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THE PRESENCE OF POLAR NANOREGIONS IN $Pb_{0.75}Ba_{0.25}Zr_{0.7}Ti_{0.3}O_3$ CERAMICS

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Elastic, piezoelectric and structural properties have been investigated as a function of temperature for $Pb_{0.75}Ba_{0.25}Zr_{0.70}Ti_{0.30}O_3$ (PBZT 25/70/30) ceramics prepared by the mixed-oxide processing technique. It has been found that macroscopic piezoelectric activity exists far above the structural transformation to which corresponds the temperature of maximum of the electric permittivity detected at 200 °C for an un-poled sample. In these ceramics very clear anomalies of the elastic and piezoelectric properties have been observed near a freezing temperature T_f = 152 °C. The unstable piezoelectric properties within the temperature range 152-220 °C can be explained by the existence of dynamically changing sizes of polar micro/nano-regions and non-trivial elastic-electric interactions between them throughout the non-polar paraelectric matrix.

Keywords: Ceramics, Dielectric Properties, Phase transition

PREPARATION AND PROPERTIES OF Ti-(5-30 wt.%)Y_2O_3 COMPOSITES FOR IMPLANT APPLICATIONS

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In this paper, preparation of Ti-(5-30 wt.%)Y_2O_3 composites by using a mechanical alloying process has been shown. Ti based materials are the best metallic biomaterials because of their excellent properties: biocompatibility, low Young's moduli and corrosion resistance. Pure Ti and Y_2O_3 powders were alloyed under the argon atmosphere in a shaker type mill (Spex 8000) followed by pressing and sintering. The ultra-low grain size structure improves mechanical properties and hardness of the new materials in comparison to microcrystalline Ti-based sintered bodies. However, because of (20-30)% porosity, there is observed a decrease in Young' s modulus. The corrosion properties were investigated in the Ringer' s solution.

Keywords: Ti-based composites, Yttrium oxide, Mechanical alloying, Biomaterials

CHARACTERISTICS OF OXIDE LAYERS OBTAINED ON TITANIUM IN THE PROCESS OF ISOTHERMAL OXIDATION

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Isothermal oxidation in air may be one of the methods to improve properties of titanium and its alloys through the influence on the structure and properties of a material's surface layer. The paper presents a description of oxide layers obtained on the surface of Grade 2 titanium as a result of oxidation at temperatures of 600°C and 700°C. On the basis of kinetic curves it has been found that the intensity of oxide layer growth was increasing with the oxidation temperature. The studies of the oxide layers surface morphology have shown that after oxidation at 600°C the size of formed the oxide particles was larger. The obtained layers were subjected to X-ray phase analysis and microhardness measurements. Irrespective of the oxidation temperature, the scale consisted of TiO_2 oxide in the crystallographic form of rutile and of Ti_3O oxide. The hardness of oxide layers amounted to around 1265 HV and was more than 4 times higher as compared to the material in the initial state.

Keywords: Titanium, Oxidation, Scale, Structure, Hardness

MICROSTRUCTURE AND PROPERTIES OF COMPOSITE COATINGS OBTAINED ON ALUMINIUM ALLOY

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Oxide coatings formed on aluminium alloys exhibit good tribological properties with polymers in oil-free associations. However the resistances to movement, resulting from cooperation of the kinematic system, affect wear of a polymer sliding partner. In the paper, it is assumed about the advisability of modifying the oxide coating by introducing carbon into its structure. That should result in a decrease of motion resistance in sliding cooperation of composite coatings with polymers, and thus contribute to the reduction of polymer wear. The preparation of composite coatings was done by using two different methods. The first method relied on the formation of coatings during constant current conditions of oxidation. Anodic oxidation of aluminium was conducted in multicomponent electrolyte with additions of organic acids and graphite – content of 20 g/dm^3 of electrolyte, at a constant current density parameter of 2 A/dm^2 and 3 A/dm^2 in the bath at 303 K. The second method was based on the formation of oxide coatings in an electrolyte without the addition of graphite and the heat treatment of the layers with succinic acid. The oxidation was conducted at a current density of 3 A/ dm^2 at a temperature of 293 K and 303 K. The process of sealing was carried out for 30 minutes at a temperature of 373 K and 20 minutes at a temperature of 368 K. The obtained coatings were tested by SEM, TEM and GDOES. The tribological and stereometric properties were measured. The studies showed beneficial effects of the used methods on the improvement of the tribological properties of associations.

Keywords: Composite coating, Hard anodizing

THE INFLUENCE OF ELECTRON BEAM IRRADIATION, PLASTIC DEFORMATION AND RE-IRRADIATION ON MECHANICAL AND SCLEROMETRIC PROPERTIES OF GUR 1050 USED FOR ARTHROPLASTY

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The paper describes the influence of electron beam irradiation (N), plastic deformation (O) and re-irradiation (N) on the GUR 1050 polyethylene deformation resistance, mechanical properties and sclerometric properties. The polymer irradiation only (the technique N) resulted in an increase in the maximum stress as compared with the material in the initial state.

The application of deformation and re-irradiation (the technique NON) allowed increasing the deformation resistance by more than 40%. Moreover, the irradiation with an electron beam resulted in the increase in hardness *(H)* and Young' s modulus *(E)* proportionally to the applied irradiation dose and in the reduction of total indentation work (W_{tot}) and its components. After deformation and re-irradiation the polyethylene hardness went down. The application of the technique N caused an improvement to the material abrasion resistance (reduction of the parameter *P4* with increasing an irradiation dose). The introduction of deformation and re-irradiation did not have a material impact on the parameter (*P4,* increasing at the same time elastic properties of UHMW polyethylene (an increase in the parameter *NPS*). The modification of NON has changed the wear mechanism (β) towards ploughing and has increased the abrasion-resistance index (W_β), and also significantly reduced the coefficient of friction *(μ)* of GUR 1050.

Keywords: UHMW Polyethylene, Electron beam irradiation, Plastic deformation, Hardness, Young' s modulus, Scratch resistance

ANALYSIS OF ACOUSTIC EMISSION EVENTS FROM EXPANDED GRAPHITE–POLYMER COMPOSITES

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Compressed expanded graphite (CEG) was applied as a base to the preparation of microporous composites as products of their impregnation, polymerization and carbonization processes. During carbonization, the original polymeric structure of poly-furfuryl alcohol is transformed into an amorphous turbostratic carbon structure with ultramicropores. The structure, porosity and many chemical and physical properties change after each stage of the technological treatment. The acoustic emission (AE) method was used for accurate determination of these changes. It is possible to determine a large number of AE parameters and therefore to increase the amount of information provided by the studied materials. The AE pulses counts rate, events rate, signal peak value and their sums were measured. Also the frequency spectrum was received as a result of analysis of AE signals with the use of the Fourier transformation procedure. The conclusions resulting from the Fourier analysis of the registered spectrum are very interesting and provide information about composite structures as well as bonds between the graphite matrix and the polymer which fills it. Analysis of AE parameters provides data on physical and chemical processes that would be very difficult to study by means of other techniques. Wide applications of these porous composites make them very interesting subject of the study.

Keywords: Compressed expand*eg*aphite, Polymerization, Carbonisation, Acoustic emission parameters, Composite membrane

CERAMIC COMPOSITES OBTAINED ON THE BASIS OF THE PZT TYPE MATERIALS

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The aim of the study was to design and obtain ferroelectric-ferromagnetic ceramic composites based on the ferroelectrics powders (*i.e.* $(Pb(Zr_{1-x}Ti_x)O_3$, $Pb(Fe_{1-x}Nb_x)O_3$, lead free $Ba(Fe_{1-x}Nb_x)O_3$, (1-*x*)PMN-(*x*)PT and $Pb_{1-x}La_x(Zr_{y-}Ti_{1-y})_{1-0.25x}V^B{}_{0.25x}O_3$) and the ferrite one. Multiferroic materials (composites) with good functional parameters (due to the magnetoelectric properties and coupling of magnetic and electric subsystems) can find numerous applications in many fields of modern technology and micromechatronics, *e.g.* to build functional transducers/ sensors in one device, integrating electric and magnetic interactions. The synthesis of our composites was carried out by conventional or sol-gel technologies. In the obtained composites, 90% originated from the ferroelectric powders and 10% from the $Ni_{0.64}Zn_{0.36}Fe_2O_4$ ferrite powder. The work presents the technology, the results of XRD measurements, the microstructures, and the dielectric properties and the magnetic properties of the PLZT-ferrite composite samples.

Keywords: Ceramic composites, Ferroelectromagnetics, Perovskite type materials, Multiferroics, Lead-free materials

THE LMO TYPE CERAMIC MICROSTRUCTURE

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An aim of this work was to characterize the LMO type ceramic microstructure. The ceramic obtained by free sintering at two temperatures of 1473 K and 1573 K and two sintering times 6 h and 12 h was the test material. One series was also obtained by the hot pressing method for a comparison. In all the cases, the material synthesis was conducted by the solid reaction method at 1173 K for 24 h. Images of the specimen fractures were taken by a scanning microscope to characterize the microstructure of the obtained ceramic in a more detailed way. The VISILOG 4 system was used, enabling to calculate a lot of parameters characterizing the material microstructure, such as a number of grains in the unit area, an average grain size, and shape indexes of the grains in question. It allows determining the grain size distribution, and frequency of appearance of grains with the specific shape index. By analyzing a set of the parameters obtained, an influence of the technological conditions on the microstructure of the material in question, and on its properties and applicability at the same time has been determined.

Keywords: LMO, Microstructure, Hot pressing, Free sintering

THE PROPERTIES OF (1-*x*)(0.5PZT-0.5PFW)-*x*PFN CERAMICS

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The ceramic samples of solid solution (1-*x*)[0.5($PbZr_{0.53}Ti_{0.47}O_3$)-0.5($PbFe_{2/3}W_{1/3}O_3$)]-*x*($PbFe_{1/2}Nb_{1/2}O_3$) [*i.e.* (1-*x*)[0.5(PZT-PFW)]-*x*PFN with *x* = 0, 0.1, 0.2 have been obtained by conventional ceramic technology, using oxides PbO, ZrO_2, TiO_2, Fe_2O_3, WO_3, and Nb_2O_5. Basing on the literature data for individual components, it can be expected that this material will have interesting multiferroic properties. The presented work is the first step in obtaining and testing this solid solution and concerns the technology and the dielectric properties. The calcined powders were crushed and next pressed into discs and sintered by using the free sintering (FS) method. For such obtained samples the following investigations have been done: EDS, XRD, observations of the microstructure of fractured samples, dielectric measurements and determination of electric conductivity. The relatively large electrical conductivity of investigated samples made not possible investigations of the *P-E* hysteresis loop.

Keywords: PZT-PFW ceramics, PZT-PFW-PFN ceramics, Dielectric properties

TESTING THE CONDITIONS OF CERAMIC COLOURS' FUSING TO GLASS SUBSTRATE BY LASER TECHNIQUE

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The tests were carried out by means of two lasers: a glass fiber laser of power up to 100 W and of 1070 nm wavelength, and a fiber laser of 10 W power and 532 nm wavelength nm. Glass panels of tempered glass were the substrates. Materials for tests were coloured on the base of lead and leadless fluxes. The influence of laser operating parameters (power density, scanning rate) on quality of coloured surface was shown on the basis of roughness parameters *Ra* and *Rz* as well as their dependence on chemical composition of tested colours and added modifying agents. Surface quality was evaluated and documented by means of a 3D optical digital microscope KH 8700 from Hirox, Japan company. Different filling geometries, namely dotted, crossing and linear, were examined in regard to the final surface quality and intensity of colours.

Keywords: Colours' fusing, Laser, Lead and leadless fluxes

SYNTHESIS AND MICROWAVE POTENTIAL OF BST THIN FILMS

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Barium strontium titanate ($Ba_{1-x}Sr_xTiO_3$ – BST) is a typical ferroelectric material suitable for microwave applications at room temperature due to its high dielectric constant and dielectric tunability, reasonably low dielectric loss and controllable Curie temperature, by adjusting the barium-to-strontium ratio. Both ferroelectric and paraelectric phases may be useful in tunable microwave devices. However, the paraelectric phase is often preferred since it has no hysteresis associated with the domain walls. In this respect $Ba_{1-x}Sr_xTiO_3$ seems to be the material of choice. Research on synthesis, characterization and determination of processing – structure – property relationships of commercially important ferroelectric thin films has been performed. The sol-gel-type solution deposition technique was applied to produce good quality thin films of $(Ba_{0.6}Sr_{0.4})TiO_3$ chemical composition on the stainless steel substrates. The thin films were characterized in terms of their microstructure, crystalline structure, phase composition and dielectric properties. Dielectric spectroscopy was used to measure frequency-dependent dielectric properties of the thin films at low frequencies. At the microwave range, scattering matrix coefficients S_{11} and S_{12} were measured within the frequency range 5.2-6.8 GHz. The results of investigation of functional properties have shown that the BST ferroelectric thin films possess a great application potential especially as elements of microwave circuits.

