z. Dostál, M. Antoš, D. Vašíček, R. Chmelík) ..... 160

We introduce the new Multimodal Holographic Microscope (MHM) designed at IPE BUT and constructed in cooperation with TESCAN Company. The design of MHM is based on the original concept of Coherence-Controlled Holographic Microscope, which uses off-axis and achromatic holography. The changes of optical design have result in comfort of the end user. MHM has transmission, reflection and fluorescent mode. The combination of holographic imaging with fluorescent mode has the contribution in biomedical fields.

**Keywords:** interferometric microscopy, incoherent holography, phase imaging

**Application of reflective optical spectroscopy for experimental studies of plasmonic nanostructures**

(P. Dvořák, F. Ligmajer, T. Šamořil, M. Hrtoň, R. Klement, J. Babočky, M. Tuček, J. Spousta, T. Šíkola) ..... 162

This article deals with application of reflective optical spectroscopy for experimental studies of plasmonic nanostructures. The optical properties of Localized Surface Plasmons (LSP) are briefly outlined and an experimental setup for their detection and spectral analysis is presented. Furthermore, we also demonstrate experimentally obtained optical spectra of samples fabricated from gold nanoparticles on silicon substrate and compare them with numerical simulations from Lumerical software.

**Keywords:** plasmon, far-field, dark-field, confocal microscopy, spectroscopy, nanoantennas

**Measurement of the angular distribution of the light intensity scattered by a solar cell** (P. Nádaský, J. Klus, M. Ohlídal).... 165

Scattermeter II (SM II) is the second generation of a device developed at the Institute of Physical Engineering at the Faculty of Mechanical Engineering, Brno University of Technology. This device is used for measurements of the intensity of the electromagnetic radiation scattered by the surface of a solid. The basic scheme and the measurement principle are described within this paper. Also measurements of scattering of the electromagnetic radiation from surfaces of selected silicon wafers used in photovoltaic cells are described.

**Development of universal control electronics for scanning probe microscope** (D. Šulc, P. Wertheimer, M. Pavera, Z. Nováček, J. Neuman, T. Šíkola)..... 169

In this article the open-source project Gnome X Scanning Microscopy is introduced. It is a universal tool for the control of the most Scanning Probe Microscopes. High Voltage Amplifier (HVA), which was developed at Institute of Physical Engineering Faculty of Mechanical Engineering at Brno University of Technology, is described. HVA has been designed for the control of Piezo Tube Scanner. The goal was to develop universal equipment able to control all common Scanning Probe Microscopes.

**Keywords:** SPM, AFM, STM, GXSM, high-voltage amplifier, I/V converter, STM preamplifier

**European Academy of Optometry and Optics, Warsaw 2014** (P. Beneš, S. Bramborová, P. Veselý, S. Synek) ..... 172

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**Utilization of the interaction chamber for the material analysis of the archeological objects by the laser-induced breakdown spectroscopy** (J. Novotný, D. Procházka, A. Hrdlička, G. Vítková, M. Brada, J. Kaiser) ..... 174

Article deals with the material analysis in the field of archeology and cultural heritage. Laser-induced breakdown spectroscopy (LIBS) is described as a tool for fast determination of elemental composition. The results of the LIBS analysis of historical artefacts are presented. Samples were provided by the College of Craft Turnov (Department of restoration of metals, minerals and organolites) for the purpose of determination of Cu and Zn concentrations and detection of Au and Ag in surface layers. Table-top LIBS setup of Laboratory of Laser Spectroscopy (IPE, BUT) including the newly developed LIBS interaction chamber has been used for the analysis.

**Keywords:** LIBS, plasma, chemical analysis, cultural heritage, archeology

**Fabrication of ordered arrays of metallic nanoparticles on semiconductor substrates and their characterization by spectroscopic ellipsometry** (F. Ligmajer, Z. Druckmüllerová, R. Měch, M. Kolíbal, T. Šíkola)..... 178

Metallic nanoparticles possess unique physical and chemical properties and therefore can be utilized for a wide range of technological and medical applications. Although one can exploit these properties while the nanoparticles are in colloidal solutions, it is equally important to immobilize these nanoparticles onto solid surfaces, preferably with a possibility to control their precise position and orientation. This article describes a simple method resulting in guided self-assembly of gold nanoparticles onto silicon substrates, which is based on modification of these substrates by electron beam and appropriate adjustment of pH of nanoparticle colloidal solution. This process results in an ordered array of nanoparticles positioned with precision better than twenty nanometres. Moreover, it is shown how to utilize spectroscopic ellipsometry for optical analysis of disordered nanoparticle films, namely to determine the size and surface coverage of nanoparticles.

**Keywords:** metallic nanoparticles, self-assembly, silicon, spectroscopic ellipsometry

**Design of an ion beam source with saddle field and thermionic cathode** (P. Glajc, J. Zlámál, J. Mach, M. Kolíbal, T. Šíkola) ... 181

This paper deals with development of a new type of ion source and with testing of its parameters. The ion source is a saddle-field type and is designed primary for sputtering of solid targets by  $N_2^+$  or  $Ar^+$  ions. The main difference between the developed ion source and classical saddle-field ion sources is that a thermionic tungsten cathode is used here. The electron current in the ionization area is therefore increased. In the paper, the simulation model created in Electron Optical Design code is described. A theoretical efficiency of the ion source is also calculated by this code. Next, the design of the source and its most important parts is described. Finally, testing and optimization of the source prototype, especially measurements of the ion current, are demonstrated.

