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Article

Characterization of Flexible Copper Selenide Films on Polyamide Substrate Obtained by SILAR Method—Towards Application in Electronic Devices

Gediminas Jakubauskas [1], Martina Gilic [2,3], Edita Paluckiene [1], Jelena Mitric [2], Jovana Cirkovic [4], Uros Ralevic [2], Egle Usoviene [1], Egidijus Griskonis [1] and Neringa Petrasauskiene [1,*]

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Abstract: Thin copper selenide films were synthesized on polyamide sheets using the successive ionic layer adsorption and reaction (SILAR) method at three different temperatures. It was found that elevating the temperature of the solution led to the creation of copper selenide films with different features. X-ray diffraction characterization revealed that all films crystallized into a cubic $Cu_{2-x}Se$, but with different crystallinity parameters. With elevating the temperature, grain size increased (6.61–14.33 and 15.81 for 40, 60 and 80 °C, respectively), while dislocation density and the strain decreased. Surface topology was investigated with Scanning Electron Microscopy and Atomic Force Microscopy, which revealed that the grains combined into agglomerates of up to 100 nm (80 °C) to 1 µm (40 °C). The value of the direct band gap of the copper selenide thin films, obtained with UV/VIS spectroscopy, varied in the range of 2.28–1.98 eV. The formation of $Cu_{2-x}Se$ was confirmed by Raman analysis; the most prominent Raman peak is located at 260 cm^{-1}, which is attributed to binary copper selenides. The thin $Cu_{2-x}Se$ films deposited on polyamide showed *p*-type conductivity, and the electrical resistivity varied in the range of 20–50 Ω. Our results suggest that elevated temperatures prevent large agglomeration, leading to higher resistance behavior.

Keywords: copper selenide; polyamide; SILAR method

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1. Introduction

Copper selenide can be formed in various stoichiometric compositions, such as CuSe, Cu_2Se, $CuSe_2$, Cu_3Se_2, Cu_7Se_4, Cu_5Se_4, Cu_3Se_4, and non-stoichiometric compositions $Cu_{2-x}Se$ [1–3]. The stoichiometric composition of copper selenide strongly influenced its crystalline structure and electronic behavior—it alters its electronic, chemical, and thermal properties [4,5]. Copper-deficient $Cu_{2-x}Se$ is an intrinsic *p*-type semiconductor with direct bandgap energies in the range of 2.0 to 2.4 eV, the work function of 4.17 eV, and high photo-electrochemical conversion efficiency (~14.6%) [3,5–8]. These features of $Cu_{2-x}Se$ can be used as Shottky diodes [9], self-repairable electrodes [10], and photovoltaic devices [8]. Furthermore, the $Cu_{2-x}Se$ columnar superstructures are used as low-cost and highly efficient counter electrodes in quantum dot sensitized solar cells [11,12].

Several decades ago, due to concerns about homeland security, medical and environmental monitoring as well as food safety, a large interest was shown in the development of gas sensors for detecting volatile and toxic gases. $Cu_{2-x}Se$ exhibits good sensitivity and short response and recovery times to Hg^{2+} [13], and organic gases such as ethanol and acetone [14].

Composition, Structure and Potential Energy Application of Nitrogen Doped Carbon Cryogels

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Abstract

Resorcinol–formaldehyde (RF) cryogels were synthesized by sol–gel polycondensation of resorcinol with formaldehyde and freeze-drying was carried out with t-butanol. Carbon cryogel (CC) was obtained by pyrolyzing RF cryogels in an inert atmosphere to 950 ^{o}C. Nitrogen doped CCs (CCN) were synthesized by introducing melamine into RF precursor mixture solution to obtain nitrogen concentration 2, 6 and 10 wt. %. Material was characterized by elemental analysis, nitrogen adsorption– desorption measurements, scanning electron microscopy (SEM), Raman spectroscopy, FT-IR Spectroscopy. Cyclic voltammetry

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Deposition of Copper Sulfide Films on Polyamide Surface

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Abstract:

In this paper, we present a novel and low – cost method for preparing copper sulfide films on polyamide. Non-treated as well as pre-treated PA6 films by 3 different methods (in boiled water; in NaOH solution; in boiled water and then in NaOH solution) were used for the formation of Cu_2S layers by the sorption-diffusion method. Molten sulfur has been used as a sulfurization agent. The XRD, FTIR, and UV-VIS methods were used to characterize the structural, optical, and electrical properties of samples and to track changes in samples after each treatment stage. The sheet resistance of Cu_2S layers depends on the pre-treatment method and varied from 7 kΩ/sq to 6 MΩ/sq. The optical band gaps (E_g) for direct and indirect transitions are determined to be 2.61–2.67 eV and 1.40-1.44 eV, respectively. Furthermore, the optical constants n, k, and σ are determined from UV-VIS measurements.