The present research was supported by University of Silesia in Katowice, Poland from the funds for science – research potential (NO 1S-0815-001-1-05-01).

Keywords: Barium strontium titanate, Microwave properties, Sol-gel method, Thin films

MECHANICAL PROPERTIES OF GRAPHENE OXIDE–COPPER COMPOSITES

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Due to their characteristics, sintered Cu-C composites are materials used in electrical equipment. These characteristics include high electrical and thermal conductivity as well as excellent resistance to abrasion. Currently, graphite nanopowder is used successfully as a carbon material. Metal-graphite, which is created on its basis, exists in different proportions of graphite to metal. A large graphite content has a positive effect on smaller wear of commutators and rings. In contrast, a material with a higher copper content is used at high current densities. An example of such machines are DC motor starters characterized by low voltages and large currents. Tribological properties of Cu-C composites depend on the form of carbon they include. Owing to the capability to manufacture graphene, it has become possible to produce composites with its content. The present study tested the effect of graphene oxide content on tribological properties in contact with steel. Tests were conducted usind a ball-on-disk apparatus in conditions of dry friction. Microscopic observation was performed using the Hitachi SU70 field emission electron microscope. EDS analyses were performed using the Thermo Scientific X-ray Microanalysis system. Disk wear and surface geometrical structure parameters (SGP) of the samples after tribological tests were determined on the basis of measurements made on a Talysurf 3D contact profilometer from Taylor Hobson.

Keywords: Tribological properties, Composites of copper, Surface microgeomety, Graphite oxide

THE EFFECT OF ADMIXED GLASSY CARBON ON THE STRUCTURE AND MECHANICAL PROPERTIES OF BONE CEMENTS

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Despite the introduction of newer and newer materials and technologies in the field of arthroplasty, bone cements are still widely used in joint surgery, especially in the elderly. They are used primarily for fixing joint endoprostheses and filling bone defects. Other applications include fracture stabilization and treatments which involve filling the vertebrae in the spine with bone cement. These materials belong to the group of polymer composites. Depending on their functions, mounting or filling, they must meet different requirements. Cements used for filling cavities have lower compressive strength than the ones used to attach prostheses. Other requirements are identical for both applications. The most important of them is biocompatibility, *i.e.* the lack of toxic, allergic or carcinogenic effect and no infection risk in an organism. In order to improve the performance of bone cements, they are admixed with, for example, carbon materials. According to Marciniak J. in the monograph ' Biomaterials', biomedical engineering achievements in the application of implant carbon materials in reconstructive surgery are positive. Therefore, the authors decided to investigate the effect of modifying Biomet bone cement with glassy carbon on its tribological properties. These properties are important for the operation of the prosthesis because during arthroplasty small amounts can get into the zone of friction of the acetabulum and endoprosthesis head. Hence in the final stage of the implant life there may occur cooperation between the head and bone cement. The object of the study was Biomet bone cement admixed with 4 g and 8 g of glassy carbon 1.6% and 3.2%. Bone cement without additives was used as a reference material. The research material was obtained in the form of rollers with a diameter of 5 mm. Tribiological tests were performed using a pin-on-disk apparatus. The tribological partner was a polished shield made of Vitalium alloy (Co-Cr-Mo). This material is used in the heads and stems of joint endoprostheses. Shield wear and surface geometrical structure parameters (SGP) of the samples after tribological tests were determined on the basis of measurements made using a Talysurf 3D contact profilometer from Taylor Hobson.

Keywords: Tribological properties, Bone cement, Surface microgeomety, Glassy carbon

DETERMINATION OF SUBCRITICAL CRACK GROWTH PARAMETERS IN DENSE CERAMIC POLYCRYSTALS BY MEANS OF THE CONSTANT STRESS RATE TEST

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Subcritical crack growth is a very important factor for estimating the lifetime of ceramics. Calculation of K_{Ic} parameter might be not sufficient for ceramics used in a long-time service. This phenomenon shows that failure of material occurs when the applied stress is smaller than the fracture one. In this case, the environment is the activating factor. Stress needed to expand cracks in material is smaller because appearance of the chemical interaction. Test methods for subcritical crack growth measurements are time-consuming. Indirect methods avoid the need of measuring the propagating crack length. The velocities are calculated from strength data. The expansion of defects in material causes reduction of strength. When different stress rates are used, there are different flaws growing times, too. For lower stress rates, there is more time for cracks to grow before the stress intensity factor reaches the critical value. It is called Constant Stress Rate Test. This method allows obtaining the general measurements without showing crack propagation details. However, it is suitable for crack growth velocity determination, which gives information about the lifetime of ceramic components under specific conditions. In the presented work, the Constant Stress Rate Test (CSR) was used for determination of subcritical crack propagation velocities for different ceramic materials. Monophase polycrystalline alumina, tetragonal zirconia, and a wide range of composites in the alumina-zirconia system. The general idea was to fabricate two groups of composites: the first one with the α-alumina matrix and the second one basing on tetragonal zirconia. The fundamental difference was that the ratio of thermal expansion coefficients (CTE = α) of composite constituent phases ($\alpha_{alumina} < \alpha_{zirconi1}$) caused compressive residual stresses in the alumina matrices and tensile stresses in the zirconia ones. In each group of composites three different amounts of second phase were applied: 5 vol.% were added to prepare a model of particulate composites with isolate grains of the minor phase; 15 vol.% were added to prepare two-phase materials with the minor phase grains content near the percola-

tion point, and a material containing 50 vol.% of both phases was manufactured as an example of the typical duplex microstructure. Tetragonal zirconia and α-alumina sintered bodies were made as reference materials. The detail analyses of residual stress state for all manufactured materials were performed utilizing the real microstructures. In the CSR Test, four rates of stress increase were applied: 0.1, 1, 10 and 200 MPa/s. The experiments allowed calculating the parameters of slow crack propagation. The influence of the residual stress state on crack growth velocity in the investigated materials was described.

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Keywords: Tetragonal zirconia, Silicon carbide, Subcritical crack growth

ELECTROCHEMICAL PROPERTIES OF CERAMIC PROTON CONDUCTING MEMBRANES FOR MICROTUBULAR SOLID OXIDE FUEL CELLS DESIGNED FOR ELECTRICALLY POWERED UNMANNED AERIAL VEHICLES (UAVS)

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The technological development of fuel cells and, in particular, the progress in the field of materials engineering enabled the reduction in the unit weight of fuel cells, which in turn enabled the first practical attempt to use fuel cells as energy sources in aerospace engineering. The advantages of fuel cells compared to internal combustion engines in these specific applications were the reason for conducting the presented tests. Fuel cells operate quietly, which particularly marks them out for use in unmanned reconnaissance aircrafts; they also do not emit exhaust gases, and hence no smoke or odours; moreover, they are characterised by minimal heat emission, making virtually impossible the identification and destruction of devices using infrared radiation (especially at night); furthermore, they contain no moving parts, thus the reduced vibration, simplified operation, and enhanced reliability are enabled; lastly, thanks to their high efficiency, they help economizing the consumption of fuel. Many examples of low-temperature PEMFC (Polymer Electrolyte Membrane Fuel Cell)-powered UAVs have been flown in recent years, all relying on a supply of hydrogen present on board of the UAV. Solid oxide fuel cells (SOFCs) operate at a sufficiently high temperature to permit some flexibility in fuel source; in particular, microtubular solid oxide fuel cell (mSOFC) stacks have been developed to run on hydrocarbon gases that are easier to store and more readily available than hydrogen. This paper explores the possibility of using ceramic proton conducting electrolytes as components of mSOFCs, when used as parts in hybrid energy sources for supplying small UAVs. A comparative study of energy sources involving low-temperature fuel cells (PEMFC), as well as intermediate temperature solid oxide fuel cells (mSOFCs) will be also performed and discussed within this paper.

Keywords: Electrochemical energy source, Polymer membrane fuel cell, Micro solid oxide fuel cell, Ceramic proton conducting membrane, Unmanned aerial vehicle

INFLUENCE OF THE ORGANOPHILISATION PROCESS ON PROPERTIES OF THE BENTONITE FILLER AND MECHANICAL PROPERTIES OF THE CLAY/EPOXY NANOCOMPOSITES

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In this comparative study, the influence of the organophilisation process on the properties of the obtained organobentonite fillers, and ability of the filters to improve the mechanical properties of clay/epoxy nanocomposites were investigated. Organobentonites were manufactured by using two organic quaternary ammonium salts (QAS) with alkyl chains of significantly different lengths. Organophilisation resulted in an increase of the interlayer space of clays, as confirmed by XRD measurments. The obtained organofillers were used to manufacture nanoclay/epoxy resin composites, and the effects

of alkyl chain length on the resulting properties of the composites were compared based on examination of the mechanical behaviour and morphology. The results were related to the properties of the reference composite filled with the non-organophilised bentonite. It was demonstrated that the organophilisation process with the usage of distearyldimethyl ammonium chloride salt with a longer alkyl chain (C18-C20) created the most favorable conditions for the compatibility of the nanofiller with a polymer matrix, resulting in a 25% increase in bending strength of the epoxy composite material filled with 3 wt.% of the organophilised bentonite compared to neat epoxy.

Keywords: Bentonite, Organophilisation, Mechanical properties, Nanocomposite

RAPID PROTOTYPING – TECHNOLOGIES, MATERIALS AND ADVANCES

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In a product development context, the term Rapid Prototyping (RP) was widely used to describe technologies that created physical prototypes directly from digital data. Recently, the RP technology became one of the fastest growing method of part manufacturing. The term Rapid Prototyping or Additive Manufacturing is used in a variety of industries to describe a process which rapidly creates a system or a part representation before final release or commercialization. “Additive Manufacturing” is a layer-based automated fabrication process for making scaled three dimensional physical objects directly from 3D-CAD data without using part-depending tools. It was originally called “3D Printing,” and this term is still frequently used. Other terms vital to this technology include Additive Layer Manufacturing, Rapid Prototyping, Direct Manufacturing, etc. There are several types of 3D printers used, but all involve the same basic approach for “ printing” an object: spraying or otherwise transferring a substance in multiple layers onto a building surface, beginning with the bottom layer. This work presents most widely-used rapid prototyping technologies and materials, which can be used by these solutions. The most popular materials include thermoplastics, photopolymers, plastic powders for the SLS methods, and metal powders for DMLS/ EBM/ SLM methods. Some methods, when the printing performs a composite element, *e.g.* for 3DP, utilize cellulose-gypsum powder, a binder and a filling, or LOM films of paper or plastic, and adhesive, but most of the technologies use homogeneous materials. However, in recent years, there were some attempts made to introduce new solutions and materials that enable printing with the use of spatial composites. Advances in rapid prototyping materials include improvements in tear and thermal resistance, shape memory, stiffness, photorealistic colour, and biocompability.

Keywords: 3D printing, FDM, Rapid prototyping, Rapid tooling

THE EFFECT OF Nd SUBSTITUTION ON THE STRUCTURE AND DIELECTRIC PROPERTIES OF $BiFeO_3$

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In the present paper, the influence of Nd on the crystal structure, microstructure, and dielectric properties of $Bi_{1-x}Nd_xFeO_3$ ceramics ($0,5 \leq x \geq 1$) was investigated. The mixed oxide method was employed for the fabrication of ceramics. $Bi_{1-x}Nd_xFeO_3$ ceramics were prepared from simple oxide powders: Bi_2O_3, Nd_2O_3 and Fe_2O_3. A stoichiometric mixture of the powders was thermally analysed with a Netzsch STA-409 system, so parameters of the thermal treatment were determined. The crystalline structure of the sintered samples was examined by X-ray diffraction at room temperature. Dielectric properties have been studied by impedance spectroscopy. The Kramers-Kronig data validation test was employed in the present impedance data analysis. Impedance data were fitted to the corresponding equivalent circuit using the CNLS fitting method.

Keywords: $BiFeO_3$ ceramics, Impedance spectroscopy, Perovskites, Nd^{3+} doping

APPLICATION OF PROTECTIVE PASTE IN LAYER-BY-LAYER FABRICATION OF CERAMIC MATERIALS VIA SOFT LITHOGRAPHY

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The ceramic microfluidic devices such as microreactors can be manufactured by combination of tape casting and soft lithography methods. Soft lithography refers to a collection of different techniques pioneered by Whitesides and his co-workers and offers a simple, low-cost route for micropatterning of ceramic materials. The common feature of this class of techniques is the use of an elastomeric material with a patterned surface. In soft lithography and tape casting, it is possible to apply the UV curable ceramic dispersion. Such combination allows manufacturing instantly a ceramic product with internal structures such as channels, layer-by-layer without the stacking of ceramic tapes and the lamination process. The fabrication of internal structures by the combination of tape casting and soft lithography requires securing them from filling during casting of the next layer. The aim of the research was the development of protective paste for securing the channels from filling them by UV curable ceramic dispersion during the casting of the next layer. The research was focused on the effect of pastes composition on viscosity and time of solidification.

