Book of Abstract

APMAS 2022

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12th International Advances in Applied Physics & Materials Science Congress & Exhibition (APMAS 2022)

13-19 October 2022

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Jan PRZYBYSZ	Central Institute for Labour Protection – National Research Institute, Poland
M. Alper SAHINER	Seton Hall University, USA
Neil MATHUR	University of Cambridge, USA
Vladimir POPOK	Aalborg University, Denmark

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PLENARY SPEAKERS

Id-1918

Solar Hydrogen Production at Scale: Materials and Systems

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Abstract: Solar water splitting is a promising approach to store sunlight into renewable, sustainable and green hydrogen energy, which is expected to play a pivotal role in realizing C (carbon, climate) – neutral society by 2050. There is an urgent societal need to develop the technology in its early stage into a practically viable one for large scale dissemination. There are three representative ways of transforming solar radiation into molecular hydrogen – photocatalytic (PC), photoelectrochemical (PEC), and photovoltaic–electrolysis (PV-EC) routes. Although these technologies are in their different stages of development and therefore have relative advantages and disadvantages, all of them need substantial further developments through basic and applied researches to become the final winner of the practical solar hydrogen production technology. In this talk, the scientific and technological progresses in this research area last two decades are discussed mostly based on the researches in my laboratory, and perspective for future developments is provided especially on the scale-up and dissemination of the solar hydrogen production technology [1,2].

Keywords: Solar Hydrogen, Water Splitting, Scale-Up, Photoelectrochemical Cell, Photovoltaic-Electrolyzer

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[2] J.H. Kim, J.S. Lee, "Elaborately Modified $BiVO_4$ Photoanodes for Solar Water Splitting" *Adv. Mater.* 1806938 (2019)

PLENARY SPEAKERS

Id-1928

Formation and Applications of Polymer Films with Gas-Phase Aggregated Nanoparticles

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Abstract: Among many physical and chemical ways of nanoparticle (NP) synthesis, the gas-phase aggregation method, also known as cluster beam technique [1, 2], has a number of advantages. It provides: (i) very good control of composition allowing for formation of homoatomic, alloy and compound NPs; (ii) absence of impurities and monocrystallinity; (iii) tuning of structure and shape (possibility to form core@shell, Janus- and dumbbell-like, spherical or cubic etc. NPs); (iv) good control of particle sizes by adjusting the aggregation parameters and using mass-filtering systems; (v) easy tuning the surface coverage or filling factor of NPs on the surface or inside a thin film; (vi) capability to form patterned nanostructured coatings with gradients of NP surface density. The listed above advantages make the gas-phase NP aggregation to be very attractive method for many research areas. However, one of the drawbacks is relatively low production rate which currently limits wide use of the cluster technology in industry. Combining the cluster beam technique with synthesis of polymers opens a way for the formation of novel composite materials. Such properties of polymers like plasticity, flexibility, easy processing and low weight allow to enhance the functionality of the nanoscale structures in terms of mechanical, electrical, optical and other characteristics as well as to add to convenience of practical use [3, 4]. The talk will overview the methods on combining the cluster beam techniques with either *in situ* or *ex situ* polymer synthesis addressing the cons and pros of different technological routes to form composite films. The important applications of polymer films and coatings with gas-phase aggregated NPs will be discusses covering the following areas: (i) tuning the surface roughness and wettability for biological and medical purposes; (ii) utilizing localised surface plasmon resonance for enhanced optical detection; (iii) controlling electrical conductance to build actuators, strain gauges and chemical sensors. The talk will also discuss the challenges in formation of novel polymer-based nanostructured composite materials and provide an outlook.

Keywords: Nanoparticles, Polymer Films

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PLENARY SPEAKERS

Id-2210

Quantum Machine-Learning for Electronic Structure Calculations of Quantum Materials

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Abstract: In this talk, I will focus on quantum machine learning, particularly the Restricted Boltzmann Machine (RBM), as it emerged to be a promising alternative approach leveraging the power of quantum computers. Such algorithms have been developed to solve problems like electronic structure calculations of molecular systems and spin models in magnetic systems. Herein we demonstrate a quantum algorithm that can filter any energy eigenstate of the system based on either symmetry properties or a predefined choice of the user. The workhorse of our technique is a shallow neural network encoding the desired state of the system with the amplitude computed by sampling the Gibbs−Boltzmann distribution using a quantum circuit and the phase information obtained classically from the nonlinear activation of a separate set of neurons. We implement our algorithm not only on quantum simulators but also on actual IBM-Q quantum devices and show good agreement with the results procured from conventional electronic structure calculations. We thus expect our protocol to provide a new alternative in exploring the band structures and dynamics of quantum materials.

Keywords: Quantum Machine Learning for Quantum Materials.

PLENARY SPEAKERS

Id-2222

Large Electrocaloric Effects in PST Multilayer Capacitors Over a Wide Range of Useful Temperatures

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Abstract: Electrocaloric effects are thermal changes that can arise with good reversibility in a material whose electrical polarization is suitably modified by a change of electric field. Electrocaloric effects tend to be large near absolute zero in paraelectrics, and at finite temperatures near ferroelectric phase transitions and in relaxors. Separately, electrocaloric effects tend to be large in thin films because breakdown fields are generically large. When many thin films are combined into a multilayer capacitor (MLC) then one has a macroscopic working body for pumping heat in cooling and heating devices. In this talk, I will introduce electrocaloric effects and their history. I will then describe electrocaloric MLCs of $PbSc_{0.5}Ta_{0.5}O_3$ (PST) that outperform the Gd working bodies in magnetocaloric prototypes. These MLCs display large voltage-driven changes of temperature (up to 5.5 K) over a wide range of starting temperatures (over 3 K across 176 K).

Keywords: Electrocaloric.

INVITED SPEAKERS

Id-1915

Low Field Microwave Absorption in Novel Spin Systems: Magnetics to Multiferroics

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Abstract: Microwave absorption is highly sensitive for small magnetic fields (0-100 Oe), which is now well known as Low field microwave absorption (LFMA). This Phenomenon was first reported in half metallic manganites [1,2] and later in several other magnetic systems. Since then LFMA has emerged as a powerful tool to probe the novel spin systems and has become a very useful characterization tool that can give additional information on certain novel spin systems [2]. Here we present and discuss our recent advancement of LFMA technique to probe multiferroics, namely, First detection of low field microwave absorption in the disordered multiferroic double perovskite $BiFe_{0.5}Mn_{0.5}O_3$ [3]. We studied the exotic magnetic phase in this system. Our study shows that the hysteresis in LFMA signals vanishes above 45 K, while the bulkM-Hloop hysteresis, persists till room temperature. The temperature at which LFMA hysteresis vanishes qualitatively corresponds to the temperature at which the local second order mechanism responsible for magnetization reversal (MRV) maximum. We further discuss our recent results on the nano BFO system, and how spin canting plays an important role on LFMA in this system. Thus, through this talk, we show that the LFMA as an emerging phenomenon in the magnetics associated in multiferroic systems.

Keywords: Low Field Microwave Absorption, Multiferroics, Exotic Magnetism.

References

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INVITED SPEAKERS

Id-1923

Fabrication of 3-Dimensional ZnO-Si Hierarchical Nanowires Anchored with CdS-Shell for Sustainable Solar Fuel Generation

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Abstract: We have studied sequential fabrication of a three-dimensional hierarchical structure high quality ZnO nanowire (NW) on patterned silicon NWs (ZnO-Si HNWs) [1] realized using Metal Organic Chemical Vapor Deposition (MOCVD) for photoelectrochemical (PEC) water splitting. The photocurrent density of ZnO-Si HNWs was enhanced (75.02 μA/cm^2 at 1 V vs Ag/AgCl) compared to ZnO NWs on planar Si (26.21 μA/cm^2 at 1 V vs Ag/AgCl) due to augmented surface area. The randomly oriented ZnO NWs increased the scattering of the incident light in the HNWs and enhanced the photoabsorption in the limited volume of ZnO. However, for a viable and commercial PEC based applications these improvements are not sufficient. Therefore, to enhance the photoelectrochemical water splitting performance of ZnO-Si HNWs, visible light active CdS anchoring on the ZnO NWs was carried out using successive ionic layer adsorption and rinsing method for various cycles (20, 40, 60, and 80). Then to improve the crystallinity of CdS shell/nanoparticles, these CdS/ZnO-Si HNWs were annealed at 350 °C in N_2 ambient. The fabricated structure was sequentially analyzed by using SEM, XRD, PL, XPS, and TEM to get confirmative insights. 60 CdS/ZnO-Si HNWs shown superior photocurrent density (3.04 mA/cm^2 at 1 V vs Ag/AgCl), photoconversion efficiency (1.79 %) as well and presumably long term photostability (over a period of 11 h). We believe that this work will lead to the efficient utilization of well-designed hierarchical nanostructures in the fields of energy conversion and energy storage.

Keywords: ZnO, Si, hierarchical, nanowire, CdS, photoelectrochemical

References:

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INVITED SPEAKERS

Id-1944

Chiral Induced Spin Selectivity in Hybrid Heterostructures Composed of Magnetic Thin Film with Adsorbed Chiral Molecules

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Enantioselectivity is ubiquitous in nature and many of the molecules in plants and living organisms have their properties depending on the type of enantiomer. Chiral recognition and enantiomeric selectivity, both in nature and in artificial systems, are commonly assumed to be related to a spatial effect. Accordingly, chromatography-based enantioseparation requires the chiral substrate to be adjusted so as to interact optimally with a specific enantiomer . Indeed, enantioseparation is an extremely important process in the pharmaceutical and chemical industries. However, despite intensive efforts, obtaining enantiomerically pure synthetic materials remains a challenge, as the cost of separation is relatively high and an extensive effort is required. We have demonstrated [1] a new effect of magnetization switching of ferromagnetic thin film without applying a magnetic or electric field but being induced solely by adsorption of chiral molecules. In this case, about 1013 electrons per cm2 are sufficient to induce magnetization reversal. The direction of the magnetization depends on the handedness of the adsorbed chiral molecules Here magnetization switching of FM thin layers is induced solely by adsorption of chiral molecules (magnetism induced by a proximity of adsorbed chiral molecules- MIPAC). The local magnetization switching is achieved by adsorbing the chiral molecules as a self-assembled monolayer (SAM) on a gold-coated FM layer with perpendicular magnetic anisotropy. The direction of the magnetization depends on the handedness of the adsorbed chiral molecules. Owing to spin-selective electron transfer, the FM layer underneath the SAM molecules becomes spin polarized, and hence magnetization direction is determined. It is commonly assumed that recognition and discrimination of chirality, both in nature and in artificial systems, depend solely on spatial effects. However, recent studies have suggested that charge redistribution in chiral molecules manifests an enantiospecific preference in electron spin orientation. Therefore it is possible that the induced spin polarization may affect enantio-recognition through exchange interactions. We have shown experimentally [2] that the interaction of chiral molecules with a perpendicularly magnetized substrate is enantiospecific. Thus, one enantiomer adsorbs preferentially when the magnetic dipole is pointing up, whereas the other adsorbs faster for the opposite alignment of the magnetization. The interaction is not controlled by the magnetic field per se, but rather by the electron spin orientations, and opens prospects for a distinct approach to enantiomeric separations. The enantioselective interaction of chiral molecules and a magnetic substrate with perpendicular anisotropy provides a potentially generic chromatographic method for enantioseparation, which does not require a specific and costly separating column. As the observed

effect depends on the electrical polarizability of the system (that is accompanied by spin polarization) and because this polarization depends on the global structure of the chiral molecule, this new method may also allow the separation of chiral molecules from a mixture of molecules, either chiral or achiral.

Keywords: Nanomagnetism, Spin Polarisation, Chiral Molecules, Magnetic Thin Films

References:

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INVITED SPEAKERS

Id-1945

Transverse-Electric Filled in a Waveguide Filled with Space-Time Modulated Magnetodielectric Medium

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Abstract: Problems related to the propagation of electromagnetic waves in a waveguides of an arbitrary cross section filled with a non-stationary and inhomogeneous magnetodielectric medium (the permittivity and permeability of the medium are functions of coordinate z and time t) $\left(\varepsilon\left(z,t\right),\mu\left(z,t\right)\right)$ are of great importance in electromagnetic theory (especially when dependences $\varepsilon\left(z,t\right)$ and $\mu\left(z,t\right)$ have periodic character). This is due to the need to develop the theory and the great possibility of practical application of such waveguides in microwave electronics [1-4]. This work is devoted to the consideration of the propagation of transverse-electric waves (TE) $\left(E_z=0,H_z\neq 0\right)$ in an ideal regular waveguide of arbitrary cross section. It is assumed that the waveguide is filled with a magnetodielectric medium modulated in space and time. For the longitudinal component of the magnetic vector (this component completely describes the TE field in the waveguide) a second-order partial differential equation with variable coefficients is obtained from the system of Maxwell equations. It looks like

$$\frac{\partial^2 H_z}{\partial x^2}+\frac{\partial^2 H_z}{\partial y^2}+\frac{\partial}{\partial z}\left(\frac{1}{\mu}\frac{\partial\left(\mu H_z\right)}{\partial z}\right)-\varepsilon_0\mu_0\frac{\partial}{\partial t}\left(\varepsilon\frac{\partial\left(\mu H_z\right)}{\partial t}\right)=0,$$

(1)

where $\varepsilon_0=\left(1/36\pi\cdot 10^9\right)\left(F/m\right)$ is the electric constant, $\mu_0=\left(4\pi/10^7\right)\left(H/m\right)$ is the magnetic constant. Further the equation (1) with help of change of variables is reduced to an ordinary differential equation of the second order with variable coefficients. If there is a small parameter in the problem under consideration, then expanding $\varepsilon\left(z,t\right)$ and $\mu\left(z,t\right)$ in this small parameter and simultaneously expanding $H_z\left(x,y,z,t\right)$ in terms of eigenfunctions $\psi\left(x,y\right)$ of the Neumann boundary value problem for the waveguide cross section from the wave equation (1) we can find an analytical expression for $H_z\left(x,y,z,t\right)$. It is curious to note that in the case of the TE field in the waveguide, all the transverse components of the electric and magnetic vectors can be expressed in terms of $H_z\left(x,y,z,t\right)$. In fact, from the system of Maxwell's equations using the expansion of all

components of vectors $\vec{H}(x,y,z,t)$ and $\vec{E}(x,y,z,t)$ in terms of functions $\hat{\psi}(x,y)$, analytical expressions for the transverse components of the magnetic b electric vectors are obtained. Calculations lead to the following:

$$\vec{H}_{\tau}(x,y,z,t)=\frac{1}{\mu(z,t)}\cdot\sum_{n=0}^{\infty}\hat{\lambda}_n^{-2}\cdot\frac{\partial\left(\mu(z,t)H_n(z,t)\right)}{\partial z}\cdot\nabla\hat{\psi}_n(x,y),$$

(2)

$$\vec{E}_{\tau}(x,y,z,t)=\mu_0\cdot\sum_{n=0}^{\infty}\hat{\lambda}_n^{-2}\cdot\frac{\partial\left(\mu(z,t)H_n(z,t)\right)}{\partial t}\cdot\left[\vec{z}_0\nabla\hat{\psi}(x,y)\right],$$

where $\nabla=\vec{i}\left(\partial/\partial x\right)+\vec{j}\left(\partial/\partial y\right)$, $\vec{Z}_0$ is the unit vector of the axis oz, index τ indicates transverse components. It should be noted that the obtained analytical expressions (2) for the transverse components of the electric and magnetic vectors of the TE field are of great importance in solving the problems of radiation of sources moving uniformly in a waveguide with a spatially and temporally modulated filling. They can be used to calculate the radiation energies using the Poynting formula.

Keywords: Transverse electric field, waveguide, propagation, Maxwell's equations, wave equation, magnetic vector.

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INVITED SPEAKERS

Id-1947

Investigating Sn Whisker Growth From SnAgCu Composite Solder Joints

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Abstract: Transition to lead-free solder materials resulted in the widespread use of the SnAgCu (SAC) solder alloys. In the past ten years, solder paste researchers tried to reduce the Ag content in the SAC solder alloys due to the high price of Ag and the thermo-mechanical problems caused by Ag_3Sn intermetallics. A good candidate is the Sn99Ag0.3Cu0.7 (SAC0307) low-silver content solder alloy, which is already used by the electronics industry. The most novel solution to improve further the solder alloys' properties is the use of nano-sized ceramic reinforcement particles, which results in „nano-composite" solder joints. A wide range of ceramic particles was already used, like TiO_2, ZrO_2, Al_2O_3, Fe_2O_3, Si_3Ni_4, SiC, La_2O_3, etc. Usually, the reinforcements increase the solder joints' quality (like mechanical properties), but the reliability of the composite solder joints has not been investigated deeply. Sn whiskers are spontaneously forming at the surface defects on the pure or high tin content solder joints or surface finishes. Their dimensions are usually between 0.5–3000 μm, so they can cause reliability risks in microelectronics via short circuit formation. The driving mechanism of the whisker growth is always a kind of mechanical stress in the Sn grains. It could originate from a direct mechanical load, thermo-mechanical effect, residual stress, or from volumetric changes in the Sn layer by oxidation or IMC formation. They cause serious reliability problems since they can form short-circuit failure between the leads of the electronics components.

In the present study, Sn whisker growth from SACX0307-(SiC/ZnO/TiO_2) nano-composite solder alloys were studied. The SACX0307 solder alloy was reinforced by 0.25-1wt% SiC, ZnO, and TiO_2 nano-particles. Primary particle sizes <50nm were used. The nano-particles were mixed into the solder paste homogeneously using the ball milling process, which was carried out for 10 min at 300 rpm using a planetary ball mill. Solder joints were prepared from the alloys by convectional surface mounting technology. PCB test board with Ag surface finish on the solder pads and 0603 chip resistor components were used. The solder joints were exposed to an accelerated lifetime test (85ºC/85RH% THB, 4000h) to enhance the Sn whisker growth. The Sn whiskers were checked at each 500h of the test by Scanning Electron Microscopy (SEM). The grain structure (β-Sn and intermetallics) of the under the Sn whiskers was investigated on metallic cross-sections by SEM and Scanning Ion Microscopy (SIM). Preliminary results show that the nano-particles limit the Sn whisker growth (in

the function of the wt%.), which could be related (but not exclusively) to the considerable grain refinement effect of the nano-particles. This phenomenon modifies the grain boundary/interfacial properties of the solder joints.

Keywords: reflow soldering; Sn whisker, ceramics, composite solder alloy, SEM.

INVITED SPEAKERS

Id-1988

AI & Cyber Technology for Advanced Engineering - An Approach For Improvement in Semiconductor Production

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Abstract: Understanding the role of AI infrastructure and its approach in engineering (e.g., in materials science, composites engineering and design, structural health monitoring, hydrodynamics, and semiconductors) goes back several years. AI is often referred to as the standard method for robotics and human-machine interaction (HMI). Of course, the fundamentals of AI and knowledge-based systems (KBS) belong to this history and contribute to some major tasks in robotics, computer vision and smart factories today. Novel developments of different research areas need to be adapted to this technical environment, for example, the approach of cognitive science and the integration of other capabilities such as machine learning (ML), deep learning (DL), decision making, knowledge discovery from text (KDT), and recommender system (RS). The semiconductor industry has been in high demand recently and production is increasing rapidly. Sensitive production needs strong analytics to ensure smooth production. For this, possible production errors must be detected at an early stage. One approach is to analyze documents (of different areas such as production development and design, production line logs, etc.) based on AI-supported techniques. For example, word association techniques are able to analyze generated and archived documents from production and prepare them in a meaningful way to respond intelligently to search requests. In addition, specialized text mining techniques such as sentiment analysis enable improved search such as the error detection by determining negative or positive weighting of text from documents. In addition, engineers are applying AI to archive their existing knowledge in meaningful way (knowledge transfer), partly in industrial archives (in the form of diverse documents) and partly via cloud solutions on the Internet. Large companies have realized that the most costly knowledge for recursive processes can be found in documents that were previously already created and open a path for a smooth production line.

Keywords: Artificial Intelligent, Knowledge Technology, Semiconductors, Applied AI in engineering.

INVITED SPEAKERS

Id-1996

The Potential of Biomimetic Cabbage Leaves in Preventing Biofouling of Escherichia coli AND Listeria monocytogenes

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Abstract: Food contact surfaces are usually colonized by microorganisms, even following cleaning and disinfection. They can grow as biofilms, which are contamination sources of finished products, reducing their shelf life and causing foodborne diseases. One way to reduce fouling is to design naturally cleaning surfaces based on biomimetic designs. Four self-cleaning leaves (Tenderheart cabbage, Cauliflower, White cabbage, and Leek) were analysed for their surface properties. The leaves and artificial replicates were subjected to attachment, adhesion and retention assays using Escherichia coli and Listeria monocytogenes. All the surfaces were non-wettable (water contact angles higher than 100 °), with the biomimetic Tenderheart cabbage demonstrating the most non-wettable surface. However, when the hydrophobicity of the surfaces was determined, the White cabbage was demonstrated to be the most hydrophobic surface (ΔG_{iwi} ≈ - 88 mJ m^{-2}). The natural White cabbage also presented the lowest roughness values (S_q = 3.5 µm), although the corresponding replica was the roughest of the fabricated surfaces (S_q = 5.3 µm). L. monocytogenes were generally bound to the surfaces in lower numbers than E. coli. The Leek leaves retained more E. coli cells than the other cabbages, and the Tenderheart cabbage promoted E. coli attachment and adhesion. Therefore, for E. coli, surface hydrophobicity was not a controlling factor in the bacterial retention, attachment and adhesion. The Leek leaves retained more culturable L. monocytogenes cells than the other cabbage leaves, suggesting a correlation between surface hydrophobicity and the retention and attachment of L. monocytogenes. Overall, the biomimetic surfaces were more efficient at avoiding bacterial retention than natural leaves.

Keywords: Biomimetic Surfaces, Fouling, Biofilms, Escherichia Coli, Listeria Monocytogenes

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INVITED SPEAKERS

Id-2015

Engineering of Magnetic Properties of Co-rich Microwires by Post-processing

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Abstract: Amorphous glass-coated microwires can present excellent magnetic properties such as magnetic bistability, enhanced magnetic softness and Giant Magnetoimpedance (GMI) effect and fast domain wall dynamics. Excellent magnetic softness and GMI effect have been reported for Co-rich microwires [1].We present our recent experimental results on influence of stress- annealing on magnetic softness and GMI effect in Co- rich glass-coated microwires. The influence of post-processing (annealing and stress-annealing) on the magnetic softness, Giant magnetoimpedance (GMI) effect and domain wall dynamics of Fe3.6Co69.2Ni1B12.5Si11Mo1.5C1.2 glass-coated microwires is studied. As-prepared Co-rich glass-coated microwire presents linear hysteresis loops and rather higher magnetoimpedance ratio with double-peak dependence, typical for materials with transverse magnetic anisotropy. Considerable magnetic hardening and transformation of linear hysteresis loop with low coercivity (Hc ≈ 4 A/m) into rectangular with Hc ≈ 90 A/m upon annealing without stress is observed. However, we observed remarkable MI effect improvement at certain annealing conditions.

Stress-annealing of studied microwire allows considerable magnetoimpedance ratio and domain wall velocity increasing. Additionally, remanent magnetization growth and coercivity decrease are generally observed upon stress annealing. Frequency dependence of maximum GMI ratio for as-prepared and annealed samples is evaluated. The obtained frequency dependence of the maximum GMI ratio allows determination of the optimal GMI measurement conditions for each sample. The observed stress-induced anisotropy and related changes in magnetic properties are discussed considering the internal stresses relaxation and “back-stresses”.

Keywords: magnetic microwires, Giant magnetoimpedance, domain wall propagation

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INVITED SPEAKERS

Id-2023

Second Harmonic Generation in Poled Glasses: Conventional Views And New Insights

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Abstract. It is widely believed that the generation of the optical second harmonic (SH) in thermally poled glasses occurs due to the electric field of a spatial electric charge formed because of mobile cations displacement from their initial positions, the displacement being “frozen” in the glasses after cooling due to kinetic restrictions. Respectively frozen electric field and third-order nonlinear susceptibility of isotropic glasses create an effective second-order nonlinear susceptibility responsible for the generation of SH. To characterize the behavior of poled glasses, the Maker fringes technique was used in combination with heat treatment and thermally stimulated depolarization current techniques. It has been shown for the first time that heating of poled soda-lime glasses to 100–150 °C leads to the relaxation of the SH signal but does not affect the spatial charge and composition of the poled layer, which relax at essentially higher temperature. Moreover, subjecting of the poled glasses with relaxed SH to DC voltages applied at room temperature results in the SH restoration. We call this procedure “cold repoling”. In particular, in corona-poled soda-lime glasses, cold repoling led to an increase in the SH signal by about 15 times which indicated the appearance of additional nonlinearity, while in glasses with vacuum poling the effect was insignificant. This additional nonlinearity appeared to be relatively short-lived, the measured relaxation time being in the range of several tens of minutes. The process of SH relaxation - cold repoling is repeatable: after the non-linearity generated by cold repoling has relaxed cold repoling can be repeated to restore the increase in SH. We supposed that this additional optical nonlinearity is caused by the orientation of H_2O/H_3O^+ related dipoles in the subanodic region of the glass, which formed because of hydronium penetration in glasses in the course of poling in the configuration which provides access of atmospheric water vapors to anodic surface of the glass. As is known, dipoles tend to orient themselves along the applied electric field, while temperature deorients the dipoles. The stronger the electric field the better the orientation, and sufficiently high field forces all dipoles to be oriented. As soon as we relate SHG to the effect of oriented dipoles, a saturation of the SH signal is expected at a voltage of cold repoling sufficient to orientate all the dipoles responsible for SHG in the glass after hot poling. Thus, we measured the dependence of the SH signal on the voltage applied during cold repoling using transparent electrodes. The obtained dependence evidences the saturation of the SHG signal when the cold repoling voltage reaches about 1700-1800 V. This behavior confirms the dipole mechanism of SH generation. Finally, our findings indicate that both frozen electric field and

dipole orientation in the vicinity of the glass surface are responsible for the nonlinearity of thermally poled alkali-containing glasses.

Keywords: Glasses, Thermal Poling, Second Harmonic Generation, Spatial Charge, Relaxation; Dipolar Orientation

Acknowledgement: The study was supported the Ministry of Science and Higher Education of the Russian Federation (project FSRM-2020-0001).

INVITED SPEAKERS

Id-2061

Phase Diagrams and Hysteresis Behaviors of Ferrimagnetic Mixed Spin-3/2 and Spin-2 Hexagonal Nanotube with Core-Shell Structure

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Abstract: In this work, the effects of different crystal fields and exchange coupling on the phase diagrams of the nanotube core–shell ferrimagnetic mixed spin-3/2 and spin-2 are examined by means of the mean field theory based on the Bogoliubov inequality for the free energy. The phase diagrams of the critical and compensation temperatures have been presented in various Hamiltonian parameter planes. In addition, much effort is also dedicated to the hysteresis behaviors of the system. Under certain parameters, the system can present interesting multi-cycle hysteresis behaviors which come from competition among several parameters.

Keywords: nanotube, mixed spins, compensation point, hysteresis behavior, Mean Field Approximation

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INVITED SPEAKERS

Id-2085

Radiation Protection Program on the VVR-S Cyclotron U-120 Particle Accelerator Deccommisioning

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Abstract: The Cyclotron U 120 particle accelerator from IFIN-HH, Romania was commissioned in 1957. The main purpose was to produce intense beams of protons, deuterons and alpha particles with 15 MeV/nucleon maximum energies and fast neutron fluxes with maximum fluxes of 10^{11}n/cm^{2}s for research purposes. Due to the safety reasons, the owner decided to shut down and decommissioning the radiological installation. According with radiological safety norms, the decommissioning of a radiological installation is done on the basis of a “Decommissioning Plan” which contains as the main component the radiation protection program. The program aims to ensure the protection and safety of workers, the environment and the population as a result of decommissioning operations (dismantling / decontamination of contaminated/activated components. The program also considers the processes of transport / handling of radioactive waste resulting from the IFIN-HH Radioactive Waste Treatment Plant, in order to condition, treat and store their intermediates, processes that could lead to a potential radiation exposure and /or to radioactive contamination of personnel, property and the environment.

Keywords: Cyclotron, Decommissioning, Radiological Protection.