**Keywords:** ion source, saddle field, thermionic cathode, sputtering, EOD

**Common-path incoherent correlation microscopy: methods, applications and research in the Center of digital optics TA CR** (P. Bouchal, Z. Bouchal, R. Chmelík)..... 184

The paper deals with the recent development of incoherent holography and common-path incoherent correlation imaging. These

methods utilize the principle of the self-interference to record holographic information in spatially incoherent light. After a brief overview of the available techniques, the attention is focused on the current progress in the Fresnel incoherent correlation holography. This method has been developed in a cooperation of the Brno University of Technology and the Palacky University, supported by the Center of digital optics TA CR.

**Dimensional inspection of reduction of the focusing camera by means of X-ray microcomputed tomography** (T. Zikmund, M. Brada, A. Zatočilová, M. Petrilak, J. Kaiser) ..... 186  
In this paper we present the utilization of X-ray micro computed tomography ( $\mu$ CT) for dimensional inspection of a workpiece. For demonstrating of this possibility,  $\mu$ CT analysis of alluminium reduction of the focusing camera module employed in the Laser-Induced Breakdown Spectroscopy setup was carried out.  
**Keywords:** X-ray Computed Tomography,  $\mu$ CT, dimensional inspection, control of production

**The measure of Schottky junction graphene/Si by EBIC method** (Z. Lišková, V. Zarevúcka, R. Zahradníček, J. Mach, P. Procházka, J. Hulva, M. Bartošík, T. Šíkola) ..... 189  
In the paper there is described a preparation of Schottky solar cell with graphene layer and with Au collecting electrode. The graphene was prepared by Chemical Vapor Deposition (CVD) and was transferred using wet method with PMMA (*methylmethacrylate*). These solar cells were studied by EBIC method (*Electron Beam Induced Current*).  
**Keywords:** Schottky solar cell, graphene, EBIC

**Preparation of micro and nanostructures by selective Si wet etching** (T. Šamořil, O. Metelka, T. Šíkola) ..... 192  
Chemical etching is widely utilized method for surface modification of many materials and is used both in industry and in basic research. This article deals with the preparation of surface structures by selective wet etching of Si(100) through a mask created by electron and ion beam lithography. Combining these high-resolution patterning techniques with etching using an aqueous solution of potassium hydroxide (KOH) allows to obtain structures with different shapes and sizes, both at micrometer and nanometer scale.  
**Keywords:** silicon, electron beam lithography, focused ion beam, selective wet etching, potassium hydroxide

**Shubnikov-de Haas oscillations on graphene fabricated by CVD method** (P. Procházka, M. Bartošík, J. Mach, Z. Lišková, J. Hulva, M. Konečný, T. Šíkola, B. David) ..... 195

The aim of this work was to prepare the monolayer graphene sample enabling the longitudinal resistance measurement at low temperatures (2 K) and high magnetic fields (9T). The fabrication procedure of graphene by chemical vapor deposition (CVD) method and design and preparation of gold wire-bonds by electron beam lithography (EBL). The presence of Shubnikov-de Haas oscillations in the dependency of longitudinal resistance on external magnetic field has proven the quantization as a consequence of dimensional constrain of charge carriers in two-dimensional graphene, and also the existence of relatively well-defined Landau levels due to magnetic field. On the basis of this, the charge carrier concentration  $1,04 \cdot 10^{12} \text{ cm}^{-2}$  and Dirac point shift by the value 13,57 V of fabricated graphene has been determined.

**Keywords:** SdH oscillation, graphene, CVD

**Fabrication of ordered arrays of gold islands** (J. Neuman, Z. Nováček, D. Šulc, P. Wertheimer, M. Pavera, A. Vaskevich, I. Rubinstein, T. Šíkola) ..... 199  
In this article we present new methods for fabrication of ordered arrays of gold islands on the silicon dioxide surface. It describes an influence of surface modification on the formation of well separated islands caused by thermal annealing. The method is experimentally verified for the fabrication of gold islands ordered on a surface patterned into a grid.  
**Keywords:** nanostructures, gold, electron lithography, plasmonics, annealing

**Detection of elements by laser induced breakdown spectroscopy with nanoparticles** (L. Sládková, E. Képeš, L. Břínek, D. Procházka, J. Novotný, J. Kaiser) ..... 201  
In this paper there is presented an enhancement of detection limits of laser-induced breakdown spectroscopy (LIBS) using nanoparticles. Nanoparticles are very common nowadays, easily accessible and their effects are studied in different scientific fields from medical science, geology up to engineering sciences.  
**Keywords:** laser-induced breakdown spectroscopy, LIBS, silver nanoparticles, enhancement of detected signal

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