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The authors would like to thank BTC Europe GmbH for free samples of Irgacure photoinitiators.

Keywords: Protective paste, Soft lithography, Microreactor, Tape casting, Photopolymerization

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DIELECTRIC AND PYROELECTRIC PROPERTIES OF Sr MODIFIED PZT CERAMICS

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The ferroelectric materials are continuously attracting considerable attention due to the interesting combination of their mechanical, electrical and chemical properties, and their application in microelectromechanical devices (piezoelectric transformers, motors and transducers). To be more specific, their excellent electrostrictive properties coupled with domain mobility, high Curie point and good stability made these “new materials” an important component of electroceramics devices. It is already known that electrical behaviour of these ferroelectric materials largely depends on random elasto-electric fields connected with diffusion of phase transition and defects distribution. The aim of this paper is the presentation of the influence of Sr^{2+} homovalent dopant on the microstructure, crystal structure as well as phase transition and piroelectric current of the $(Pb_{1-x}Sr_x)(Zr_{0,70}Ti_{0,30})O_3$ ceramics, basing on the temperature dependence of dielectric properties.

Keywords: Ceramics, Dielectric properties, Phase transition

THE EFFECT OF SEMICONDUCTOR ELEMENTS SUBSTITUTION ON THE ELECTRICAL PROPERTIES OF BARIUM TITANATE CERAMICS

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The perovskite-type $BaTiO_3$ ceramics show the ferroelectricity state below 400 K, at which the structure is changed from cubic to tetragonal in a first-order transition. Moreover, $BaTiO_3$ also shows two structural phase transitions at about 285 K and 190 K. Pure $BaTiO_3$, doped $BaTiO_3$ and substituted $Ba_{1-y}Ti_{1-x}O_3$ (called $BaTiO_3$-like compounds) that are ceramic, nanocrystalline or films have many kinds of electrical functional properties. The wide industrial applications of the Ba-

TiO_3-like compounds are based mainly on the ease of obtaining the structural and electrical properties by doping or by substitution of Ba^{2+}or Ti^{4+} ions with other ions. Among the possible modifications, the substitution of Ti^{+4} (0.0605 nm) ions by the smaller ionic radius silica ions Si^{+4} (0.040 nm) in the B site leads to the $BaSi_xTi_{1-x}O_3$ solid solution. In addition the presence of small amounts of Si ions in $BaTiO_3$ prove to be particularly important for the electrical properties. The electric studies of the ceramic samples were performed using an Alpha-AN High Performance Frequency Analyzer system combined with Quatro Cryosystem of the temperature control and the WinDATA Novocontrol software. The measurements were carried out in the temperature range from 500 K to 130 K on cooling. The frequency varied from 20 Hz to 1 MHz.

This study was partially supported by the National Science Centre Poland (Project DEC-2012/05/N/ST8/03764) and DS (PK/C-1/KWC/2014).

Keywords: Barium titanate, Electroceramic, Impedance spectroscopy

RHEOLOGICAL PROPERTIES OF YTTRIA SUSPENSIONS: INFLUENCE OF PARTICLE SIZE

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Yttria ceramics find applications both in the technical and advanced fields. The high thermal and chemical stability predisposes yttria for foundry applications. Moreover, the regular crystallographic structure of Y_2O_3 makes it attractive as a matrix material for rare earth elements for laser application. Various methods of ceramic powder moulding include the wet processing, as it is frequently easier to handle with the suspension of a powder than with the powder itself. This is valid especially in case of nanopowders which easily rises in air. Airborne nanoparticles can be transported to the respiratory system. As the impact of nanoceramic particles on human health is still not well known, the powders should be handled with great care and one must prevent them from getting to the environment. One of the recent method designed for micro- and nanosized powder processing is freeze granulation. In this method, a suspension of ceramic particles is sprayed directly into liquid nitrogen, where the suspension droplets freeze and afterwards water from granules is sublimed in vacuum. The suspension for freeze granulation should fulfil a few criteria including proper rheological properties *i.e.*: suspension should be of low viscosity and has shear thinning characteristics. The rheological properties depend on numerous factors and one of them is the size of the particles in a suspension. In the presented work, yttria suspensions obtained from various powders derived from three different sources were investigated. It has been observed that the rheological characteristics of the suspensions vary in nature depending on the particles size and shape.

Keywords: Freeze granulation, Nanopowder, Y_2O_3, Rheology

INTELLIGENT COMPOSITES FOR PROTECTION OF THE HUMAN BODY BASED ON SHEAR THICKENING FLUIDS

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Intelligent materials are capable of controllable changing their properties in response to an external stimulus. Ceramic-polymer composites based on shear thickening fluids (STF) have a great potential in systems used for human body protection. They are non-Newtonian liquids that are characterized by the rapid viscosity increase with increasing the shear rate. Materials and devices based on STF dissipate energy associated to shocks, impacts and vibrations. The mechanism of shear thickening can be interpreted by many theories. The main assumption is the increasing of internal friction forces with shear rate, and consequently rising viscosity. Nevertheless, this phenomenon still requires further research in various fields to achieve entire knowledge of this process. In preparation, a silica powder, polyglycols and polymeric additives were used. It has been found that the content of solid loading, the average particle size of silica, the molecular weight of dispersant, the addition of dopants and the temperature had the influence on the rheological properties and capability of

energy absorption of designed systems. Detail characterization of materials is necessary for optimization of a suitable composition of STF depending on application.

This work was supported by the National Center for Research and Development (agreement No. PBS1/A5/19/2012).

Keywords: Liquid armor, Rheology, Shear thickening fluids, Smart materials, Viscosity

INFLUENCE OF ADDITIVES ON CRYSTAL STRUCTURE OF LMO-TYPE CERAMICS

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LMO-based ceramics are of high technological importance because of their interesting electronic and magnetic properties and find potential applications in the field of magnetic sensors, in memory applications and in prototype disc drivers employing read-head technology. In manganite perovskites, substitution of divalent ions (alkaline earth metals viz. Ca, Sr, Ba) in the A sublattice introduces Mn^{4+} ions or holes into the system. It is generally considered that the concentration of holes is equal to the concentration of divalent cations because of the charge compensation by controlled valences. In the present study, addition of Ca^{2+} and Fe^{3+} ions to LMO-based ceramics is studied. Ceramic powders were synthesized by the conventional mixed oxide method (MOM). A stoichiometric mixture of component powders was thermally analyzed with a Netzsch STA-409 system, so parameters of the thermal treatment were determined. The morphology of the ceramic materials was observed by SEM, whereas the crystalline structure was studied by the X-ray diffraction method and energy dispersive X-ray spectroscopy (EDS).

Keywords: EDS, LMO-based ceramics, MOM, SEM

MÖSSBAUER SPECTROSCOPY FOR CERAMIC MATERIALS CHARACTERIZATION

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Mössbauer spectroscopy is a research method based on the Mössbauer effect which involves resonant and a recoil-free emission and absorption of gamma radiation by atomic nuclei in solids. It was discovered by Rudolf Mössbauer in 1957. In the presentation, the basics of this method and its applications for ceramic materials characterization will be given. Spectroscopy in transmission geometry and conversion electron Mössbauer spectroscopy (CEMS) are very powerful tools in investigations of powdered samples as well as bulk samples and thin films. For very broad range of materials, *i.e.* alloys, compounds, ceramics, nanoparticles, meteorites, biological materials, minerals, etc., the main information obtained from Mössbauer spectroscopy concerns local atomic order, magnetic properties, hyperfine interactions, and magnetic phases. Some experimental results of Mössbauer spectroscopy for multiferroic ceramics based on $BiFeO_3$ will be presented, *i.e.* for the Aurivillius compounds $Bi_{m+1}Ti_3Fe_{m-3}O_{3m+3}$ and solid solutions $(BiFeO_3)_{1-x}$-$(BaTiO_3)_x$ and $Bi_{1-x}Nd_xFeO_3$. The materials were prepared by both standard solid-state sintering method and by mechanical activation with subsequent thermal treatment. Mössbauer spectroscopy measurements were performed at room, liquid nitrogen and liquid helium temperatures, and revealed magnetic ordering of the samples. Hyperfine interactions parameters were determined from the numerical fitting of the spectra.

Keywords: Multiferroic ceramics, Solid-state sintering, Mechanical activation, Mössbauer spectroscopy, Hyperfine interactions

DEVELOPMENT OF Ti-BASED NANOCOMPOSITES WITH ENHANCED ANTIBACTERIAL ACTIVITY

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Streptococcus mutans is known to be a major causative bacterium of dental caries in human and can also be a source of infective endocarditis. Here we present a new kind of biomedical titanium-based nanocomposites with antibacterial characteristics developed by the introduction of hydroxyapatite, 45S5 Bioglass and B atoms into the titanium matrix. To investigate the properties of Ti-based nanocomposites, compositional analysis, microstructural observations and phase identifications were performed. Titanium nanocomposites were more corrosion resistant in Ringer's solution than microcrystalline titanium. *In vitro* bacterial adhesion study indicated a significantly reduced number of *Streptococcus mutans* on the bulk of nanostructured Ti-20 wt.% HA, Ti-10 wt.% 45S5 Bioglass and Ti-2 wt.% B plate surfaces in comparison with that on the microcrystalline Ti plate surface. Experiments have shown that the Ti-based nanocomposites with HA, 45S5 Bioglass and B contents produced by the powder metallurgy method can be used successfully as the raw material in the production of dental implants with antibacterial properties.

Keywords: Nano-biomaterials, Titanium, Corrosion, *Streptococcus mutans,* Dental caries

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ELECTRIC PROPERTIES OF $BaBi_2Nb_2O_9$ CERAMICS PREPARED BY THE SOL-GEL METHOD

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$BaBi_2Nb_2O_9$ (BBN) is a ferroelectric material which possesses many interesting properties that are a consequence of not only of its chemical composition, but also specific structure. Multilayer perovskite structures of Aurivilius type, to that BBN belongs, overweight the monolayer ones with better anisotropy, higher values of mechanical elastic coefficients and higher strength. Ceramic powders obtained in our experiment were produced taking advantage of the sol-gel method, and were densified with two methods, namely conventional free sintering and hot pressing. Our main point was to make comparative analysis of effects of the sintering routes on key BBN ceramics properties such as density, stoichiometry and microstructure and resultant electric properties to final application connected conclusions.

Keywords: Ceramics, Electric properties, Impedance spectroscopy

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CHALLENGES IN PRODUCTION OF CERAMIC-METAL COMPOSITES BY THE GELCASTING METHOD

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The metal particles can successfully improve mechanical properties of ceramic material. Homogeneous metal-ceramic composites have higher fracture toughness, abrasion and even hardness in case of nanocomposites. Colloidal proces-

sing allows obtaining required properties of composites. One of a new way to form materials with complicated shapes is gelcasting. This method bases on addition of monomer, crosslinking agent and initiator to a stable aqueous powder suspension in which polymerization occurs. In case of ceramic-metal-water based systems there is a lot of details which determine properties of final material. Interaction between particles plays the crucial role in behaviour of composite suspensions. By changing the Zeta potential of particles it is possible to obtain the stable suspension with homogeneously dispersed metal phase even using metal particles with density of 19.3 g/ cm^3. Furthermore, the reactivity of metal particles in the water base system with organic additives is challenging. The presentation will focus on description of the preparation of the stable composite slurry, interpretation of Zeta potential measurements, particle size distribution and impact of these parameters on the stability of the composite suspension.

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Stability measurements were done with the use of equipment from the Laboratory of Nanostructures for Photonics and Nanomedicine, IHPP PAS, Warsaw, Poland.

Keywords: Ceramic-metal composites, Composite suspension, Zeta potential, Static multiple light scattering technique

THE MICROSTRUCTURE AND SURFACE MORPHOLOGY OF ANODIC Al_2O_3 COATINGS ON ALUMINIUM OBTAINED BY THE PULSE METHOD

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The usage of aluminium alloys in kinematic pairs of working machines requires the modification of their surface layers. A technological surface layer in the form of an anodic hard coating Al_2O_3 (AHC), obtained by hard anodization, improves tribological properties. The properties of anodic oxide coating on aluminium (the surface morphology, structure and mechanical properties, *e.g.* microhardness) may be altered by, *inter alia,* the composition, pH and electrolyte, temperature, process time and anodization current conditions: current density and shape alterations. The paper presents the possibilities of modifying the surface morphology and microstructure of anodic oxide coatings on aluminium alloys through the application of a pulsed method or modification of current density in their electrochemical production. The pulse anodizing process was conducted using a rectangular current waveform of variable frequency (0.1-0.0003 Hz) and a variable duty cycle of the pulse (33%-100%). The second method was based on the formation of AHC at the instantaneous change in current density (1-7 A/ dm^2). The anodizing process (in both methods) was performed using a stabilized impulse feeder and was conducted in a multicomponent electrolyte at a temperature of 303 K. The examination of surface morphology and microstructure (carried out in transverse microsections of the coatings) shows the opportunities to form the above-mentioned properties of anodic oxide coatings while using the pulsed method or instantaneous change in current density during the anodizing process.