INVITED SPEAKERS

Id-2118

Complexity of Electronic Waste Recycling: The Path of EPT Company in SMARTELECTRODES Projects

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Abstract: Recycling contributes to the security of supply of raw materials and helps improve the circularity of materials in the EU economy. Recycling is also regarded as a tool for improving sustainability due to the potentially lower environmental impacts of secondary materials provision when compared to primary raw materials production. The main factors that currently limit the contribution of recycling to meet demand for raw materials in the EU can be summarized as: (1) recycling of many materials from end-of-life products and waste streams is currently not economically feasible; (2) there is a lack of suitable technologies available for recycling; (3) some materials are embodied in products stocked in use for long time periods (e.g. buildings or wind turbines); (4) demand for many materials is growing [1]. In this view, the increasing need for electronics, especially, handheld and portable electronics, and the need to reduce their size and increase their efficiency, generates a lot of various electronics waste all over the globe, which contains different based (e.g. Cu, Pd, Zn, Fe) and precious (Au, Ag, Pt) metals. There are many ways to reclaim used metals in electronic waste; however, electrowinning is a very efficient and quite selective process allowing the recovery of high amounts of various pure metals [2]. However, before actual electrowinning, the another key-process is involved in recovery of the metals from wastes or other secondary sources which is leaching. The process usually is using aggressive and hazardous hydrochloric acid or cyanidization at elevated temperatures coupled with various oxidizing agents [3], in HCl, NaCl and H_2O_2 or mixtures of aggressive acids. Therefore, development and implementation of advanced chemical/electrochemical technologies and equipment for e-waste treatment and metal recovery in the environmentally friendly way that has to be profitable for both company and clients is still a challenge. Especially, during the upscaling of leaching processes form lab-scale to industrial scale. The usage of aggressive hydrochloric acid (with generation of chlorine gas) or ionic liquids, special microwave for heating supposes some special strict requirements for equipment and premises, and for individual and environmental protection, which are hardly overcoming by SMEs. Thus, in order to minimize the impact of e-waste treatment EPT company is developing new environmentally friendly strategies for both leaching and electrowinning processes, including targeting technologies that will treat relatively small lots of e-waste, which will increase sustainability by decreasing steps for overall logistics and maintaining.

Keywords: Electronic Waste, Recovery, Electrowinning, Leaching.

Acknowledgements: This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement Nº 778357-SMARTELECTRODES.

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INVITED SPEAKERS

Id-2119

Design of Materials Based on Electrodeposited Iron Group Metals

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Abstract: Producing electrochemically deposited coatings is a convenient way to improve surface properties of a metal substrate. Electrodeposition of metals and alloys can be carried out at low energy consumption and provides flexibility, convenience, and scalability e.g. electroplating in micro/nano templates or recesses, which have been considered as potential method to acquire diverse micro-/nanostructured materials, which can provide selected functional properties [1]. Research in the area of electrodeposition of alloys between iron group metals and W/Mo in the form of bulk materials, thin films, and quasi-one-dimensional structures (e.g., nanowire, nanotube, and nanoribbon ensembles) is continuously expanding, because new mechanical, magnetic, and catalytic properties of these materials continue to emerge [2]. Management of the composition and properties of such coatings depends on specific characteristics of their electrodeposition mechanism, which still remains open to discussion. The electrodeposition process allowing us to obtain these coatings has been named as “induced codeposition”, because tungsten or molybdenum cannot be deposited from aqueous solutions and require an iron group metal. Nevertheless, alloys with a tungsten content up to 50 wt. % (and more) can be deposited in the presence of certain complexes of iron group metals added to the electrolyte. However, electrodeposition typically operates far from equilibrium conditions [3]. Consequently, the material obtained can show a non-equilibrium structure, which can manifest as small grain sizes and the associated large volume fraction of grain boundaries and triple junctions, as well as non-equilibrium phases. In addition, alloys produced by this method can show considerable extensions of the solid solubility range similar to what is observed in materials produced by other non-equilibrium processing routes, such as e.g. rapid solidification. The given overview will present versatile possibilities of iron group metals and alloys as multiscale materials obtained by electrodeposition, which are suitable candidates to meet many technological demands at macro-, micro- and nano-scale as coating films, composites and nanowires.

Keywords: Electrodeposition; iron group metals; nanocrystalline materials

Acknowledgements:

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement Nº 778357- SMARTELECTRODES.

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INVITED SPEAKERS

Id-2213

Cobalt Oxide (CoO) Nanocrystals Embedded in Borate (B-O) Network to Induce an Analogue Nano-Memristor for Neuromorphic Applications

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Abstract: The development of cost-effective neuromorphic computation hardware with a low power consumption per synaptic event, comparable to the energy consumption of the human brain, is demanding new materials and innovative material designs. Herein, a cobalt borate (CoBi) based synaptic device (nano-memristor) was fabricated via solution process electrochemical deposition technique, in which equally spaced nanocrystalline cobalt oxide (CoO) particles were embedded in an amorphous borate (B-O) mesh. The synaptic properties across the fabricated film were investigated with the help of a conductive mode atomic force microscopy (CAFM) for the first time. The physical and chemical analysis of the prepared synaptic device was studied in detail using HRTEM, XPS, SEM, and EELS micro/spectroscopic techniques. It is revealed that the presence of ultrathin (≤ 2 nm) interstitial amorphous mesh of B-O is critical to introducing the reproducible analog switching characteristics caused by the gradual formation and dissolution of thermodynamically unstable filament at the confined sub-nanometer scale. The analog switching exhibited by the device is analyzed by device flux, device charge, and charge-flux relation, confirming CoBi as an emerging material for neuromorphic computing and emulation of Hebbian learning rules. Hence, the optimized pulse stimuli were used to emulate the brain functions like spike rate-dependent plasticity (SRDP), spike time-dependent plasticity (STDP), and learning and forgetting characteristics in the prepared synaptic device. This work opens up a new avenue to engineer low power and cost-effective nanoscale-memristors to mimic brain functions.

Keywords: Conductive Mode Atomic Force Microscopy, Memristor, Thin Film, Analogues Switching, Neuromorphic Device, RRAM

INVITED SPEAKERS

Id-2233

Displacement Monitoring with Highly Performing Piezoresistive Sensors

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Abstract: The objective of this work is to summarize the results of a recently developed microsensor system for real time equipment status monitoring based on the simultaneous detection of specific local displacements. Primarily, in-plane displacements or deformations in the range from about 10 μm to over 500 μm, are considered. The monitoring system consists of novel original highly performing MEMS displacement sensors with small footprints (<100mm2) and different travel strokes, as well as an electronic board for signal processing and communicating sensor information to a local network or a computer. A range of monolithic displacement sensors comprising built-in flexures with sidewalls' embedded piezoresistors, were designed and prototyped. By varying the flexures' layout, different travel strokes ranging from 10 μm to over 500 μm were demonstrated. Specifically, by optimizing the layout, as high signal level as above 200mV/V and a dynamic range of up to 1,000,000 scale intervals, were achieved. The electronic board consists of analog signal part, digital signal processing and communication blocks. Due to the embedded 24-bit ADCs, 24 bit off-set voltage compensation and gain, C8051F351-GM microcontroller was chosen for the analog part. Further, the digital processing unit exploits a PIC16F1519 microcontroller and a specialized integrated circuit FT232 delivers a bidirectional communication with a local computer via USB 2.0. A dedicated mechanical test set-up for accurate characterization of the displacement sensors was developed. It contains a multi-lever monolithic compliant mechanism, specific mounting elements and a piezoelectric actuator (model P-840.6B, PI) with a power supply & driving unit. The specific flexure design was chosen to provide displacement strokes in the range of 20 μm to 750 μm in tensile and compressive testing, of both longitudinal and transversely sensitive devices. The prototype of the compliant mechanism is made of 1.2316 (DIN: X38CrMo16) instrumental steel. To provide reversible attachment the sensors specific hybrid carriers comprising FR4 and alumina ceramic parts, were employed. Exploiting the testing set-up and reference displacement sensors, sensitivities of the tested sensors varying from about 1 mV/μm.V to 16.6 mV/μm.V were manifested. By analysing the corelation of the signals from the reference and from the tested displacement sensors, it was found that sensitivity can be measured with an uncertainty of < 0.1% without releasing the embedded flexures. Thus, a critical constrain for versatile applications was resolved. The achieved high sensitivity and large displacement range of the currently developed MEMS sensors could enable future multi-parameter monitoring systems for different industrial applications.

Keywords: Displacement Sensors, Piezoresistors, Compliant Mechanisms, Equipment Monitoring.

INVITED SPEAKERS

Id-2238

PZT Ferroelectric Capacitors: Role of Interfaces

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Abstract: Lead zirconate titanate (PZT) films due to a relatively low crystallization temperature of perovskite phase, high values of spontaneous polarization and piezoelectric coefficient are extensively used in FRAM (ferroelectric random-access memory), piezoelectric MEMS (micro-electro-mechanical systems), flexible electronics, high-energy storage, and other integrated ferroelectrics application areas. Ferroelectric/electrode interface strongly effects device performance. These properties could be to high extent influenced by defect chemistry in PZT caused by uncontrolled volatility of PbO vapor during a high-temperature synthesis of ceramics and formation of oxygen and lead vacancies. The migration of oxygen vacancies and the corresponding charge redistribution in PZT films is most responsible for leakage current, electrical degradation, fatigue, retention, imprint, and other electrical characteristics of PZT ceramic films. The report contains a detailed analysis of electrical properties of PZT thin film capacitors with different electrode materials, including Pt, Ir, Au, $LaNiO_3$ (LNO), Hg (mercury probe). The steady-state current-voltage techniques and low-frequency relaxation techniques were used to examine PZT capacitors with different electrode materials. To determine the presence and distribution of local electric fields inside the ferroelectric film we used the electron beam-induced current (EBIC) technique. It uses the e-beam for generation of electron-hole pairs and their separation in the regions with the built-in electric field. The steady-state dependences of the leakage current on voltage were obtained by a long-time observation of current at each applied voltage value and subsequent data processing to exclude relaxation contribution. In the case of impermeable to oxygen vacancies interface (e.g. Ir/PZT or Pt/PZT), their accumulation near the interface causes electrons injection with formation of an induced *p-n* junction. We propose a model that adequately describes leakage current in these structures. In contrast, if the interface is transparent to oxygen vacancy (e.g. Au/PZT) the space charge region is not created at the interface. As vacancies leave the PZT volume, an injection of electrons decreases, and an experimental current-voltage dependence demonstrates a nonlinear behavior with a region of negative differential conductivity at high electric fields. The capacitors with interfaces transparent to oxygen vacancies demonstrate 1.5–2 times higher relaxation charge and more than two times lower relaxation times in contrast to those ones with impermeable interfaces.

Keywords: Ferroelectrics, interface, charge transport, lead zirconate-titanate

Acknowledgement: We suggest that proposed model of induced *p-n* junction can be useful for engineering of FRAM and MEMS devices based on PZT films.

INVITED SPEAKERS

Id-2250

Ecofriendly Metal Reclamation from Casting Sand Waste by Bioleaching

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Abstract: Metal casting production industry produces wastes including the form of sand. Foundries use high-quality sand for molding and casting operations, which although is reused, is eventually discarded as waste and is laden with various metals making it hazardous to the environment. Concentrations of metals in the sand can be significant. Namely, rather than an end-waste, this waste actually is a secondary resource. Recycling them back increases the process efficiency, reduces the energy input and cost. Among methods used for recycling of these metals, bioleaching is an eco-friendly technique to reclaim the metals from the waste sand. The culture supernatant of *Acidithiobacillus thiooxidans* was applied for the recovery of metals from waste foundry sand using two-step bioleaching process. The effect of various physicochemical parameters including temperature, shaking speed, and increasing pulp density on bioleaching process was studied. Complete recovery of Mg, P, Si and Cu and nearly 98% of Zn was achieved during the process in 24 and 72 hours respectively. The phytotoxicity study using mung bean revealed that the untreated sand inhibited the growth of mung bean, whereas the use of bioleached sand in combination with soil (50:50) showed growth similar to that of the control with soil only. This shows the other usefulness of treatment of casting sand by *At. thiooxidans* culture supernatant for agriculture purpose.

Keywords: Casting Sand, Bioleaching, Metal Recycling, Acidithiobacillus thiooxidans, phytotoxicity

Acknowledgements: This study was supported by Ministry of Science and Technology in Taiwan under MOST 103－2221－E－007－136－MY3.

INVITED SPEAKERS

Id-2255

Effectiveness and Productivity Improvement of Conventional Pultrusion Technology

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Abstract: Pultrusion is a technological process, where fibers impregnated with resin move through the heated die and solidify into composite profile with a constant cross section as in the metallic die. An effectiveness and productivity of conventional pultrusion processes, preserving the quality of pultruded profiles, could be improved by the process optimization or by an application of new effective heating sources instead of electrical resistances with high heat losses. Due to the large dimension of numerical problem and multiple iterations applied for the solution of government equations, an optimization methodology is developed, employing the method of experimental design and response surface technique. In each point of the plan of experiments the thermo-chemical problem is solved by the mixed time integration scheme and nodal control volumes method successfully validated by experimental trial, utilizing new cure sensors for the measurement of electrical resistivity and temperature on the profile surface. More accurate and realistic process optimization is achieved with the temperature control executed by the heaters switch-on and -off strategy. Some parameters of the pultrusion processes (power and number of electrical heaters) are taken into consideration as constant values in optimization problem, another (pull speed, control temperature on electrical heaters and their location), and room and resin temperature are examined as design variables. Constrains are introduced into optimization problem with the aim to provide a qualitative profile production when the resin is fully cured and no overheated during the pultrusion process. Using non-direct optimization methodology, interactive technological maps for cylindrical rod profiles with ears, thin-walled angle and rectangular profiles made of glass fibers TEX4800, and polyester C-L ISO 112G, epoxy Resoltech 1401+1407+AC140 and vinyl ester Crystic VE 676-03 resins have been developed for their direct application in an industrial shop. Among all possible heating methods, a high frequency electromagnetic energy source characterized by the fast, instantaneous, non-contact and volumetric heating could be examined as the best choice for the pultrusion applications. To develop microwave assisted pultrusion processes, as well as pultrusion tooling design and process control, new effective electro-magnetic-thermo-chemical finite element models and algorithms are developed by using the general-purpose finite element software that results in considerable savings in development time and costs and makes available various modelling features of the finite element packages. An effectiveness of the optimized conventional pultrusion processes and developed microwave assisted pultrusion processes is estimated in comparison with the real pultrusion processes used in laboratory and industrial shops. So, optimizing pultrusion processes their pull

speed has been increased by 50 - 125% and the energy consumption has been reduced by 20 – 35% per 1 meter of pultruded profiles depending on the ambient industrial shop temperature. The proposed use of new microwave heating sources instead of traditional electric heaters has made it possible to increase the productivity (pull speed) of the developed pultrusion processes in five times, while the energy efficiency of the processes has also been improved twice, preserving the quality of pultruded profiles.

Keywords: Pultrusion, Finite Element Simulation, Optimization, Microwave Heating; Effectiveness, Productivity.

INVITED SPEAKERS

Id-2283

Superconducting Order Parameter in Alkali-Based Iron Arsenides by Means of the Planar Break-Junction Technique

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Abstract: Remarkable features of alkali-metal iron pnictides of the 111 and 1144 families, such as absence of magnetism, superconductivity in stoichiometric state and nontrivial band structure [1-3] still challenge experimenters. Here we present direct spectroscopic study of the superconducting (SC) order parameter in single crystals of LiFeAs with $T_c \approx 17.5$ K, and novel $EuCsFe_4As_4$ with $T_c \approx 34$ K. In order to reveal the structure of the SC order parameter, here we used incoherent multiple Andreev reflection effect (IMARE) spectroscopy. The superconductor-thin normal metal-superconductor (SnS) junctions with semiballistic high-transparent barrier were produced by a planar break-junction technique [4]. Below T_c, IMARE causes an excess current in a I(V) curve of SnS junction at any bias voltages, and a series of dynamic conductance dips in the dI(V)/dV spectrum at bias voltages directly determined by the value of the SC gap(s) at any temperature up to T_c: $eV_n(T) = 2\Delta(T)/n$, where n is natural number [5,6]. The used method provides local probe of the bulk order parameter (nearly unaffected by surface), and enables to resolve its fine structure (anisotropy). In LiFeAs single crystals, we determined three bulk SC gaps: the small gap $\Delta_S(0) \approx 1.3$ meV (possibly shows ~35% anisotropy in the k-space) leads to corresponding characteristic ratio $r_S \equiv 2\Delta_S(0) / k_B T_c \approx 1.7$; the middle gap Δ_L with $r_L \approx 3.5$–5.0 (~30% anisotropy, the range corresponds to the minimum and maximum Cooper pair coupling energies in the bands with Δ_L); and the nodeless large gap Δ_Γ having ~10% k-space anisotropy and $r_\Gamma \approx 8$ [7,8]. The moderate level of anisotropy for all order parameters supports their nodeless nature. The three SC gaps turn to zero at one and the same $T_c \approx 17.5$ K, whereas their temperature trends are typical for a moderate interband coupling. The anisotropy degree of the Δ_Γ and Δ_L gaps remains almost constant with temperature until T_c. In $EuCsFe_4As_4$ we determined two bulk SC gaps, $\Delta_L(0) \approx 4.6$–7.7 meV with moderate in-plane k-space anisotropy about 40%, and possibly isotropic $\Delta_S(0) \approx 2.9$ meV. While the Δ_L temperature dependence is BCS-like, the small gap decreases more rapidly with temperature to the same T_c, thus indicating rather weak crossband coupling. Above the gap edge $2\Delta_L$, a fine structure likely caused by resonant electron-boson coupling is observed until T_c. Above T_c, in both SC compounds we reproducibly observe manifestation of an electron density of states peak in the vicinity of the Fermi level. The

relation between superconducting and normal-state features in the studied compounds is also discussed. We compare the determined gap structure of alkali-metal LiFeAs and $EuCsFe_4As_4$ compounds with that of other iron pnictide families, such as Ba-122 and 1111.

Keywords: Unconventional Superconductivity, Iron-Based Superconductors, Lifeas, Andreev Reflection, Andreev Spectroscopy, Planar Break-Junction, PBJ

Acknowledgement: The studies of LiFeAs were supported by Ministry of Science and Higher Education of the Russian Federation project no. 075-15-2021-1353. The experiments on $EuCsFe_4As_4$ samples were provided under RSF grant no. 22-22-00776.

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INVITED SPEAKERS

Id-2289

Glass-ceramics for White Light Emitters: the Effective Conjunction of CdS QDs in Glass and Ce doped garnets

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Abstract: Currently, there is a huge demand for light sources with high efficiency in various fields of human activity. Art workshops, museums, printing, medicine, automobile, and aviation industry take the highest requirements on lighting devices: extreme working conditions, high luminous flux, high color rendering index (CRI). Today, most commercial white LED devices imitating sunlight are still based on yttrium aluminum garnet doped by Ce^{3+} as yellow phosphor. It demonstrates high photoluminescence efficiency and maximum intensity at 530-570 nm. However, the white light sources based on this material still has a low CRI and high correlated color temperature due to the lack of red component in the spectrum. Thus, the developing of new phosphors with continuous spectrum and high CRI is highly relevant. The purpose of this study is to create a new composite material for white light sources with improved efficiency and CRI based on cerium-doped yttrium/lutetium aluminum garnet and silicate glass with cadmium sulfide quantum dots (CdS QDs). The concept of proposed material implies that glass with CdS QDs simultaneously performs two functions. First, it serves as a matrix that binds the crystalline phase of garnet structured phosphor. This might increase thermal conductivity and resistance to the high light fluxes. Second, the glass with CdS QDs compensates for the unbalanced Ce^{3+} emission spectrum due to appearing of the red component in the emission spectrum of the composite material. Suggested way of synthesis opens possibilities for creating continuous range of ceramic material with tunable luminescent properties.

Keywords: Alkali-Silicate Glass, Luminescent Glass-Ceramics, YAG, Luag, Cds Quantum Dots, White Light Sources.

Acknowledgement: The work was supported by the Russian Science Foundation [Agreement no. 21-72-00060].

INVITED SPEAKERS

Id-2300

Sustainable Concrete made with Treated Domestic Wastewater and Recycled Concrete Aggregates

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Abstract: The unprecedented depletion of concrete natural resources due to the worldwide excessive employment of concrete has become a subject of global concern. Therefore, researchers' interest has recently focused on producing concrete with more sustainable resources. Concrete manufactured with domestic treated wastewater (TWW) and recycled concrete aggregates (RCA) is identified as one of the potential alternatives to minimize the exploitation of fresh water (FW) and natural aggregates (NA) in concrete applications, thereby combating the reduction of the concrete natural ingredients and the rise of greenhouse gas emissions. In this study, four concrete mixes were prepared for investigation with different types of mixing water (FW and TWW) and coarse aggregates (NA and RCA). Tests conducted were compressive and flexural strengths, electrical resistivity, porosity, and rapid chloride penetration test. Test results showed that the mechanical properties of concrete were reduced by 6% to 12% with TWW. In addition, the chloride permeability of TWW concrete was increased by 77%. Moreover, RCA decreased the mechanical characteristics of concrete by 10% to 21%, whereas it decreased the porosity and chloride permeability of TWW concrete by 16% to 42%.

Keywords: Recycled Concrete Aggregates, Treated Domestic Wastewater, Sustainable Concrete, Mechanical Characteristics.

REGULAR SESSIONS

Id-1951

Studies Concerning Stress Relaxation in Apple

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Abstract: Stress relaxation tests are an essential source of knowledge about the physical state of high water content agricultural products such as fruit and vegetables. The tests are of particular significance because their results make it possible to propose a model of studied material. Viscoelastic parameters are closely correlated with chemical composition, e.g. soluble solids content or acidity as well as texture features, e.g. hardness, springiness or chewiness. The aim of this study was to determine the apple flesh force response in the wide range of deformation velocities (quasi static and impact mechanical loading conditions). During the research the cylindrical samples of apples in the range of deformation velocities from 0.0002 to 1ms^{-1} were studied. The five-parameter generalized Maxwell model was used to describe the experimental stress relaxation curves. The relaxation times of the generalized Maxwell model decreased with the increase of deformation velocity. The relaxation times were related to the processes of gas and liquid flows in the intercellular spaces. The rapid decrease of both relaxation times was stated between deformation velocity of 0.0002 and 0.002 m^{-1}. It testifies to the existence of critical deformation velocity associated with the weakness of the apple structure at the velocity mentioned above. The increase in the peak force response along the increase of deformation velocity shows typical viscoelastic behaviour of apple flesh.

Keywords: Apple, Mechanical impact, Stress relaxation, Maxwell model.

REGULAR SESSIONS

Id-1961

Adsorption of Copper from Aqueous Solutions by Using Clay-Chitosane Modified

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Abstract: The objective of this In this study, is the adsorption of copper Cu (II) from aqueous solutions using natural clay-chitosane modified. The composite (modified natural clay with chitosone) was synthesized by intercalation of chitosan into the sodic bentonite. It was characterized by X-R-ray diffraction (XRD), Fourier transform infrared (FTIR) and X-ray fluorescence analysis.During adsorption process, batch technique is used, and the effects of pH, material amount, heavy metal concentration, time and temperature on adsorption efficiency are studied. Langmuir, and Freundlich isotherms are applied to determine the efficiency of material used as an adsorbent. Experimental results showed that the adsorption rate was very rapid during the initial contact time due to the availability of active adsorption sites at the surface of composite and the adsorption capacity was 96%. Also results show that all isotherms are linear. It is determined that adsorption of Cu (II) is well-fitted by the second order reaction kinetic. It is concluded that material (clay modified by chitosane) can be used as an effective adsorbent for removing Cu (II) from aqueous solutions and heavy metals.

Keywords: Chitosane**,** Natural Clay, Copper, Isotherm Freundlich, Langmuir Isotherm, Kinetic Model.

REGULAR SESSIONS

Id-1978

Structure and Ferroelectric Properties of Modified Lead-Free Perovskite Materials

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Abstract: Lead-free perovskite materials are being intensively studied mainly in order to replace widely used Pb-based ones. They are promising for development of materials for capacitors, piezoelectrics, electrocaloric and other devices. We studied influence of cation substitutions and preparation conditions on structure parameters, microstructure, dielectric, relaxor ferroelectric, and piezoelectric properties of solid solutions in the systems based on $(K_{0.5}Na_{0.5})NbO_3$ (KNN), $BaTiO_3$ (BT) and $(Na_{0.5}Bi_{0.5})TiO_3$ (NBT) perovskites. Ceramic samples in systems KNN-BT, NBT-BT with compositions close to Morphotropic Phase Boundaries (MPB) were prepared by the two-step solid-state reaction method at temperatures of 800 – 1450 K. The samples were additionally modified by acceptor and donor cations in A- and B-sites of perovskite lattice, and various overstoichiometric additives with low melting temperatures were used to improve density of ceramics. Ceramics were characterized using complex of physical-chemical methods: X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), Second Harmonic Generation (SHG), Dielectric Spectroscopy (DS) and Atomic Force Microscopy in Piezorespone Force mode (PFM). The unit cell volume changes were observed by the XRD method in modified ceramics depending on ionic radii of substituting cations. Ferroelectric phase transitions at ~ 400 – 700 K were confirmed using the DS and SHG methods. At high temperatures > 800K effects of dielectric relaxation were observed in NBT-based ceramics studied caused by formation of oxygen vacancies in compositions with aliovalent substitutions. At the room temperature, non monotonous changes of the dielectric parameters and increase in the spontaneous polarization values were proved for modified ceramics. Using the PFM method ferroelectric polarization switching at nanoscale was proved, and increase of effective d_{33} piezoelectric coefficient in some modified KNN- and NBT-based ceramics correlated with increase in dielectric permittivity was observed. The results obtained confirmed improvement of functional properties and prospects of new lead-free piezoelectric and electrocaloric materials development on the base of modified KNN- and NBT-based compositions.

Keywords: Ceramics, Perovskite Structure, Ferroelectrics, Piezoelectrics.

REGULAR SESSIONS

Id-1979

The Influence of Process Parameters on Structural And Morphological Properties of Different Metallic Nanowires

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Abstract: Some of the most interesting nanostructures used in sensing devices are nanowires, especially due to the fact that the fabrication of nanostructures with controlled morphology is extremely practical when following specific applications. The control of key parameters such as chemical composition, diameter, length, doping, electronic properties is of high importance when manufacturing a sensing device with certain features. In this study we focused on determining the best conditions to obtain metal (Ni, Cu, Co, Sn) nanowires electrochemically grown via template method at different electrochemical potentials. Furthermore, we used several types of oxidation processes in order to optimize the fabrication process of metallic nanowires with the purpose to obtain metal - metallic oxide- metal. The nanowires (Ni, Cu, Co, Sn) were synthesized electrochemically using polycarbonate membranes as templates. The membranes are first irradiated with heavy ions and then immersed in a NaOH based solution in order to form cylindrical pores with the diameters in the range of 100-200 nm. For each type of metal there were different growth conditions (bath temperature, deposition potential); and for each type of metallic nanowire we used thermal oxidation, plasma oxidation and electrochemical oxidation. The resulting nanowires have been characterized by scanning electron microscopy, energy-dispersive X-ray spectroscopy, and X-ray diffraction. Thus, we were able to have a better insight on how the fabrication parameters are influencing the physical and chemical properties of the nanowires.

Keywords: Nanowires, MOM, Nanostructures.

REGULAR SESSIONS

Id-1980

High Field Dependence of the Magnetocaloric Effect in Laves Phase RNi_2 Intermetallic Compounds

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Abstract: Intermetallic compounds based on rare earth elements undergoing a second-order transition from ferromagnetic to paramagnetic state are of particular interest because they can exhibit a large reversible magnetocaloric effect (MCE) in the nitrogen and hydrogen liquefaction temperature range. Interesting physical properties of RNi_2 compounds (R = rare earth metal) result from the high localized magnetic moments, which are derived from the incompletely filled 4*f*-electron shell of lanthanide atoms. The non-magnetic state of Ni atoms in these compounds results in low magnetic ordering temperatures because the wave functions derived from the lanthanides have a small range as compared to interatomic distances, and 4*f*-4*f* interactions are weak [1]. Due to these features, some of the RNi_2 compounds exhibit a high magnetocaloric effect (MCE) and, therefore, show promise as ideal materials-refrigerants at low temperatures [2-4]. Most of the experiments performed for this material system were focused on the intermediate magnetic field range ($\mu_0\Delta H \leq 2$ T) which is more relevant for applications [5-6]. In this work, the behavior of magnetocaloric effect at both low and high magnetic-field changes has been studied experimentally by an example of the RNi_2 Laves-phase, where R = Tb, Dy, Ho and Er. The application of direct measurements over a wide field range along with indirect methods allowed us to find high-field regularities of magnetocaloric effect in these compounds, which was estimated as the adiabatic temperature and isothermal magnetic entropy changes. Temperature dependencies of isothermal magnetic entropy change were obtained using magnetization and heat capacity measurements, while the adiabatic temperature changes were determined directly using a measuring device designed and constructed by the authors and were derived from the experimental data on the heat capacity as well. Precise experimental characterization of the structure and magnetic properties of the RNi_2 compounds were also performed.

Keywords: Magnetocaloric Effect, Laves Phase, Adiabatic Temperature Change, Magnetic Properties

Acknowledgements: The work was supported by the National Science Center, Poland through the OPUS Program under Grant No. 2019/33/B/ST5/01853.

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REGULAR SESSIONS

Id-1981

Electrospun Nanostructured Scaffold for Electrochemical Sensing In Cell Cultures

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Abstract: An electrochemical (bio)sensor is a device consisting of a transducer (working electrode) that converts the interaction with the analyte of interest into a measurable electronic response. The measurement of the electronic response requires an electrochemical cell consisting of three electrodes placed in the same electrolyte solution: the working, the counter and the reference. During the measurements the current flows between working and counter electrodes, while the potential of the working electrode is measured in relation to the reference electrode.