Keywords*: Thin film; Copper sulfide; Polyamide 6; X-ray diffraction; Optical properties.*

1. Introduction

Copper sulfides, Cu_xS, x=1–2, are one of the most important compounds of chalcogenide semiconductor materials due to their low toxicity, versatility, and availability. They can be used as absorbers and *p*-type semiconductors due to their excellent electrical, optical, and structural properties [1–3]. The electrical conductivity of copper sulfides is decreasing from CuS to Cu_2S, direct bandgap values vary from 2.2 to 2.9 eV in Cu_2S, 2.1 eV in $Cu_{1.8}S$, and 1.7 eV in CuS [1,4–6].

Copper sulfides are widely applied as thin films and composite materials with technologically important applications in optoelectronic devices [7,8], sensors [9,10], photocatalysis [11,12], photovoltaic cells [10,13], for high-energy supercapacitors [14,15], battery electrodes [7,16,17], and in biomedical fields [18,19]. Recently, they found application as counter electrodes in quantum dot sensitized solar cells [15,20]. For all these applications, the material must be highly accessible; therefore, it is very important to identify simple and inexpensive production technologies on a large scale.

The deposition of a thin layer of copper sulfide on the surface of an organic polymer is one of the simple ways to obtain electrically conductive films for the manufacture of electronic devices, because they can change properties from a semiconductor to a metal conductor. The ability of a polymer to sorb fine particles from a solution provides

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Nanocomposite Cu_xS on Flexible Polymers: Raman Study

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Abstract

Flexible polymers modified with copper sulfides have emerged as a novel class of materials, presenting composite structures with remarkable properties suitable for applications in flexible electronics. This study focuses on the deposition of copper sulfide (Cu_xS) layers onto the surfaces of polyamide and polypropylene through the chemical bath deposition method, employing either 2 or 3 deposition cycles. The objective is to explore the impact of deposition cycles and discern the optimal conditions for the deposition process. Comprehensive analysis of the Cu_xS thin films entails techniques such as scanning electron microscopy (SEM), Raman spectroscopy, UV-VIS spectroscopy, and X-ray diffraction to shed light on their structural and optical characteristics.

Keywords: *Copper Sulfide, Nanocomposite, Optical properties, SEM, Raman spectroscopy, UV-VIS spectroscopy, X-ray diffraction*

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nanomaterials

MDPI

Article

Tuning SERS Signal via Substrate Structuring: Valves of Different Diatom Species with Ultrathin Gold Coating

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Abstract: The discovered light modulation capabilities of diatom silicious valves make them an excellent toolkit for photonic devices and applications. In this work, a reproducible surface-enhanced Raman scattering (SERS) enhancement was achieved with hybrid substrates employing diatom silica valves coated with an ultrathin uniform gold film. Three structurally different hybrid substrates, based on the valves of three dissimilar diatom species, have been compared to elucidate the structural contribution to SERS enhancement. The comparative analysis of obtained results showed that substrates containing cylindrical *Aulacoseira* sp. valves achieved the highest enhancement, up to 14-fold. Numerical analysis based on the frequency domain finite element method was carried out to supplement the experimental results. Our results demonstrate that diatom valves of different shapes can enhance the SERS signal, offering a toolbox for SERS-based sensors, where the magnitude of the enhancement depends on valve geometry and ultrastructure.

Keywords: diatom valve; SERS; surface-enhanced Raman scattering; guided-mode resonance; finite element method; hybrid SERS sensors

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1. Introduction

Since its discovery in 1974 as an outstanding technique for enhancing the Raman signal [1], surface-enhanced Raman scattering (SERS) is gaining increasing interest due to its sensitivity, which could enable single-molecule detection [2]. Despite the exponential growth of publications on SERS, the true mechanism of enhancement is not fully understood, although electromagnetic theory tends to cover all major SERS observations [3]. This technique is based on plasmonically active substrates, which couple laser photons and free electrons within these substrates to induce localized surface plasmon resonances (LSP) and surface plasmon polaritons (SPP) in metallic nanoparticles and the planar metallic surface with adjacent dielectric interfaces, respectively [2]. This leads to an enhancement of electromagnetic fields in close proximity to the surface, where the analyte molecules are adsorbed, consequently enhancing their Raman signal.