Keywords: Anodic oxide coatings, Pulse anodizing

DEPOSITION OF SILVER NANOPARTICLES ON THE ANODISED TITANIUM SURFACE

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In the paper, we describe a process of high-voltage anodic oxidation of titanium in the 2M H_3PO_4 + 1% HF electrolyte water solution. The oxidation was carried out at different electrical potentials for 30 min. The treatment results in development of a porous surface of titanium oxide. Finally, silver nanoparticles were electrochemically deposited on the surface. For silver deposition, an electrolyte containing 0.01M HNO_3 and 0.01M $AgNO_3$ was used for 60 s at a voltage of −1 V. In order to properly describe effects of the processes, the materials were characterized by XRD, EDS, and SEM; corrosion resistance and wettability was also measured. XRD and EDS confirmed the presence of the silver nanoparticles on the titanium oxide surface. The SEM observations showed the morphology of the oxidized substrate and the deposited particles. Examination of the wettability showed how the embedded particles affect wettability of the surface. In our process,

the silver particles were dendritic in shape, and started to grow mainly from pits and valleys in the titanium oxide layer. This is particularly evident in the most complex oxide surface observed after oxidation at a voltage of 210 V. The study allowed us to determine the suitability of the combined anodic and cathodic electrochemical titanium treatment for medical purposes. The titanium oxide morphology was developed with the characteristics needed for the proper osseointegration processes (structure, high corrosion resistance, developed morphology and improved biochemical activity of osteoblast cells). The silver particles on the surfaces give some extra properties such as bactericidality.

Keywords: Titanium, yitanium dioxide, Silver, Biomaterials, Electrochemical

THE SCANNING ELECTRON MICROSCOPE ANALYSIS OF THE ANODIC OXIDE LAYERS

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Coatings with high wear, corrosion resistance and sliding properties are desirable in tribological applications especially for oil free nodes. In order to obtain such a coating on aluminium alloy the anodizing process is one of methods which is commonly used. In the present research, two kinds of anodic oxide layer were prepared. One series of samples consisted of amorphous oxide layers of Al_2O_3 obtained on aluminium alloy EN AW 5251. Second one was composite oxide layers of Al_2O_3 with inorganic fullerene like tungsten disulfide (IF-WS_2). The addition of IF-WS_2 to the acid bath was used to reduce the coefficient of friction for an oil-free friction pair. The aim of the study was the analysis of the surface and fresh cross section of the samples depending on a method of sputtering used for the SEM examination. The gold and carbon sputtering were used in order to prevent charging of a specimen with an electron beam in the conventional SEM mode. The significant differences in the interpretation of results were found.

Keywords: Composite coatings, Hard anodizing, Gold sputtering, Carbon sputtering, SEM

MECHANICAL AND CORROSION PROPERTIES OF MAGNESIUM-BIOCERAMIC NANOCOMPOSITES

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The number of placed medical implants has risen dramatically during the past years due to a population aging and simplicity of treatment. Magnesium alloys with the elastic modulus close to that of human bones have recently attracted much attention as a new generation of biodegradable metallic materials. It is however well known that the fast degradation rate of magnesium in the human bio-environment limits its clinical applications. One of the methods that allow the biological properties of Mg alloys to be altered is the modification of its microstructure and chemical composition. The other option is to produce a composite that will exhibit the favorable mechanical properties of Mg and the excellent biocompatibility and bioactivity of a ceramic. The most commonly used ceramics employed in medicine are hydroxyapatite and bioglass. The nanocrystalline structures can be produced by a non-equilibrium processing technique such as the mechanical alloying. In this work, Mg-bioceramic nanocomposites and their scaffolds were synthesized using a combination of the mechanical alloying and a space-holder sintering process. The phase and microstructure analysis was carried out using X-ray diffraction, and scanning electron microscopy, respectively, and the properties were measured using hardness and corrosion testing equipment. Nanostructured Mg-bioceramic composites with a grain size of approximately 40 nm were synthesized. The Vickers' hardness of the bulk nanostructured Mg-based composites was

two times greater than that of the pure microcrystalline Mg metal (50 $HV_{0.3}$). In case of the Mg-based scaffolds with 70% porosity the Young' s modulus was below 30 GPa. The produced bionanomaterials can be applied in medicine.

The work was financed by the Polish National Science Centre under the decision no. Dec2013/11/b/st8/04394.

Keywords: Bionanocomposites, Magnesium, Bioceramics, Microstructure, Properties

PROGRESS IN XPS DIFFRACTION OF DEFECTS DETERMINATION RELATED TO PLZT MICROFIBER SURFACE LAYER GRADIENTS AND ANISOTROPY

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From all published ceramics, single crystals, or polymers particular $(Pb_{0.93}La_{0.07})(Zr_{0.65}Ti_{0.35})O_3$ composition have ever the largest pyroelectric sensitivity suitable for pyroelectric sensors and energy harvesters. The most effective detector form for such applications is micro fiber because of small heat capacitance allowing the short response time even for nano second laser excitation. Unfortunately due to very short diffusion distances of 125 μm from the middle part to the surface, the fabrication of not defected structure in the produced fibers is a real big challenge. The main goal of the present work was the investigation of the damaged structure in a view to get practical knowledge on chemical, physical and structural processes during the fibers manufacturing to effectively prevent its destruction. The well known XPS method elaborated for a surface chemical analysis can be used to analyze the micro fibres defects chemistry across the microfibres volume in the form of line profiling or mapping. Moreover the link between the drop in electrical parameters on one hand and structural properties on the other hand is still missing, consequently the current work focuses on composition reliability issues investigated by the XPS method. The paper offers not only a report of PLZT fibres defects investigation but also a concept to utilize the surface properties material evaluation in cooperation with bulk electrical parameters for the optimized detector performance. Subsequent to the mentioned research, there should be an ability to control technology procedures in the piezoelectric materials manufacturing to effectively convert ambient heat into usable electrical energy, which is an important consideration for many practical applications.

Keywords: Ceramics Fibres, Piezoelectric Ceramics, Extrusion method

THE ROLE OF ALUMINIUM SOURCE (Al_2O_3 / AlN) IN THE SYNTHESIS OF THE Ca-α-SIALON: Eu^{2+} PHOSPHOR

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The purpose of the presented research was to compare the effect of changing the aluminium source in a mixture of initial powders on the final phosphor powder characteristics of Ca-α-SiAlON doped with Eu^{2+}. The phosphor composition was designed as $Eu_{0.048}Ca_{0.752}Si_{9.6}Al_{2.4}O_{0.8}N_{15.2}$ and it was prepared by the reaction in the solid state. AlN and η-Al_2O_3 powders were used as a source of aluminium. The samples were hold for 2 hours at a temperature 1450°C, 1550°C or 1650°C in a reducting atmosphere of N_2+CO. The resultant materials were characterized with XRD, photoluminescence and SEM studies. The microstructure of samples was examined by scanning electron microscopy (SEM). It has been found that the presence of aluminium nitride or oxide in the mixture of initial materials significantly changes the course of α-sialon for-

mation. As a consequence, the final Ca-α-sialon material accommodates europium ions in various positions, and different photoluminescence properties are observed.

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Keywords: wLED, Phosphors, Oxynitrides, Sialon, Photoluminescence

TECHNOLOGY AND APPLICATION OF ALUMINOSILICATE MATERIALS

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Highly activate and selective catalysts are under consideration of many scientific groups around the world. The oxidation of organic compounds contain C=C double bound to the corresponding epoxides is of great relevance because these products are important and versatile synthetic intermediates for the chemical industry. Selectivity of these processes depend on various factors such as oxygen source, solvent, chemical properties of complex (catalyst) and support. Heterogenisation of homogeneous catalysts (transition metal complexes) has become an important strategy for obtaining supported catalysts that retain the active catalytic sites of the homogeneous counterparts while at the same time providing advantages of easy separation, recycling of the catalyst and preventing of active sites leaching. In this study as supporting materials clay, modified clay and zeolite based materials were applied. The comparison of different methods used for preparation of supported catalysts containing transition metal complexes is presented. The effects of support nature and metal ion as well as preparation methodology on catalytic properties of the catalysts will be presented and discussed. The stability of the catalysts, their re-utilization and influence of the preparation methodology on active species leaching will be evaluated. The results of characterization of parent, organo-inorganic hybrid materials as well as materials with complex incorporated will be presented. The catalytic properties of these materials in epoxidation of organic molecules (styrene, α-methylstyrene, 6-cyano-2, 2-dimethylchromene) in liquid phase will be discussed.

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Keywords: Heterogeneous catalysis, Immobilization, Inorganic porous materials, Liquid phase, Oxidation, Transition metal complexes

AFM STUDY OF MgO-MODIFIED BST THIN FILMS

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Ferroelectric materials such as barium strontium titanate ($Ba_{1-x}Sr_xTiO_3$ – BST) exhibit a lot of useful properties. Among others, one can mention the high dielectric coefficients, the large piezoelectric coefficients, and the high pyroelectric coefficient. In addition, the significant non-linearities in electromechanical behaviour, field tunable permittivities and refractive indices, and electrostrictive effects made it possible to apply BST as dielectrics in integrated or surface mounted device capacitors, variety of electromechanical sensors, actuators and transducers as well as infrared sensors and memory applications. A growing interest in ferroelectric materials opens up a broad field for further different applications. In the present study $Ba_{0.6}Sr_{0.4}TiO_3$ (BST) compound was synthesized by the sol-gel method. In addition, BST was doped with 1, 3 and 5 mol.% of MgO. The thin films were deposited by spin-coating on polished stainless steel substrates. The BST thin films were studied in the terms of microstructure and mechanical properties so the influence of MgO dopant on thin films was revealed by atomic force microscopy and nanoindentation.

The present research was supported by the University of Silesia in Katowice, Poland from the funds for science – research potential (NO 1S-0815-001-1-05-01).

Keywords: BST, Mechanical properties, Nanoindentation, Sol-gel, Thin films

FABRICATION AND STUDY OF $Bi_6Fe_2Ti_3O_{18}$ CERAMICS

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One of the very promising approaches to create novel materials is to combine in one material different physical properties to achieve rich functionality. It is commonly known that materials of $Bi_4Ti_3O_{12}$-$BiFeO_3$ system, combine ferroelectric, semiconducting and ferromagnetic properties and are potentially attractive for producing high-performance ceramics for information processing and information storage applications. The aim of the present research was to fabricate and study the properties of Aurivillius phases described with the general formula $Bi_{m+1}Fe_{m-3}Ti_3O_{3m+3}$, where m = 5. This compound has a layered perovskite-like structure in which fluorite-like bismuth-oxygen layers of composition $\{(Bi_2O_2)^{2+}\}_\infty$ alternate with (001) perovskite-like slabs of composition $\{(Bi_{m+1}Fe_{m-3}Ti_3O_{3m+1})^{2-}\}_\infty$. The values of m indicates the number of perovskite-like layers per slab and may take integer or fractional values. The mixed oxide method was employed for the ceramics fabrication. Simple oxide powders Bi_2O_3, TiO_2 and Fe_2O_3 were used for stoichiometric mixture preparation. Parameters of the thermal treatment were determined by simultaneous thermal analysis (DTA/ TG/ DTG). After the calcination process, pellets were formed and pressed into disks with a diameter of 10 mm and 1 mm thickness. Pressureless sintering was used for final densification of ceramic samples. The crystalline structure of the sintered samples was examined by X-ray diffraction at room temperature. Dielectric properties were studied with an analyzer coupled with a cryogenic temperature control system within the temperature range from 130 K to 600 K and the frequency range from nearly DC up to 10 MHz.

The present research was supported by the University of Silesia in Katowice, Poland from the funds for science – research potential (NO 1S-0815-001-1-05-01).