At the same time, the electrochemical sensing of biomolecules produced by the living cells exposed to different stimulus requires the cultivation of the cells at the (bio)sensor surface. In order to minimize the undesirable effects, *e.g.* passivation of the (bio)sensor surface during cell cultivation or the decrease of the viability of the cells due to the electric field which appears during the measurement, an appropriate experimental model is essential. Thus, in the present work, a nanostructured polymer scaffold, which allow the cell cultivation at specific condition (*i.e.* 5% CO_2, 37 °C, humidity) and the transfer on the (bio)sensor surface, was fabricated. In this process, nanometric fibers were obtained by electrospinning a solution of nylon 6/6 dissolved in formic acid and collected on the surface of an adhesive micrometric porous membrane. After optimization of the fabrication parameters, *i.e.* polymer concentration, flow rate, applied potential on the spinneret, and the collection time, the surface morphology of nanostructured polymer scaffold was characterized by scanning electron microscopy and the biocompatibility was evaluated using florescence microscopy and the melanoma B16F10 cell line. Finally, the scaffold was used for the real time electrochemical sensing of melanin produced by B16F10 cells after irradiation with a light beam of 390 nm using a planar three-electrodes sensor.

Keywords: Nanofibers, Scaffold, Cell Culture, Biosensing.

Acknowledgment: Financial support from the Executive Agency for Higher Education and Research Funding (UEFISCDI) and National Research Council (CNCS) the Core Program 2019–2022 (contract 21N/2019) and the project PN-III-P4-ID-PCE-2020-1403, within PNCDI III, are gratefully acknowledged.

REGULAR SESSIONS

Id-1982

Study of Polydopamine Strong Adhesion by Solid-State NMR

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Abstract: Inspired by the strong adhesion of mussels to any solid substrate, Messersmith has discovered in 2007 polydopamine (PDA) as a readily accessible synthetic analogue of the naturally occurring melanin's, showing strong and universal adhesion ability to virtually any substrate. Despite the growing number of PDA applications reported each year, there are still fundamental challenges remained in the field, such as the formation and adhesion mechanisms as well as a widely accepted structural model. The amorphous character of PDA, and the high degree of disorder at all levels (monomers, oligomers, supramolecular aggregates), pose serious limitations upon the information content provided by the analytical techniques widely used for its investigations: mass spectrometry – mainly because this is a destructive technique, X Ray photoelectron spectroscopy, Fourier transform infrared spectroscopy – although non-destructive, they only offer global information, with no site-specificity. By contrast, solid-state NMR spectroscopy is non-destructive and offers a higher degree of chemical-site selectivity. Here we review the latest progresses in our ss-NMR investigations of polydopamine, focusing on the spectral differences between PDA thin films deposited on silica nanoparticles and the PDA in bulk. The observed differences will be discussed in terms of potential adhesion mechanisms. This study is expected can bring new and valuable insights into this fascinating material.

Keywords: Polydopamine, Adhesion, Functional Surfaces.

REGULAR SESSIONS

Id-1983

Superconductor/Ferromagnet Heterostructure $YBa_2Cu_3O_{7-x}$ /$CaRuO_3$

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Abstract: YBCO is one of the most promising superconductors for large-scale applications while superconductor/ferromagnet heterostructures have potential applications for superconducting electronics. Thus, it is necessary to investigate the influence of a ferromagnetic layer on the properties of high-temperature superconductor underneath. We studied heterostructures of $YBa_2Cu_3O_{7-x}$ (YBCO) superconducting thin films and ferromagnetic $CaRuO_3$ when the layers are either in direct contact or separated by a barrier layer of 5 nm $SrTiO_3$. Using SQUID magnetometry, detailed measurements of the magnetic moment of the superconductor and ferromagnet as a function of magnetic field and temperature have been performed. The change of the superconducting properties of YBCO strongly depends on the interaction with the ferromagnetic layer on top, as was shown from magnetometry and relaxation measurements. The barrier layer has an important impact on both the superconducting properties of the YBCO film and the ferromagnetic ordering of $CaRuO_3$. Detailed XRD analysis was made to corelate the physical properties mentioned above with the materials' structure.

Keywords: Superconductor-ferromagnetic Heterostructures, Critical Temperature, SQUID Magnetometry.

REGULAR SESSIONS

Id-1985

Rare Earth-Doped $Y_3Al_5O_{12}$ (YAG) Nanophosphors: Synthesis and Applications in Energy-Savings Devices and Nanomedicine

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Abstract: Yttrium aluminum garnet (YAG) with chemical composition $Y_3Al_5O_{12}$ is a well-known host material to obtain highly efficient luminescent materials (phosphors) that offer unprecedented applications capabilities to the scientific and technologic community. The structure of $Y_3Al_5O_{12}$ permits facile doping of the lanthanide ions leading to the formation of different composition possessing emission properties in a wide range (UV-NIR). Ease of tuning emission and high chemical stability of YAG host lead to their wide applicability in various advantageous applications, including lasers, white-emitting LED lamps, biomedical theranostics platforms, thermoluminescence dosimetry, nanothermometry and long persistent luminescence. We present an overview of YAG based nanophosphor and their synthesis pathways related morphology and luminescence properties. In addition, we explore various fields where the YAG based nanophosphors have been implemented and also discuss their futuristic applications. Examples are YAG:Nd nanophosphors as nanothermometers for detection of temperature at cellular level [1], YAG:Pr nanoscintillator [2] for the development of radiation activatable therapeutics for the treatment of cancer [3,4] and YAG:Ce for energy savings solid state white-emitting lamps.

Keywords: Energy Savings Devices, Nanomedicine, Nanophosphors as Nanoheaters/Nanothermometers

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REGULAR SESSIONS

Id-2010

Flammability and Explosive Characteristics of Mixtures of Wood Dust

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Abstract: The burning rate of a solid block of wood is relatively slow due to the limited penetration of the dense material. Wood dust, on the other hand, consists of fine wood particles generated during wood processing. It has explosive properties, especially when it is lifted and creates a dust-air mixture. In a dust-air cloud, the initiation of combustion is extremely easy and leads to the propagation of combustion throughout the volume of the mixture. The rate of flame spread will vary depending on the type of wood, size of airborne particles, humidity, temperature, and other factors. The more fines there are in the floating dust, the greater the risk of explosion. An experimental investigation was carried out to determine the ignition sensitivity and the explosion parameters of hardwood and softwood dust mixtures, depending on the size of the dust particles and the type of wood. The samples were tested in two particle size ranges, included 6 tree species and three dust mixtures of different tree species obtained from a wood processing plant. Complete fire characteristic requires several parameters describing softwood and hardwood dust behaviour under fire conditions, including Heat Release Rate (HRR), ignition time, or fire growth index. To determine those parameters, a cone calorimeter was used. Explosion characteristics were tested for chosen wood dust samples in a 20-L spherical vessel. Minimum Ignition Energy (MIE) was tested on MINOR II Apparatus, which is a modified Hartmann's Tube. Minimum Ignitions Temperatures were tested with the use of Layer Ignition Temperature Apparatus and Godbert-Greenwald Apparatus for minimum ignition temperature of a dust layer and dust cloud respectively. The data are shown that hardwood dust reaches their maximum heat release rate only during flashover, while the highest value of HRR for softwood dust is observed a few seconds after ignition. For oak, dust had obtained the highest KST value, the lowest minimum ignition temperature of a dust layer and dust cloud. MIE of all tested samples is less than 100 mJ. All data will be presented and discussed with details during the upcoming conference meeting.

Keywords: Lower Explosive Limit, Minimum Ignition Energy, Minimum Ignition Temperature, Wood Dust.

REGULAR SESSIONS

Id-2011

Mn_2FeSi Heusler Alloy Prepared in Bulk, Ribbon, and Powder Form: Microstructure and Magnetism

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Abstract: Heusler alloys represent an extraordinary class of tunable materials with more than 4000 potential members and a wide range of multifunctionalities and applications. Currently, many papers are devoted to theoretical calculations of existing and/or newly proposed compositions of Heusler alloys with possible applications mainly in microelectronics and spintronics. Similarly, various laboratories over the world try to prepare such Heusler compositions experimentally and to study their structural and physical properties. Among them, the Heusler Mn_2FeSi compound was also subjected to theoretical DFT-based calculations and subsequently synthesized by several procedures. However, the unified view concerning its physical properties in connection with microstructure and mainly magnetic ordering is still vague. This work is devoted to a production of this Heusler composition in an ingot form using conventional induction melting, in a powder form by mechanical alloying using ball milling with ball to powder ratio 10:1, and in a form of thin ribbon using planar flow casting. The as-produced materials were subsequently thermally treated in Ar atmosphere; the ingot- and ribbon-type samples at 773 K for 100 h and powder-type samples at 1223 K for 1.5 h. X-ray diffraction confirmed the $L2_1$ cubic Heusler phase at all samples with the lattice constants close to the theoretically calculated value of 0.560 nm for Mn_2FeSi. Nevertheless, several small diffraction peaks can indicate a presence of other minor phases, e.g., the iron and/or manganese oxides. The EDX area analysis resulted in the very similar chemical compositions at all samples in agreement with the nominal ones despite different grain size ranges between about hundreds of μm and 5 μm. The particles of powders were of irregular shape with the 3.8 μm median diameter and they have shown a tendency to agglomeration. An effect of producing technology was tested by the magnetic measurements of the as-prepared and annealed samples at the selected temperatures between 3 K and 573 K. The room temperature Mössbauer measurements resulted in the single- and/or double-lines spectra representing at first sight a dominant paramagnetic state at all samples. However, the magnetization curves being linear at higher magnetic fields supporting the paramagnetic behaviour have shown also a weak magnetization reversal in the low magnetic fields close to zero at all samples. This part of curves represents a small contribution of ferro- and/or

ferrimagnetic phase depending on the sample preparation. Consequently, different courses of the ZFC-FC curves were obtained at low temperatures between 300 K and 3 K. Nevertheless, the clear peak values on these ZFC-FC curves at all samples were detected between about 45 K and 70 K in dependence on technology of their preparation. They correspond to Neél temperature bellow which the samples transform into antiferromagnetic state. They are in good agreement with results in the literature.

Keywords: Heusler Alloys, Induction Melting, Planar Flow Casting, Ball Milling, Microstructure, Magnetism.

REGULAR SESSIONS

Id-2012

The Effect of Manufacture Process Properties of Epoxy-Based Hybrid Co mposites

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Abstract: Many papers describe the effects of the configuration of multi-layer laminates manufactured with various reinforcement materials. However, it should be emphasized that usually these works relate to systems containing two or three types of fabrics, focused on using one with natural origin or high performance [1]. In most cases, the impact of ratio and mutual layering in the composite was the most crucial issue. At the same time, considering the flammability of hybrid composites, systems containing up to two types of fibers are investigated, with the simultaneous introduction of a flame retardant or inorganic particle-shaped fillers [2]. Still, no comprehensive studies have been reported on evaluating multi-material laminates produced by various manufacturing techniques, considering the analysis of mechanical and flammability properties related to the structure and quality of final products. The presented studies of hybrid composites are evaluated by low-impact drop and three-point bending tests compared with the results of flammability analysis using the cone calorimetry method. Numerous studies have shown that the simultaneous introduction of several appropriately selected types of fabrics with different properties (e.g., nylon–basalt [3], glass–kenaf [4]) allows increasing low-impact strength by obtaining a layer-by-layer failure mode, translating into a much larger energy absorption. Thus, the introduction of higher stiffness fillers to the system will, each time, be associated with the noticed changes in the strength of the product (e.g., the introduction of carbon fibers to the glass–epoxy composite) [5]. Taking into account the discussed characteristics, i.e., lower flammability, the introduction of reinforcing layers with higher temperature stability, such as basalt, glass, or carbon, will allow increasing the thermal resistance of the final components, in contrast with products based on natural fibers [6].

In this study, five fabrics were used to manufacture composites by the hand lay-up, vacuum bagging, and resin infusion methods. Research methods, including flexural tests, puncture impact behavior, and cone calorimetry tests, were applied to establish the impact of the manufacturing method and

the fabrics layout in laminate structure on the mechanical and fire behavior of epoxy-based composites. Moreover, the properties' evaluation was related to the microstructure analysis carried out before and after the cone calorimetry tests.

Keywords: Epoxy Composites, Glass Fabrics, Aramid Fabrics, Carbon Fabrics, Basalt Fabrics, Flax Fabrics

Acknowledgements: This paper has been based on the results of a research task carried out within the fifth stage of the National Programme "Improvement of safety and working conditions" partly supported in 2020–2022 — within the scope of research and development — by the National Centre for Research and Development (project no. III.PB.03 entitled "Development of hybrid composites modified with inorganic and plant fillers with reduced flammability, smoke emission and high resistance to vandalism for use in public transport vehicles"). The Central Institute for Labour Protection – National Research Institute is the Programme's main co-ordinator.

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REGULAR SESSIONS

Id-2020

An Application of The Analytical Solution of the Small Signal Steady-State Equations: Analysis of Low-Temperature Field-Dependent Measurements For Nc-Si:H Sample

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Abstract: The expression of Beta (β) resulted from the analytical solution of a small signal steady-state photocarrier grating (SSPG) in the presence of external electric field using Galerkin's method [R. I. Badran, Results in Physics, 17, 103079 (2020)] is tested and applied to numerically analyze the low-temperature experimental data of nc Si: H sample placed in an evacuated cryostat. Some important transport quantities are extracted from the numerical analysis. The values of hole and electron mobilities together with the recombination life time are found and compared to corresponding ones obtained from the applications of other approaches. The expression of Beta derived from our method can be successfully employed for the field- dependent data at low temperatures for nanocystalline samples prepared by plasma enhanced chemical vapor deposition technique.

Keywords: Steady-State Photocarrier Grating (SSPG), Nanocrystalline and Amorphous Semiconductors

REGULAR SESSIONS

Id-2024

Local Crystallization of Glass

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Abstract: Modification of multicomponent glasses by applying a high electric field causes a change in their properties, including molar volume, hardness, refraction, and chemical resistance, and changes the diffusivity of ions in the modified regions. The latter, in combination with modifications of the structure and composition, should significantly affect the crystallization ability of glasses, which is important for the formation of glass ceramics, glasses with embedded semiconductor quantum dots, metal nanoparticles, and dielectric nanocrystals doped with rare earth elements. Local crystallization can also be achieved by irradiating glasses with a laser. In this case, the area of crystallization will be determined by the area affected by the laser beam. In our study we used both application of a DC voltage at elevated temperature (thermal poling) and UV laser irradiation to induce local crystallization of glasses. In experiments, potassium-titanosilicate multicomponent glass was poled in air at 460^{o}C during 40 min under 700 V DC. During the poling of the glass, nanocrystals of anatase phase with a size of ~10 nm were formed in the subanodic region, while the unpoled region of the glass remained amorphous. Confocal micro-Raman characterization of the sample cross-section evidenced the presence of ~3 μm-thick layer containing TiO_2 nanocrystals beneath the anodic surface of the poled glass, in the region of spatial electric charge formed in thermal poling. Under subsequent annealing, anatase, being a metastable structure, partially transformed into rutile nanocrystals, which makes it possible to control the ratio between the two phases, anatase and rutile, by varying the temperature and duration of the heat treatment. Also, a synthesized photosensitive glass containing silver and cerium was irradiated by a laser beam. In such glasses, under the action of laser UV irradiation, silver ions are reduced with the formation of silver atoms, subsequent heat treatment of glass leads to clustering of silver atoms (formation of metallic silver nanoparticles), and then, during secondary heat treatment, to crystallization of the glass. Silver nanoparticles act as nuclei of this crystallization, while cerium ions act as electron donors. For laser irradiation, we used the third harmonic of a femtosecond laser with radiation wavelength of 1030 nm. The primary and secondary heat treatments were performed at 500°C for one hour and at 600°C for 45 minutes, respectively. In irradiated glass after primary and secondary heat treatment, local crystallization occurred, i.e. microcrystals of lithium metasilicate, Li_2SiO_3 grew. During subsequent etching, the crystalline regions were etched faster, which provided a surface relief. The formation of grooves up to 50 microns deep was experimentally demonstrated. The relief pattern can be set by a laser beam,

which makes it possible to avoid "wet" lithography. The results obtained demonstrate the capability of poling and laser irradiation as methods for the formation of local crystalline phase in the glass.

Keywords: Glass, Crystallization, Local field, Microstructuring.

Acknowledgement: The research was funded by the Ministry of Science and Higher Education of the Russian Federation as a part of World-Class Research Center program: Advanced Digital Technologies (contract No. 075-15-2022-311 dated 20.04.2022).

REGULAR SESSIONS

Id-2038

Soft Magnetic Composites FeSi/Al_2O_3-B_2O_3 with High Resonance Frequency

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Abstract: Soft magnetic composites (SMC) metal/insulator are promising materials that find applications in a large number of modern areas such as 5G networks, wearable electronics, and the internet of things (IoT). Properties of SMC depend on many parameters. There are three cornerstones: the type of ferromagnetic material, the type of insulator, and the coating method. Classical soft magnetic materials with well-known properties, such as Fe, FeSi, FeSiAl, FeNi are usually used. At the same time, the selection or development of an optimal insulator is a more difficult issue. An ideal insulator should have high electrical resistivity, good compressibility in a mixture with a ferromagnetic powder, and withstand high temperatures, which are necessary for efficient stress relief annealing and sintering of the composite. For example, the use of polymeric insulators greatly limits the possibilities of heat treatment of the composite. Ceramic-type insulators are less susceptible to this problem, but metal-ceramic systems suffer from poor compressibility and mechanical properties. For this reason, active work is underway to find and develop new materials, which can be used as an insulator in SMC with improved properties. In this work, Al_2O_3-B_2O_3 ceramics was used as an insulator, since it has a high electrical resistivity and the ability to control the sintering temperature by the ratio between Al_2O_3 and B_2O_3. As a ferromagnetic material, the Fe-6.5 % Si alloy was selected. It has increased resistivity in comparison with pure iron or Fe-3%Si which will favorably affect the high-frequency magnetic characteristics. In the work, we study the influence of various parameters such as the content of insulator and coupling agent, pressing pressure, and sintering regime on the basic magnetic properties of SMC.

Keywords: Soft magnetic composites, magnetic properties, frequency stability

Acknowledgment: This work was realized within the frame of the project 'FUCO' financed by the Slovak Research and Development Agency under the contract APVV-20-0072

REGULAR SESSIONS

Id-2067

Failure Analysis of Gear Fracture in Wire Rope Production

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Abstract: There are many application areas of rope production from steel wires in industry. Winding mechanisms in steel rope production facilities are exposed to high stresses. In this study, failure analysis studies are included as a result of failure to a gear mechanism in rope production construction. In this context, the fracture surfaces were examined under the scanning electron microscope (SEM) with EDX analysis. The heat treatment history of the fracture zone and the main body was investigated and the microstructures and hardness measurements were compared. Failure root cause analysis was carried out. As a result of the study, it was determined that fatigue cracking occurred with the effect of improper heat treatment and caused fracture. It has been understood that the inhomogeneity of the hardening depth causes fracture with the effect of increasing stresses and cycles.

Keywords: Wire Rope, Steel Gear, Failure Analysis, Heat Treatment.

REGULAR SESSIONS

Id-2073

Dark-Bright Excitons Mixing in Alloyed Quantum Dots

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Abstract: Despite its name, the dark exciton reveals weak luminescence that can be directly measured. The origins of this optical activity remain largely unexplored. In this work [1], using the atomistic tight-binding method combined with the configuration-interaction approach, we demonstrate that atomic-scale randomness [1-4] strongly affects the oscillator strength of dark excitons confined in quantum dots with no need for faceting or shape-elongation. We show that this process is mediated by two mechanisms: mixing dark and bright configurations by exchange interaction (Fig. 1), and the equally important appearance of nonvanishing optical transition matrix elements that otherwise correspond to nominally forbidden transitions in a nonalloyed case. The alloy randomness has an essential impact on both bright and dark exciton states [1-4], including their energy, emission intensity, and polarization angle. We conclude that, due to the atomic-scale alloy randomness, finding dots with the desired dark exciton properties may require exploration of a large ensemble, similarly to how dots with low bright exciton splitting are selected for entanglement generation.

Keywords: Quantum Dots, Dark Excitons, Atomistic Calculations.

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REGULAR SESSIONS

Id-2075

Non-Destructive Method of Scanning Magnetometry for Determining Magnetization of Weakly Magnetic and Magnetically Soft Materials

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Abstract: Measurement of magnetic fields of various objects using a scanning magnetometer is a modern method underlying a number of non-destructive magnetic testing techniques. The essence of this method lies in the point-by-point measurement of local magnetic fields near the surface of the object under study, the construction of the corresponding magnetic images based on the obtained data and their subsequent interpretation. Using this method, it is possible to find current flow paths in electrical circuits, detect defects in conductive structures, determine the presence of a magnetic structure, etc. In this work, using a scanning magnetometer based giant magnetoimpedance (GMI) sensor [1], we propose a new method for determining magnetization curves and hysteresis loops of samples with a small magnetic moment (10^{-3} - 10^{-6} emu) in the region of weak magnetic fields (up to ± 30 Oe). The off-diagonal GMI-sensor was based on a 4 mm amorphous ferromagnetic microwire segment and a miniature measuring coil wound around the microwire [2]. Distinctive features of the GMI scanning magnetometer are a high sensitivity to the magnetic field (~ 10^{-4} Oe) and a spatial resolution of order of 1 mm. As the samples, we used thin strips of a magnetically soft materials 0.1 × 1 × 5 mm in size. During measurements, the samples were successively magnetized in external longitudinal fields up to values of ± 30 Oe with steps of 1-3 Oe. For each value of the magnetizing field, the distribution of the perpendicular component of the magnetic field near the sample surface was recorded. Comparison of the experimental distributions of magnetic fields with the calculated magnetic fields of the sample makes it possible to find the value of the magnetization of the sample depending on the longitudinal magnetizing field and to plot step by step the magnetization curve or hysteresis loop of the sample in the indicated region of external magnetic fields. The characteristics obtained show good agreement with the hysteresis loops measured by the vibrating sample magnetometer. At the same time, the resulting magnetic images provide additional information about the presence of the magnetic structure of the sample.

Keywords: Giant Magnetoimpedance, Scanning Magnetometry, Soft Magnetic Materials, Magnetization

Acknowledgement: The authors gratefully acknowledge the financial support of the Russian Science Foundation, grant 20-19-00607.

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REGULAR SESSIONS

Id-2076

Electrochemical Characterization of Screen-Printed Electrodes Modified with Conductive Materials

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Abstract: The redox behavior of amino acids represented an important topic of proteomic electrochemistry. Of the common amino acids, only tyrosine (Tyr), tryptophan (Trp), histidine (His) and sulphur containing amino acids, cysteine (Cys) and methionine (Met) presents electroactive properties. These properties allow the proteomic research to be extended to broad studies regarding different phenomena such as protein adsorption, aggregation, fibrilization, structural modifications, protein/enzyme – substrate interaction etc. Based on their voltammetric profile and susceptibility for electrochemical oxidation, Tyr and Trp electrochemical oxidation reaction present the highest interest, especially for analytical propose in complex matrix. On the other hand, at common carbon-based electrodes, the electrochemical oxidation of Tyr and Trp take place at the same potential., Therefore, there is a need for new electrode materials that will allow the separation of their oxidation potentials, while maintain a high current/concentration ratio. The main aim of this study was to develop and fabricate new type of electrodes based on conductive materials which can provide the separation of the oxidation reactions of tyrosine and tryptophan. Another goal was to obtain low-cost electrodes, easy to use and ready to be produced in mass. This was accomplished through the development of a planar three-electrode system, Fig. 1, consisting on a metal oxides nanotube functionalized carbon-based working electrode and silver reference electrodes fabricated on the same surface.

Keywords: Screen Printed Electrodes, Sensors

Acknowledgements: The authors acknowledge the financial support given by project number ERANET-MANUNET-III-MINaFBioS.

REGULAR SESSION

Id-2089

Comparing CO2 Emission Realities for Usable Life Cycle of Industrial Use Focused Concrete Floors, Surfaced with Industrial Coatings

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Abstract: Global environmental issues get more problematic per day and finding long-term solutions to our environmental issues is becoming more and more important. Our society is highly industry-dependent, thus all globally scalable emissions reduction activities in the industry context, are extremely valuable. Globally, concrete as a building material is causing a substantial amount of emissions and it is also one of the main building materials utilized, when industrial floors are produced. An industrial floor includes a concrete slab groundwork which is coated with a finishing option suitable for the specific use of the industrial floor. The concrete slab base itself is typically designed to last up until the building itself is demolished, whereas the coating could be treated more like a consumable as it wears off within time and can require maintenance. Depending on the usage level and topping selection, the amount of maintenance is a function of time, for the floor. The actions taken with the coating selection have a major impact on the life time emissions and thus substantial environmental impact (microplastics, nano dust particles, closure of business for maintenance, and so on). However, it is important to understand that emissions can be reduced in many different ways. One option would be to utilize more durable concrete base and concrete mixes which help to decrease the amount of needed iron reinforcements. Additionally, emissions can be reduced by utilizing different concrete mixes which include different low-carbon cement formulations and low-carbon cement formulation including fly ash or GGBS (ground granulated blast furnace slag), can also be utilized. The coating option also influences emissions, as the selected option impacts the emissions on the construction time and when the floor is maintained. This study analyses the CO2 emissions of different concrete mixes, paired with two different typical concrete floor surface coating options. The study goal is to map, what sort of and how substantial potential there is, for reducing the building's lifetime CO2 emissions, with different bases and floor coating selections. For the groundwork, the study compared Portland cement-based mix with CEM3a and CEM3b mixes, whereas the coating compared a traditional epoxy floor coating with a dry shake-based option. The analysis shows major benefits in the dry shake-based option, which reduces emissions drastically, compared to the epoxy-based coatings.

Keywords: Emission, CO2, Sustainability, Environmental, Concrete, Floor, Surface, Coating.

REGULAR SESSIONS

Id-2093

Challenges in Graphene-Based Nanomaterials for Advanced Bone Tissue Regeneration

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Abstract: Graphene materials research has significantly influenced the landscape of several fields such as tissue and membrane engineering or biosensors. Tissue engineering has provided innovative graphene based strategies able to restore defective bone based on stem cell or bone substitutes (empty or incorporating growth factors and / or stem cell). Although several solutions have been actively promoted in the past years there are challenges, for both strategies, that need to be properly addressed in order to enable clinical application and successful replacement of autografts that are currently the gold standard for this purpose. Several, 3D scaffolds potentially attractive for bone repair based on biopolymers (sodium alginate, chitosan, and gelatin), synthetic poly(vinyl alcohol) and graphene derivatives were proposed and investigated under the complex condition envisaged by real-life bone repair application. In vitro assessment in terms of biocompatibility and osteogenic properties ensured that the GO-polymer bone graft substitute material sustains bone cell attachment, proliferation and differentiation. The in vivo performance of the biopolymer-graphene 3D scaffold in mice model displayed a much improved effectiveness and seems a feasible alternative for current treatment options in the restoration of non-healing bone. A key requirement for properly conducted trials for tissue engineering involving stem cells is the feature of a potency assay to give *a priori* indication of administered cell functionality. Graphene has unique qualities suited to sensitive detection and measurement of the potency molecules but also to improve osteocoductive features of current bone scaffolds. Graphene based optical and electrochemical biosensors with significant improvement over conventional methods, and with potential to greatly enhancing the clinical applicability of adult mesenchymal stem cells for bone repair were fabricated and investigated. Related to graphene based materials and their application in biomedical field such as platform for biomolecule detection or scaffolds for bone regeneration much has yet to be revealed nevertheless graphene seems to play a key role in improving the features of health sector products.

Keywords: Graphene oxide, Biosensing, Bone regeneration, Potency assay.

Acknowledgments This work was supported by a grant of the National Authority for Scientific Research and Innovation, Operational Program Competitiveness Axis 1 - Section E, Program co-financed from European Regional Development Fund "Investments for your future" under the project number 154 / 25.11.2016, P_37_221 / 2015.

REGULAR SESSIONS

Id-2095

Metallized Electropun Polymeric Fibers as a New Platform for Flexible (Bio)Sensors

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Abstract: Wearable biosensors allow the analysis of sweat and their development requires a flexible platform/substrate able to resist mechanical/bending stress which must be investigated. Electrospuned polymeric fibers are among the promising materials for such applications. These nanostructured surfaces can be easily coated with metal layers in order to obtain a conductive path. By nanostructuring electrodes surface, the sensing performance of the devices and the detection of analytes in specific environments is improved. Information regarding pH, salts or some other biomolecules such as glucose, lactate or uric acid [1-2] can be obtained using sensors with various configurations. Thus, through the real-time and continuous monitoring of the processes that take place in the human body by using wearable (bio)sensors, a tool for early diagnosis of certain medical conditions can be obtained. Moreover, the flexible substrates can be used also for determining the oxidative stress in cell culture by building SOD based biosensors [3]. This type of sensors can be applied also for the determination of antioxidant activity in different beverages (red wine, green tea, orange juice). This work is based on the design and manufacture of new (bio)sensors obtained from functionalized metallized electrospun polymeric fibers with different receptors in order to obtain a device able to detect specific molecules. From sweat, the targeted molecules were different ions and glucose, while for the antioxidant activity it was applied for green tea, red wine and orange juice. The obtained sensors were characterized by scanning electron microscopy with energy dispersive X-Ray spectroscopy, Fourier-Transform Infra-Red Spectroscopy and by electrochemical techniques. The potentiometric electrochemical sensors served for ions determination and quantification in different media, including artificial sweat in presence of targeted ions and interferences or served as an amperometric biosensor for the detection of potassium superoxide.