In recent years, the sensitivity of the SERS technique has been further improved by employing hybrid substrates, which additionally incorporate dielectric photonic crystals (PCs) or resonant gratings [4]. Such structures have a characteristic interaction with light that can, in a certain wavelength range, obtain a high evanescent field at the surface where the plasmonic structures are often located and thus additionally enhance the SERS signal. For instance, in Hu et al. [5], the presence of a resonant 2D dielectric grating led to the coupling of a guided-mode resonance (GMR) with the LSP, resulting in an improved SERS signal. Nevertheless, the fabrication of such structures often requires clean-room techniques that come with high environmental and financial costs.

As an alternative green solution, some biomaterials have been suggested to replace such artificial dielectric structures in the fabrication of hybrid SERS substrates [6–10]. Among these, diatoms have been proposed as an outstanding source of biosilica with

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Synthesis and Characterization of Monophase Cao-TiO_2-SiO_2 (Sphene) Based Glass-Ceramics

Jelena Maletaškić[1,5*)], Bratislav Todorović[2], Martina Gilić[3], Milena Marinović Cincović[4], Katsumi Yoshida[5], Anna Gubarevich[5], Branko Matović[1]

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Abstract:

Sphene based glass-ceramics ($CaTiSiO_5$), an excellent candidate for a host lattice of ceramic materials and for nuclear waste immobilization, has been prepared from a powder mixture of $CaCO_3$, TiO_2 and SiO_2 using vibro-milling for homogenization. Starting powders were melted at 1400 °C for 2 h, cooled to room temperature, grounded again, then crystallized by thermal treatment yielding a sphene glass-ceramic. The evolution of the phase composition during thermal treatment was investigated by X-ray powder diffraction (XRPD), FT-IR, Raman and thermal analyses (TG-DTA). Pure synthetic single phase sphene was formed at 800 °C for 4 h, even it is very hard to obtain monophase powder at such low temperature. Powder morphology was analyzed by scanning electron microscopy (SEM).

Keywords*: Sphene; Glass-ceramics; Mechanochemistry; XRPD, TG-DTA.*

1. Introduction

Glass-ceramics can be used for various applications, such as thermal, chemical, biological and dielectric ones. These kinds of materials offer great possibilities as we can control their properties, including strength, resistance to abrasion and coefficient of thermal expansion [1]. Another advantage is the simple fabrication process in combination with a lower production cost [2-5]. The synthesis of the parent glass is an important step in preparing the final glass-ceramic material because the precursors and their percentage in the glass composition manage the precipitation of the crystalline phases. The results of this process can provide glass-ceramic with the desired properties.

Beside the biomaterials field, the glass-ceramics can be used as nuclear waste storage. They are significantly more durable than borosilicate glasses in a wide variety of leachates at

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Surface optical phonon (SOP) mode in ZnS/Poly (methylmethacrylate) nanocomposites

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ABSTRACT

The polymer nanocomposite ZnS/Poly (methylmethacrylate) was prepared by the solution casting method and its structural and optical properties were investigated using XRD, SEM, TEM, HRTEM, and Raman spectroscopy. The basic material, ZnS, has the cubic structure and its crystallite size was estimated to be 2.3 nm, which implies that a strong confinement regime is in effect. Analysis of Raman spectra was performed using the fitting procedure based on effective medium theory. As a result, the surface optical phonon (SOP) mode was detected. It was found that the shape and position of the SOP mode depend on the type of the composite.

1. Introduction

As a semiconductor, the zinc sulfide (ZnS) has gained considerable attention and is found to be applicable in optoelectronic, electroluminescent, and blue light emitting diode devices [1–8]. ZnS has two available allotropic forms – the wurtzite and zinc blende. The crystallographic form of wurtzite is hexagonal, whereas the zinc blende has the cubic crystallographic structure, is more stable and as such, is more common of the two. The ZnS in the form of the bulk material has a direct band gap positioned primarily in the UV region [9,10]. The wurtzite and the zinc blende forms have the band gaps of 3.77 and 3.72 eV, respectively. The band gap increases with a decrease in size from the bulk to the nanoscale [11,12]. Since ZnS easily absorbs moisture and oxidizes in air [13], it is not very stable as a pure compound in the atmosphere. Therefore, surfactants or capping agents are added to the ZnS nanoparticles to prevent structural transformation and surface reactions.