Keywords: Aurivillius phases, $Bi_6Fe_2Ti_3O_{18}$, Ceramics, Dielectric spectroscopy, X-ray analysis

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CHARACTERISTIC OF COMPOSITES FROM THE ZrO_2–Ti SYSTEM PREPARED BY SINTERING IN VARIOUS TEMPERATURES

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One of the most popular ceramic materials is zirconium oxide stabilized with 3 mol.% yttrium oxide. Its main properties are as follows: excellent fracture toughness, high thermal shock resistance, high impact strength and also biocompatibility. Zirconium oxide can be used as a thermal barrier coating or as a construction of dental restorations. Titanium is a metal of low density, high corrosion resistance and high melting point (1668 °C). Applications can be found for titanium in medicine or in aerospace. A combination of both materials: zirconium oxide and titanium gives possibilities to create new, interesting composite with wide application prospect. This work shows the preliminary analysis of composite from the ZrO_2 – Ti system. The samples were prepared from the nano-size ZrO_2 powder stabilized with 3 mol.% Y_2O_3 and 10% by volume Ti powder with a particle size of about 15 μm. The samples were formed by uniaxial pressing and sintering at three temperatures: 1300 °C, 1450 °C and 1550 °C. The physical properties of the prepared samples were measured by the Archimedes method. The microstructure of the composites was characterized by X-Ray diffraction and SEM with EDS analysis. The composites ZrO_2 + 10 vol.% Ti have the low density of about 50% after the uniaxial pressing. The relative density of sintered samples was about 90% of theoretical density. The obtained results of microstructural analysis revealed that Ti reacts with ZrO_2 and solubles in the ceramic matrix. The EDS analysis confirmed that the Zr and Ti are distributed homogenously in analyzed areas. Moreover, tetragonal (t-ZrO_2) and monoclinic (m-ZrO_2) zirconium oxide were identified by X-Ray analysis. The initial ZrO_2 powder was t-ZrO_2 which means that the phase transformation of t-ZrO_2 into m-ZrO_2 occurred.

The work was done in frame of the project financed by the National Center of Science (NCN), project DEC-2013/11/B/ ST8/00309.

Keywords: Zirconium oxide, Titanium, Uniaxial Pressing, Composite

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FABRICATION AND DIELECTRIC PROPERTIES OF CALCIUM MODIFIED $(Pb_{0.75}Ba_{0.25})(Zr_{0.7}Ti_{0.3})O_3$ CERAMICS

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Structural studies of the $(Pb,Ba)(Zr,Ti)O_3$ (PBZT) ceramics were performed by Ikeda who worked out the phase diagram on this base. The investigations were continued by Li and Haertling. It has been found, that ceramics for the range of compositions nearby the boundaries between the ferroelectric (FE) rhombohedral, and tetragonal phases and paraelectric (PE) cubic ones show behaviour being typical for relaxor ferroelectrics. The example of such compositions is PBZT 25/70/30 ceramics. Further investigations revealed that heterovalent additives intensified the behaviour considerably. The scope of the present work is a report from investigations concerning the influence of homovalent modificator on relaxor proporties of the PBZT 25/ 70/ 30 ceramics. The selection of the proper homovalent additive was very important; the literature reports as well as data taken from the periodic table indicated calcium ions, that substitute themselves for the lead ones with high probability. The preliminary investigations showed that the substitution not only changed significantly the microstructure and crystal structure, but also, what is more important, resulted in weakening properties typical for relaxor ferroelectrics. The fact will be widely reported during the lecture.

Keywords: Ceramics, Dielectric properties, Relaxor ferroelectrics

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THE INFLUENCE OF ROTATION SPEED ON THE MICROSTRUCTURE OF Al_2O_3-Ni GRADIENT COMPOSITES FORMED BY CENTRIFUGAL CASTING

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Centrifugal slip casting is a method for powder processing that combines the effects of centrifugation and slip casting. If the particles in the slurry have different densities, due to centrifugal force one can obtain a functionally graded material (FGM). In the experiment the following materials were used: alumina powder (TM-DAR, *d* = 140 nm) and nickel powder of an average particles size of 3 μm. Composite water-based slurries were prepared with 10 vol.% nickel powder with respect to the total solid volume. After homogenization, the slurry was casted into a plaster mold and spinned with different rotation speed. For comparative purposes, a sample was casted without the action of centrifugal force. Subsequently the samples were dried and sintered in a reducing atmosphere at 1400 °C. No new phases were observed after sintering.In order to investigate the stability of slurries, the sedimentation study was performed. Microstructural observation and EDS analysis performed the distribution of metallic particles in the ceramic matrix. Quantitative description of the microstructure of the graded region in the composites was made based on SEM images using computer analysis.

The results presented in this paper were obtained within the project from The Polish National Science Centre (NCN) No. 2013/11/B/ST8/0029.

Keywords: Centrifugal slip casting, Functionally graded material (FGM), Nickel

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THE INFLUENCE OF HOMOGENIZATION AND MICRO/NANO SOURCE OF STARTING POWDERS ON PREPARATION OF THE SINGLE YAP PHASE

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Yttrium aluminium perovskite (YAP) is one of the three phases in the equilibrium binary Y_2O_3-Al_2O_3 system, next to yttrium aluminium monoclinic (YAM) and a well known yttrium aluminium garnet (YAG). RE doped YAG monocrystals are commonly used as a lasing medium for solid-state lasers; powdered or polycrystalline RE:YAG ceramics are used as phosphors. RE doped YAP finds his place as a scintillator. Manufacturing high purity polycrystalline YAP ceramic could replace monocrystalline YAP thus recently it is an interesting task for low cost producers of scintillators. The paper presents influence of different sources of initial oxide powders (micro/nano powders of Y_2O_3 and Al_2O_3) on formation of YAP phase. The solid state reaction and sol-gel method were used to prepare the precursor of YAP mixture. After preheating, all samples in the form of powders and pellets were synthesized in the temperature range of 1000-1650 °C. X-ray diffraction patterns (XRD) were applied for characterization of the phase composition. X-ray microanalysis (EDS) were used to control homogeneity in small areas. Morphology of the resultant samples are presented on SEM pictures. The results show strong influence of starting powders on homogeneity and temperature of formation of the main phase.

The financial support by NCN under the project No: UMO-2013/09/D/ST8/03976 is gratefully acknowledged.

Keywords: YAP, Scintillators, Polycrystalline ceramic

THE INFLUENCE OF SYNTHESIS PARAMETERS ON MANUFACTURING AND PROPERTIES OF $SrSi_2O_2N_2:Eu^{2+}$ POWDERS

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This paper presents the effects of synthesis temperature and time of annealing on properties of the ceramic powders of $SrSi_2O_2N_2:Eu^{2+}$ obtained by the solid-phase reaction. Synthesis was carried out in the temperature range of 1250-1650 °C for 1-4 hours in the nitrogen flow in the reducing atmosphere of a graphite furnace. The powder particle size was determined by the laser diffraction method. The phases present in the resultant powders were identified by X-ray structural analysis (XRD). Scanning electron microscopy (SEM) made possibility to display the changes in the powder morphology as a result of the synthesis. The excitation and emission spectra measurements permitted to characterize phosphors photoluminescence properties. The results show the strong temperature influence on the formation and purity of expected phases. The synthesis temperature also affects the luminescent properties of $SrSi_2O_2N_2:Eu^{2+}$ ceramic powders.

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Keywords: Luminescence, LED, Oxynitrides

CORROSION RESISTANCE OF TITANIUM BASED COMPOSITES REINFORCED WITH *IN SITU* PRECIPITATION TiB_2 PHASE

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The paper presents the results of corrosion resistance tests carried out on titanium based composites reinforced with a different amount of different TiB_2 precipitation phase which was dependent on a boron addition in starting blends. Precursor powder preparation and processing parameters of conventional powder metallurgical approach influence density and porosity of bulk compacts. The potentiodynamic tests performed in the 0.1 M NaCl solution by the technique of linear voltammetry shows visible difference between the compared composite structures. Studies have confirmed that the reinforcement phase amount and its morphology influence the obtained microstructure and has a very important effect on composite corrosion resistance.

Keywords: Corrosion resistance, Titanium based composites, Microstructure, *In situ* TiB_2 reinforcement phase

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PHOTODEFLECTION RESPONCE OF A DENSE LAYER OF CARBON ABSORBING NANOTUBE IRRADIATED WITH BESSEL LIGHT BEAMS

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In this paper, the features of appearance photodeflection signal in the dense layers of absorbent carbon nanotubes such as zigzag and armchair by irradiation of the TE-mode polarization Bessel light beam (BLB). It is shown that the amplitude of the photodeflection signal complicated dependence on dissipative, geometric and thermal parameters of nanotubes, as well as energy, time, and polarization properties of the BLB. The paper considers the possibility of implementing the method of controlling the amplitude of the photodeflection signal by the use of axicons with adjustable cone angle or the realisation of optical schemes with reconfigurable conicity Bessl light beams. Development of methods for the process control photodeflection conversion using the BLB is very promising for nondestructive testing and diagnostics of low-dimensional structures.

Keywords: Nanotubes, Photodeflection, Bessel light beam, BLB

COMPOSITE CATHODE MATERIALS FOR SOLID OXIDE FUEL CELLS

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Slow reduction of oxygen is the main problem in the development of intermediate temperature solid oxide fuel cells. Cathode materials should reveal, at relatively low temperatures, good catalytic activity in ORR, high electronic and ionic conductivities as well as thermal expansion coefficient compatible with the electrolyte. The known cathode materials did not fulfil all these demands. That problem may be overcome using composite materials. Several composite materials were prepared by different routes and investigated. $La_{0.6}Sr_{0.4}Co_{0.8}Fe_{0.2}O_{3-\delta}$ (LSCF) or $Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_{3-\delta}$ (BSCF) powder was added into a solution containing $AgNO_3$, then pH was set by adding NH_3, and finally a reducer was added.

The mixed oxide particles were covered by silver ball-shaped nanoparticles of an average size of 48 nm. The obtained composite powders were mixed with an organic vehicle. The resultant pastes were screen printed on the samaria doped ceria (SDC) electrolyte surface and sintered. BSCF – LSCF, BSCF – Ag $La_{0,6}Sr_{0,4}FeO_{3-\delta}$ – $Sm_{0,5}Sr_{0,5}CoO_{3-\delta}$ (LSF – SSC) composites were prepared by mixing both powders with organic vehicle. Obtained pastes were screen printed on the electrolyte surface and sintered. The prepared composite electrodes were tested as cathodes in the oxygen reduction reaction in the temperature range 500-700 °C, and at different concentrations of oxygen with the application of electrochemical impedance spectroscopy (EIS).

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Keywords: LSCF, BSCF, LSF, SSC, SDC, Composite cathode, SOFC, EIS

LEAD-FREE BFN CERAMICS DOPED BY CHROMIUM, LITHIUM OR MANGANESE

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The material of the study was lead-free $BaFe_{0.5}Nb_{0.5}O_3$ ceramics (BFN) subjected to modification. The base composition BFN was obtained from the simple compounds: $BaCO_3$, Fe_2O_3 and Nb_2O_5, and subjected to doping by chromium, lithium or manganese. Synthesis was performed by the powder calcination method at a high temperature of 1250 °C for 4 h, while the densification was carried out by the free sintering method for 4 h at 1350 °C. A detail study of the influence of admixtures on the crystal structure, microstructure and dielectric properties of the BFN type ceramic samples was performed. The research has shown the that admixtures of chromium, lithium or manganese in the BFN ceramics reduce the maximum of electric permittivity (at the phase transition temperature), simultaneously reducing their high value of dielectric losses.

Keywords: Ferroelectromagnetics, Multiferroics, Lead-free materials, Perovskite type materials

FERROELECTRIC CERAMICS AND COMPOSITES – HOW IT'S MADE?

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Materials showing ferroelectric behaviour are being used in many applications in electronics. A large number of applications of ferroelectric ceramics and ceramic-polymer composites also exploit properties that are an indirect consequence of ferroelectricity, such as piezoelectric or pyroelectric properties. The final properties of ferroelectric ceramic greatly depend upon the processing conditions. Each step of processing has to be carefully controlled to get the best product. During the calcination step, the solid phase reaction takes place, giving the ferroelectric phase. The proper calcination at a right temperature is necessary to obtain the best mechanical and electrical properties. The sintering temperature and time should be optimal for proper densification. For lead containing ferroelectric ceramics (PZT, PLZT, etc.), lead loss occurs at the temperatures above 800 °C. When the ferroelectric ceramic is cooled after sintering, it does not show any piezoelectricity or pyroelectricity because of the random orientations of the ferroelectric domains in the ceramic. The piezoelectric behaviour can be induced in a ferroelectric ceramic by poling. The interest for ferroelectric (piezoelectric, pyroelectric) composites stems from the fact that desirable properties (for example flexibility to conform to a curved surface) could not be obtained from ceramics. The ferroelectric (piezoelectric, pyroelectric) composites are made up of an active ceramic phase embedded in a passive polymer. The properties of the composite depend on volume percent of active ceramic phase in the composite and the connectivity of the phases.