Keywords: Sensors, Electrospinning, Polymeric fibers

Acknowledgements: Financial support from the Executive Agency for Higher Education, Research, Development and Innovation Funding (UEFISCDI), Romania, Project code: PN-III-P1-1.1-PD-2021-0319 and PN-III-P1-1.1-TE-2019-0387.

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REGULAR SESSIONS

Id-2103

Highly Efficient Removal of Methylene Blue Dye by a Hybrid Adsorption–Photocatalysis Process Using $Ti_3C_2t_x$ Mxene/Cryogel Composites

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Abstract: In this study, we report a new composite based on a macroporous 3D cryogel, multi and single layer $Ti_3C_2T_x$ MXene nanosheets modified by Ag nanoparticles (designated as m-MXene/Ag/Cryogel and s-MXene/Ag/Cryogel), applied for methylene blue (MB) removal via synergistic effect of adsorption and photocatalytic degradation. 4-vinylpiridine and methacrylic acid based cryogel was synthesized via free-radical polymerization under sub-zero temperatures containing a large number of negatively functional groups. Multi and single-layer MXenes were produced via etching of Al from Ti3AlC2 MAX phase with further incorporation of AgNPs via one-step method. The synergistic effect of adsorption/photocatalysis of the MB removal was reached due the superb adsorption capacity of the cryogel (up to 368 mg/g) and the high photocatalytic activity of s-MXene/Ag (657 mg/g). Incorporated AgNP expands the ability to absorb light that excites the surface electrons of Ag NP through the effect of surface plasmon resonance, while MXene with high electrical conductivity properties served as co-catalyst to enhance the photodegradation rate. The obtained results indicate that the synergistic effect of adsorption-photocatalysis is an effective way to remove organic pollutants.

Keywords: $Ti_3C_2T_x$ Mxene; Cryogel; Adsorption; Photocatalysis; MB Removal.

REGULAR SESSIONS

Id-2127

Metal Plasmon Resonances Induced Enhanced Photons Harvesting in Inverted Thin Film Organic Solar Cell

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Abstract: Copper doped lanthanum phosphate ($LaPO_4$:Cu) nano-composites were successfully synthesized using hydrothermal processes for potential application in solar energy harvesting via thin film organic solar cells (TFOSCs). $LaPO_4$:Cu finds an interest in application for photovoltaic because of its stability and broad absorption band in visible spectrum. The structure and morphological properties the synthesized nano-composite were studied using high resolution tunnelling and scanning electron microscopy (HRTEM and HRSEM). The solar absorber layer of the solar cells under investigation was composed of the mixture of poly-3-hexylthiophene(P3HT) and (6-6) phenyl-C61-butyric acid methyl ester (PC61BM)at 1:1 ratio by weight. The absorber layers are then mixed with $LaPO_4$:Cu nano-composites at different concentrations. The inverted device architecture is employed in this investigation which is composed of different layers of materials as: glass/ITO/ZnO/P3HT:PC61BM : $LaPO_4$:Cu/MoO_3/AL. The results showed that an improved power conversion efficiency(PCE) was observed from all devices containing the nanocomposite. The PCE has increased from 3.58\% to a maximum of 6.11% due to the incorporation of $LaPO_4$:Cu nano-composite. The changes in device performance was attributed to the enhanced optical absorption by virtue of light scattering processes and localized surface plasmon resonance (LSPR) in the photoactive medium. Moreover, the $LaPO_4$:Cu nano-composites-doped inverted solar cells were found to be very stable under ambient environment.

Keywords: Plasmon, Organic Solar Cell.

REGULAR SESSIONS

Id-2130

The Future Technologically Ironmaking-H2 (Hydrogen)

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Abstract: The iron used in the steelmaking process is currently chemically reduced from iron ore through the use of fossil resources – natural gas or coal. This process is known as Direct Reduced Ironmaking (DRI).Carbon combines with the oxygen in the iron ore, producing metallic iron and a carbon-rich process gas. Currently, for every tone of iron that is produced from iron ore, on average 2.25 tons of CO2 is emitted. It is also possible to reduce iron ore using hydrogen instead of carbon; in this case the waste gas produced is water, as per the following reactions: 2Fe2O3 + 3C -> 4Fe + 3CO2; Fe2O3 + 3H2 -> 2Fe + 3H2O ; FeO +H2 -> Fe + H2O.The transition to a low-carbon world requires a transformation in the way we manufacture iron and steel. There is no single solution to CO2-free steelmaking. The 2020 technology roadmap, the IEA suggests that green hydrogen is introduced as a primary reducing agent at a commercial scale in the mid-2030s. Use expands to 14 Mt/year by 2050. While this represents a fast scale up and deployment of a new technology, the IEA's modeling suggests that by 2050 under 9% of total steel production will rely on electrolytic hydrogen as the primary reducing agent (or 15% of primary production). We analysis multiple technological pathways to reduce CO2-emissions, different steelmaking routes were analyzed in terms of feedstock consumption, energy demand and carbon saving potential. The goal of this work was to point out possible CO2-reduction potentials of the considered routes and the additional energy demand required for the direct reduction with hydrogen. Hence, the availability of sufficient amounts of renewable energy to produce green hydrogen plays a dominant role for the decarbonization of the steel industry.

Keywords: Steel, Hydrogen, Reduce CO2, Decarbonization, Ironmaking.

REGULAR SESSIONS

Id-2136

Designing of 2D, 3D-Conducting Polymers & Their Nanocomposites

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Abstract: Conducting polymers have drawn broad attention of scientific communities due to their important applications in electronics, energy conversion and storage, sensors and medical devices[1]. Moreover, 2D-organic materials such as graphene[2] with unique properties such as electrical, mechanical, and thermal properties, and their nanocomposites have been played important roles in advancing the Materials science and engineering field[3]. However, fabrication of 2D and 3D structures of conducting polymers and their nanocomposites is at present still desirable since they are expected to improve the device performance including polymer solar cell, batteries, supercapacitor, sensor, and medical applications[4,5]. Therefore, goal of this research work is to develop a novel fabrication method of 2D-, and 3D- conducting polymers, and their nanocomposites with a cost-effective, environmental-benign and scalable synthesis technique, and study the relationship between the structure and properties of these materials. A bicontinous emulsion reactor was developed to produce 2D and 3D conducting polymer in combination with interfacial polymerization technique. The reactor conditions are vital to modify morphology and the physical properties of the polymeric materials and their nanocomposites. In this work we will also discuss the effect of oxidant, solvent systems, and temperature on the polymeric materials morphology and their properties including electrical, mechanical, and thermal conductivity by using various analytical tools including SEM, BET, XRD.

Keywords: Conducting polymers, Nanostructures, Composites, Layered Nanostructures.

REGULAR SESSIONS

Id-2142

Ni Nanophase Segregation in $Zn_{1-x}Ni_xS$ Thin Films

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Abstract: In several ternary semiconductor materials, the local atomic structure differs in a substantial manner from the average crystalline structure, determined by conventional diffraction experiments. Therefore, we have studied the local atomic structure of $Zn_{1-x}Ni_xS$ thin films, grown by atomic sputtering, using X-ray Absorption Spectroscopy. Ni concentrations x = 0.00, x = 0.04, x = 0.08 and x = 0.14, were investigated. X-ray diffraction shows that the lattice parameter contracts with increasing Ni concentration, optical absorption reveals a reduction of the bandgap as Ni concentration increases, except for sample x = 0.14 where a complex behavior is observed. Results from X-ray Absorption Near Edge Structure (XANES) spectroscopy indicate a shift in the valence state of Ni for the x = 0.14 sample. Extended X-ray Absorption Fine Structure (EXAFS) spectra shows a contraction of the Ni-S bond distance compared to the Zn-S bond length, which generates an increment of the static disorder as the Ni concentration increases. The EXAFS results for the x = 0.14 sample show the presence of a $Zn_{1-x}Ni_xS$ phase and a nanoscopic metallic Ni phase with domain sizes below the diffraction limit. These results reveal that the local atomic structure differs in a significant manner from the average crystalline structure. This study highlights the importance of the local atomic structure in the determination of electronic properties materials.

Keywords: $Zn_{1-x}Ni_xS$, Thin films, Crystal structure, EXAFS.

REGULAR SESSIONS

Id-2168

Development of a New UAV Concept and Flight Method to Increase Flight Autonomy and Maximum Flight Speed Using Wings and Tilt Motors

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Abstract: Over the years, many types of UAVs (unmanned aerial vehicles) were developed, they are mainly divided into fixed-wing UAVs and multi-rotor UAVs. Fixed-wing UAVs achieve their aerodynamic lift using the wing leading to a higher flight autonomy compared to multi-rotor UAVs. In case of multi-rotor type UAVs, the flight is achieved entirely by the propulsion force generated by the engines (usually, by the rotation of some propellers). This implies a high energy consumption which leads to a low autonomy, but brings the great advantage of fixed-point flight and vertical take-off/landing. Therefore, at the moment it is desired to optimize multi-rotors because they are much more practical in their use. The current work presents the development of a new quadcopter concept and the related flight method applied to increase the flight autonomy compared to multi-rotor UAVs, especially quadcopters. A hybrid quadcopter with a frame size of 1553 mm was designed from scratch. It is characterized by the fact that the support arms that hold the motors were transformed into mounting areas for four wings (one on each arm). Each wing is provided with a servo motor that ensures an independent angle of incidence. To be able to fly such a vehicle and to obtain the advantages of the four wings in terms of aerodynamic lift, a control and flight method was developed. Based on calculations and simulations, it was observed that for the concept optimization, the engines should have a tilt in the travel direction. The manufacturing of the hybrid quadcopter experimental model, conventional and advanced manufacturing technologies were applied. The advanced additive manufacturing technology was used to manufacture some of the components from polymeric composites reinforced with continuous carbon fibres, for other components, conventional manufacturing technologies were applied. Based on theoretical flight simulations, the following advantages were obtained for the experimental model: by maintaining a constant Cd (drag coefficient), the maximum flight speed increased by 59%, the necessary energy consumption to achieve a uniform rectilinear route decreased by 36%, and the maximum distance of flight was increased by 58%.

Keywords: UAV, Drone, Wings, Quadcopter, Tilt.

REGULAR SESSIONS

Id-2172

Detection of Surface Cracks in Underwater Concrete Structures

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Abstract: This work aims to develop a system based on artificial neural networks for crack detection in underwater concrete structures. Real-time images captured by underwater robotic cameras are processed by convolutional neural networks (CNN) for the identification of cracks on the surface of underwater structures. CNN based computer vision applications have been successfully employed for the automatic detection of surface concrete cracks above the waterline [1, 2]. However, the situation deteriorates if CNN are not trained to tackle optical effects generated by light travelling through various shallow water settings, resulting in poor accuracy of crack detection (~70-80%). Surface waves, seafloor topography, depth and the geometry of the underwater structures do affect the quality of captured images. This is due to optical effects of light travelling through the surface of water (refraction, reflection, ripples, caustics, etc.). These effects disturb optical images captured by underwater cameras and compromise the functionality of algorithms for the detection of cracks on the surface of underwater structures. The first task is to develop realistic physical models the water surface and the optical effects caused by light on the surfaces of concrete underwater structures. The second task is to augment the rendered images and train CNN with those images in order to improve the accuracy of the automatic identification of underwater cracks. To solve this problem, we simulate realistic water surfaces and capture light effects on underwater concrete surfaces. Then, the generated underwater optical effects are augmented and blended with the Mendeley concrete surface data base containing over 4000 images taken in laboratory conditions and labeled with having cracks or without cracks. Finally, AlexNet CNN is trained and tested with the newly generated image dataset. That results into the underwater crack automatic classification accuracy exceeding 99%.

Keywords: Underwater Optical Effects, Surface Crack, Convolutional Neural Networks

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REGULAR SESSIONS

Id-2184

Additive Manufacturing of All-Copper Elements with Complicated Geometry and High Surface Quality for Microwave Technologies.

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Abstract: The demand for microwave radiation sources stimulates the development of technology for their creation. However, traditional methods based on turning and milling processes do not allow a significant increase in the efficiency of production of copper elements with a complex surface shape, which are key components of these devices. The presence of internal channels, for example for a cooling system, requires the creation of an element from its several parts, which complicates both the production process and the preparation of drawings.

Significantly less costly, both in terms of finances and time, is the creation of complex-shaped models using 3D printing. However, for high thermal load regimes from either electron beams or microwave energy, a pure copper component is required. In the case of high frequencies, the existing expensive laser sintering technologies cannot provide the required quality of surface roughness. Therefore, in this work, for such problems, it is proposed to use a modified technology of Chemical Metallization of Photopolymer-based Structures (CMPS), which allows to quickly and inexpensively create copper elements of complex shape. The paper presents a description of the method for creating all-copper elements, including those with a complex system of internal channels. The problem of removing the photopolymer base from the metallized body is being studied, because during the heating process, due to the difference in the thermal expansion coefficients of the polymer skeleton and the copper shell, the metal coating can be destroyed. Microwave cavities were fabricated and successfully tested at frequencies up to the W-band at a multi-megawatt power level. Using a pulsed high-energy electron flow (20 ns, 500 keV / 5 kA) as a radiation energy source, frequency generations of 32 GHz and 75 GHz with an output power of about 200 MW and 100 MW were obtained in the created Bragg cavities with a two-dimensional periodic structure, respectively. The manufacturing technology of the cavities made it possible to reduce the wall thickness of the element to 1 mm, which significantly simplified the requirements for power sources of a pulsed magnetic field that is shielded with a copper wall of the resonator. In the process of adjusting the intense electron flow, the fabricated structure was successfully tested in the mode of interception of accelerated particles by the cavity corrugation. The results obtained were applied to create the collector sector of a high-power (55 kW) gyrotron with thermal sensors integrated into the copper case and a channel for turbulent fluid flow. In the experiment with profiled heating, which simulates the impact of an electron beam on the collector wall, stable operation of both the collector section itself and the integrated thermal sensors was

achieved. It makes possible to display the correct shape of the thermal trace under conditions of high thermal conductivity, which is extremely important for creating a research complex for studying the effect of secondary emission in gyrotrons.

Keywords: 3D-Printing, Microwave High-Power Devices, Chemical Metallization, Gyrotron, Electron Optics

Acknowledgement: The work is supported by the Russian Science Foundation under grant #21-19-00884.

REGULAR SESSIONS

Id-2205

Adsorption of Mercury on the Surface of Coal Fly Ash Derived Zeolites and Nanocomposites: Equilibrium Studies and Mechanisms

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Abstract: This work presents the utilization of coal power plants waste, namely coal fly ash for the synthesis of synthetic zeolites and silver nanocomposites for the removal of Hg^{2+} from water. Equilibrium data are derived for all materials for the mercury concentration range of 10-500 mg/L and models are applied. The removal mechanisms are discussed in detail and complemented by XRD, XRF, SEM-EDS, and TEM characterizations and water phase mercury speciation modelling. According to findings, the adsorption capacity of zeolites is about 4 mg/g, increased by almost 5 times after the modification with silver nanoparticles to 20.5-22.3 mg/g. Langmuir equilibrium model fits well the experimental data for the nanocomposites indicating the monolayer adsorption process. The mechanism complex, involving Hg^{2+} reduction to Hg+ and possibly Hg followed by the formation of calomel and amalgams on the surface of the nanocomposites. The mercury reduction is accompanied by Ag oxidation to Ag^{+} and subsequent formation of silver chloride.

Keywords: Coal Fly Ash, Zeolite, Nanocomposite, Mercury, Adsorption.

REGULAR SESSIONS

Id-2254

Study of New Downhole Gas Liquid Separator Designs

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Abstract: Liquid accumulation in deeper wells is critical issue because it reduces the productivity index of a well. One of the lifting mechanisms for the accumulated liquid is sucker rod pump system (SRP). There has been a challenge lifting large volumes of liquid and associated gas artificially to the surface, especially with rod pumps system since SRP doesn't handle a large quantity of gas and the difficulty of separating liquid from gas downhole. Several downhole gas liquid separators have low efficiency and lack an acceptable guide for their optimum design. The objective of this paper is to perform an assessment on several conceptual downhole gas separators design. The assessment includes the effect of positioning and geometry of the separator, the effect of tubing diameter on flow characteristics and economical comparison between the assessed technologies. A downhole gas separator can be deployed below the pump intake to separate free gas from the produced liquid. The gas that is separated downhole can be produced through the tubing casing annulus while the liquid is artificially lifted through the tubing. In this study, eleven designs were investigated to determine the most optimum design applicable for 5-1/2-inch casing well and can handle high CGR up to 450 BBL/MMSCF/day. The first screening of the 11 technologies were based on the type of separator, simplicity, capability of being deployed in a well without packer in the annulus, and compatible with a SRP technology. The second screening involved calculations of pressure, temperature and density profile for each depth in the candidate well, then published equations were used to calculate the critical gas velocity for different tubing dimensions. The last screening step was to perform an economical study to compare the cost of the final four selected technologies. The results after calculating gas velocities showed liquid loading problem starts at the depth near the kickoff point. The study displayed that the installation of a separation device would help in the separation between gas and liquid if it was assembled with a tail pipe length of 1000 ft. This assessment can be utilized as a guide for the development of downhole gas liquid separation technologies in the industry. It also suggests which technology can be deployed with SRP to boost the SRP efficiency in wells that suffer liquid loading issues.

REGULAR SESSIONS

Id-2265

Effects of Erbium Nanoparticles on Luminiscence Properties of Rice husk Silicate Borotellurite Glasses

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Abstract: Four series of rare earth doped borotellurite silicate glass were prepared by melt quenching method. The first and second series are a quaternary erbium oxide and erbium oxide nanoparticles doped glass with chemical composition $\{[(TeO_2)_{0.8}\ (B_2O_3)_{0.2}]_{0.8}\ (SiO_2)_{0.2}\}_{1-y}\ (RE)_y$, y= 0.01, 0.02, 0.03, 0.04, 0.05 molar fraction and RE = Er_2O_3 /Er_2O_3 NPs, while the third and fourth series are a multicomposition $[\{[(TeO_2)_{0.8}\ (B_2O_3)_{0.2}]_{0.8}\ (SiO_2)_{0.2}\}_{0.99}\ (Ag_2O)_{0.01}]_{1-y}\ (RE)_y$ where y = 0.01, 0.02, 0.03, 0.04, 0.05 molar fraction. This research proposes to extract silica from the rice husk and use it to synthesize a series of selected chemical composition of borotellurite silicate glasses doped with different concentration of Er_2O_3, Er_2O_3 nanoparticles (NPs) and doped with Ag_2O in order to study their effects on the physical, structural, optical and thermal properties. This will go a long way in turning waste into wealth. Addition of Ag_2O into the glass composition modifies the optical properties of the glass system. A novel type of glasses containing rare earth ions and silver ions has recently emerged and already attracted significant attention, the reason for such interest lies in the efficient enhancement of the fluorescent properties in rare earth doped glasses when appropriate silver ions is introduced to it. Results of X-ray diffraction (XRD) confirmed the amorphous nature of the glass. The X-ray fluorescence (XRF) verified the achievement of 98.6% of silicate from rice husk. Fourier transform infrared (FTIR) has revealed the basic structural units such as TeO_4, TeO_3, BO_4, BO_3, Si-O-Si and O-Si-O in the glass system. The presence of erbium nanoparticles in the second and fourth series was verified from transmission emission microscopy (TEM) and the size of the nanoparticles were recorded within the range of 25 – 28 nm and 41 – 50 nm. The differential scanning calorimetry (DSC) measurements indicate a good thermal stability of borotellurite silicate glasses with the values of $T_s > 100\ ^oC$, and the transition temperature, T_g in all the glass series are found to increase from 437 to 511 ^oC, 447 to 498^oC, 452 to 482 ^oC and 469 to 495 ^oC with the increasing dopants concentrations in all the four glass series.

Keywords: Rare Earth, Laser, Borotellurite, Glass, Luminescence, Rice Husk.

REGULAR SESSIONS

Id-2266

MET Sensor with a Sensitivity Controlled by Electrical Signals

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In recent years, MET sensors have proven their high performance. Practically speaking, the most important is their ability to provide measurements with a sensitivity ten times higher than that of electrodynamic geophones, including measurements in the low frequency region ≤ 1 Hz. That is why devices of this type are now considered as one of the most promising technologies for creating new, mass-produced highly sensitive sensors for geophysical exploration in the nearest future. These benefits have been confirmed at room temperature. At the same time, however, the sensitivity of MET sensors is known to decrease hundreds of times when the temperature drops from room temperature to -40 °C, and for such temperatures, the use of MET sensors does not provide advantages over standard geophones. In this regard, it is extremely important to create sensors whose sensitivity can be changed with the help of external electrical signals. In this work, we studied an approach associated with the use of a conversion element based on an electrochemical cell containing six electrodes. Compared to the conventional four-electrode anode-cathode-cathode-anode configuration, a pair of gate electrodes has been added.

Keywords: Molecular-Electronic Technology, Sensors, Stabilization.

Acknowledgments: This work was supported by the Russian Science Foundation by the grants № 22-19-00211.

REGULAR SESSIONS

Id-2270

Hybrid Pyroelectric and Piezoelectric Wind Energy Harvester Using Vortex Generator for Self-Powered Devices Applications

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Abstract: In this work a novel micro-energy harvester using combined piezoelectric and pyroelectric conversion is reported. The design, simulation, and experimental study of the harvester is discussed. The goal of this project was to find innovative way to exploit vibration and variation of the temperature both induced by the vortex phenomena to harvest wind energy. We have used PVDF film which presents piezoelectricity and pyroelectricity characteristics in the design of our harvester. The advantage of this new method is to expand the interval of wind velocity which can be used by the harvester. In fact, using vortex generator, the power produced by the piezoelectric behavior of the PVDF film decreases for the wind velocity over 14 m/s, however the power produced by the pyroelectric behavior of the PVDF film increases considerably for wind velocity over 12 m/s. So, we have developed a mechanical system with two parts of PVDF film with 2 cm^2 of area: the first was totally fixed to copped substrate to produce pyroelectric current as a result of the temperature variation produced by the vortex and the second part was able to oscillate and to generate piezoelectric current as a result of the vibration induced by the vortex. We have demonstrated the capability of this mechanism + the vortex generator for producing uninterrupted current when subjecting to wind flow and its signal increases with the increase of the wind velocity. We have used SolidWorks in the simulation study and for the experimental validation we have used an accredited ISO/CEI 17025 wind tunnel equipped with flow calculation system for the air flow velocity measurements from 0,3 m/s to 36 m/s. Using our developed system, we harvested up to 2 milliwatt of power. We also have presented the output power of our device stored in 1 µF capacitor with demonstration examples of loading charges. These results offer opportunities for self-powered devices like wireless sensors on a very large scale of wind energy.

Keywords: Pyroelectric Piezoelectric Micro-Generator, Vortex Generator, Wind Harvesting Energy, Self-Powered Devices.

REGULAR SESSIONS

Id-2298

3D Printing of Multi-layered Graphene Oxide - Hydrocolloid Composite Hydrogels

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Abstract: The advent of improved fabrication technologies, particularly 3D printing, has enabled the engineering of bone tissue for patient-specific healing and the fabrication of in vitro tissue/organ models for ex vivo testing [1,2]. However, inks made from polymers often fall short in terms of mechanical strength, scaffold integrity, and the induction of osteogenesis. For one thing, most polymeric hydrogels expand and contract on their own accord and don't have any bioactive properties [3,4]. Using a 3D printing technology, we produced hydrocolloid-graphene oxide (GO)/gelatin/gellan composite ink to create bone-like scaffolds in three dimensions. Our research suggests that stress can easily break away the physical crosslinks between colloid and polymers. When exposed to shear, stretched macromolecules regain their freedom and align themselves along the flow direction, resulting in shear-thinning ink compositions. To simulate critical-sized flaws and demonstrate scaffold fidelity, 3D-GO defect scaffolds with complex geometry were successfully printed using formulations including varied GO concentrations (0.25, 0.5, and 1% with respect to polymer content). The addition of GO to hydrogel inks enhanced not only the compressive modulus but also the printability and scaffold fidelity compared to the pure functionalized gelatin/gellan system. With its strong potential for 3D bioprinting, GO 0.5 shown to have highest perspectives for bone tissue models and tissue engineering applications.

Keywords: Graphene oxide, 3D printing, Biomaterials, Tissue Engineering.

Acknowledgement: The authors would like to thank for the financial support provided by a grant of the Romanian Ministry of Education and Research, CNCS - UEFISCDI, project number PCE 103/2022.

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POSTER SESSIONS

Id-1914

Bio Degradable ReRAM for Green Computing: Advances and Limitations

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Abstract: Due to heavy drive to limit the pollution and power consumption, green technologies are emerging. Green computing is one such leading technologies. Biodegradable ReRAM is a memory element that forms core of a green computer [1]. Extreme low power operation and bio degradability are the two important features of a Bio degradable ReRAM. Advances and progress in various biodegradable ReRAMs based on Chitosan, Gelatin, along with other water soluble polymer nano composites will be discussed. Further our recent work on the pure raw Cow milk [2] and plant extract based ReRAM shall be presented. In particular 'S-type' memory characteristics were observed using the medium fat milk, whereas fat-free and full-cream milk showed 'O-type' memory characteristics. Switching voltages are remarkably low V_{SET}=+0.48 V and V_{RESET}=−0.25 V. This allowes these devices to be operated at low powers. The transport mechanisms that lead to switching was analysed. Both fat-free and full cream milk-based devices showed conduction and switching is due to hopping mechanism driven conductive filaments. Space-charge limited conduction mechanism dominates the medium fat milk-based device. We also shall discuss ReRAM based on plant extracts. We then summarise all Bio ReRAMS, compare advances and limitations in this presentation.

Keywords: ReRAM, biodegradable, green computing

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POSTER SESSIONS

Id-1927

Effect of The Laser Processing Parameters on The Selective Laser Melting of TiC-Fe Based Cermets

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Abstract- The influence of laser pulse shaping on the formation of TiC-Fe-based cermets with different laser process parameters is investigated. The impact of pulse shaping and laser melting peak power on the microstructural development and mechanical properties of SLM-built parts has been addressed. This research focuses primarily on the process parameters required to produce crack-free components and includes investigations of mechanical properties such as microhardness and fracture toughness. To acquire an optimal process parameter, samples were manufactured using pulse shaping technology with varying laser peak melting power and exposure time. The influence of laser melting peak power and pulse shape on the microstructure development and phases was analyzed using Scanning Electron Microscope and X-ray diffraction.

Keywords: Cermets, additive manufacturing laser processing, laser pulsing

POSTER SESSIONS

Id-1929

Nonvolatile Resistive Switching Memory Based on Euphorbia Cotinifolia Plant Extract

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Abstract: The current memory devices such as dynamic random access memory (DRAM) and flash memory have shown serious architectural limitations which affect their scalability at the sub-nanometer level. This is due to the use of at least one metal oxide semiconductor field-effect transistor (MOSFET) in both these memories. The heavy metal content of these memory devices is also another significant contributor to environmental waste after disposal. Emerging memory, namely, resistive switching memory (ReRAM) has simple capacitor-like architecture and does not need a driving transistor. Furthermore, ReRAMs have been demonstrated with organic materials. Therefore, they do not only address the scalability challenges of the current memories but also constitute significantly less environmental pollution. In the present study, a nonvolatile ReRAM device has been fabricated using raw euphorbia cotinifolia plant extract-based film sandwiched between silver (Ag) and indium doped tin oxide (ITO) electrodes. This device has been fabricated to completion without the use of heat or electricity. The device showed memory parameters such as the $ON/OFF = 5$; the endurance of over 32 write/erase cycles, and data retention of $> 10^3\ s$.

Keywords: Resistive switching memory, euphorbia cotinifolia plant extract, nonvolatile memory, environmental friendly electronics

POSTER SESSIONS

Id-1936

An Electron Spin Resonance Study of Multiferroic Perovskite $BiFe_{0.5}Mn_{0.5}O_3$ Displaying Spontaneous Magnetization Reversal

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Abstract: $BiFe_{0.5}Mn_{0.5}O_3$ was prepared through High Pressure- High Temperature (HP/HT) synthesis [1, 2] for Electron Spin Resonance characterization. This system is known to display bulk multiferroism [3] (coexistence of Antiferromagnetism and Ferroelectricity). In particular, the system presents a weak ferromagnetic resultant and a very rare phenomenon: the spontaneous magnetization reversal in low field regimes. This behaviour was explained in terms of a pronounced competition of two magnetic populations (one highly rich in Fe and another one highly rich in Mn), whose presence is determined by the intrinsic inhomogeneity of the sample determined by the exotic synthesis conditions. As this system has in-built magnetic inhomogeneity and frustration, it is interesting to probe this system using ESR technique. Our detailed study shows violent fluctuations of g-factor in the low temperature regime, exactly where appear the thermal crossover marking the appearance of the magnetization reversal. Further, the asymmetry parameter, which represents the magneto-crystalline anisotropy shows a peak around 75K, which falls in the temperature window where a crossover of susceptibility occurs from positive to negative. Thus, a comprehensive analysis of ESR data suggests frustration and competition between Fe and Mn-rich clusters, supporting the earlier interpretation[1] at the origin of the magnetization reversal.

