

# Preface

The modern theoretical, experimental, and computational methods provide R&D of numerous processing techniques for different advanced materials and composites. Based on last achievements and proposed solutions of Materials Science, Condensed Matter Physics and Mechanics of Deformable Solids, novel materials and structures meet broad applications in the modern science, techniques and technologies operating in the ranges from nano- up to macroscale. Modern requirements for improvement of material properties, obtainment of preliminary given characteristics, and extension of possibilities of devices, created on their base, support tremendous and continuous interest to fast development of the theoretical, experimental, and numerical methods. These methods create new knowledge and are capable to ensure control and prediction of critical phenomena and improvement of very fine processes (for instance, nano- and microstructure transformations during processing, loading, and operating modern materials and composites under critical conditions, in aggressive media and complex physical and mechanical treatments). Practical and industrial needs require from modern devices and goods a very high accuracy, reliability, longevity, and extended possibilities to operate at broad temperature and pressure ranges. At the same time, the device characteristics are directly defined by used materials and composites, opening new possibilities in study of various physical processes.

This collection of 50 papers presents selected reports of the 2015 International Conference on “Physics, Mechanics of New Materials and Their Applications” (PHENMA-2015), which has taken place in Azov, Russia, May 19–22, 2015 (<http://phenma2015.math.sfedu.ru>) and is devoted to 100-year anniversary of the Southern Federal University. The conference was sponsored by the Russian Department of Education and Science, Russian Foundation for Basic Research, Ministry of Science and Technology of Taiwan, South Scientific Center of Russian Academy of Sciences, New Century Education Foundation (Taiwan), Ocean & Underwater Technology Association, Unity Opto Technology Co., EPOCH Energy Technology Corp., Fair Well Fishery Co., Formosa Plastics Co., Woen Jinn Harbor Engineering Co., Lorom Group, Longwell Co., Taiwan International Ports Co., Ltd., University

of 17 Agustus 1945 Surabaya (Indonesia), Khon-Kaen University (Thailand), Don State Technical University (Russia), and South Russian Regional Centre for preparation and implementation of international projects.

The thematic of the PHENMA-2015 continued ideas of previous international symposia: PMNM-2012 (<http://pmnm.math.rsu.ru>), PHENMA-2013 (<http://phenma.math.sfedu.ru>), and PHENMA-2014 (<http://phenma2014.math.sfedu.ru>) whose results have been published in the edited books “Physics and Mechanics of New Materials and Their Applications”, Ivan A. Parinov, Shun-Hsyung Chang (Eds.), Nova Science Publishers, New York, 2013, 444 p. ISBN: 978-1-62618-535-7, “Advanced Materials—Physics, Mechanics and Applications”, Springer Proceedings in Physics. Vol. 152. Shun-Hsyung Chang, Ivan A. Parinov, Vitaly Yu. Topolov (Eds.), Springer, Heidelberg, New York, Dordrecht, London, 2014, 380 p. ISBN: 978-3319037486, and “Advanced Materials—Studies and Applications”, Ivan A. Parinov, Shun-Hsyung Chang, Somnuk Theerakulpisut (Eds.), Nova Science Publishers, New York, 2015, 527 p. ISBN: 978-1-63463-749-7, respectively.

The presented papers are divided into four scientific directions: (i) processing techniques of advanced materials, (ii) physics of advanced materials, (iii) mechanics of advanced materials, and (iv) applications of advanced materials.

In framework of the first theme, the structural modification of sulfide minerals irradiated by high-power nanosecond pulses; the magnetic nanoparticles and heterogeneous persulfate oxidation of the nanoparticles and organic compounds are considered. Then the microstructure optimization of Pt/C catalysts for PEMFC; the synthesis of titanium dioxide, polyacrylonitrile-based materials; and also features of phase formation in bismuth ferrite are considered. Moreover, this section contains investigations of growth of the strongly doped  $\text{LiNbO}_3\text{:Zn}$  single crystals and features of crystallization of sapphire melt. The first section is finished by considering the lignin degradation and production of slow release fertilizer from waste materials.

The second direction is opened by the numerical study of dielectric resonant gratings; the method of equilibrium density matrix in theory of superconductivity; new investigations of 1–3-type composites based on relaxor-ferroelectrics single crystals and ZTS-19/clay composite. Novel results are present at the modeling and characterization of advanced functional materials. In this section, in particular the following are studied: diffusion of ferroelectric phase transition and glass-dipole state in the PZT-based solid solutions; the electromagnetic microwave radiation absorption by ferroelectric complex niobium oxides; and the structural ordering in ceramic ferroelectromagnets. Special attention is given to physical properties of the graphene materials; morphology, and atomic and electronic structure of metal oxide ( $\text{CuO}_x$ ,  $\text{SnO}_x$ ) nanocomposites and thin films; dispersion characteristics of zinc oxide nanorods organized in two-dimensional uniform arrays. Finally, new technical and technological solutions for measurement of displacements of the control object surfaces by laser interferometer and contactless method of temperature measurements are provided.

From viewpoint of mechanics the models for nanosized magnetoelectric bodies with surface effects and general theory of polarization of the ferroelectric materials are present. The surface SH-waves in the weakly inhomogeneous pre-stressed piezoelectric structures; elastic waves in layered phononic crystals with strip-like cracks; ultrasonic guided waves in laminated fiber-reinforced composite plates; low-frequency elastic waves penetrating the triple periodic array of cracks; and ultrasonic torsional guided waves in pipes with defects are studied. Then, why and how residual stress affects metal fatigue and also present the mathematical modeling dynamics of prismatic body of two- and three-component materials and numerical study of three-dimensional anisotropic viscoelastic solids are discussed. In the third section, the conclusion is brought by investigations of the thermo-physical processes in boundary layers of metal-polymeric systems; the antifriction fillers influencing the characteristics of the metal polymer tribosystems and carbon brake discs with frictionally induced thermoelastic instability.

On the whole, the presented applications are devoted to lot of modern devices based on novel approaches. In particular, the developments of new metamaterials for advanced element base of micro- and nanoelectronics; the radiation detector with sensitive elements on the base of array of multi-walled carbon nanotubes; and the magnetic field sensor with nanosized elements are discussed. Then the transducer designs for ultrasonic diagnostics and therapy, and also the electric power harvesting system based on the piezoelectric stack transducer and non-uniform polarization of multi-layered piezoelectric transducer are considered. Then, the multifrequency sonar equipment based on the self-action nonlinear effect is regarded. Finally, the singular nullor and mirror elements for circuit design; the usage of Markov chain model for wireless local area networks; and the time-frequency features in the Berardius Baird whistles are discussed.

The book is addressed to students, postgraduate students, scientists, and engineers taking part in research and development of nanomaterials, nanostructures, ferro-piezoelectrics and other advanced materials and composites, and also to manufacturing of the different devices based on novel materials having broad applications in various areas of modern science and techniques. The book include new studies and results in the fields of Processing Techniques and Engineering of Nanomaterials, Piezoelectrics, other Advanced Materials and Composites, Condensed Matter Physics, Mechanics of Deformable Solids, Materials Science, Physical and Mechanical Experiment, and Numerical Methods with various applications, in particular developed devices and goods.

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