Keywords: Ceramic-polymer composites, Ferroelectric ceramics

TRANSPORT AND CONSERVATION OF HONEY IN ANTIQUITY MATERIAL – CULTURE AND CHEMICAL ANALYSIS

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Honey, with its different traits and uses, was a commercialized good, on par with other important foodstuffs. The first evidence of containers to transport honey date to the Bronze Age, as is recorded on Egyptian frescos of the fifteenth dynasty and on some Mycenae Linear B tablets. Other types of containers used to transport honey are referenced in papyrus of the Ptolemaic era. The ceramic containers recovered by archaeology are of roman and Byzantine time. Identifying them is possible due to the inscriptions (grafitto and *tituli picti*), mostly present on amphorae forms used to transport wine.

As well as selling honey in amphorae and in other medium-long distance transport containers, this product was also stored and sold at a local or regional level, in *instrumenta domestica*, mostly in multifunctional containers or secondary re-usage without specific features that made it possible to distinguish according to functionality. Although it is difficult to recognise the containers used to transport and conserve honey, some specific forms are known, specifically adapted for this purpose, known as honey pots. These vessels are notable due to a particularly pronounced shoulder (rarely two) in the shape of a brim or " eyelash", generally placed at about one third of the superior part of the vessel or near the mouth.

The chemical analysis of honey pots and ceramic beehives from roman period found in current Portuguese territory, from well-known archaeological sites such as *Bracara Augusta* (Braga, *Monte Castêlo* (Matosinhos), *Aquae Flaviae* (Chaves) and Conimbriga give us proof that they were meant for transporting honey, as the ethnographic parallels that exist in the peninsula suggest.

Keywords: Chemical analysis, Gas chromatography, Ceramic beehives, Ceramic artefacts, Archeology

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APPLICATION OF THE SOL-GEL METHOD AT THE FABRICATION OF PLZT:Yb^{3+} CERAMICS

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The aim of the presented study was to obtain of PLZT:Yb^{3+} optoelectro-ceramics. Nanopowders of itterbium doped PLZT materials were synthesized by the sol-gel method from high quality precursors, as lead(II) acetate, lanthanum acetate, ytterbium acetate, zirconium(IV) propoxide and titanium IV) propoxide. Glacial acetic acid and n-propyl alcohol were used as solvents, and acetyloacetone was added as a stabilizer, followed by hydrolysis. Thermal evolution of the dried gel, before and after calcination, was studied by simultaneous thermal analysis. The amorphous gel of PLZT:Yb^{3+} was first calcined in the furnace, mixed in the planetary ball mill, and then pressed into pellets. The compacts were subsequently sintered by the free sintering method at temperature T=1200°C. Morphology of PLZT:Yb^{3+} ceramic powders and samples were studied by transmission electron microscopy and scanning electron microscopy HITACHI S-4700. The stoichiometry of PLZT:Yb^{3+} ceramics was investigated using the chemical composition analysis system EDS. Our study gives a detailed account of the relationships between doping and preparing conditions on the basic physical and chemical properties of obtained ceramic materials.

The present research has been supported by the National Science Centre in years 2013-2016, as a research project No 2012/07/D/ST8/02634.

Keywords: PLZT: Yb^{3+}, Sol-gel, Ceramics

MICROWAVE CERAMIC-POLYMERIC COMPOSITES DEVICES – FERROELECTRICS IN ELECTRONIC

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Ferroelectric materials have shown great promise for microwave applications as tunable devices. So far the most promising ceramic materials were used in the form of thin layers applied to the silica, or alumina substrate. However, in the last decade we note attempts to create liquid crystal polymer (LCP) which operates at high frequencies. These materials, despite the complex technology of preparation, are relatively cheap when compared to ceramic elements based on thin layers applied to a ceramic substrate. Barium strontium titanate, $Ba_xSr_{1-x}TiO_3$ (BST) is the most extensively investigated material to date because of its high tunability and low dielectric losses at room temperature. The study developed ceramic-polymer composites that have the desired properties of barium-strontium titanate (BST), and the flexibility and low loss characteristics provided by the polymer component. Microwave complex systems have been built. The characterized electrical parameters of the composites indicate the potential use in radio communications.

Research funded by the Faculty of Chemistry, Warsaw University of Technology.

Keywords: Ferroelectric composites, Sub-terahertz range, Microwave frequency, Barium strontium titanate

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SYNTHESIS OF YTTRIUM ALUMINIUM GARNET BY THE MICROWAVE COMBUSTION METHOD

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Nowadays an advanced ceramic technology is based on nanopowders. Research centers over the world are exploring and developing new methods to obtain nanometric grains of ceramic powders. Microwave assisted combustion synthesis gives a possibility to receive nanopowders of yttrium aluminium garnet (YAG) in the fast and easy way from an aqueous solution of nitrates of yttrium and aluminium as oxidizer, and urea or glycine as the fuel which are takem in stoichiometric quantities. The synthesis is fast and vigorous; it is assisted by significant amount of gases and flame. The obtained precursor is a basis for further researches. In the Department of Nanotechnology, Institute of Ceramics and Building Materials we took into consideration the influence of quantity and type of fuel on the properties of a final product. Glycine and urea have been investigated as well as its mixtures in different ratios. The synthesized nanopowders were analyzed by XRD and SEM.

Keywords: Nanopowders, Yttrium aluminium garnet, Microwave combustion synthesis

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FERROELECTRIC CERAMIC-POLYMER COMPOSITES FOR MICRIWAVE APPLICATIONS

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Ferroelectric ceramic-polymer composites are a very promising group of materials which can be used in microwave applications. They are able to change their dielectric permittivity. Moreover, they can be used to develop tunable devices operating in a wide range of frequencies up to sub-THz. A typical example of a ferroelectric material is barium strontium

titanate which is applied in microwave technology. Perovskite $Ba_xSr_{1-x}TiO_3$ is a material with a high dielectric constant value (up to 5000) which depends on its purity, grain size, method of preparation and crystallographic direction. Additionally, BST is characterized by a low value of dielectric loss, high mechanical strength, negligible effect of aging and good thermal stability. The characteristic properties of barium strontium titanate make it a key component of a suspension which enables one to obtain thin films by the tape casting method. The obtained ceramic-polymer composites are characterized by suitable thermal stability, durability, flexibility, homogeneous surface, resistance to vibration and are environmentally friendly. For this reason, these materials are competitive in designing many different tunable devices such as antennas, phase shifters and filters. The optimized composition of the slurry enabled to obtain thin and flexible tapes based on barium strontium titanate, prepared by using the solid-state synthesis process and an aqueous polymeric dispersion. The sample made of doped $Ba_{0.65}Sr_{0.35}TiO_3$ had the best microwave properties with tunability of above 25%. Furthermore, the addition of 5 mol.% Ni_2O_3 caused an increase in the tunability value. The barium strontium titanate (BST) thin tape is one of the most promising candidates for applications in electronically controlled microwave tunable devices.

This work has been supported by the Warsaw University of Technology, Faculty of Chemistry.

Keywords: Barium strontium titanate, Ferroelectrics, Tape casting, Ttunability

MAGNETOELECTRIC EFFECT IN $BiFeO_3$-BASED MULTIFERROIC CERAMICS

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Multiferroics are the materials which exhibit at least two ferroic states simultaneously. Especially interesting is the group of magnetoelectrics in which both ferroelectric and magnetic ordering coexist. They exhibit magnetoelectric effect which is manifested by the appearance of electric polarization on applying an external magnetic field or by the appearance of magnetization on applying an external electric field. The possibility of mutual control of magnetic and electric properties is very promising from the industrial applications point of view. The most frequently investigated multiferroic compound is $BiFeO_3$. This is a very rare example of a single-phase material in which ferroelectricity and antiferromagnetic properties coexist in a broad temperature range. However, the existence of a spin cycloid in this compound inhibits a linear magnetoelectric effect. Many current investigations tend to destroy the spin cycloid and to release the inherent magnetization and magnetoelectric coupling in order to improve multiferroic properties of $BiFeO_3$. This may be achieved *e.g.* by structural modifications or deformations introduced by cation substitution or doping. In the presentation, the basics of magnetoelectric effect measurements with dynamic method will be given. In particular, the experimental set-up which allows us to measure the value of magnetoelectric coupling coefficient will be introduced. Moreover, some experimental results obtained for selected $BiFeO_3$-based ceramics, *i.e.* $Bi_5Ti_3FeO_{15}$ and (1-*x*)$BiFeO_3$-(x)$BaTiO_3$, will be presented.

Keywords: Magnetoelectric effect, Multiferroic ceramics, Bismuth ferrite

PREPARATION AND CHARACTERIZATION OF 8/65/35 PLZT:Pr^{3+} CERAMICS

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Luminescent ferroelectric ceramics are very interesting materials for many electro-optical devices. One of them is ferroelectric PLZT ceramics with the perovskite structure, described with general formula of $Pb_{1-x}La_x(Zr_yTi_{1-y})_{1-x/4}O_3$. This lanthanum-modified lead zirconate titanate (PLZT) ceramics are known as materials, to exhibit a range of interesting dielectric, ferroelectric and electrooptical properties. In recent years, there has been an increasing interest in lanthanide-doped PLZT ceramics because of their very interesting properties and various electronic and optical possible applications. This work reports the influence of Pr^{3+} ions (0, 0.1 and 0.5 at.%) on structural, microstructural and spectroscopic characteristics of 8/65/35 PLZT ceramics. The Pr^{3+} ion exhibits a prominent red luminescence from the $_1D^2$ level ($_1D^2 \rightarrow {}_3H^4$ transition) connected with partial and, in some cases, total quenching of $_3P^0$ emission. All ceramic powders were synthesized from high purity raw oxide materials (> 99,9%) by the conventional mixed oxide method. Bulk ceramic samples were sintered

by the presureless sintering and the hot uniaxial pressing method, and the study gives a detailed account of the relationships between doping ions and technology conditions on basic physical properties of the obtained PLZT: Pr^{3+} materials.

The present research has been supported by the National Science Centre in years 2013-2016, as a research project No 2012/07/D/ST8/02634.

Keywords: Ferroelectric material, PLZT, PLZT: Re^{3+}, Luminescent ceramics, Photostrictive actuators

GALLIUM NITRIDE (GaN) – THE SEMICONDUCTOR OF THE 21ST CENTURY

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In forecasting mainstream trends of technology and civilization for the 21st Century, it has been suggested that gallium nitride (GaN), a relatively new semi-conductor, may have the same impact Silicon (Si) had on the second half of the 20th Century (without which today's reality would be hard to imagine). This year's Nobel in Physics to I. Akasaki, H. Amano and S. Nakamura for constructing a blue-light emitting GaN diode confirms the forecast. This discovery by the Nobel winners will enable a dramatic increase in the efficiency of converting electric energy into light, which by 2030 will reduce – according to the American Department of Energy – the consumption of energy for lighting in the USA by almost 50%.

The research into Gallium nitride has been expanding dynamically and it is now evident that this radical new departure in lighting, developed by the Nobel winners, is only the ' tip of the iceberg' of this semi-conductor' s potential – most importantly in tele-communication, energy, optoelectronics, and medicine.

Polish research in these areas is advancing intensively. Research in the areas of physical and technological resource of this relatively new semi-conductor is presently carried out in 11 research institutes; and two companies – Ammono S. A. (Inc.) and TopGaN Sp. z o. o. (LLC) – lead experimental research in the mono-crystalline base of GaN and blue lasers. Poland belongs to the elite group of countries (Japan, Germany, USA, and Poland) who possess comprehensive technology for generating blue lasers.

Several principal results in the areas of GaN research, and the opportunities of its practical application, will be discussed in the presentation. Special note will be drawn to new findings in the GaN phase diagram regarding high pressure and temperature (P to 9 GPa, T to 3400 K).

Keywords: Gallium nitride, GaN, Semi-conductor

INFLUENCE OF BARIUM DOPING ON MICROSTRUCTURE AND DIELECTRIC PROPERTIES OF $SrBi_2Nb_2O_9$ CERAMICS

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$SrBi_2Nb_2O_9$ (SBN) is a layered perovskite ceramic that belongs to the Aurivillius crystallographic family. The structure of the material can be represented by the following chemical formula: $(M_2O_2)^{2+}(A_{n-1}B_nO_{3n+1})^{2-}$, where M represents a cation (usually bismuth). Such a notation points out that the structure consists of two components: perovskite blocks $(A_{n-1}B_nO_{3n+1})^{2-}$, where *n* represents a number of the block layers, and $(Bi_2O_2)^{2+}$ layers distributed alternatively. During the last ten years the increase of the interest in the structure could be observed, however, there is still a shortage of information about the influence of A cation size on electric and dielectric properties of the materials. As it seems to be a promising field, the study is focused on barium impact on structure dielectric features, since barium has the biggest ion radius from divalent metals. To fulfil the lack of information about a correlation between the structure properties and the size of ion in the perovskite block, the $Sr_{(1-x)}Ba_xBi_2Nb_2O_9$ ceramics were synthesised with *x* values as follows: x = 0, 0.01, 0.02, 0.04, 0.06, 0.08 and 0.1. Afterwards a series of tests had been conducted including scanning electro microscopy (SEM) imaging and sample composition analysis, X-ray powder diffraction (XRD) structural characterisation and thermal analysis. The main goal was to determine the characteristics of dielectric properties, and the results turned out to be rewarding. The very thorough analysis of DTA and TG results allow determining the best conditions of thermal synthesis.