Keywords: Low field microwave absorption, multiferroics, spontaneous magnetization reversal, e lectron spin resonance

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POSTER SESSIONS

Id-1957

Influence of 0.5 wt% SiC Reinforcement on Microstructural and Thermal P roperties of SAC0307 Solder Joints

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Abstract: The effect of SAC0307-
SiC 0.5 wt % composite solder joint on the thermal properties of MOSFETs soldered onto MCPCB (m etal core printed circuit board) was investigated. Metalcore glass-
epoxy substrates with a thickness of 1.50 mm, covered with a 35 μm thick Cu layer, were used. A surf ace finish was prepared from a hot air leveling (HAL) Sn99Cu0.7Ag0.3 layer with a thickness of 1 ÷ 40 μm. MOSFET transistors were soldered in a batch oven with composite solder pastes. SiC nanoparti cles and nanofibers with 0.5 wt % were used as the reinforcements of the joints. SACX0307 (Sn99Ag 0.3Cu0.7) was used as a reference sample. The thermal impedance $Z_{th}(t)$ and thermal resistance R_{th} of MOSFETs were measured. Furthermore, the void formation and the microstructure of solder joints were also studied. The results showed that SiC composite solder joints positively influence the therma l parameters of mounted transistors. A 10% decrease of R_{th} can be observed for the samples soldered with composite SiC solder alloys. The voiding properties were acceptable however higher than the re ference sample (6.5%) i.e. 21% for SAC0307-0.5%SiC nanofiber joints and 12.5% for SAC0307-
0.5%SiC nanopowder joints. The thermal parameters of mounted transistors depend on the microstru cture of the solder joint. It was found that the microstructure of the solder joints depended on the form of SiC particles (powder or fiber). SAC0307-
0.5%SiC nanofiber joints contained agglomerated Ag_3Sn islands in the solder bulk and relatively large β-Sn grains were found (around 50 μm). In the SAC0307-
0.5%SiC nanopowder samples, no isolated Ag_3Sn islands were found resulting in considerable grain r efinement.

Keywords: Composite solder, SiC; nano-particles, reinforcement, microstructure, thermal behavior

POSTER SESSIONS

Id-1964

Formation of Self-Assembled Organosilane Nanolayers on Al Surfaces by Adsorption of Alkoxysilanes on The Metal and Effect of The Surface Organosilicon Layers on Aluminum Corrosion

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Abstract: The objective of this work was to examine the adsorption of diaminosilane and vinyltrimethoxysilane on Al as well as study the structural and protective properties of organosilane films on its surface. Adsorption of vinyltriethoxysilane(VS) and diaminiosilane(DAS) on the surface of aluminum from an aqueous solution is studied with the use of a quartz-crystal nanoobalance. Upon adsorption o fsilanes, adsorbed water is found to be displaced from the surface. For the interpretation of adsorption data, Langmuir, Brunauer-Emmett-Teller, Flory-Huggins, multisite Langmuir, Temkin, Frumkin, and Freundlich adsorption isotherms were used. The surface orientation of adsorbed molecules is determined. The heats of adsorption of silanes have been calculated in different ways and it was shown that both of silanes are found to be chemisorbed on the surface of aluminum. It was determined that at the initial stage of the formation of organosilane films on Al, the VS molecules are chemisorbed monolayer, and the DAS molecules are chemisorbed polymolecularly. Exposure of aluminium samples to aqueous solutions of organosilanesfor 60 min, led to the formation of vinyltrimethoxysilane and diaminesilane films on its surface, with layer thickness 0.5–0.8 μm and 1.2–1.9 μm for VS and DAS, respectively. In addition, the methods of quartz nanobalance, atomic force microscopy (AFM), scanning electron microscopy (SEM), Fourier-transform IR spectroscopy, and X-ray structural microanalysis were is used to show that adsorption of vinyl silane on an aluminum surface from an aqueous solution results in formation of a uniform, self-organizing protective siloxane nanolayer covalently bound with surface metal by Al-O-Si bonds. thickness can be controlled by variation of deposition conditions. The effect of a siloxane nanolayer on dissolution of aluminum have been studied in chloride-containing solutions. It is found that an ordered vinyl siloxane nanolayer with a thickness of up to 5 molecular layers causes efficient inhibition of uniform and local corrosion of aluminum. It is shown that the vinyl siloxane nanolayer is preserved on the surface of aluminum after 30 days of orrosion tests, which indicates its stability at exposure to water and corrosive components. Electrochemical and corrosion test results demonstrated that the presence of organosilane films on Al led to the inhibition of its dissolution. Thus, for VS, the local depassivation potential was 70 mV and for DAS was 180 mV. The exposure of metal samples with films for 720 h in the climatic chamber illustrated the best protective capacity of the A1 + DAS system. For this system, the proportion of corrosion damage was 3% and the time before the appearance of the first defect was 242 h, whereas for A1 +

VS, it was 10% and 218 h. This result can be explained by the higher hydrophilicity of DAS compared to VS due to the presence of two NH-groups, which promoted better chemisorption of diaminosilane molecules on A1 and,as a consequence, formation of a more complete and protective film on its surface.

Keywords: Corrosion inhibition, aluminum, organosilanes, coupling agents, adhesion, self-assembled nanolayers, corrosion

POSTER SESSIONS

Id-1966

Pair Interatomic Interactions in Liquid Cu-Ag Alloy

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Abstract: Theoretical investigations of metals and their alloys often based on the consistent consideration of ions' and electrons' subsystems. For melts of transition metals, the Wills-Harrison (WH) approximation [1] and its various modifications are among the best in this area. On the other hand, the Bretonnet-Silbert (BS) local model pseudopotential [2] (which takes into account the external d-electron existence in the metal only by means of the replacement of the s-electron valence by an effective s-electron valence) does not cease to be used for the same aim up to the present time [3]. The WH model assumes two contributions into the pair interatomic interaction – due to the valence s electrons and due to the external d electrons, respectively. The first contribution is calculated in the framework of the nearly-free-electron (NFE) approximation [4] via the pseudopotential method. Wills and Harrison used for this aim the simplest local model pseudopotential suggested by Ashcroft [5]. In the work [6], we proposed to use the BS pseudopotential instead of the Ashcroft one. Later, we suggested modifying the WH model in order to take into account the non-diagonal with respect to the magnet quantum number d-d-electron couplings between neighboring atoms [7]. In [8], it was observed that in the case when all possible non-diagonal couplings are taken into account, the d-electron contribution to the Wills-Harrison effective pair potential vanishes and latter becomes equal to the NFE (i.e., in our case, to the BS) contribution only. Thus, our modification of the WH model has two limit cases – the original WH model and the BS model. Some years ago, we studied the behavior of the partial pair potentials between these limit cases in liquid Fe-Co, Fe-Ni and Co-Ni alloys [9]. Here, the same investigation is performed for the liquid Cu-Ag alloy. This work is supported by the Russian Federation's Ministry of Science and Higher Education through the state research target № 122013100200-2 for the Institute of Metallurgy of the UB RAS.

Keywords: Melts of transition metals, partial pair potential, Wills-Harrison model, Bretonnet-Silbert local model pseudopotential

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POSTER SESSIONS

Id-1970

Physicochemical Characteristics and Activity of Polyphenols of Arctic Mac rophytes

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Abstract: Brown algae polyphenols are highly active natural compounds with a diverse structu re. Its structural unit is phloroglucinol (1,3,5-trihydroxybenzene), which can form various oligom ers and polymers in brown algae. The main feature of polyphenols is the presence of a large number of hydroxyl groups, which determine the activity of polyphenols (antioxidant, antibacteri al, antiviral, neuro- and cardio-protective, antitumor, etc.). The aim of this study is to evaluate the physicochemical properties of the polyphenols of the brown alga Fucus vesiculosus to ide ntify the structure-activity relationship. Seaweeds were collected in the coastal zone of the Sol ovetsky Islands (White sea). Previously it was found that the maximum content of polyphenols is reached by the end of summer - the beginning of autumn. It makes August the most pers pective month for collecting seaweed samples to obtain the maximum amount of polyphenols. The polyphenol fraction was isolated by extraction with acetone according to the scheme prop osed by the authors [1]. The content of polyphenols in Fucus vesiculosus is 7.7±0.1%. The is olated fraction has a purity of 84.0±1.9% and an antiradical activity of 461±29 mg of ascorbic acid per 1 g of extract. The weight average molecular weight is 32.9 kDa. Hydrodynamic prop erties of the polyphenols in the extract have been established. An inverse dependence of the viscosity on the concentration is observed. This effect is probably caused by polyelectrolyte s welling, which was not overcome by adding a low molecular weight electrolyte. The determine d sedimentation and viscosity parameters suggest that polyphenols have a flexible chain struct ure, prone to folding into a macromolecular coil with a higher density due to an increase in m olecular weight and the formation of intramolecular bonds. Polyphenols are characterized by t wo constants (pKa1 9.5, pKa2 11.1), which correspond to the dissociation of free and bound -OH groups, respectively. The proportion of free -OH groups not involved in intermolecular inter actions is 31%. The redox potential is 879 mV. It has been established that the antiradical act ivity of polyphenols is characterized by a nonlinear dependence on molecular weight [2]. Ther efore, it strongly depends on the amounts of -OH groups, especially those free for interaction. The studied polyphenols have a pronounced antiradical and bacteriostatic activity, determining the prospects for use of them for the health protection. The effects of surface modification of

immune cells and blood cells (intensification of sorption effects, formation of clusters and roset tes) were found [3], which demonstrate an immunostimulatory effect of the studied polyphenol s.

Keywords: Algae, polyphenols, hydrodynamics, redox potential, activity

Acknowledgements: The research was carried out with the financial support of the state assig nment of the Ministry of Science and Higher Education No 0793-2020-0005 using the equipme nt of the Central Research Center NO «Arctic» of the Northern (Arctic) Federal University nam ed after M.V. Lomonosov, and Federal Center for Integrated Arctic Research.

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POSTER SESSIONS

Id-1972

Characterization of Al2O3/Ni/Ti Composites Fabricated via The Slip Casting Method

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Abstract: In this study, ceramic-metal composites in the Al2O3/Ti system were investigated. The research aims to characterize the microstructure and mechanical properties of innovative Al2O3/Ti composite fabricated via the slip casting method, which is one of the cheapest and most effective methods of forming composites. In the manufacturing process, a solution of nanometric alumina and submicrometric titanium as metallic components was used. In the research, composites with 10% of metallic phase and 50% of solid phase were produced during the sintering at 1450°C. Many research techniques were used to characterize the base powders, the slurries used in the slip casting method, and the composite samples after the sintering process in an air atmosphere. The initial powders, green body samples, and sintered composites were characterized by XRD, SEM/EDS studies, and density measurements using picnometric and Archimedes methods. Rheological properties and analysis of the sedimentation tendency of slurries were investigated as well. The microstructure and phase composition and mechanical properties of the sintered composites obtained were determined. A monotonic compression test and hardness measurements were used to investigate the mechanical properties of the composites. A fractography investigation was also carried out. Research results revealed that the proposed method of fabrication allows for obtaining a ceramic-metal composite from Al2O3/Ti system enhanced with new phases. XRD studies showed that after the sintering process, new TiO2 and Al2TiO5 (Tialite) phases appeared in the produced composites. The presence of Tialite as a new phase significantly affects the final properties of the composite due to its low thermal expansion coefficient, high thermal shock resistance, relatively high refractoriness, and high chemical resistance. The prepared samples were characterized by a density exceeding 96% of the theoretical density.

Keywords: Ceramics, composites, slip casting, titanium, alumina

POSTER SESSIONS

Id-1975

Effect Of Organic Shell Nuts Addition on Physical Properties of Concrete

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Abstract: The search for alternative solutions for using aggregate in concrete is right due to the depletion of natural aggregate deposits, sustainable development and circular economy. This study aims to assess the effect of the using walnut shells as replacement of aggregate in concrete on the material, mechanical and thermal properties compared to plain concrete. The 5.0, 10.0 and 15.0 wt.% addition of walnut shells were used. With increasing walnut shells dosage the bulk density decreased and the porosity increased. The results showed that all tested mechanical properties linear increased by the increase of walnut shells content. The increase in compressive strength of 1.4, 1.5 and 1.7 times, flexural strength of 1.2, 1.4 and 1.5 times and split tensile strength of 10.0, 15.3 and 29.7%, respectively, compared to plain concrete were determined. The exponential relationships between the thermal properties and walnut shells dosage were observed. With the increase of walnut shells content, the thermal conductivity and the diffusivity decreased, while the specific heat increased. The relationships between the mechanical properties and density and between the thermal properties and density were found. Also, the correlations between the most important mechanical parameters (compressive strength) and the other mechanical and thermal properties were obtained. The usage of walnut shells as concrete component is rarely included in literature while the amount of production and consumption of walnut shells is increasing. This experimental study was conducted as an attempt to produce eco-friendly structural concrete with walnut shells as a replacement of basalt aggregate in different weight ratio. The four different contents of walnut shells (0.0, 5.0, 10.0 and 15.0 wt.% of traditional aggregate) were used. Based on the results obtained in this study and the results cited in this work, walnut shells can be considered as replaced aggregate that could be applied successfully in concrete construction. The resulting increase in mechanical properties using walnut shells particles was unexpected and unprecedented in the literature. Thus, as part of further research, it is planned to carry out tests for different contents, dimensions and other types of those walnut shells, with particular emphasis on thermal and fatigue tests.

Keywords: Recycling, waste materials, organic aggregate, sustainable development, mix modification, workability, mechanical properties, thermal properties

POSTER SESSIONS

Id-1986

Low Temperature Refrigerants Based on Laves-Phase Pseudo-Binary (Dy,Er)Ni_2 Intermetallic Compounds

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Abstract: A wide variety of intriguing and exciting effects observed in solids results from the coupling of their magnetic sublattice with an applied magnetic field. In particular, it concerns the magneto thermodynamic phenomenon well-known as the magnetocaloric effect (MCE), which manifests itself in the absorption and emission of heat by a solid under an external magnetic field change. The compounds from the RNi_2 family, where R stands for rare earth metal, attached a significant amount of attention due to their special properties associated with high localized magnetic moments that originate from the incompletely filled 4*f*-electron shell of the lanthanide atoms. In those compounds Ni atoms stay in the non-magnetic state. The 4*f*-4*f* interactions are weak since the wave functions derived from the lanthanides have a small range as compared to the interatomic distances. As a result, one can observe low magnetic ordering temperatures, which makes those materials ideal candidates for low-temperature refrigerants, since they exhibit a high magnetocaloric effect (MCE) [1-3]. Here, we investigated polycrystalline pseudo-binary (Dy,Er)Ni_2 intermetallic compounds with different components compositions. Their magnetic and thermodynamic properties were extensively studied over a wide field range, which enables to define and describe high-field regularities of magnetocaloric effect. The isothermal magnetic entropy change ΔS_{mag} was estimated based on magnetization measurements. The magnetocaloric parameters obtained for the temperatures from the phase-transition range are discussed in the framework of Landau theory for the second-order phase transitions. Precise experimental characterization of the magnetic properties of the (Dy, Er)Ni_2 intermetallic compounds was also performed. For a magnetic field change that reaches 5 T, the maximum values of magnetic entropy change for the $Dy_{0.75}Er_{0.25}Ni_2$, $Dy_{0.5}Er_{0.5}Ni_2$ and for $Dy_{0.25}Er_{0.75}Ni_2$ composites equal 20.6, 18.0 and 17.9 J/kgK, respectively. The maximal isothermal magnetic entropy change values, as example, for $Dy_{0.75}Er_{0.25}Ni_2$ compound around T_C as a function of the final magnetic field can be seen in Fig. 1. The relatively large reversible and close values of ΔS_{mag} allow stating that these pseudo-binary solid solutions can be perceived as promising materials for magnetic refrigerators operating within a defined low temperature range.

Keywords: Magnetocaloric effect, Entropy change, Laves phase, Magnetic properties

Acknowledgement: The work was supported by the National Science Center, Poland through the OPUS Program under Grant No. 2019/33/B/ST5/01853.

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POSTER SESSIONS

Id-1987

Polydopamine Coatings Morphology on Spherical Nanoparticles vs Flat Substrates

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Abstract: Polydopamine (PDA) is regarded nowadays as an almost universal surface modificati on agent due to its strong adhesion to virtually any substrate, easy and inexpensive deposition method, and capacity to bind many types of functional molecules, including large biomolecules. From a technological perspective, it is important to engineer functionalized PDA films with desir ed characteristics on a variety of substrates. From this perspective, we report here the results of a comparative study aimed at determining the morphology of the deposited PDA layers on s ubstrates with different geometries: flat glass surfaces and silica nanoparticles. The study is per formed by Atomic Force Microscopy (AFM) and Scanning (Transmission) Electron Microscopy (SEM/TEM) of the polydopamine coating layers obtained by using two different oxidants: air-O2 and NaIO4. The focus was on comparing specific morphological parameters of the PDA coating layers formed on the two investigated substrates. The obtained data are correlated with the p urpose of introducing a reliable methodology for quality control of the deposited PDA thin film, which is a necessary initial step in the perspective of the potential technological applications of the coated substrates

Keywords: Polydopamine thin films, AFM, SEM/TEM

POSTER SESSIONS

Id-1990

PAMAM Dendrimer-Encapsulated Ketoconazole for Bioavailability Enhancement

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Abstract: Azole antifungal agents are the most important drugs used in clinical treatment of fungal infections, Ketoconazole (KTZ) being the first broad-spectrum oral antifungal Active Pharmaceutical Ingredient (API) approved by FDA. Its high lipophilicity and extremely weak basicity contributes to its poor aqueous solubility (0.017 mg/mL), insufficient to dissolve the administered dose under normal conditions. In order to improve the bioavailability of KTZ we obtained a new formulation with PAMAM dendrimer. This three-dimensional macromolecule is capable to encapsulate and complex with APIs being a viable alternative to increase the therapeutic efficacy of drugs. The supramolecular assembly between PAMAM dendrimer and KTZ was obtained by co-precipitation method, their interaction being investigated by powder X-ray diffraction (XRPD) and differential scanning calorimetry (DSC) analysis. The structural changes in complex were characterized by FTIR and liquid state NMR, and UV-Vis was used to estimate the amount of KTZ interacted with the dendrimer. The complex solubility in aqueous solution at different pH values and the in vitro release profile of the encapsulated KTZ by the dialysis method were also determined. The physical stability of complex, by exposure to elevated and controlled temperature and humidity, was evaluated by HPLC-MS (chemical stability) and XRPD (structural changes). All the results sustain the improvement of KTZ properties making the new supramolecular Ketoconazole-PAMAM dendrimer carrier system an interesting candidate for developing solid oral dosage formulation of enhanced bioavailability and therapeutic effect.

Keywords: Ketoconazole, dendrimers, encapsulation, bioavailability

POSTER SESSIONS

Id-1991

New Crystalline Forms with Improved Stability of Representative Statin Drugs

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Abstract: Solid dosage forms of an API may exist in both crystalline and amorphous forms. Crystalline forms are thermodynamically more stable than amorphous varieties. The better solubility of amorphous varieties results in their higher bioavailability, which is the fraction of the administered dose of the drug that gets into systemic circulation at a specific rate, and is a factor determining the pharmacological activity of the drug [1]. Statins are the most commonly used group of drugs in the treatment of lipid disorders [2] but they are poorly soluble in water. Because the stability of the crystalline forms is higher than their amorphous state, we provide attractive alternative for the drug formulation of two representative statins: Pitavastatin and Pravastatin. By using high-throughput parallel crystallization technique on two selected statins we obtained crystalline forms of these drugs. The new solid forms were identified and structural characterized by X-ray Diffractions techniques.

Keywords: Statins, bioavailability, crystalline, X-ray diffractions

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POSTER SESSIONS

Id-1994

Application of Scanning Electron Microscopy to Characterize Biocompatible Microplasma Spray Coatings with Controlled Porosity

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Abstract: Nowadays, the problem of joint replacement and engraftment in the human body and, accordingly, the problem of increasing the biocompatibility of the implant surface is in the focus of research around the world [1, 2]. However, despite such advantages of the thermal plasma spray technologies as its relative cost effectiveness and ability to spray biocompatible refractory metals (Ta, Zr, Ti, etc.) on substrates made of various materials, its use for the manufacture of coatings for medical implants has not yet become as widespread [3]. This is mainly due to the high heating temperatures of the substrate resulted from the thermal spraying process. The microplasma spraying (MPS) avoids the issue of overheating, because it introduces a very small thermal impact into the bulk due to the low power of the process (up to 2 KW). The results of authors' previous research [4, 5] proved that it was possible to obtain coatings from biocompatible materials (metals and ceramics) with controlled porosity and satisfactory adhesion to the titanium implant using robotic microplasma spraying. The new robot assisted MPS technique resulting from this research provides a promising solution for medical implant technology, along with a technique for applying Scanning Electron Microscopy (SEM) and analyzing digital images of coatings and particles forming them to select optimal MPS parameters. *The objective of the work* was to develop a technique for SEM study of the shape and size of sprayed particles, which makes it possible to establish the regularities of the effect of MPS parameters on the resulting porosity of coatings made of biocompatible materials. The coating experiments were accomplished in a two-level fractional factorial design by varying such MPS parameters as electric current, spraying distance, plasma gas flow rate and wire (or powder) flow rate. MPS of the ceramic powders and metallic wires was carried out by MPS-004 microplasmatron (E.O.Paton Institute of Electric Welding, Kiev, Ukraine) mounted on an industrial robotic arm (RS010L, Kawasaki Heavy Industries, Japan). To evaluate the shape and size of sprayed particles and the porosity of biocompatible coatings, the images obtained by the scanning electron microscope JSM-6390LV (JEOL Ltd, Japan) were processed using computer-aided programs. *The main results and accomplishments of this study* were as follows: an experimental technique for using SEM to characterize the coating and the particles that form it has been developed and tested. The application of this technique made it possible to obtain regression equations for assessing the influence of the MPS parameters on the coating porosity and the size of the sprayed particles. The influence of the spraying parameters on the particle size, shape and consequently on the

coating porosity was analyzed to select the optimal MPS parameters. The results are of significance for a wide range of researchers developing technologies of thermal plasma spraying of biocompatible coatings on medical implants.

Keywords: Robotic microplasma spraying, biocompatible coatings, scanning electron microscopy (SEM), porosity

Acknowledgements: This research is funded by the Science Committee of the Ministry of Education and Science of the Republic of Kazakhstan (Grant No. AP13068317)

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POSTER SESSIONS

Id-1995

Magnetron Sputtering of Cu-Ti Thin Films with Antibacterial Activity to Pseudomonas and Staphylococcus

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Abstract: Currently, studies are underway to impart antibacterial properties to orthopedic implants by coating them with metal particles (Cu, Ag, etc.) [1-3]. Challenges for the introduction of these technologies are cytotoxicity, poor adhesion, and heterogeneity of the microstructure of such coatings, as well as the complexity of coating methods [1-3]. Among metals with antibacterial properties, copper has demonstrated excellent antibacterial properties in vitro while maintaining an acceptable level of cytotoxicity [1, 2]. It is noted that Cu-Ti thin films can prevent the early formation of biofilms of Staphylococcus bacteria on the surface of a titanium implant and prevent the development of periprosthetic infection [1, 2]. The authors of this study are developing a technology for the production of orthopedic titanium implants with multilayer microplasma spray biocompatible coatings [4]. The main idea of this study was the deposition of Cu-Ti thin films on the surface of titanium implants with biocompatible microplasma coatings in order to protect the implants from the growth of bacterial thin films. However, despite a large number of studies on the properties of Cu-Ti films and methods for their deposition, there is still no certainty with the desired amount of released copper and the Cu-Ti film composition, the researchers note that the antibacterial properties of the Cu-Ti film strongly depend on the state of the substrate surface, on the amount of Cu (% wt.) and on the deposition method, of which the most common is magnetron sputtering [1-3]. *The objective of the work* was to evaluate the amount of released Cu and the antibacterial activity against Staphylococcus aureus and Pseudomonas aeruginosa (in vitro) of Ti-Cu films of different compositions (% wt.) in order to select the optimal parameters of DC magnetron sputtering and the Ti-Cu film composition that provide the maximum antibacterial effect. Magnetron sputtering of Cu and Ti on titanium alloy disks was carried out using an EPOS-PVD-440 (Beams&Plasmas, Russia) equipped with three DC magnetrons. The concentration of Cu released from Cu-Ti films deposited on Ti-6Al-4V alloy was measured using an inductively coupled plasma mass spectrometer ICP-MS Agilent 7500cx (Agilent Scientific Instruments, USA). Microstructure study, film thickness estimation, and elemental analysis were performed using a scanning electron microscope JSM-6390LV (JEOL, Japan) with EDX INCA ENERGY (Oxford Instruments, UK). The phase analysis was carried out by the X'Pert PRO diffractometer (PANalytical, Netherlands). Bacterial cultures of Staphylococcus aureus (gram-positive) and Pseudomonas aeruginosa were used for in vitro study of the antibacterial properties of Cu-Ti films and the surface of an uncoated titanium alloy. *The main results and accomplishments of this study* were as follows: the composition of Ti-Cu films which provides the maximum antibacterial effect against Pseudomonas and

Staphylococcus bacteria has been established and the parameters of DC magnetron sputtering of these films on a titanium alloy have been selected. Certain pretreatment parameters for the titanium alloy have been recommended. The results are of significance for a wide range of researchers developing technologies of magnetron sputtering of antibacterial thin films on medical implants.

Keywords: Magnetron sputtering, antibacterial thin films, orthopedic implants

Acknowledgements: This research is funded by the Science Committee of the Ministry of Education and Science of the Republic of Kazakhstan (Grant No. AP13268737).

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POSTER SESSIONS

Id-2008

Obtaining and Studying the Structural and Optical Properties of Nanodots Based on Graphene Oxide Derivatives by Laser Ablation

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Abstract: The effect of laser ablation of sheets of graphene oxide (GO), reduced graphene oxide (rGO) and N-doped graphene oxide (NGO) on their structural and optical properties has been studied. It was shown that after ablation, the average lateral size of the sheets of all studied graphene oxides decreases to 110 – 70 nm. The particle sizes were also confirmed by transmission and electron microscopy and dynamic light scattering data. The FTIR spectroscopy showed that the intensity of the bands associated with the bending vibrations of the O–H and C=O groups, as well as the stretching vibrations of the C–OH, were decreased for both GO and rGO and NGO after ablation. The optical density of solutions and the intensity of their luminescence also was changed after ablation. For all samples, an increase in the fluorescence intensity by several times was registered. At the same time, the most noticeable changes were obtained for NGO dispersions (by 11 times). This growth is accompanied by a decrease in the average lifetime of fluorescence. It was shown that both for GO, rGO and NGO, the intensity of long-lived luminescence was also increased after ablation of their dispersions. In this case, for NGO, intense long- lived luminescence was obtained without additional degassing of the solution.

Keywords: Graphene oxide, nanodots, properies, laser ablation

POSTER SESSIONS

Id-2015

Engineering of Magnetic Properties of Co- -rich Microwires by Post-processing

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Abstract: Amorphous glass-coated microwires can present excellent magnetic properties such as magnetic bistability, enhanced magnetic softness and Giant Magnetoimpedance (GMI) effect and fast domain wall dynamics. Excellent magnetic softness and GMI effect have been reported for Co-rich microwires [1]. We present our recent experimental results on influence of stress- annealing on magnetic softness and GMI effect in Co- rich glass-coated microwires. The influence of post-process ing (annealing and stress-annealing) on the magnetic softness, Giant magnetoimpedance (GMI) effect and domain wall dynamics of $Fe_{3.6}Co_{69.2}Ni_1B_{12.5}Si_{11}Mo_{1.5}C_{1.2}$ glass-coated microwires is stu died. As-prepared Co-rich glass-coated microwire presents linear hysteresis loops and rather hi gher magnetoimpedance ratio with double-peak dependence, typical for materials with transvers e magnetic anisotropy. Considerable magnetic hardening and transformation of linear hysteresis loop with low coercivity ($H_c \approx 4$ A/m) into rectangular with $H_c \approx 90$ A/m upon annealing without stress is observed. However, we observed remarkable MI effect improvement at certain anneali ng conditions. Stress-annealing of studied microwire allows considerable magnetoimpedance rati o and domain wall velocity increasing. Additionally, remanent magnetization growth and coercivit y decrease are generally observed upon stress annealing. Frequency dependence of maximum GMI ratio for as-prepared and annealed samples is evaluated. The obtained frequency dependence of the maximum GMI ratio allows determination of the optimal GMI measurement conditions for each sample. The observed stress-induced anisotropy and related changes in magnetic properties are discussed considering the internal stresses relaxation and “back-stresses”.

Keywords: Magnetic microwires, giant magnetoimpedance, domain wall propagation

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POSTER SESSIONS

Id-2019

Synthesis of Antimicrobial Polyurethane Foam/NpAg Nanocomposites Involving the Use of Gamma Ionizing Radiations

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Abstract: Radiochemical synthesis of metallic nanoparticles is an eco-friendly method that allows the obtaining of controlled size, well dispersed, fully reduced, highly stable particles at very mild conditions. Also, given the pandemic context caused by SARS CoV-2 and high percentage of nosocomial infections in hospitals, development of metal nanoparticles polymeric nanocomposites could reduce the effects caused by such health crises, improving the health of patients and medical staff. The AgNPs were synthesized in one step process through gamma irradiation (r.t., up to 100 kGy) directly in the polyol component (MW: 3000, f=3) of Pu foam. The PU foams/AgNPs composites were obtained by mixing at room temperature the polyol component (including Ag NPs, blowing agent, catalysts and surfactant) with MDI prepolymer (Isocyanate with various NCO: 18, 23, 27.2 %) component. Both, AgNPs/polyol and Pu foam nanocomposites were characterized by UV-Vis spectroscopy, DLS, X-ray Diffraction (XRD) and SEM analysis. The UV-Vis spectra shown AgNPs characteristic absorption peaks between 395-440 nm. The SEM analysis revealed a good dispersion of spherical shapes (average sizes between 20-90 nm) AgNPs in the Pu foam matrix. Also, the Pu foam nanocomposites have shown good antimicrobial properties against *P. aeruginosa* and *S. aureus*. These materials are intended for professional environments with specifically high levels of pathogenic contamination (hospitals, clinics a.s.o.), with various applications: antimicrobial bed mattress in hospital, cover materials (floor mats, work table coverings), antimicrobial polyurethane paints, a.s.o.

Keywords: Gamma radiation, nanocomposite, PU foam, silver nanoparticles

Acknowledgements: The financial support was provided by Ministry of Research, Innovation and Digitization, through contract PN 19310101-46N/2019.

POSTER SESSIONS

Id-2022

Formation and Electric Characteristics of Ultra-thin SiO_2 by Low-temperature Direct Oxidation Using H_2O/H_2 Decomposition Species

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Abstract: There is still a strong demand for Ultra-thin SiO_2 of a few nm in the semiconductor industry. The reason for this is that SiO_2 has extremely excellent interfacial properties compared to other materials. Ultra-thin SiO_2 is used as a liner film for high-k gate insulator and as a surface passivation film for photovoltaics, and contributes to improving their performance. The ultra-thin SiO_2 should be formed at a temperature below 400°C from the view point of semiconductor manufacturing. In this work, we investigated the formation of ultra-thin SiO2 by direct oxidation of crystalline Si by H_2O/H_2 decomposition species generated by a heated catalyzer and its electrical characteristics. H_2O/H_2 decomposition species were generated using catalytic decomposition reactions on tungsten (W) wires directly energized and heated in a Hot-wire (HW) CVD system. In general, W heated at high temperature is easily surface oxidized by O_2, H_2O, etc. to form tungsten oxide. Since the vapor pressure of tungsten oxide is much higher than that of W, it evaporates easily. Therefore, tungsten oxide film is deposited on the substrate. To solve this problem, we used H_2O which was diluted with a large amount of hydrogen as an oxidant in the HWCVD system. This method is called the wet hydrogen method [1] and was developed to re-oxidize the silicon oxide film that was etched and damaged during W plug formation in the silicon process. The oxidation conditions for Si (100) in this work were as follows; the catalyzer temperature: 1450°C, the stage temperature: 150-350°C, the treatment time: 20 minutes, H_2O flow rate: 0.02 sccm, H_2 flow rate: 100 sccm. Composition analysis and film thickness were characterized by photoelectron spectroscopy (XPS). In addition, MIS structures were prepared and current density-electric field characteristics (J-E) and capacitance-voltage (C-V) were measured. It was found that an ultra-thin SiO_2 films of 5.8 nm could be obtained at a low temperature of 150°C by this method. The film thickness increased as the stage temperature decreased, confirming a trend different from that of thermal oxide films. It was also found that the breaking electric field was about 10 MV/cm under the condition of the stage temperature of 350°C.

Keywords: Ultra-thin SiO_2, low temperature oxidation, hot-wire, J-E, C-V

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POSTER SESSIONS

Id-2032

Features of Interaction of Nanosecond UV Laser Pulses with Germanium Single Crystals of Various Crystallographic Orientation

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Abstract: The surface morphology of germanium corresponding to the {111}, {100}, and {110} planes after laser heat treatment has been studied. Industrial samples with a dislocation density of ~ 10^4 cm^{-2} were used, as well as dislocation-free crystals. The samples had an electronic type of conductivity, electrical resistivity 5 Ohm·cm (doping impurity - antimony, concentration $3 \cdot 10^{14}$ cm^{-3}). Samples were prepared from one single crystal. The deviation from orientation of the {111}, {110}, and {100} crystallographic planes was less than 10 minutes. The dislocation-free samples were also cut from one crystal and had similar characteristics. The samples were optical polished. The initial surface roughness was 50 – 60 Å. Heat treatment was carried out by repetitively pulsed nanosecond laser radiation (wavelength = 355 nm, duration = 10 ns, energy density ~ 0.5–1.3 J/cm^2, pulse repetition rate up to 100 Hz). The sample was moved relative to the stationary beam along a raster trajectory ("snake") in such a way that neighboring spots overlapped with an overlap coefficient of ≥ 99%. Before and after heat treatment, the samples were examined on a Zygo NewView 7300 profilometer and a JEOL JSM 6610LV scanning electron microscope. It has been confirmed that in industrial samples on the {111} plane, exposure to radiation leads to the appearance of etch pits, identical to those that appear during chemical etching. Their concentration corresponds in order of magnitude to the density of dislocations. The optimal value of E (0.8 – 1.25 J/cm^2), when the entire irradiated zone was completely covered by the etch zone. It was found for the first time that etching results of a crystallographic nature also appeared on the {100} plane. At E ~ 0.4 J/cm^2, on all surfaces corresponding to the {111}, {100}, and {110} planes, individual spots ~ 50 μm in size appeared, as well as separate micro craters ~ 0.1 – 1 μm in size. These spots weakly depended on the orientation of the sample, although it should be noted that they were the least pronounced on the {110} surface. The influence of the orientation of the surface on the shape of the spots and on the features of the structure had practically no effect. Similar results were also obtained for dislocation-free crystals. On the {110} surface of industrial and all dislocation-free samples, there are traces of laser radiation exposure. The density of spots increased with increasing E, the spots became somewhat more distinct, but the mode of etching with the formation of characteristic structures was not installed. The dependences of the surface roughness on E are measured. Dependences are identical for all six samples and are linear.

Keywords: UV laser, nanosecond pulses, roughness, ablation, laser etching, germanium single crystal, dislocations

POSTER SESSIONS

Id-2040

Influence of The Spatial Arrangement of Products in The Chamber of Arc-PVD Installations on The Structure of The Deposited Coatings

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Abstract: The paper considers the influence of the spatial arrangement of samples in the unit chamber on parameters of deposited coatings when using controlled accelerated arc-physical vapor deposition (CAA-PVD) technology compared to the standard arc-PVD technology. The distance from a sample to the cathode surface and an offset of the sample about the central axis of the cathode were varied. The study reveals the regular patterns' influence on the spatial sample arrangement on coating properties, such as thickness, microhardness, surface macroparticle content density, and crystal structure. Using the CAA-PVD technology allows reducing the distance from the cathode surface to the samples from 230 to 150 mm, forming a coating with a higher microhardness and lower density of macroparticles than the standard arc-PVD technology. The use of CAA-PVD technology significantly (by 30% to 270%) reduces the density of macroparticles on the coating surface under deposition conditions similar to the standard arc-PVD technology. In contrast, the coating has a more uniform thickness and density distribution of macroparticles.

Keywords: Arc-PVD technology, coatings, macroparticles

POSTER SESSIONS

Id-2041

Influence of Tribological Properties of Ti-TiN-(Ti,Al,Nb,Zr)N Coating on The Character of Tool Wear During Steel Turning

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Abstract: The results of a study of the tribological properties of the Ti-TiN-(Ti,Al,Nb,Zr)N coatin g in the temperature range of 500 - 1000 ° C are considered. The process of wear of a metal -cutting tool with the studied coating during steel turning was also investigated. It was found th at with an increase in temperature to 700 ° C and higher, the value of the adhesion compone nt of the friction coefficient for a coated sample becomes significantly lower (by about 20%) th an for an uncoated sample. The process of cracking in the structure of the coating during cutti ng was also investigated. With an increase in the cutting speed, the value of the adhesion co mponent of the friction coefficient a slightly decreases, respectively, the value of the adhesive c omponent of the tool wear mechanism decreases. At the same time, diffusion mechanisms are activated, as well as a direct temperature effect on the coating, leading, in particular, to the for mation of internal transverse cracks and delaminations.

Keywords: Tribological properties, coating, turning, adhesion

POSTER SESSIONS

Id-2042

Influence of The Properties of a Multilayer Nanostructured Wear-resistant Coating Ti-TiN-(Ti,Cr,Mo,Al)N on The Wear Resistance of a Cutting Tool When Turning Steel

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Abstract: The article presents the results of a study of the process of tool wear with a multilayer nanostructured wear-resistant coating Ti-TiN-(Ti,Cr,Mo,Al)N during steel turning. Particular attention is paid to the study of the diffusion of iron from the processed material into the coating and coating elements into the processed material. It was found that the diffusion of iron into the nanolayer structure of the coating has a periodic decaying character. Coating nanolayers with a high Cr-Mo content exhibit the best barrier functions with respect to iron diffusion. The active oxidation of the layer of the processed material in contact with the coating was established, while the formation of individual grains of iron oxide, which can have an abrasive effect on the coating surface, is noticeable. The diffusion of iron into the coating to a depth of 600 nm and the diffusion of elements of the coating (primarily chromium) into the processed material to a depth of 100 nm was established. The process of crack formation in the coating and the role of the crystal structure and interlayer interfaces in the inhibition of crack propagation are investigated.

Keywords: Tool wear, nanostructured wear-resistant coating, steel turning

POSTER SESSIONS

Id-2043

Features of The Formation of Microdroplet Structures During The Deposition of Wear-resistant Coatings by The Arc-PVD Method

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Abstract: The article discusses the peculiarity of the formation of microdroplets during the deposition of coatings of various compositions by the arc-PVD method. Microdroplets of various shapes are considered and their crystal structure is considered. The influence of the distance from the cathode to the deposition surface on the prevailing type of microdroplets has been investigated. The influence of the density of thermal contact of a microdroplet with a substrate on the character of its crystallization is investigated. The influence of microdroplets on the performance properties of wear-resistant coatings is considered.

Keywords: Microdroplets, deposition of coatings, thermal contact

POSTER SESSIONS

Id-2044

Investigation of The Nature of Cracking and Brittle Fracture in Nanostructured Multilayer Composite Coatings Based on The (Hf, Zr, Al) N System

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Abstract: The article presents the results of studying the nature of cracking and brittle fracture in nanostructured multilayer composite coatings based on the (Hf,Zr,Al)N system when turning structural steel. The effect of introducing such elements as titanium (Ti), chromium (Cr) and molybdenum (Mo) into the coating composition (Hf,Zr,Al)N on the wear resistance of a metal-cutting tool is considered. The nature of the formation of cracks in the nanolayer structure of the coating was studied on transverse sections of the worn area of the coated cutting tool using SEM. The factors that inhibit the development of cracks in the structure of coatings are considered.

Keywords: Cracking, brittle fracture, nanostructured multilayer composite coatings

POSTER SESSIONS

Id-2050

Effect of Copper Doping on Sintering and Dielectric Properties of $LiZnPO_4$ Ceramics for Terahertz Applications

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Abstract: Demand for higher frequency of microelectronic devices operation, their lower size and lower production cost creates need for new substrate materials with well-tuned properties. LTCC/ULTCC technology (low/ultra low temperature cofired ceramics) offers perspectives for miniaturization, higher integration, lowering of processing costs and great diversity of compositions. This work was aimed at the fabrication procedure and properties of low dielectric permittivity $LiZnPO_4$ ceramics doped with copper destined for LTCC/ULTCC (low/ultra low temperature cofired ceramics) applications. The preparation of green tapes and measurements of the dielectric properties in the THz range have not been so far reported for such materials. X-ray diffractometry, termogravimetry, differential scanning calorimetry, scanning electron microscopy and THz time domain spectroscopy were used as characterization methods. The solid state reaction method was applied for preparation of undoped and copper doped $LiZn_{1-x}Cu_xPO_4$ (x=0, 0.06, 0.08, 0.1, 0.12) ceramics. Green tapes were fabricated using tape casting technique. Test conductor patterns were screen printed on green tapes and test LTCC structures were laminated and cofired. The observed single phase composition of the ceramics implies that Cu^{2+} ions substitute Zn^{2+} in the crystal lattice of $LiZnPO_4$ due the same valency and similar ionic radii of both ions. Thermal analysis revealed endothermic peaks on DSC curves in the temperature range 690-790°C which are not accompanied by the mass change and are dependent on the copper dopant level. The fabricated ceramics show a low sintering temperature of 750°C, dense microstructure and co-sinterability with commercial Ag pastes. The dielectric permittivity is low (5.1-5.5) and almost frequency independent in the 0.1-1.3 THz range. In this range the loss tangent is also relatively low (0.005-0.01). Some peaks which occur in the measured frequency range above 1.3 THz are supposed to be related to phonon absorption. The variation of dielectric permittivity with temperature was found to be small in the temperature range up to 90°C (below 1%). The fabricated $LiZn_{1-x}Cu_xPO_4$ ceramics demonstrate good potential for LTCC/ULTCC submillimeter wave applications owing to low sintering temperature, single phase composition and excellent dielectric properties in the THz range. The most advantageous dielectric properties at 1 THz were attained for x=0.1 – dielectric permittivity of 5.1, loss tangent of 0.007 and small changes in dielectric permittivity (0.9%) in the temperature range 20-90°C.

Keywords: LTCC, dielectric constant, LiZnPO4, ceramics, copper, terahertz applications

Acknowledgements: The work was financed by National Centre for Research and Development, Poland, under grant M-ERA.NET2/2020/1/2021.

POSTER SESSIONS

Id-2054

Mesoporous Silica Particles for Quick Methylene Blue Dye Removal From Water

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Abstract: Because of the fast growth of the fashion industry, water contamination has become one of the most pressing issues. It is well known that approximately 10%–15% of all dyes used in the textile industry are released into water bodies after processing [1]. Toxic dye-containing wastewater contaminates surface and groundwater, harms human health, and disrupts the ecological system [2]. Hence, the removal of dyes from wastewater has sparked widespread interest around the world. The adsorption process is recognized as a promising strategy among various methods due to its high efficiency, simplicity of operation, biocompatibility, and economic feasibility. In this study, we proposed a simple synthesis strategy for fabricating low-cost and environmentally friendly mesoporous silica particles with high potential for cationic dye removal. Scanning electron microscopy (SEM), Fourier-transform infrared spectroscopy (FTIR), nitrogen porosimeter, and X-ray diffraction have been used to thoroughly characterize the prepared samples. We found that prepared silica particles (~ 350-1215 nm) are negatively charged and have a well-structured mesoporous structure. Next, prepared silica particles have been tested as an adsorbent for cationic methylene blue (MB) dye removal. The as-prepared silica particles demonstrated quick and satisfactory MB adsorption efficiency (7.8 μg/mg at pH 6 and 9.2 μg/mg at pH 9). The effective adsorption properties are mainly controlled by electrostatic interactions between silica particles and cationic MB molecules. Thus, prepared silica particles hold the good potential to be used in wastewater treatment to remove some cationic contaminants.

Keywords: Silica particles, adsorbent, wastewater treatment, dye removal

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POSTER SESSIONS

Id-2059

Influence of Adding Pb^{2+} in Various Forms to TeO_2-ZnO Glasses on Electrical and Dielectric Properties

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Abstract: Electrical and dielectric properties of glasses in the TeO2-ZnO system with the addition of Pb^{2+} in different forms were investigated. The glasses were prepared by standard melt-quenching technique. During glass preparation, Pb^{2+} was used in forms: PbO, Pb_3O_4, PbF_2, $PbBr_2$, $PbCl_2$, PbI_2, $Pb(NO_3)_2$ and $PbCO_3$. Direct electric conductivity was determined using volt-ampere method in a temperature range from 20 °C up to 200 °C at a heating rate of 5 °C/min. The dependence of DC conductivity on temperature follows the so-called Arrhenius-like equation. The DC conductivity values and activation energies od DC conductivity are significantly affected by the form of added Pb^{2+}. AC conductivity and permittivity measurements using LCR Hi-tester Hioki 3522-50 at a frequency range of 0.2 Hz–100 kHz in the same temperature range from 20 °C up to 200 °C were performed. The method of cascade heating was used; the measurements were performed in steps of 10 °C. The permittivity of the glasses increases slightly with the temperature, the permittivity values depend strongly on the form of Pb^{2+} added.

Keywords: Heavy metal oxide glasses, electrical conductivity, permittivity

Acknowledgements: This work was supported by the Slovak Science Foundations, projects VEGA 1/0144/20, APVV SK-FR-19-0007, and APVV DS-FR-19-0036. P. Kostka acknowledges support from the Czech Science Foundation – project no. 19-07456S, and the Czech Academy of Sciences in cooperation with the Scientific & Technological Research Council of Turkey (TÜBITAK) for the support of the project TÜBITAK-21-11 (120N754). This publication is partially supported by the European Union through the European Regional Development Fund (ERDF), the Ministry of Higher Education and Research, the French region of Brittany and Rennes Métropole.

POSTER SESSIONS

Id-2066

Effect of Boron Dispersion Phase Content and Heat Treatment on The Microstructure and Mechanical Properties of The Ni-B/B Composite Coatings

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Abstract: The paper presents the results of research on Ni-B composite coatings with boron particles as the dispersion phase produced by the chemical reduction method. Influence of boron dispersion phase content and heat treatment on the properties of produced coating was presented. Composite coatings were deposited on a steel substrate using the dispersion phase of boron powder with the size of the particles under 1 μm. The coatings were deposited from a baths differing in content of the dispersion phase equal to 0.1 g/dm^3; 0.5 g/dm^3; 1.0 g/dm^3 and 1.5 g/dm^3. Surface morphology and topography were examined using the scanning electron microscopy (SEM) and light microscopy. The structure of the produced materials was defined using X-ray diffraction analysis. Thickness of the produced coatings was examined using X-ray fluorescence spectroscopy whereas mechanical properties of the coatings were determined by Depth Sensing Indentation (DSI) method. The scratch tests were carried out to determine the adhesion of the produced coatings to the substrate. The conducted research allowed to determine the effect of the dispersion phase content in the bath as well as the influence of the heat treatment on the properties of the produced coatings.

Keywords: Ni-B, electroless deposition, composite coatings, heat treatment

Acknowledgements: The project „New electroless Ni-B/B and Ni-B/MoS_2 composite coatings with improved mechanical properties” benefits from grant from Norway. The aim of the Small Grant Scheme (SGS) call is to support applied research projects led by female scientists in technical sciences.

Keywords: Ni-B, electroless deposition, composite coatings, heat treatment

POSTER SESSIONS

Id-2070

Microstructure and Corrosion Resistance of Ni-B Matrix Composite Coatings with Boron as a Dispersion Phase Produced by Electroless Plating

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Abstract: The paper presents the results of studies of composite coatings with nickel-boron matrix and boron particles as a dispersion phase produced by the chemical reduction method on a steel substrate. Three variants of composite coatings differ in the content of the dispersion phase in bath were produced as well as a nickel-boron coating without dispersion phase. The topography and surface morphology using the scanning electron microscopy (SEM) were presented. Characterization of the structure of the produced materials was performed using X-ray diffraction analysis and light microscopy. The corrosion tests of the Ni-B and Ni-B/B coatings were carried out with electrochemical potentiodynamic method. The conducted research allowed to determine the effect of the dispersion phase content in the bath on the corrosion resistance of the produced coatings.

Keywords: Ni-B, boron particles, electroless deposition, composite coatings

Acknowledgements: The project „New electroless Ni-B/B and Ni-B/MoS_2 composite coatings with improved mechanical properties” benefits from grant from Norway. The aim of the Small Grant Scheme (SGS) call is to support applied research projects led by female scientists in technical sciences.

POSTER SESSIONS

Id-2115

Features of Using Tools with Me-MeN-(Me,Mo,Al)N Coatings (where Me = Zr, Ti, or Cr) in Turning Nickel Alloy

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Abstract: Nickel alloys, in particular the alloy NiCr20TiAl (machinability group S under ISO 513: 2004-07) are widely used in various fields of production, in particular in the production of valve s for internal combustion engines. Although the melting point of nickel (1452°C) is lower than t he melting point of iron (1535°C), nickel and its alloys are generally more difficult to machine t han cast iron and steel. Nickel is a very plastic material with a face-centered cubic structure, a nd, unlike iron, no transformations occur in its matrix up to the melting point. Technically pure nickel has poor machinability in almost all criteria. Tool life is on average shorter, and the maxi mum allowable metal removal rate is low, tools fail due to rapid wear of the flank and deforma tion of the cutting edge at relatively low cutting speeds. In this work, carbide inserts with three types of coatings - (Zr,Mo,Al)N, (Ti,Mo,Al)N, or (Cr,Mo,Al)N were used for turning a nickel alloy. Cutting tests were carried out at three speeds - 45, 60, 74 and 90 m/min. If at cutting speed s of 45 and 60 m/min the tool with coatings containing Cr and Ti showed the best wear resist ance, then at speeds of 75 and, especially, 90 m/min, the coating with Zr showed the best we ar resistance. This result can be explained by the active formation of tribologically favorable zir conium and molybdenum oxides, as well as by the better crack resistance of the coating conta ining Zr.

Keywords: Nanostructured coatings, nickel alloy, turning, crack resistance

POSTER SESSIONS

Id-2117

Processing Methods of The Measured Values with Passive Dosimeter Used in Occupational Exposure and Dose Assessment Accuracy

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Abstract: The measurement accuracy of the personal dosimeters depends of a lot of factors from detector features, technical processing, human factors till methods of information processing recorded by the dosimetry system. Considering the detector features depend of the manufacturer the other factors depend of dosimetry services. In this work is presented the dose assessment accuracy as a result of processing by different mathematic equations of the measured data with film personal monitoring dosimeter. In this way, the film dosimeters where exposed to different dose values from 0.1 mSv ÷ 1.0 Sv to Cs 137 standard source. The film dosimeter system consists from two films with different radiation sensitivity and FD-III-B dosimeter badge with the folowing filters Cu 1.00 mm; 0.1mm and 0.5 mm; Al 0.1 mm; Pb 0.40 mm; Plastic (polystirene 0.23 g/cm^2). The mathematical equations used in the fitting of the dosimeter response are sigmoidal, exponential or linear. For each optical density versus dose dosimeter response obtained on the film under metallic filter the fitting process by mathematical equation was performed. The mathematical equation choosing for data fitting is determined by the residual size. The mathematical equations studied in this paper allow a good assessment of the radiation doses but there is no mathematical equation that fully fits the measuring range (0.1-1000) mSv. In the case of film dosimeter with two photographic emulsions, it is necessary to have a dose range that can be measured on both films. This must be 20% of the entire dosimeter measuring range. Combined use of these equations allows a quantitative assessment of the dose with a good accuracy. The uncertainty resulting from the fit procedure for each individual equation was calculated. Only the method results for which the uncertainty of fitting the dosimetric response was less than 10% were considered. The lowest residual values were obtained by approximating the response of the most sensitive film with sigmoidal equations and with linear equation of the film with lower sensitivity.

Keywords: Dose, dosimetry, accuracy

POSTER SESSIONS

Id-2125

Hydrogels Obtained by Electron Beam Irradiation Designed for Mineral Salts Adsorption

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Abstract: An important need for a better plants growth is the soil quality as a major source of nutrients. Nutrient deficiency in poor or depleted soils may be due to the geographical conditions, environmental disasters or simply to the cultivation of the same agricultural crop several seasons in row. The three main nutrients needed for plants growth are nitrogen, phosphorus and potassium but traces of oligoelements as calcium, magnesium, sulfur, iron, manganese, zinc, copper, boron and molybdenum are also needed [1]. For these soil conditions, hydrogels as source of water and nutrients may represent a viable solution. Various techniques are used for hydrogels preparation [2], such as physical and chemical cross-linking [3, 4], grafting polymerization [5] and radiation cross-linking [6-8]. The radiation technique is more preferable than the chemical one, because of the advantage offered by the gentle control of cross-linking level by variation of the absorbed dose [8]. Hydrogels of poly(acrylamide co-acrylic acid) type were prepared by electron beam irradiation in the dose range of 2.5 kGy to 6 kGy in atmospheric conditions and at room temperature. Different quantities of reaction initiator potassium persulfate (PP) and cross-linker trimethylolpropane trimethacrylate (TMPT) were used. The influence of monomeric solution recipe (AMD/AA ratio, PP and TMPT content) and obtaining conditions (irradiation dose and dose rate) on hydrogels physical, chemical and structural characteristics were investigated by swelling experiments, specific network studies, mesh size, porosity and FTIR analysis. The uptake of solutions of $CaCl_2$, $MgCl_2$ and KCl with concentrations between 0.1 and 0.5 M was also tested. The gel fraction, cross-link density mash size and porosity are improved by the irradiation dose increases from 82.33 to 93.24%, 0.61 x 10^{-4} to 4.65 x 10^{-4}, 263 to 64 μm and 98.91 to 96.3 % respectively. The absorptions of nutrients from solutions were between 1360 and 2089% for KCl, 1110 and 1554 % for $CaCl_2$ and 999 and 1618 % for $MgCl_2$. FTIR analyzes provided information on the PP and TMPT binding in the structure of the formed hydrogel, that correlated with irradiation conditions, the results of physico-chemical analyzes and nutrient (Ca, Mg and K) absorption experiments have led to the establishment of the optimal hydrogel variant for the proposed purpose.

Keywords: Hydrogels, electron beam irradiation, cross-linking, nutrients uptake

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POSTER SESSIONS

Id-2126

Swelling Studies on Hydrogels of Sodium Alginate-g-Acrylamide/Acrylic Acid Type for Agricultural Use

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Abstract: Agriculture is both a cause and a victim of water scarcity. The excessive use and degradation of water resources is creating threat to the sustainability of livelihoods dependent on water and agriculture [1]. Application of hydrogels reduces the frequency of irrigation in almost all the crops (cereals, pulses, vegetables and flowers) thus reducing time and money spend on irrigation, labor and water costs. These are mainly used for improving irrigation efficiency and are smart delivery materials that can help to combat plant pathogens even with lower pesticide dosage, reducing the quantity of soluble fertilizers per crop cycle thus contributes towards the conservation of water and environment [1]. Hydrogels of Sodium Alginate-g-Acrylamide/Acrylic Acid type were obtained by electron beam irradiation using the linear accelerator ALID 7 of 5.5 MeV at the irradiation doses of 5 and 6 kGy. For this, were prepared monomeric solutions in which the mass ratio between acrylamide and acrylic acid was 1: 1 and 1.5: 1, respectively, and the sodium alginate content was 1 and 2%, respectively. Reaction initiator potassium persulfate (PP) and cross-linker trimethylolpropane trimethacrylate (TMPT) were used. The renewable and biodegradable sodium alginate has been chosen to be grafted with polyacrylamide and acrylic acid due to its properties (a nontoxic, very user and consumer friendly polysaccharide) [2, 3] and potential to induce biodegradability of hydrogels that will be used for hydrating and enriching soils with nutrients. To combine the best properties of natural and synthetic polymers in order to obtain a material with hybrid properties is still topical [4, 5, 6]. The influence of monomeric solution recipe (AMD/AA ratio, sodium alginate, PP and TMPT content) and obtaining conditions (irradiation dose and dose rate) on hydrogels physical and chemical characteristics were investigated by specific swelling, diffusion and network studies, mesh size and porosity determination. The Sodium Alginate-g-Acrylamide/Acrylic Acid hydrogels swells after 10 hours between 8014 and 17612%, that corresponds to variations of gel fraction between 79.55 and 92.91%, cross-linking degree between 0.71-99,57 x 10^{-5} %, mash size between 0.371 and 0.844 μm and porosities over 99%.

Keywords: Hydrogels, electron beam irradiation, grafting, sinthetic polymers, biopolymers

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POSTER SESSIONS

Id-2139

Stability Criterion of Dendritic Growth for a Multicomponent Melt with Convection

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Abstract: The problem of choosing a stable mode of dendrite growth in the melt arose from the analysis of Ivantsov solutions and experiments for a parabolic needle-shaped crystal. These comparisons and tests led to the conclusion that the continuous family of isotropic Ivantsov thermal and solute concentration distributions is unstable - the needle crystal loses its original parabolic shape in the steady-state growth regime. Therefore, the Ivantsov solution is used as the main approximation for the analysis of stable growth, where the role of a small parameter is played by the anisotropy of surface tension or the anisotropy of growth kinetics. After establishing the criterion for stable growth of the dendrite apex in a one-component medium, the problem was extended to the case of convective motion of the medium, to the case of dendrite growth in a binary system without convection, and to the case of dendrite growth in a binary system with convection. This theory was then developed for the phenomena of rapid dendritic growth. In many circumstances, however, a comparative analysis of dendritic growth must be carried out considering the multicomponent nature of the system. The present work, which continues and develops the aforementioned studies, examines the effect of a multicomponent melt when considering a stable dendritic growth regime with forced flow. In this study, the steady state growth mode of a single dendritic crystal solidifying in a supercooled multicomponent melt is studied, taking into account forced convective flow. For two- and three-dimensional problems, stationary values of temperature, concentration of dissolved substance, and velocity component of the liquid are found. The stability criterion and the balance of total supercooling, taking into account the anisotropy of surface tension at the solid-melt interface, are derived.