The obtained ceramics show well developed grain structures. The grains of the pure SBN ceramic have the lamella-like shape with sharp edges. The outline of grains comes to more rounded, and their thickness increases with increasing the barium content. The EDS analysis confirms the homogeneous distribution of all the elements throughout the grains. The obtained XRD results proved that the Aurivillius structure was preserved even though the doped ion was bigger than originally occurring strontium. The dielectric measurements reveal the significant influence of barium content on the maximum value of dielectric permittivity, and the temperature of that maximum.

Keywords: Ceramics, Dielectric properties, Phase transition, Aurivillius family

STUDY OF DETERMINANT FACTORS OF SILICEOUS ELECTRICAL PORCELAIN RESISTANCE TO STRUCTURAL DEGRADATION

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The subject of this study was investigation of the factors that have a decisive influence on the resistance of siliceous porcelain to degradation processes. There was tested a material of C 110 type which was widely used for the production of low-voltage (LV) elements such as insulators and bushings. On the basis of mechanical-acoustic and microscopic research of small-sized samples, which were subjected to compression, there were distinguished successive stages of degradation of the material structure. In the authors' opinion, they have a reference to the ageing process, taking place during many years of work under operating conditions. Thus, it was possible to assess the structural factors that determine the durability and reliability of LV electroinsulating elements. The results were related to electrical aluminous porcelains.

Keywords: Porcelain insulating materials, Ageing processes, Acoustic emission (AE), Optical microscopy

SYNTHESIS OF $SrBi_2Nb_2O_9$ CERAMICS BY THE MIXED OXIDE METHOD

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A challenge of modern materials science is to develop synthetic methods to prepare oxides with structures and compositions that are not accessible using conventional methods. In the case of layered perovskite oxides, generally described as the Aurivillius phases $[Bi_2O_2]^{2+}[A_{n-1}B_nO_{3n+1}]^{2-}$it has been found that the majority of these oxides were ferroelectric at room temperature as a consequence of the displacement of the B-type cations from the center of the BO6 octahedra. The Bi^{3+} cations in the $[Bi_2O_2]^{2+}$ layers have a stereochemically active $6s^2$ lone pair of electrons that extends towards the perovskite A-site repelling the surrounding oxygen anions. Atomic displacements along the *a* axis from the corresponding positions in the parent tetragonal (*I4/mmm*) structure cause ferroelectric spontaneous polarization. Among the bismuth layer structured ferroelectrics $SrBi_2Nb_2O_9$ (n = 2) (SBN) and its solid solutions have attracted much attention for the development of nonvolatile random access memories and high-temperature piezoelectric transducers since they offer several advantages like better fatigue properties, low operating voltages and low leakage current. In the present study the Aurivillius oxide SBN was synthesized by the mixed oxide method and solid-state reaction. Simultaneous thermal analysis (DTA/ TG/ DTG) and X-ray diffractometry were used for characterization of the synthesis process. Ceramics were sintered by the pressureless sintering. Dielectric properties were studied with an analyzer coupled with a cryogenic temperature control system within the temperature range from 130 K to 600 K and the frequency range from nearly DC up to 10 MHz.

The present research was supported by the University of Silesia in Katowice, Poland from the funds for science – research potential (NO 1S-0815-001-1-05-01).

Keywords: Aurivillius phases, $SrBi_2Nb_2O_9$, Ceramics, Phase and structural analysis

GLASSES REVEAL FUNDAMENTAL MYSTERIES UNDER PRESSURE

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Glass transition constitutes one of the most challenging fundamental mysteries nowadays. This report shows that the long expected understanding breakthrough can approach due to innovative analytic concepts ('*free route model*') matched with high pressure and high temperature (HP–HT) studies up to extreme limits. The consistent insight into both sides of the glass transition (utraviscous/ultraslowing 'liquids' and amorphous solids) lead to a set of findings, such as the prove of Kauzmann temperature empirical existence or lacking so far a link of fragility to basic fundamental properties. It is worth recalling that fragility is considered as the most important metric for any glass former. All these findings are associated with surprisingly large densification, matched with a hardness increase (up to 20%), emerging after HP-HT treatment at an appropriate temperature and pressure below the glass temperature. All these can be preserved after returning to ambient conditions (!). This report presents new results obtained by the authors of the given field, supplemented the sequence of results published within the last 2 years. Surprising consequences for some " classical" ceramic materials are also presented.

Keywords: Glass transition, HP-HT Treatment

DISPERSION OF DIELECTRIC PERMITTIVITY AND MAGNETIC SUSCEPTIBILITY IN MULTIFERROIC AND BIRELAXOR MATERIALS

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In general, multiferroic materials can posses two or more ferroic properties, such as ferromagnetism, ferrolelectricity, ferroelasticity and ferrotoroidicity in the same phase. However, nowadays what most people mean by multiferroic predominantly applies to the coexistence of magnetism and ferroelectricity. Such materials are interesting due to their potential practical applications as well as the possibility to investigate the basics of physical phenomena occurring in them. Many multiferroics exhibit also relaxor properties. Relaxor behaviours are normally associated with the existence of polar nanoregions (PNRs) as a result of nanoscale compositional inhomogeneities. Materials are very rare in which the change of ferroelectric polarization can be controlled by magnetic field at room temperature, and the change is very small. As a result the researchers are looking for the materials in which electric and magnetic properties are connected together. Recently there were described the materials in which the feedback between electric and magnetic subsystems has been realized by rotations of common PNR. For such materials it has been proposed the name birelaxors. One of the major problems in the case of both multiferroics and birelaxors is a large electrical conductivity and high dielectric losses. This is due to the fact that ions, which cause good magnetic properties, provide high electric conductivity and high losses. Therefore, understanding the mechanisms of dielectric dispersion and electrical conductivity may be important during the design and production of new materials, as well as modify the already known compositions. The presentation comprises basic informations about multiferroics, main properties of 'normal' ferroelectric relaxors, characteristics of birelaxors, basics of the theory of dispersion of dielectric permittivity, dispersion of dielectric permittivity in multiferroic and birelaxor materials, and dispersion of magnetic susceptibility in birelaxor materials.

Keywords: Multiferroic, Relaxor, Bi-relaxor, Dispersion, Electric conductivity

SELECTED MODELS OF MODIFIED OXIDE LAYERS FOR TRIBOLOGY

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This paper presents an overview of selected models of anodic oxide layer being pure or modified with nanomaterials. By means of computer image analysis (CIA) the ceramic-graphite composite layer is determined by average of oxide fibers, average distance between the fibres and their shape coefficient. The computer analysis of selected parameters of the oxide layers was carried out in the program ImageJ. Basing on the qualitative CIA and previous models of the literature and our own, 2D and/or 3D 'micro-macro' models of oxide layers were proposed. The oxide layers were formed on alloy EN-AW-5251 and modeled in SolidWorks. A SolidWorks three-dimension model of the oxide layer was done. The layer may be subjected to further modification by pore filling nanomaterial, and the model will be a support in variety of patented (*e.g.* by authors) processes. These 'micro-macro' models can be used in analysis of the layers by a computers simulation finite element method (FEM).

Keywords: Anodic oxide coatings (AO), Composites, Modification nanomaterials, Finite element method, Simulation, Model micro-macro, Computer image analysis (CI1, SolidWorks)

THERMAL PHENOMENA IN THE FRICTION MATERIAL PAIRS TG15 – ANODIC OXIDE COATING

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The paper presents a one-dimensional model of heat conduction in a cylindrical element with a hard anodic coating, when warmed with heat generated by a friction process. The problem of frictional heating is presented to a pair of sliding material, composed of TG-15 (PTFE+15% graphite) and anodic oxide coating on aluminium or its alloys. TG15 material is used for lubrication-free compressor piston rings. The experiment was realized using a linear reciprocating friction tester. The tribological tests with the measurement of temperature near the friction zone were made in parings of TG-15/ cast iron or composite materials. The problem of heat transfer during the friction of composites was solved by the finite difference method (FDM). The simulation of the heat flow generated through the friction was made under the assumption of one-point heat source. On the base of the test, the significant differences between the temperatures near the friction area were found. Some results were obtained by theoretical simulation based on the Fourier-Kirchhoff heat transfer function.

Keywords: Anodic oxide coatings, Composites, Frictional heat, Lubrication-free, Tribological test, Finite difference method, Simulation

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THE COMMERCIALIZATION OF THE TECHNOLOGY OF FABRICATION OF CERAMIC AGGREGATE FROM ASHES AFTER COAL COMBUSTION IN AUTOTHERMAL SINTERING PROCESS

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Since the year 2000 in Białystok and the Warsaw University of Technology, KTCH, within the projects donated from private and public sources, the research was conducted on the economically beneficial handling of combustion by-products both agglomerated in landfills (above 500 millions Mg) in the past years and from current production. The original concept of handling of power plant ashes has been proposed. The concept is based on the production of lightweight sintered

aggregate (LSA) which can be used in building and road constructions and many others. The method of fabrication of sintered ceramic aggregate has been invented, distinguishing itself with low costs of manufacture among other methods. According to this method, the aggregate can be fabricated without any other source of fuel except of the heat coming from combustion of coal which remained in ash. This was possible thanks to two original devices – a streamwise rotary furnace and a vertical shelf dryer, being pivotal for autothermal sintering. A company named LSA sp. z o. o. has been created in Białystok to commercialize the technology. In the years 2012-2014, a factory has been built in Sowlany. The production is 50 thousand Mg per year. The factory is localized near the landfill of power plant ash which provides the amount of ash for about 20 years. The production is in progress and the cost of the aggregate is a little higher than the cost of a natural aggregate, and decidedly lower than the cost of other ash or clay based aggregates.

Keywords: Ceramic aggregate, Combustion By-products, Sintering

MANUFACTURING AND CHARACTERIZATION OF Al,Si-Si_3N_4-C COMPOSITES FOR PADS IN THE AUTOMOTIVE BRAKE SYSTEM

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The paper presents results of studies on manufacturing AK-12-based composites with superior wear resistance and ability to withstand harsh working parameters in the friction couple of the automotive brake system in the sport cars. It has been assumed that against C/C-SiC brake disc, only pads with the chemical composition and similar mechanical properties, could be considered as a counterpart. Consequently, silumin-based composites with coactive reinforcing particles: silicon nitride and glassy carbon has been chosen as a perspective material. Mechanochemical processing of involved powders aiming at formation of composite Al, Si-Si_3N_4 particles and their homogeneous dispersion in the Al matrix, cold isostatic pressing and semi-liquid densification were applied for manufacturing the relevant specimens. Several methods of composite powder characterization were applied in order to find relationship between powder processing parameters and their ability for densification. It has been found that the type of gas atmosphere, temperature and pressure during densification involved various chemical reactions and resulted in formation of the side phases: Al_4C_3, AlN, sialon or Al_2OC. The resultant composites were characterized in terms of their mechanical properties, microstructure and wear resistance under various geometry and applied load. The latter was tested against C/C-SiC counter disc in a special braking machine as well as they were mounted in a sport motorbike and checked in a field-test. It has been found that distribution of Si_3N_4 nanoparticles was sufficient to ensure excellent wear resistance of the resultant specimens. The highest stability of the composites was achieved if sialon formed between the Al, Si matrix and Si_3N_4 reinforcing particles. If AlN in nitrogen atmosphere or Al_4C_3 in argon atmosphere were formed then poor resistance against water environment was observed. Application of glassy carbon led to a stable friction coefficient at a level of 0. 6 without significant changes up to 600°C.

Dr Miklavz Zornik from MS Production (Slovenia) is acknowledged for his helpful discussion and comments as well as for the field tests with the pads prepared in SUT.

Keywords: Al, Si-Si_3N_4 composite, Mechanochemical processing, Glassy carbon

DEVELOPING CERAMIC PAINTS THAT WOULD ENABLE CREATION OF MULTILAYER COATINGS USING THE CMYK COLOUR MODEL

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The project involved developing a series of lead-free fluxes, analysing their thermal expansion coefficient and identifying their characteristic melting points, chemical resistance and the quality of the fired flux surface. A range of ceramic paints was developed on the basis of the selected flux and pigments. Further research involved analysing colour parameters and chemical resistance. Finally colourful patterns were printed out and assessed with regards to the quality of the surface and the obtained colours and their shades.