Keywords: Stability criterion, dendritic growth, convection, multicomponent melt

Acknowledgements: The theory and computations under consideration were made possible due to the support of the Russian Science Foundation (project no 20-61-46013).

POSTER SESSIONS

Id-2143

Semiconductor Core-shell Nanowires: Synthesis, Characterization and Photodetecting Applications

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Abstract: Recently, intense research was focused on core-shell nanowires, being a unique type of heterostructure that can combine the physical properties of two different materials into a complex architecture with enhanced properties, which can be implemented in a wide range of applications such as sensing, photovoltaics, optoelectronics, etc. [1,2]. Thus, semiconductor core-shell nanowires can be envisage as new key elements in the future sensors, light emitting diodes, photodetectors, etc. Exploring novel configurations of semiconductors and different growth methods on core-shell nanowire heterostructures, band engineering can be achieved, promoting a new generation of optoelectronic devices with novel functionalities. Lately, metal oxide semiconductors such as CuO, TiO_2 and ZnO have been used for applications in like photodetectors, light emitting diodes, sensors, photocatalysis, etc., being environmental friendly materials and easily obtained employing low cost preparation routes. In this work, metal oxide based core-shell nanowire architectures were obtained by joining two n-type and p-type semiconductor materials into a type II band alignment that can enhance the separation of charges at the interface. The metal oxide based core-shell nanowire architectures were prepared by combining different wet and dry preparation techniques such as hydrothermal method, thermal oxidation in air, radio-frequency magnetron sputtering, etc. The morphological, structural, optical, compositional, photocatalytic and photoelectrical properties of the metal oxide based core-shell nanowire architectures were thoroughly analyzed and discussed. Moreover, a fine tune of the core-shell nanowires photoelectrical properties was made using different thicknesses for the shell in order to investigate their potential use in photodetecting applications.

Keywords: Core-shell nanowires, metal oxide, photodetectors

Acknowledgements: This work was supported by a grant of the Romanian Ministry of Education and Research, CNCS – UEFISCDI, Project code: PN-III-P2-2.1-PED-2021-3984, within PNCDI III.

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POSTER SESSIONS

Id-2144

Bio-inspired Fiber Webs Based on Metal Oxides by Replicating Eggshell Membranes

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Abstract: One of the common wastes in our daily life and plentiful industrial waste product, the eggshell membrane is an affordable, eco-friendly and easy-handling material that can be used for the synthesis of new value-added functional materials with potential applications in water purification, actuators, antibacterial materials, etc. [1-3]. Eggshell membrane is featured by a unique tridimensional porous interwoven meshwork that makes it very attractive for bio-templating. Versatile bio-inspired path, bio-templating offers the possibility to replicate the specific complex morphology and structure of eggshell membranes into metal oxide architectures. Hence, the bio-templating consists in the immersion of the eggshell membrane into solutions containing the metal salt precursors followed by the calcination of the organic membranes impregnated with the metal ions in order to obtain the inorganic semiconducting replica. Metal oxides such as ZnO, CuO and SnO_2 are technological semiconducting materials due to their low-price and environmental friendly features and to the involvement of low-cost chemical reagents in their preparation as nanostructures by various wet and dry routes. Thus, nanostructures based on ZnO, CuO or SnO_2 with tuned morphology and properties are widely applied in electronic and optoelectronic devices, photocatalysis, UV-shielding, chemical sensing, etc. In this study, semiconducting fiber webs based on ZnO, CuO or SnO_2 were prepared by replicating the eggshell membranes. The morphological, structural, compositional and optical properties of the prepared metal oxide fibers were evaluated by complementary techniques: field emission scanning electron microscopy, X-ray diffraction, energy dispersive X-ray analysis and reflection spectroscopy. The assessment proves that the particular hierarchical porous architecture of the organic template is accurately replicated into inorganic webs containing interconnected fibers formed by inorganic nanoparticles as building blocks. Developing such bio-inspired fiber webs based on eco-friendly semiconducting compounds (ZnO, CuO or SnO_2) using green bio-templates is an attractive approach for preparing functional materials involving simple and low-cost preparation procedures, which do not require complex apparatus and which are more environmentally friendly.

Keywords: Bio-template, eggshell membrane, metal oxide fiber webs

Acknowledgment: This work was supported by a grant of the Ministry of Research, Innovation and Digitization, CNCS - UEFISCDI, project number PN-III-P4-PCE-2021-1131, within PNCDI III.

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POSTER SESSIONS

Id-2145

Magneto-optical Resonances at The D Line of Rb in a Hot Cs Buffer Gas Confined in a Micrometric Thickness Optical Cell

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Abstract: Optical magnetometry is a field attracting increasing attention due to its various applications [1-4]. There are different approaches for the realization of such devices based on control of the atomic population on sublevels whose energy is determined by the external magnetic field. One of these approaches includes realization of coherent superposition of the magnetic sublevels of a single ground-state hyperfine level of alkali atoms. In zero magnetic field they are degenerate, and application of additional scanned around zero value magnetic field removes the degeneracy. This leads to the registration of a narrow resonance in the fluorescence/absorption of the atomic medium in dependence on the scanned magnetic field. The scheme is sometimes referred to as ground-state Hanle configuration. Reduced absorption (dark resonance) using this scheme is first reported in [5], while increased absorption (bright resonance) has been observed in [6]. Since the atoms themselves serve as a magnetic field quantum sensor [7], it is important to study possibilities for the miniaturization of the optical cells containing them. The unique cells with micro- and nanometric thickness [8] are a way to study the atomic confinement in one dimension, unlike cold atoms in traps, hollow fibers or porous structures. It has been shown that the fluorescence and absorption spectra show sub-Doppler features of velocity-selective optical pumping (VSOP) by means of single-beam spectroscopy [9]. The coherent magneto-optical resonances obtained in such cells are characterized by large linewidth due to the fast depolarization of the atoms during collisions with the cell walls [10]. In the present communication we will show our results on the registration of ground-state magneto-optical signals at the D line of Rb atoms, which are contained as a small admixture in a 700 μm thick cell filled with Cs atoms. Increasing the temperature of the cell, we increase the amount of Rb admixture to achieve a measurable fluorescence [11]. We will compare the magneto-optical signals of the atoms in such medium (the Rb atoms in a “buffer gas” of hot Cs atoms in our case) and the signals from atoms without hot “buffer gas” (Cs atoms in our conditions). These results are of importance for the investigation of the one-dimensional confinement for the miniaturization of this type of micro-sensors.

Keywords: Magneto-optical resonances, coherent spectroscopy, micrometric optical cells

Acknowledgements: The work was supported by the Bulgarian National Science Fund under bilateral project BNSF No KP-06-Rissia/11 (Russian Foundation for Basic Research Grant no. 20-52-18004)

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POSTER SESSIONS

Id-2150

Coherent Magneto-Optical Resonances on The Potassium D2 Line in Modified Hanle Configuration for Magnetometry Applications

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Abstract: Magneto-optical spectroscopy is a tool that is extensively applied in many scientific fields [1]. A key feature of this type of coherent spectroscopy is the possibility to register narrow magneto-optical resonances (MOR), whose width is determined by the ground-state hyperfine (hf) level lifetime. Potassium (K) vapor is used in the most sensitive optical pumping atomic magnetometers, since for K the hf groundstate splitting is smaller than the Doppler width, the nonlinearity of the Zeeman splitting dependence on the magnetic field is more significant than that for other alkali atoms and the isotopic shifts of the two stable isotopes (^{39}K, ^{41}K) are smaller than the Doppler width [2]. A new method for registration of narrow-width and high contrast MOR of EIA in Hanle configuration was proposed in [3,4]. It is based on a special configuration of electromagnetic fields composed of two counter-propagating laser beams with perpendicular linear polarizations and a static magnetic field applied along the wave vectors. For improving the properties of the subnatural-width resonance buffer gas or a cell with antirelaxation coating should be used. The first registration of Electromagnetically Induced Absorption (EIA) in K was reported in [5]. EIA was produced by interaction of a weak probe beam with the atomic ground state driven in a degenerate coherent superposition by either co- or counter-propagating pump beam for circular polarization of the laser light in PDMS coated cell. In this work we investigate the dependence of the coherent MOR in K cell with buffer gas registered in fluorescence and absorption on potassium D_2 line in Hanle effect configuration of crossed laser beam and magnetic field on the polarization and the direction of the laser light [6]. Magnetically unshielded 8-mm-long cell (containing K+30Torr Ne) was used to reduce the gradients influence of laboratory magnetic field to the spectral width of the resonances. The spectral transition overlapping results in very good signal, non-critical to laser frequency shifts. Moreover, this principle of magnetic field measurement allows development of self-calibrated optical magnetometer with potential for calibrating various commercially available magnetometers that need frequent calibrations.

Keywords: Coherent magneto-optical resonances, potassium D_2 line, magnetometry

Acknowledgements: This work was supported by the Bulgarian National Science Fund under contract No KP-06-Russia/11 and Russian Foundation for Basic Research Grant No. 20-52-18004 in the framework of a joint research project.

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POSTER SESSIONS

Id-2153

Impedimetric Biosensor Based on Reduced Graphene Oxide Functionalized with Gold Nanoparticles for DNA Detection

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Abstract: The rapid advancement of medicine and nanotechnology opens the path for new and improved devices. Tissue engineering has evolved into a therapeutic strategy for tissue repair or regeneration with the use of scaffolds in conjunction with stem cells. However, current stem cell-based treatments for bone regeneration are not always successful, therefore there is a need to determine the osteogenic potential of the cells before implantation to avoid an unnecessary surgical procedure and to provide the best care for patients. We aim to design a point-of-care device that detects osteogenic biomarkers using an electrochemical platform based on reduced graphene oxide (RGO) and gold nanoparticles (AuNPs). Screen printed carbon electrodes (SPCEs) were used as the basis for our detection platform, that were then modified with graphene oxide reduced electrochemically and functionalized with AuNPs using cyclic voltammetry (CV) technique to obtain AuNPs-RGO/SPCE. The bioreceptor, i.e., single-stranded DNA probe, was immobilized on the electrode surface by physical adsorption, then the functionalized SPCEs were incubated with the complementary single-stranded DNA target to obtain double-stranded DNA through the hybridization event that needs to be detected. Morphological characterization of AuNPs-RGO/SPCE was performed by scanning electron microscopy (SEM) evidencing the immobilization of gold nanoparticles on the electrode surface. The functionalization is confirmed by structural characterization conducted by Raman Spectroscopy, both techniques showing also the difference between different concentrations of AuNPs used. The electrochemical properties were investigated after each electrode modification by CV and electrochemical impedance spectroscopy (EIS) carried out in 0.1 M KCl solution containing $[Fe(CN)_6]^{3-}$/$[Fe(CN)_6]^{4-}$ redox pair (1:1). The functionalization of RGO/SPCE with gold nanoparticles resulted in enhanced electrical conductivity, a very important feature needed to fabricate a biosensor with increased sensitivity. Moreover, the binding of target DNA to the bioreceptor is determined by measuring the changes in the electrochemical signal, looking especially at the charge transfer resistance measured by EIS and confirming the results by CV.

Keywords: DNA hybridization, biosensor, electrochemistry, reduced graphene oxide, gold nanoparticles

Acknowledgements: This work was supported by a grant of the Ministry of Research and Innovation, Operational Program Competitiveness Axis 1 - Section E, Program co-financed from European Regional Development Fund "Investments for your future" under the project number 154/25.11.2016,

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POSTER SESSIONS

Id-2164

Magnetic Fe_3O_4-Ag Nanocomposites for Effective Mercury Removal from Water

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Abstract: In this study, magnetic Fe_3O_4 particles and Fe_3O_4-Ag nanocomposites were prepared by a facile and green method, fully characterized and used for the removal of Hg^{2+} from water. Characterizations showed that the Fe_3O_4 particles are quasi-spherical with an average diameter of 217 nm and metallic silver nanoparticles formed on the surface with a size of 23–41 nm. The initial Hg^{2+} removal rate was very fast followed by a slow increase and the maximum solid phase loading was 71.3 mg/g for the Fe_3O_4-Ag and 28 mg/g for the bare Fe_3O_4. The removal mechanism is complex, involving Hg^{2+} adsorption and reduction, Fe^{2+} and Ag^0 oxidation accompanied with reactions of Cl^- with Hg^+ and Ag^+. The facile and green synthesis process, the fast kinetics and high removal capacity and the possibility of magnetic separation make Fe_3O_4-Ag nanocomposites attractive materials for the removal of Hg^{2+} from water.

Keywords: Nanocomposites, magnetite, silver, mercury, amalgamation

POSTER SESSIONS

Id-2165

Ba (II)-doped Mesoporous Silica Nanoparticles (SiO_2-Ba NPs) as a Promising Contrast Agent for Effective CT X-ray Attenuation

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Abstract: The development of radiocontrast agents based on mesoporous silica nanoparticles has been of special interest in the field of nanomedicine due to their chemical stability, biocompatibility, and excellent fluorescent properties. As elements with high atomic number and electron density are known to enhance X-ray attenuation, in this study, the X-ray attenuation efficiency of Ba(II)-doped mesoporous silica nanoparticles (SiO_2-Ba NPs) was investigated for the first time. Morphological analysis revealed the formation of quasi-spherical SiO_2-Ba NPs within a size range of ~15 to 45 nm. Elemental analysis revealed that the concentration of Ba (II) ion in the SiO_2-Ba NPs was ~6.5 wt%. The prepared SiO_2-Ba NPs exhibited high X-ray attenuation efficiency (352.1 ± 4.7 HU/mM) as compared to a conventional intravenous iodine-based contrast agent at the same iodine mass concentration, suggesting the possible applicability of SiO_2-Ba NPs as a promising contrast agent in computed tomography.

Keywords: Mesoporous silica, Ba (II) -dopant, computed tomography, X-ray attenuation

POSTER SESSIONS

Id-2170

Gaining Impermeability to Linear Handle Locks Used in Industrial Cabinets

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Abstract: Linear handle locks are more preferred than swing handle Locks in industrial cabinets due to their ease of use. Since the opening and closing events of swing handle locks involve movements that need to be performed in more than one direction and require more force, this type of lock is not preferred much in the industry and their use is decreasing day by day. Linear handle locks, on the other hand, are easily opened and closed with a single linear movement, thus offering a comfortable use and finding more usage areas. Sealing feature is a must in the locks used in industrial cabinets. While the sealing feature can be easily achieved with a sealing element in swing handle locks, it is very difficult to gain this feature because the working gap and leakage surface area are large in linear lever locks. Thanks to the R&D studies and improvements carried out with this project, our design linear handle locks, which do not have sealing feature, have obtained IP65 sealing certificate. The basis of the studies is design improvement and material change in linear lever locks.

Keywords: Linear handle locks, industrial cabinets, IP65

POSTER SESSIONS

Id-2185

Study of 3D-Printed Materials for Manufacturing of Dielectric Components for Microwave Devices

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Abstract: The last decade has been marked by great advances in the field of additive technologies for manufacturing complex-shaped parts (3D printing). The possibilities of manufacturing complex microwave components either by printing from metal or printing from plastic followed by galvanic metal deposition and removal of the dielectric, are being widely explored in many laboratories. In this paper another approach is considered: the direct printing of elements from a dielectric. This approach is applied for two types of microwave components, namely waveguide mode converters and calorimeters for microwave power measuring. Converters of waveguide modes into other modes or into quasi-optical wave beams are widely used in various microwave systems and devices. These components typically are metal waveguide elements of complex shape, sometimes with small-scale corrugation. The design and manufacture of these elements are expensive and time-consuming. It can take a long time to obtain a non-standard element required for scientific research and development in the field of microwave and terahertz radiation. We propose a novel type of waveguide mode converters made as complex-shaped dielectric inserts into standard-form metal waveguides (for example, circular or rectangular waveguides). These inserts can be directly fabricated by simple and cheep FDM printers. Measurements show that some of plastics used for FDM have fairly good dielectric characteristics, for example SBS (styrene-butadiene-styrene) and SLS plastics have tangent delta as low as 0.002. The use of printed dielectric elements is possible for low and medium power applications (up to few watts or sometimes tens of watts). As an example of proposed approach, we have designed and tested the converter of the TE_{11} wave of a circular waveguide into a Gaussian beam, the polarizer converting linearly-polarized TE_{11} mode into mode with rotating polarization, and the converter of the TE_{10} mode into the TE_{20} mode of a rectangular waveguide. The fast and very accessible manufacturing method opens new perspectives for a wide range of research and development experimental studies in the in the field of microwave techniques. To measure the output power of wave beams produced by subterahertz microwave sources, in particular gyrotrons, unique calorimeters has been implemented using 3D printing. The first variant of a calorimeter was designed and printed from a material with low thermal conductivity with an integrated vacuum window for microwave beam input made of Teflon film with a thickness of 100 μm (Teflon was chosen as a material having the minimum absorption at this frequencies). The calorimeter allows to easily measure the energy of few Joules in microwave pulse. For gyrotron with a frequency of 670 GHz and pulse length of 10 μs, the pulse power of more than 100 kW was measured. Due to the

low absorption of the selected materials (in particular, SBS plastic), it was possible to print the second version of a calorimeter as a single plastic element, where the walls of the water channel at the same time work as a window for input radiation which is then absorbed in water flow. The low plastic thermal conductivity and, hence, low heat exchange with the surrounding space made it possible to significantly improve the quality of measurements performed at relatively low power (several hundreds of watts) for CW gyrotrons at the frequencies up to 520 GHz.

Keywords: 3D-printed materials, microwave dielectric components, calorimetric measurements, waveguides, dielectric mode converters

Acknowledgements: The work is supported by the Russian Science Foundation under grant No. 21-19-00877.

POSTER SESSIONS

Id-2200

Investigation of Wear Resistance at Room and Elevated Temperatures of Samples with Nanostructured Multilayer Coatings ZrHf-(Zr,Hf)N-(Zr,Hf,Cr,Mo,Al)N and Ti-TiN-(Ti,Cr,Al)N

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Abstract: Titanium and nickel alloys are actively used in medicine in the manufacture of implants. Improving the wear resistance of products made from these alloys is an urgent and important task. The article compares the properties of two nanostructured multilayer coatings Ti-TiN-(Ti,Cr,Al)N and Zr,Hf-(Zr,Hf)N-(Zr,Hf,Cr,Mo,Al)N. The Ti-TiN-(Ti,Cr,Al)N coating has a higher hardness, but at the same time it is prone to increased adhesion in a tribological pair. The results of the wear resistance study showed that the sample coated with Zr,Hf-(Zr,Hf)N-(Zr,Hf,Cr,Mo,Al)N has a noticeably better wear resistance. A study of the nature of wear in the temperature range of 20 - 400 °C of coatings revealed significant differences between them. For a sample coated with Ti-TiN-(Ti,Cr,Al)N, significant adhesion with contact material (nickel alloy) is typical, and wear is dominated by cracking and fatigue processes. For a sample coated with Zr,Hf-(Zr,Hf)N-(Zr,Hf,Cr,Mo,Al)N, the key role in wear is played by oxidative processes associated with the formation of a mixture of $(Zr,Hf)O_2$ oxides on the surface.

Keywords: Nickel alloys, nanostructured multilayer coatings, wear, tribology

POSTER SESSIONS

Id-2201

Improving the Corrosion Resistance of Titanium Alloy Samples by Depositing Protective Nanostructured Nitride Coatings on Their Surface

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Abstract: Titanium alloy implants are widely used in such areas of medicine as dentistry, osteo synthesis and endoprosthetics. Improving corrosion protection is an important task in the manuf acture of such implants, since direct contact of titanium with the environment of the human bo dy can cause the phenomenon of metallosis. In turn, metallosis requires implant replacement, c an cause allergic reactions and other negative health effects. In this paper, we consider an incr ease in the corrosion resistance of titanium alloy samples by depositing corrosion-resistant nan ostructured coatings based on (Ti,Zr)N, (Ti,Cr)N, and (Zr,Cr)N on their surface. Conducted studi es of corrosion resistance, carried out in an environment simulating the environment of the hu man body, as well as in environments with electrolytically stimulated corrosion, show good prot ective properties of all three coatings. In this case, the lowest degree of corrosion (determined by weight loss of samples and changes in the composition of the experimental medium) is obs erved for a sample with a nanostructured (Ti,Zr)N coating.

Keywords: Titanium alloy, medical implants, corrosion resistance, nanostructured coatings

POSTER SESSIONS

Id-2201

Ensuring the Best Properties of Protective Coatings for Titanium Alloys by Choosing the Optimal Parameters for Thermal Activation of The Surface by Self-sustained Glow Discharge Plasma

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Abstract: The task of increasing the corrosion resistance and wear resistance of titanium alloy products by depositing protective coatings on their surface often arises in various areas of production. In particular, this task is associated with the production of medical implants for various purposes, aircraft construction and mechanical engineering. Perfect adhesion between the coating and the substrate is a prerequisite for obtaining a quality coating that can withstand high levels of mechanical, thermal and chemical influences. In turn, ideal adhesion can only be ensured under the condition of complete and uniform thermal activation of the surface, as well as complete removal of micro-pollution and oxide films. To ensure such preparation, we used a technology based on glow discharge plasma processing and its modification - self-sustained glow discharge technology based on a cold hollow cathode. The parameters of the coatings (hardness, strength of the adhesive bond with the substrate during the scratch test, internal structure) deposited under different modes of glow discharge plasma etching and without such etching were compared. The corrosion resistance of samples with coatings was also compared. As a result, the process parameters were determined that provide the best properties of the deposited coatings.

Keywords: Thermal activation, protective coatings, titanium alloys, self-sustained glow discharge plasma, corrosion resistance

POSTER SESSIONS

Id-2221

The Effect of Yttrium doped Borophene for Hydrogen storage: A Density Functional Study

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Abstract: Hydrogen is a source of energy that is gaining a lot of popularity as green, clean energy that will soon replace fossil fuel energy in the near future. To make hydrogen a reality, lightweight and cost-effective hydrogen storage materials are needed. The optimal physical hydrogen storage system should favor reversible adsorption energy of (0.1 ~ 0.8 eV/H_2) for hydrogen uptake and release at room between chemical and physical adsorption energy. Theoretical discovery and fabrication of 2D materials with novel electronic, optical and magnetic properties is of significant importance for the wide application towards nanotechnology and energy. Recently, two-dimensional materials(2D) have emerged as promising candidates in the fields of energy conversion and storage, due to their large surface area and novel physical and chemical properties. Among the varieties of 2D materials, the monolayer boron sheet named borophene. Borophene has attracted extensive scientific interest since its recent progression from conception to realisation for practical applications. Borophene is an atomically thin, corrugated, 2D crystalline covalently bonded boron sheet. It is a highly anisotropic material which exhibits outstanding mechanical, thermal, electrical and optical properties. As a result, the material has been identified as a potential candidate for numerous practical applications including energy and hydrogen storage, battery electrode, fuel cell, catalyst, gas sensing, strain, quantum electronics and photo sensing. Since the discovery of unique structural and electronic characteristics of the borophene, X_3 and β_{12} phases some studies experimentally and theoretically have already been reported many aspects about the application for hydrogen storage. Existing studies have also shown that transition metal decoration can effectively improve the effect of hydrogen storage and stability. As result, in the current study the borophene has been systematically explored by first-principles calculations (DFT) on hydrogen storage capacity. In addition, the structures, stability, and electronic properties of borophene attachment on Yttrium are investigated. The yttrium doped Borophene can lead the hydrogen gravimetric density to exceed the 5.5 wt% target of US Department of Energy. Moreover, the obtained electronic properties exhibit the charge transfer which occurred from the Y atom to boron atoms of borophene.

Keywords: Borophene, hydrogen storage, density functional theory, yttrium-doped

POSTER SESSIONS

Id-2224

Structural Synthesis, Geometry and Inverse Kinematics of a 3PRPS Type Parallel Manipulator

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Abstract: Parallel manipulators with six degrees of freedom and three legs or tripods have a large workspace and less complex singular configurations compared to parallel manipulators with six degrees of freedom and six legs or hexapods. In this paper, a structural synthesis is carried out and a geometry of a novel parallel manipulator-tripod of a 3-PRPS type is investigated, where P, R, S are prismatic, revolute and spherical kinematic pairs, respectively. According to the developed principle of forming parallel manipulators, this tripod of a 3-PRPS type is formed by connecting a moving platform with a base using three passive closing kinematic chains of a PRPS type. Each of these three passive closing kinematic chains of a PRPS type has zero degree of freedom and they do not impose geometric constraints on the movement of the moving platform. Therefore, the six degrees of freedom of the moving platform are retained. To describe a geometry of a 3-PRPS tripod, right-hand Cartesian coordinate systems are fixed to each element of each kinematic pair. Based on the transformation matrices of these coordinate systems, matrices of binary links and matrices of kinematic pairs are formed. The matrices of binary links contain constant parameters that characterize the geometry of the tripod, and the matrices of kinematic pairs contain variable parameters that characterize the kinematics of the tripod. Constant and variable parameters of the investigated tripod were determined. Variable parameters of two prismatic kinematic pairs are input parameters, i.e. generalized coordinates. Inverse kinematics of a 3-PRPS type tripod is solved, i.e. variable parameters of the input prismatic kinematic pairs are determined by the given positions of the moving platform.

Keywords: Parallel manipulaotor, tripod, geometry, inverse kinematics

POSTER SESSIONS

Id-2226

Fabrication of Graphene Nanoflakes with Laser Induced Graphene for Use in Thermoelectric Applications

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Abstract: Graphene is a 2D material composed of sp2 hybridized carbon atoms in a hexagonal lattice. It has attracted a lot of attention as a thermoelectric material due to its very high electrical conductivity, lightness, flexibility and non-toxicity. Laser induced graphene (LIG) is a simple, fast, scalable and inexpensive alternative technique used in the production of graphene. In this technique, graphene is produced by using a CO2 laser to write directly on polymers or natural carbon sources in the atmospheric air. Graphene can be obtained in the form of a film, and this film on the polyimide(PI) can be scraped to obtain graphene powders. Herein, graphene was produced by laser induced graphene technique, and then graphene powder was obtained. Microstructural and chemical properties of graphene powder were investigated using characterization techniques such as X-ray diffraction (XRD), scanning electron microscopy (SEM), X-ray photoelectron spectroscopy (XPS), and Fourier transform infrared spectroscopy (FTIR). We showed that we can produce graphene in a single step by laser induced graphene. In addition, the graphene we produce has been shown to have electrical conductivity of 1100 S/m and seebeck coefficient of 35μV/K@300K. Therefore, we predict that this material can be used as an organic material in thermoelectric generators that can generate electricity from temperature difference.

Keywords: Graphene, laser induced graphene, thermoelectric

POSTER SESSIONS

Id-2243

Preparation of Piezoelectric PVDF-TrFE Thin Film for Wearable Electronics

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Abstract: In response to the emerging demand for sustainable energy sources, energy harvesting from ambient vibration and human body motion is getting a lot of research interest. Although batteries improved significantly in terms of safety, energy density and lifecycle thanks to huge efforts of researchers, it lacks one feature to charge wearable and portable electronics, which is self-powering. Hence, the research on the development of self-charging batteries featuring simultaneous energy harvesting and storage and excellent flexibility is essential. It has great potential in many applications such as IoT (Internet of Things), in-vivo monitoring devices and wireless sensors.The key idea behind this concept is replacing conventional separators in Li-ion batteries with piezoelectric polymer films. Piezoelectric thin films have already demonstrated their effectiveness in nanogenerators to power small electronic devices such as watches, in-vivo sensors, etc. This work presents the fabrication and characterization of PVDF (Polyvinylidene fluoride) nanofilms for separator applications. Different research on the topic of PVDF-TrFE crystal structure phases was made in order to differentiate the most preferable for the practical usage in the energy-generating devices. The PVDF crystalline phases predominantly consist of α (non-polar), β (polar), γ (polar), and δ (polar). It was denoted that Poly(vinylidene fluoride - co- trifluoroethylene) (PVDF TrFE) polymer form crystallization phases similar to the ferroelectric all-trans β phase of PVDF itself. Due to the correct order of dipole moment (negative charge on one side, positive charge on the other side), only the β phase can have piezoelectric properties. However, it is challenging to obtain a high percentage of β phase in the polymer, so different additives like barium titanate (IV) (BTO) should be used. The preparation method consisted of mixing the PVDF-TrFE/BTO solution and making a thin film on aluminum foil by electrospinning method. According to SEM images, the film demonstrated uniform fibers and showed promising voltage output at various stress frequencies. X-ray diffraction (XRD) and Fourier Transform Infrared Spectroscopy (FT-IR) analysis showed the presence of β phase of PVDF-TrFE polymer material. According to XRD data, all samples showed intensive peaks at 19.85 degrees, characteristic of β phase formation. The distinct peaks in FT-IR data confirmed the presence of the β phase. To test the electrical output of such film, a particular testing device has been developed that can apply cyclic stress at different frequencies, so that voltage generation across the surfaces of the film is validated. Further, this piezoelectric PVDF film can be used as a separator for LIB.