Keywords: Flux ceramic, Paint ceramic, Triad, CMYK

COLLOIDAL CHEMISTRY IN PROCESSING OF ADVANCED CERAMICS

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Colloidal processes are recently willingly applied in fabrication of high-quality ceramic elements not only of complicated shape but also thin films. Among these we can distinguish *e.g.* preparation of powder for die pressing, tape casting, gelcasting, etc. Gelcasting is a method which combines conventional moulding from slips with polymer chemistry. These methods are used in fabrication of ceramic materials for different applications, *e.g.* ceramic engineering, electronics, bionaterials. Colloidal processes of ceramics and composites require new, effectively working processing agents like deflocculants, binders, organic monomers, etc. The results of studies on the application of new water dispersible binders such as poly(acrylic-styrene), poly(acrylic-allyl) for die pressing and tape casting of Al_2O_3 ceramics will be presented. The properties of these polymers were modified by insertion of selected amphiphilic macromonomers into the polymeric chains. These amphiphilic macromonomers, due to the proper ratio of the hydrophilic to hydrophobic fragments, play the role of not only an internal plasticizer, but they also modify the adhesion of such binders to the ceramic powder particles. The influence of chemical structure of these copolymers on the properties of alumina ceramics will be discussed. Then the investigations on the properties of oxide ceramics obtained by the gelcasting method, using new water soluble acrylic monomers containing hydroxyl groups in their chemical structure, will be also discussed. The author will present the synthesis and application of new organic compounds based on glycerol and saccharides. The synthesized compounds are glycerol monoacrylate, 3-O-acryloyl-D-glucose, 1-O-acryloyl-D-fructose and 6-O-acryloyl-D-galactose. The author with his group has elaborated the synthesis route of acrylic derivatives of saccharides, which have many advantages. They are low-toxic, water-soluble, inexpensive and renewable materials. The research showed that the synthesized compounds could play multifunctional role in gelcasting of ceramic powders: organic monomers able to polymerize in situ, compounds forming self cross-linked polymeric network without external additives and dispersing agents for selected nanopowders.

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Keywords: Colloidal processing, Advanced ceramics, Gelcasting, Tcasting, Die pressing

PEROVSKITE AND PEROVSKITE-LIKE NANOPOWDERS OBTAINED BY MECHANOCHEMICAL SYNTHESIS

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Perovskites and perovkite-like compounds (the best materials for smart structures, sensors and actuators) are conventionally obtained by solid-state reactions or wet-chemistry. The methods are related to high production costs and have serious disadvantages: high-temperature calcinations that are needed in the solid state reactions, and high-temperature processing of sol-gel prepared powders resulting in a coarsening and aggregation of the particles. A much less expensive alternative to the chemistry-based techniques is a direct synthesis from respective oxides at room temperature via mechanically triggered chemical reaction. The room temperature synthesis lowers the fabrication costs, eliminates the undesirable losses of volatile elements and enables the control of chemical and stoichiometry composition. The method has been recently used to obtain nanocrystalline electroceramic materials of perovskite structure. This paper is focused on preparation of simple, doped and solid solution perovskites and perovskite-like compounds (like $BiFeO_3$, PZT, Ba(Ti, $C1O_3$, $Ba(Fe_{1/2}Nb_{1/2})O_3$) by mechanochemical synthesis. The influence of the mechanochemical synthesis or mechanical activation on the final properties of the nanopowders and/ or ceramics (obtained from those powders) has been discussed.

Keywords: Perovskites, Mechanochemical synthesis, Nanopowders, Ceramics

THE EFFECT OF THE PREPARATION PROCEDURE ON THE PHYSICOCHEMICAL PROPERTIES OF COBALT-CERIUM OXIDES MATERIALS

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In the literature, cobalt catalysts promoted with cerium and barium, obtained by co-precipitation, are known as more active than the commercial iron catalyst in the ammonia synthesis process. They exhibit favourable physicochemical properties and can work effectively under milder conditions ($T \leq 400°C$, $p \leq 10$ MPa) than used in the industrial NH_3 plants. These benefits give them some prospects for their potential application. The aim of the studies was to determine the effect of the preparation procedure on the physicochemical properties of cobalt-cerium oxides materials which are precursors of the final cobalt catalysts. Oxides materials were prepared by co-precipitation and subsequent calcination under various conditions. Studies of the influence of several parameters, such as temperature, final pH of precipitation and concentration of starting solutions allowed specyfying the optimal conditions for the preparation of the catalysts precursors. Moreover, the effect of aging time and calcination temperature on properties of the cobalt-cerium oxides materials were examined. The oxide samples were characterized by TG-MS and N_2 physisorption. The obtained results revealed that the physicochemical properties of cobalt-cerium oxides materials depend on the preparation procedure.

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Keywords: Ammonia synthesis, Cobalt catalyst, Co-precipitation

ELECTROPLASTIC DEFORMATION AND SPIN RESONANCE SOFTENING IN METALS

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According to some authors, the impact of electromagnetic fields on deformable solids, in particular, on a metal during its processing or pressure cutting should be attributed to high-energy impacts. However, these effects tend to have relatively low energy – not more than 10^{-4} eV per atom *i.e.* one-two orders of magnitude less energy than a simple mechanical deformation of 10^{-3}-10^{-2} eV or thermal action of 10^{-2} eV. Therefore, it is advisable to refer these factors mostly to the stimulating effects on a solid during deformation, and the main impact is considered from machining and deformation of samples by external mechanical forces, as demonstrated by all methods of metal forming (OMD). The paper summarizes the results of the experimentally established and theoretically informed electro-plastic effect, and shows the principal opportunity to influence the electron subsystem of metals high energy actions in order to control the programmed processes of plastic deformation slip and twinning.

Keywords: Electroplastic deformation, Electro-plastic effect, Electromagnetic fields

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FABRICATION, STRUCTURE AND PROPERTIES OF THE FERROELECTRIC PEROVSKITE CERAMICS DOPPED WITH SPECIAL GLASS

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The aim of the lecture is presentation of the influence of special glass, made from a mixture of simple oxides (PbO, B_2O_3, Al_2O_3, WO_3), on the chemical composition, crystalline structure, microstructure, density and electro-physical properties of a selected (1-*x*)$BaTiO_3$–(*x*)$PbTiO_3$ solid solution. The $(Ba_{0,6}Pb_{0,4})TiO_3$ powders were obtained by using the solid-phase synthesis, reaction. After synthesis the initial powders were dopped with the special glass in proper stoichiometry and milled for 16 hours. Next, the obtained powders were pressed into the form of disk. The compacts were sintered by the conventional sintering method. The XRD measurement confirmed the single phase tetragonal structure (*P4mm*). The samples were used to dielectric and DC conductivity measurments. The results of investigations revealed very interesting behaviour, caused by the partial substitution of Ti^{4+} ions in the base composition with the W^{6+} ions from the glass. The presence of wolfram ions led to appearing the PTCR effect.

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Keywords: $(Ba_{0,6}Pb_{0,4})TiO_3$, ferroelectric ceramics, Perovskites, Special glass

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INTERNAL FRICTION PHENOMENA IN COMPOSITES BASED ON PZT-TYPE FERROELECTRIC POWDER AND FERRITES

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The aim of the work was to determine the phenomena of internal friction (mechanical losses), occurring in ferroelectric-ferromagnetic composites created basing on a PZT-type ferroelectric powder and ferrite. The composites were obtained using ceramic powders – multi-component PZT-type solid solutions with ferroelectric properties. Their magnetic component included zinc-nickel powder $Ni_{0.64}Zn_{0.36}Fe_2O_4$. Test specimens of 30 × 10 × 1 mm^3 were obtained using free sintering. Temperature $Q^{-1}(T)$ and amplitude $Q^{-1}(\varepsilon)$ internal friction dependencies were determined. Wide high tem-

perature maxima were observed with regard to the internal friction temperature dependencies obtained for the tested specimens. The conducted measurements of amplitude (isothermal) dependencies of internal friction $Q^{-1}(\varepsilon)$ for the tested composites have allowed for interpreting the previously observed maximum on the temperature dependencies of internal friction.

Keywords: Internal friction, PZT ceramics, Ferrites, Ferroelectric-ferromagnetic composites

FABRICATION AND STRUCTURE OF $LaMnO_3$

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Perovskite type $LaMnO_3$ (LMO-based ceramics) is one of the most widely studied compounds due to its many useful properties and behaviours which include promising colossal magneto-resistance (CMR), metal-insulation (MI), charge ordering (CO), and magnetoelectric coupling. The interplay among magnetic, transport and structural properties gives rise to the above mentioned complex phenomena. In view of the above mentioned promising applications, there are many interesting modifications of LMO that have been reported to optimize its physical properties. In this paper we report the influence of technological aspects on the crystalline structure and microstructure of the $LaMnO_3$ (LMO) based ceramics. The synthesis of ceramic powders was conducted by the reaction method in the solid phase from the simple oxides – La_2O_3 and MnO_2. The oxides after weighing in the stoichiometric amounts were ground in a ball mill of the Fritsch firm for 15 hours with an addition of propyl alcohol. The powder synthesis was performed at 1173 K for 24 h after pressing the oxide mixtures into discs of $2 \cdot 10^{-2}$ m in diameter and about $3 \cdot 10^{-3}$ m in thickness. The synthesis conducted in such a way made the initial components to react precisely. To densify the ceramic specimens, two methods were used: the conventional sintering method and the hot pressing one. The influence of preparation conditions on properties of the synthesized manganites was investigated by using X-ray diffraction, scanning electron microscopy (SEM), and energy dispersive X-ray spectroscopy (EDS).

Keywords: EDS, LMO-based ceramics, SEM

INFLUENCE OF SN AND PB SUBSTITUTION ON THE DIELECTRIC PROPERTIES OF BARIUM TITANATE

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The results of structural and dielectric measurements performed for polycrystalline samples of $(Ba_{1-x}Pb_x)(Ti_{1-x}Sn_x)O_3$ (BPTSx) (x = 0.5%, 10%, 30%) are presented. The samples were obtained by a high temperature synthesis and their expected stoichiometry has been confirmed by energy dispersive spectroscopy (EDS) measurements. The dielectric properties of BPTSx were studied using broadband dielectric spectroscopy. The measurements over a wide range of temperatures from 140 K to 600 K and frequencies from 0.1 Hz to 10 MHz were performed. Paraelectric – ferroelectric diffused phase transitions (DPT) (for x = 10% and 30%) were observed. From electric modulus measurements in the frequency domain, the relaxation times and activation energy were determined.

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Keywords: Barium titanate, Ceramic, Dielectric properties

ELECTRET-THERMAL ANALYSIS OF LIQUID DIELECTRIC BIOMATERIALS

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The electret-thermal analysis was used for study electro-physical properties of specific biomaterials – food vegetable oils (sunflower, rapeseed, palm, palm-kernel). The methodological applicability of electret-thermal analysis for this purpose is justified because oils are liquid dielectric media, in which the polarization takes place under certain conditions. It has been established that each oil showed individual spectrum of thermally stimulated current with peaks of 10^{-12}-10^{-11} intensity, that were differently displaced on the temperature the scale in the range 25-100 °C. Available data about the oils composition of the oils have made possible an idea of the existence of metastable associates, that unite molecules of fat acids triglycerides. The associate's destruction under heating was accompanied by the liberation of electrical charges and the occurrence of current. The associate's thermal stability is controlled by the type of fat acid which enters triglycerides chiefly into the composition – saturated, mono-unsaturated, or poly-unsaturated. Evidently, the associate's thermal stability grows in the mentioned row, and this has been registered as the current peaks shift to the high temperature range. The comparative contain of any associate type is also limited by the fat acids composition, and is estimated by the intensity of the corresponding current peak. Data on the electro-physical properties can add information about the terms of oils quality.

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Keywords: Electret-thermal analysis, Vegetable oil, Thermally stimulated current, Metastable associates

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CERAMIC-POLYMER SUSPENSIONS DESIGNED TO DISSIPATE ENERGY

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Due to high expectations of the civilization in such areas as electronics, medicine and sport, the significant progress of science has been done. As a result of synergy of chemistry of polymers, chemistry of colloids, nanotechnology and metallurgy, the advanced ceramics based on composite materials were established. A good example of an innovative ceramic-polymer composite is shear thickening fluid (STF) which has the ability to suppress and dissipate an impact energy. The typical property of this type of liquids is an increase in viscosity with increasing shear rate. Generally, the increase in fluid resistance, as a result of an external force, causes problems with flow in technological installations. On the other hand, shear thickening fluids can be widely used in the production of the systems for protection of the human body, mainly dedicated for representatives of the uniformed services and sportsmen. This work is devoted to the development of composition and analysis of the rheological properties of STF based on silica dispersed in various organic liquids with polymeric additives. The aim of the research was to verify applicability of the final suspensions to produce liquid armor. Herein we present the studies on the effects of concentration of solid loading, addition of dopants, temperature and time on the rheological properties of suspension. We also show the results of energy absorption test.

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Keywords: Liquid armor, Rheology, Shear thickening fluids, Viscosity

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