Keywords: Electrospinning, nanogenerators, piezoelectric PVDF, self-charging li-ion batteries
Acknowledgements: This work was supported by the project 240919FD3914 “Self-Charging Rechargeable Lithium-ion Battery” from Nazarbayev University, Kazakhstan.

POSTER SESSIONS

Id-2259

Alginate-modified β-cyclodextrin Nanoparticles- Analysis, Physicochemical Properties

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Abstract: One of the most virulent primary tumors is malignant glioma of the brain. It is almost impossible to eliminate all cancer cells from a patient's body without damaging healthy brain tissue. The focus is on the selective destruction of neoplastic cells. Cyclodextrin polymers (PCDs) are products that contain two or more covalently linked cyclodextrin units. PCDs are characterized by high molecular weight, exceeding 3000Da. The use of cyclodextrins as precursors for the formation of derivatives and polymers is justified due to their biodegradability and complete biocompatibility with human tissues. A large number of hydroxyl groups on the outside and inside of the CD ring, especially with different properties, make it possible to modify the cyclodextrins. The introduction of cationic groups (-NH2) to the cyclodextrin polymer molecule significantly improves the solubility of the obtained material, and the presence of the polysaccharide core guarantees its biodegradability. The obtained polymeric material can form hydrogels with many known polycations (chitosan) and polyanions (alginic acid), and consequently nanoparticles packed with e.g., boron compounds. Introducing some modifications in further stages of research will allow for the selective transport of drugs to target cells. Therefore, we synthesized a polymer based on β-cyclodextrin, to which an amino group has been attached, cross-linked with pyromellitic dianhydride. To better characterize the polymer system, was done: Fourier-Transform Infrared Spectroscopy (FTIR), Nuclear Magnetic Resonance Spectroscopy (NMR), Raman Spectroscopy- confirmation of reaction products, species characterization; (EDXR) Energy Dispersive X-ray Spectroscopy, Scanning Electron Microscope (SEM)- surface analysis and elemental composition; Thermogravimetric Analysis (TG) and Differential Scanning Calorimetry (DSC)- study of physicochemical properties; Gel Permeation Chromatography (GPC-SEC)- analysis of polymer mass distribution. Spectroscopic examinations confirmed the products of chemical reactions and the final product -the polymer system. SEM made it possible to compare the surfaces of polymers without an amino group with the surface of polymers with an amino group. It also revealed the surface of the nanospheres. EDXR gave a picture of the elemental composition of the polymers. An accurate assessment of the weight loss of the samples was obtained, considering the first loss as water evaporation and the next as decay. DSC analysis gave information on the intensity of thermal effects of the decomposition of the samples. GPC-SEC analysis confirmed the formation of high molecular weight polymers above 5000 Da.

Keywords: Nanoparticles, b-cyclodextrin, b-cyclodextrin polymer, polymer

POSTER SESSIONS

Id-2286

Syntheses, Spectroscopic and Crystallographic Characterizations of The 2-Thiophenylmethylspiro(N/N)di/tetrachlorocyclotriphosphazene Derivatives

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Abstract: Phosphazenes are inorganic compounds composed of conjugated P=N units that can be linear, cyclic, dendrimeric or polymeric. The structures of these compounds [$(N=PX_2)n$], [X=Cl, Br, I and organic groups; n=3, 4, 5, 6….] range from low molecular mass molecules to high molecular mass polymers, depending on the number of repetitions of conjugated (–P=NX_2-) bonds (1). The most studied cyclophosphazenes are hexachlorocyclotriphosphazene, $N_3P_3Cl_6$, (HCCP, trimer) and octachlorocyclotetraphosphazene, $N_4P_4Cl_8$, (OCCP, tetramer) (2). Phosphazene derivatives can give substitution reactions with different reactive reagents. The products that occur as a result of these reactions can acquire very different properties according to the groups bonded to their structures. Thus, these chlorophosphazenes facilitate the preparation of phosphazene derivatives with different properties (3). They can take an active role in the preparation of materials needed by scientific studies and technology in this regard. In this study, the Cl replacement reaction of HCCP (**1**) with *N*-ethyl-2-thiophenylmethylethanediamine gave 2-thiophenylmethylspiro(N/N)tetrachlorocyclotriphosphazene (**2**). Partially substituted three cyclophosphazenes (**2a, 2b** and **2c)** were synthesized from the reactions of **2** in a 1:2 molar ratio and excess amounts of *n*-propylamine, *iso*-propylamine and morpholine, respectively. The structures of phosphazenes were elucidated by the elemental analyses, FTIR, ESI-MS, ^{1}H, ^{13}C, and ^{31}P NMR techniques. The crystal structure of 2-thiophenylmethylspiro(N/N)dichlorodii*iso*propylamino cyclotriphosphazene (**2b**) was determined by X-ray crystallography.

Keywords: 2-Thiophenylmethylspirophosphazenes, spectroscopy, crystallography

Acknowledgements: This study is supported by a grant “Scientific and Technical Research Co uncil of Turkey” (Grant No. 121Z238).

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POSTER SESSIONS

Id-2287

Syntheses, Spectroscopic and Crystallographic Characterizations of Coumarin and Piperidine Substituted 2-Thiophenylmethylspiro(N/N)cyclotriphosphazenes

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Abstract: One of the most important members of the phosphazenes is hexachlorocyclotriphosphazene (**1**) [$N_3P_3Cl_6$, **HCCP**, trimer] and can be converted into a wide variety of cyclotriphosphazene derivatives *via* Cl replacement reactions (1). In fact, the N_3P_3 ring of HCCP is widely used as a scaffold for organocyclotriphosphazenes because it is a very robust ring (2). As seen, HCCP has six Cl atoms that can be easily replaced with different functional reagents. For instance, when reactions between HCCP and monodentate ligands are carried out stepwise, partially and fully substituted compounds are obtained (3). In addition, thiophenes are important heterocyclic compounds and are widely used as building blocks in many reactions. Thiophene has herbicidal, anti-inflammatory, analgesic and antihypertensive effects, and antimicrobial, antiallergic, antitumor and cholesterol inhibiting activities (4,5). In this study, *N*-methyl/ethyl-2-thiophenylmethylethanediamines were synthesized from the reactions of 2-thiophenecarboxaldehyde with *N*-methyl-1,2-ethanediamine and *N*-methyl-1,2-ethanediamine. Tetrachloro-2-thiophenylmethylspiro(N/N)cyclotriphosphazenes (**2** and **3**) were obtained as a result of the reactions of the HCCP and the diamines obtained by conventional methods at a molar ratio of 1:1. Fully substituted cyclotriphosphazenes (**2a, 3a, 2b** and **3b)** were synthesized from the reactions of tetrachlorocyclotriphosphazenes with excess piperidine and coumarin. The structures of the phosphazene derivatives were elucidated with spectral data. The crystal structure of tetrapiperidino-2-thiophenylmethylspirocyclotriphosphazene (**3a**) was demonstrated using X-ray crystallography.

Keywords: 2-Thiophenylmethylspirophosphazenes, thiophene, spectroscopy, crystallography

Acknowledgments: This study is supported by a grant “Scientific and Technical Research Council of Turkey” (Grant No. 121Z238).

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POSTER SESSIONS

Id-2291

Design of a Compact Air-Cooled Solenoid for a Low-Voltage Gyrotron

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Abstract: Gyrotrons are the most well-known type of cyclotron resonance masers and are successfully used to solve a wide range of problems, including growing diamond films and disks, microwave processing of dielectric materials and others [1]. The vast majority of existing gyrotron complexes created for microwave technologies use gyrotrons operating at the second harmonic of cyclotron resonance, which makes it possible to reduce the energy consumption of the magnetic system, but complicates the task of selective excitation of the operating type of oscillations [2]. When operating on the harmonics of the gyrofrequency, the starting current of the generated oscillation type increases significantly. This problem is especially acute in the low-voltage low-power gyrotron complex considered in this work. The accelerating voltage was chosen to be U_a = 5 kV, which drastically reduces their cost and eliminates the problem of X-ray radiation. In this case, the current of the electron beam should be 200–300 mA for the problems under consideration. Such a range of currents unambiguously assumes operation at the main cyclotron resonance, which is a serious challenge for creating the necessary homogeneous magnetic field region with an induction of about 1.1 T in the region of electron-wave interaction for generating a frequency of 30 GHz. In addition to being compact, this solenoid must have low power consumption and be able to operate without an external water-cooling circuit. To radically reduce energy consumption, it is proposed to use soft magnetic alloys that concentrate the stray magnetic field in the region of the gyrotron cavity [3]. It is necessary to maintain the correct longitudinal distribution of the magnetic field for the operation of the electron optics of the gyrotron by optimizing the ferromagnetic screens [4]. To develop magnetically shielded and electron-optical systems (MSS, EOS), both problems must be solved in concert. The shape of the internal screens of the MSS is associated both with the efficiency of operation and with the technological possibilities of placing the gyrotron inside the magnetic system. The configuration of the magnetic system and electrodes of the electron-optical system was developed, allowing the formation of a high-quality helical electron beam from the point of electron-wave interaction (I_{beam}=0.2 A, the beam pitch factor g=1.5 and the spread of transverse velocities $v_\perp$=10%). The power consumption of the magnetic system was optimized, first of all, based on considerations of reducing the transverse dimensions of the winding and a corresponding increase in the operating current of the solenoid. As a result of optimization, the power consumption of the MSS was 5.3 kW at a current I=190 A, U=28 V, the number of turns N=416. To ensure the compactness and ease of operation of the microwave complex, a system of liquid cooling of the solenoid windings was proposed. In turn, the temperature of the refrigerant is proposed to be maintained by an external radiator blown by air flow through the fans. To test the performance of such a scheme, a thermal calculation was

carried out in the Comsol Multiphysics program [5].

Keywords: Ferromagnetic, solenoid, magnetic field, gyrotron

Acknowledgments: This work was supported by the Russian State Assignment Program, IAP RAS project 0030-2019-0027 and by the Russian Foundation for Basic Research (project no. 21-58-53051).

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POSTER SESSIONS

Id-2296

Biodegradable Materials of Carbohydrate, Lipid and Protein

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Abstract: Due to the depletion of petro- and carbochemical raw materials, political (raw material dictate), economic and ecological factors, more and more attention is paid to natural renewable resources, i.e. polysaccharides, proteins and fats. The aim of the research is to obtain a new generation of biodegradable construction materials. They are ternary systems of three basic components of renewable raw materials, which are agricultural crops. Native polysaccharides, proteins and fats are used to prepare these biodegradable materials. The literature describes biodegradable ternary plastics, but they are not materials consisting of polysaccharides, proteins and fats. Usually, in addition to polysaccharides and proteins, they contain polyacids, polyesters or polyamides. Therefore, the proposed research subject is completely new. The research results allow to create ternary systems biodegradable polysaccharide-protein-fat engineering plastics. The full biodegradability of such plastics is in line with the long-term pro-ecological plans of the European Union providing for the dynamic development of the industry without the use of minerals, based on the use of renewable raw materials. The requirements of the European Union directive on the use of renewable materials are met only by composites made of polysaccharides and proteins and fats. Increasing the role of agricultural raw materials in the production of biodegradable plastics will have a positive impact on increasing agricultural production in Poland. The research topic is also related to waste management by producing biodegradable materials with the use of food waste, which will partially replace polymeric materials of synthetic origin, mainly for the packaging industry, as plastic packaging currently accounts for about 35% of all waste. The method of obtaining new biodegradable plastics is simple and virtually waste-free, and therefore environmentally friendly. Ternary systems were tested. TGA thermogravimetric analysis and DSC differential scanning calorimetry were carried out using a Mettler Toledo thermal analyzer, SEM microscopy using a TESCAN electron microscope equipped with a WDS analyzer and rheological analysis using RS 6000 and RS1 rotational rheometers.

Keywords: Polysacchrides, protein, lipids

POSTER SESSIONS

Id-2307

Broad-Band Excitation of Rare Earths in Glasses Based on the Energy Transfer between Host-Glass and Rare-Earth Ions

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Abstract: We show how the nature of the host material affects the interaction between the doped-in rare earth (RE) ions and the surrounding glass matrix by comparing two very different types of glasses doped with RE ions that differ in the position of the short-wavelength absorption edge, bond strength and phonon energy. Strong covalent bonds, high phonon energy and absorption edge in the UV/VIS region are the fundamental properties of silica glass, while the weaker bonds, low phonon energies and the edge in the visible region (400-500 nm) are typical for tellurite glasses. RE ions embedded in a matrix – in our case in glass – can be excited in principle in two ways. The direct excitation of RE ions by absorption of radiation resonating with their internal 4*f*-4*f* transitions takes place with little or no interaction with the surrounding material. But the RE can be excited also indirectly via the host material. In that case the host material itself is excited by absorption of radiation with wavelength overlapping with its absorption edge or in resonance with some deep levels in its band gap, then the absorbed energy is transferred to the doped-in RE ions. the low-temperature photoluminescence spectroscopy allows for simultaneous observation of the host-glass luminescence, which is characterized by a broad luminescence band centered at approximately mid-gap energy, with the superposed narrow bands associated with inner shell 4*f*-4*f* transitions in RE ions. In some cases, these sharp emission bands are preceded by narrow dips in the broad luminescence band of the host glass. The dips correspond to Stokes-shifted up-transitions related to the observed emission peaks. We argue that these narrow absorption dips represent a direct evidence of energy transfer between the electronic structure of the host and 4*f* states of doped-in RE ions. The low-temperature photoluminescence spectroscopy allows for simultaneous observation of the host-glass luminescence, which is characterized by a broad luminescence band centered at approximately mid-gap energy, with the superposed narrow bands associated with inner shell 4*f*-4*f* transitions in RE ions. In some cases, these sharp emission bands are preceded by narrow dips in the broad luminescence band of the host glass. The dips correspond to

Stokes-shifted up-transitions related to the observed emission peaks. We argue that these narrow absorption dips represent a direct evidence of energy transfer between the electronic structure of the host and 4*f* states of doped-in RE ions.

Keywords: Rare-earths, tellurite glass, photoluminescence, broad-band excitation, energy transfer

Acknowledgments: The authors acknowledge the Czech Academy of Sciences and TÜBIAK Agency for the support of the project No. TÜBITAK-21-11 on the Czech side and No. 120N754 on the Turkish side, and the Czech Science Foundation for the support of the project No. 19-07456S.

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POSTER SESSIONS

Id-2308

NIR Laser Up-Converted $Ho^{3+}/Tm^{3+}/Yb^{3+}$ Rare Earths Doped Tellurite Glasses for 3D Display Applications

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Abstract: During continuous-wave excitation of rare-earth (RE) co-doped materials, an equilibrium between the ground and excited states of RE ions is established, resulting in an emission with a fixed intensity distribution of the individual emission bands. However, when the material is excited in a pulsed regime using pulses of different frequencies, energy transfer processes between individual levels in a single RE ion and between different RE ions embedded in the material come into play. These processes are of course governed by different kinetics and this results in frequency dependent emission spectra – the intensities of the individual emission bands depend on the excitation radiation pulse frequency. Simply expressed – different pulse parameters of excitation radiation result in different colors of the emitted radiation. We attempt to exploit this phenomenon in a volumetric 3D display concept based on up-conversion of the NIR to the visible region in tellurite glasses doped with Ho^{3+}, Tm^{3+} and Yb^{3+} ions. 3D imaging may overcome the limits of perception of 3D reality when displayed by common 2D imaging technologies. Currently available 3D technologies have major constraints limiting their general application – a need to wear uncomfortable gear, the 3D image can be viewed only by a single user and/or at a narrow viewing angle. A concept of a laser-based volumetric display has been recently developed to tackle these shortcomings. However, none of the proposed screen materials has so far met the criteria needed for a successful volumetric display. Tellurite glasses are promising materials for photonic applications in visible and infrared region because of their physico-chemical properties including high optical transmittance in a large transmission window, thermal and chemical durability, high lanthanide ions solubility and low phonon energy – both of the latter properties enhance RE based photoluminescence and efficiency of up-conversion processes. With our tellurite glass doped with Ho^{3+}, Tm^{3+} and Yb^{3+} ions we demonstrate that we are able to obtain full-colour photoluminescence emission

using the 980 nm excitation source by modifying the pulse width, power density and frequency values. Finally, a volumetric display prototype is tested by visualizing simple 3D shapes and figures via scanning a 3.0 cm^3 rare earths doped tellurite glass cube via dual-axis galvanometer and 980 nm NIR laser setup. The shape and size of the displayed figures can be successfully changed by modifying the rotation angle of the galvanometer's mirrors.

Keywords: Tellurite glass, rare earths, up-conversion emission, 3D imaging, volumetric display

Acknowledgements: The authors acknowledge the Scientific & Technological Research Council of Turkey (TÜBITAK) and the Czech Academy of Sciences for their financial support under the projects numbered 120N754 and TÜBITAK-21-11, respectively. Petr Kostka acknowledges the Czech Science Foundation for the support of the project No. 19-07456S.

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POSTER SESSIONS

Id-2309

Moisture-to-Electricity Converters of Continuous and Intermittent Action - The Advantages and Disadvantages of the Moisture Evaporation Process

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Abstract: Air humidity is a huge reservoir of low-potential energy in gaseous water molecules, which can be used as an alternative energy source by converting it into electricity. Now it has been found that some materials can generate electricity directly when they interact with moisture. These are protein nanowires, carbon nanoparticles, graphene materials[1] could generate intermittent power in the ambient environment due to a self-maintained moisture gradient in the film. The cyclicity in the operation of the converter is due to with a decrease in the moisture gradient along the sample. It is necessary to periodically dry and moisten the sample. Thus, determining the physical principles of the process of generating electric potential in the converter and creation of optimal type of converter is the aim of this study. Zirconia nanopowders and xonotlite powders in form of cylindrical compacted samples (16 mm diameter, 2 mm height) were used. The powders and samples structures were characterized by XRD, TEM, SEM. For testing the performance of the MEC powders samples, we used the multimeter DMM7510 (Keithley, USA) for long-term voltage acquisition. The samples were studied in the chamber with an adjustable humidity level (30 - 95 %) and constant temperature (293±1 K). For the creation of continuous generation the RH value from the opposite sides were 80 and 40%. In case of intermittent generation, one side of the sample was covered with wax and sample was periodically put in the chamber with the RH = 80% and 40%. It has been found that intermittent converters can generate a higher peak electrical potential. For example, a xonotlite-based converter generates peak electric potentials of 270 and 340 mV in intermittent mode, during the moisture desorption stage, and only 120 mV in continuous mode, with a constant humidity gradient.Time dependence of output voltage of $Ca_6Si_6O_{17}(OH)_2$ sample during intermittent and continuous generation. In the case of constant generation, a constant moisture gradient along the sample causes the formation of a constant flux potential. The dielectric properties of the porous system saturated with moisture remains constant. In the case of periodic generation caused by the adsorption and desorption of water molecules from the atmosphere in porous channels, both the flow potential and the dielectric constant of the porous material saturated with water change. In the both cases the amount of adsorbed moisture is 6-8% and desorbed

(in the intermittent mode) – 5-6%. In the periodic mode, the peak of electric potential occurs at the desorption stage. The dielectric constant decreases in 2-2.5 times due to desorption of water with dielectric constant 81 and, accordingly, the electric potential (of a charged capacitor) increases in 2-2.5 times. The magnitude of the generated streaming potential is associated with this direction of movement of moisture in the porous channels (filling/emptying channels) and the rate of adsorption/desorption of moisture in the material.

Keywords: Zirconia nanopowders, humidity, electricity, converter

Acknowledgements: The authors are thankful the H2020-MSCA-RISE-2019 Program, project 871284 SSHARE for support of this work.

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POSTER SESSIONS

Id-2310

Innovative Water-Soluble Phytomaterial Inhibitors for Alzheimer's and Parkinson's Diseases Prevention

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Abstract: Due to the consumption of therapeutic drugs based on natural products, interest, especially in edible plants, is constantly growing around the world. Natural plant products (phytochemicals) are known to have antioxidant, antibacterial, antifungal, antidiabetic, anti-inflammatory, and radioprotective activities. Phytochemicals, either as pure compounds or as standardized extracts, show significant potential to produce new drugs due to the unrivaled diversity of active compound chemistry. According to the World Health Organization (WHO), there are about 20,000 medicinal plants in 91 countries. To date, of the 255 medicines that are considered certain and essential, 11% are derived from plants, and several synthetic drugs are also derived from natural precursors. However, the solubility of most water bodies among active phytochemical infestations is extremely high for their application in practice. In addition, low solubility in a pronounced drug population causes poor bioavailability. Many different methods are used to overcome limitations, such as dissolving them in a non-polar solvent, preparing them as injections, and/or converting the active ingredients into their saline to test their solubility in an aqueous medium. However, these methodologies are different, such as the accuracy of the toxic solubilizing agent, the actual activity of the salt form, etc., which leads to the need for scientific research on the presence of a biologically active form of the drug and its degree of bioavailability. The use of nanotechnology is very promising for easy-to-use herbal pharmaceuticals for their wide distribution in pharmaceutical formulations. Numerous nanoparticles are being developed, manufactured in various shapes, sizes, compositions, functionalized, and chemically/physically modified in accordance with changes in properties depending on the characteristics of both drugs and target organs. Existing systems of nanoparticles are used in the encapsulation and release of active, extracted, or extracted from natural resources. In the framework of previous studies, 2 stable water-soluble complexes based on DHA with C60 and C60(OH)24 were found. A detailed structural analysis of the complex was carried out using advanced nuclear physics facilities at the Laue-Langevin Institute, Grenoble (the world's largest neutron science). They have high solubility in aqueous complexes [C60-DHQ] and [C60(OH)24-DHQ] high results in tests for various types of biological activity in vitro, namely antioxidant activity, antiviral activity (H3N2 sugar virus strain) and cytoprotective activity and an inhibitory effect on the formation of amyloid fibrils S100A9, α-synuclein and Aβ (responsible for Alzheimer's and Parkinson's

diseases). Among others, it is necessary to highlight the inhibitory effect on fibril formation, tk. the results of the expected potential and prospective earnings of the complex to solve this urgent problem have been obtained since modern medicine cannot yet cure these diseases, but only slow down the progression of the disease. The main goal of the project is the development and creation of a stable laboratory production of modified nanomaterials - inhibitors of amyloid fibrils. To achieve the main goal, three main tasks are envisaged:

1. Confirmation of the likelihood and likelihood of using water-soluble complexes of functionalized phytocomposites.
2. Adaptation of laboratory technology for growth and stable repeatability of obtaining products.
3. Practical testing on the "dummy" of the experimental model.

Confirmation of observation, as well as a significant increase in the production of complexes, will be achieved through:

• expanded studies of water-soluble complexes on the kinetics of inhibition of the formation of amyloid fibrils of proteins S100A9, α-synuclein, and Aβ;
• comprehensive studies of the biological activity of water-soluble complexes in vitro and in vivo;
• preliminary tests;
• optimization of the synthesis process based on the structural characteristics of soluble water-soluble complexes.

Main Scientific Results: An experimental series of samples of water-soluble complexes was obtained - inhibitors of the formation of amyloid fibrils, namely S100A9, α-synuclein, and Aβ, responsible for Alzheimer's and Parkinson's.

2. Completed in vitro and in vivo studies that also will include the study of BBB permeability for nano-product and the assessment of anticipated therapeutic effects of chronic administration of the nano-product on molecular, histological, and functional hallmarks of neurodegeneration in APP5 mouse model, FUS-tg model, and model of aberrant expression of synuclein beta
3. Scaled-up laboratory production of water-soluble complexes in the amount of up to 100 g will be measured and debugged in terms of product yield in one cycle.

Keywords: Fullerene C60, Dihydroquercetin, Neurodegenerative diseases, amyloid fibrils

Topic	Submission
Condensed Matter Physics	Id 1983 - Superconductor/Ferromagnet Heterostructure YBa2Cu3O7-x/CaRuO3
	Id 2073 - Dark-Bright Excitons Mixing in Alloyed Quantum Dots
	Id 2139 - Stability Criterion of Dendritic Growth for a Multicomponent Melt with Convection
	Id 2283 - Superconducting Order Parameter in Alkali-Based Iron Arsenides by Means of the Planar Break-Junction Technique
Crystallography	Id 2232 - The Impact of the Crystal Structure on the Antimicrobial Properties in Cu2+-Doped B-Ca3(Po4)2-Type Phosphates
	Id 2286 - Syntheses, Spectroscopic and Crystallographic Characterizations of the 2-Thiophenylmethylspiro(N/N)di/tetrachlorocyclotriphosphazene Derivatives
	Id 2287 - Syntheses, Spectroscopic and Crystallographic Characterizations of Coumarin and Piperidine Substituted 2-Thiophenylmethylspiro(N/N)cyclotriphosphazenes
Semiconductors Physics and Devices	Id 2020 - An Application of the Analytical Solution of the Small Signal Steady-State Equations: Analysis of Low-Temperature Field-Dependent Measurements for Nc-Si:H Sample
	Id 2032 - Features of Interaction of Nanosecond UV Laser Pulses with Germanium Single Crystals of Various Crystallographic Orientation
	Id 2127 - Metal Plasmon Resonances Induced Enhanced Photons Harvesting in Inverted Thin Film Organic Solar Cell

	Id 2142 - Ni Nanophase Segregation in Zn1-xNixS Thin Films
Ferroics and Multiferroics	Id 1915 - Low Field Microwave Absorption in Novel Spin Systems: Magnetics to Multiferroics
Magnetic materials	Id 1936 - An Electron Spin Resonance Study of Multiferroic Perovskite $BiFe_{0.5}Mn_{0.5}O_3$ Displaying Spontaneous Magnetization Reversal
	Id 1980 - High Field Dependence of the Magnetocaloric Effect in Laves Phase RNi2 Intermetallic Compounds
	Id 1986 - Low temperature refrigerants based on Laves-phase pseudo-binary(Dy,Er)Ni2 intermetallic compounds
	Id 2011 - Mn2FeSi Heusler Alloy Prepared in Bulk, Ribbon, and Powder Form: Microstructure and Magnetism
	Id 2015 - Engineering of Magnetic Properties of Co-rich Microwires by Post-processing
	Id 2291 - Design of a Compact Air-Cooled Solenoid for a Low-Voltage Gyrotron
Nanoscience and Nanotechnology	Id 1923 - Fabrication of 3-Dimensional ZnO-Si Hierarchical Nanowires Anchored with CdS-Shell for Sustainable Solar Fuel Generation
	Id 1944 - Chiral Induced Spin Selectivity in Hybrid Heterostructures Composed of Magnetic Thin Film with Adsorbed Chiral Molecules
	Id 1985 - Rare Earth-doped Y3Al5O12 (YAG) Nanophosphors: Synthesis and Applications in Energy-Savings Devices and Nanomedicine

Nanoscience and Nanotechnology	Id 2019 - Synthesis of Antimicrobial Polyurethane Foam/NpAg Nanocomposites Involving the Use of Gamma Ionizing Radiations
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	Id 2101 - Nanostructuring as a Way to Change the Thin Film Layer's Features
	Id 2153 - Impedimetric Biosensor Based on Reduced Graphene Oxide Functionalized with Gold Nanoparticles for DNA Detection
	Id 2228 - Ameliorating Seed Germination and Seedling of Nano-Primed Wheat and Flax Seeds by the Using Seven Biogenic Metal-Based Nanoparticles
	Id 2309 - Humidity-to-Electricity Converters of Continuous and Intermittent Action - the Advantages and Disadvantages of the Moisture Evaporation Process
	Id 2310 - Innovative Water-Soluble Phytomaterial Inhibitors for Alzheimer's and Parkinson's Diseases Prevention
Materials Science	Id 1808 - Electrical Properties Investigation of Synthetic Polyisoprene Composite Layers For Stretchable Electronics
	Id 1947 - Investigating Sn Whisker Growth from SnAgCu Composite Solder Joints
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	Id 2043 - Features of the Formation of Microdroplet Structures During the Deposition of Wear-Resistant Coatings by the Arc-PVD Method.
	Id 2243 - Preparation of Piezoelectric PVDF-TrFE Thin Film for Wearable Electronics
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	Id 2265 - Effects of Erbium Nanoparticles on Luminiscence Properties of Rice husk Silicate Borotellurite Glasses

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	Id 2038 - Soft Magnetic Composites FeSi/Al_2O_3-B_2O_3 with Increased Resonance Frequency.
	Id 2209 - Effect of Cerium Oxide on the Catalytic Properties of FeNi/Al2O3 in Methane Decomposition
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	Id 1957 - Influence of 0.5 wt% SiC Reinforcement on Microstructural and Thermal Properties of SAC0307 Solder Joints
	Id 2166 - Thermal Cycling Setup for Testing and Inspecting Thermal Barrier Coatings Systems

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Computational Materials Science and Engineering	Id 1966 - Pair Interatomic Interactions in Liquid Cu-Ag Alloy
	Id 2013 - Setting Damper Parameters in Dynamic Structure Calculations
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	Id 2270 - Hybrid Pyroelectric and Piezoelectric Wind Energy Harvester Using Vortex Generator for Self-Powered Devices Applications
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