A nanocomposite consists of two or more different materials in which at least one of the components has a dimension smaller than 100 nm [14]. In polymer nanocomposites, the composing elements are an organic polymermatrix and inorganic components (semiconductors). Nanocomposites can include three dimensional metal matrix composites, lamellar composites, colloids, porous materials, gels, as well as copolymers in which nanosized material is dispersed within the bulk matrix. The properties of the nanocomposites depend on their components, morphology, and interface characteristic. In order to extend the area of their potential applications, mechanical, thermal, and electronic properties of conventional polymer materials had to be improved [15,16]. As a thermoplastic polymer, Poly (methylmethacrylate) i.e. PMMA has many excellent properties. Its favorable properties include excellent transparency and ultraviolet resistance, as well as good abrasion resistance, hardness, and stiffness. Consequently, it is widely used in many applications, for example in lenses, light pipes, bathroom fittings, skylights, toys, etc. In addition, PMMA is non-degradable and biocompatible, which qualifies it for use in tissue engineering where typical applications are fracture fixations, intraocular lenses, and dentures [17].

For nanocrystals of relatively small dimensions, surface modes and the effects of dimension are expected to appear, along with the normal modes of an infinite lattice. Namely, in the frequency range between longitudinal optical phonon frequency (ω_{LO}) and transversal optical phonon frequency (ω_{TO}), a new mode known as a surface optical phonon (SOP) mode appears.

In our previous papers [18–22] we worked on investigating surface optical phonons (SOP) in semiconducting nanoparticles or thin films. In all those cases, SOP appeared because the nano-objects of investigated materials were well separated in the air.

In this paper we report the synthesis and structural and optical

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Surface optical phonon and multi – phonon transitions in YVO_4: Eu^{3+} nanopowders

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ABSTRACT

In this paper two methods of preparation of yttrium orthovanadate nanopowders were presented: Solid State Reaction (top – down approach) and Solution Combustion Synthesis (bottom – up approach). For starting structural characterization, X – Ray Powder Diffraction (XPRD) and Field Emission Scanning Electron Microscopy (FESEM) were used. We report the change in reflection spectra in europium doped YVO_4 nanopowders with comparison to its bulk analog. In UV–Vis reflection spectra we consider the change in values of band gap in these structures, after resizing it from bulk to nanomaterial. In Far – Infrared (FIR) reflection spectra, we registered the existence of Surface Optical Phonon (SOP) and different multi – phonon processes which alter the reflection spectra of bulk YVO_4. The influence of Eu ions is reflected through multi – phonon processes that occur and are connected with energy transfer from YVO_4 lattice to Eu ions. All IR spectra were modeled using classical oscillator model with Drude part added which takes into account the free carrier contribution. Since our samples are distinctively inhomogeneous materials, we use Effective Medium theory in Maxwell Garnett approximation to model its effective dieletric function.

1. Introduction

Semiconducting nanomaterials, especially nanophosphors have attracted great attention of researchers, due to their wide spectrum of applications in industry, technology as well as in fundamental science. When made in nanorange, phosphor materials exibit enhanced optical properties as against their bulk counterparts, due to quantum size effects and increased surface – to – volume ratio. Yttrium orthovanadate is a widely used red phosphor with many applications in just recent years – in solar cells [1], cancer treatment [2], biotechnology [3], optical imaging [4] etc.

For nanopowders, a valuable tool in the investigation of the structural and optical changes in a material made due to resizing the bulk crystal on nanoscale is the optical spectroscopy – in this case specifically far – infrared and UV – VIS spectroscopy. When excited by UV light, photoluminescence quantum yield of the europium emission in yttrium orthovanadate crystal, goes up to 70% [5]. In YVO_4:Eu^{3+} structure UV radiation excites the vanadate group, which has the ability of efficient excitation transfer to the europium ions (Fig. 1).

When irradiated with UV radiation, three major steps occur in the excitation and emission process in YVO_4:Eu^{3+} structure. First step is the absorption of UV light by $(VO_4)^{3-}$ groups. Then, thermal activated energy, which comes from the UV excitation source, migrates through the vanadate sub – lattice, inducing the transfer of excited energy to europium ions. In the end, strong red ($^5D_0$ – $^7F_2$) and orange ($^5D_0$ – $^7F_1$) emission due to de – excitation process of excited europium ions occur [6].

One of the important properties of semiconductors is their band gap. Studying the band gap of semiconductors is important for interpreting their structural and optical properties and it is of a great importance examining its expansion in order to understand their properties. Application of semiconductors is in large level determined by their band gap width. Bulk semiconductors are usually very limited in their application due to their small and indirect band gap. Bulk crystal is set up of a large number of atoms and molecules, with a number of adjacent energy levels, which form bulk electronic bands. With the reduction of particle size to a nano level, where every particle is made up out of a small number of atoms or molecules, the number of overlapping orbitals decreases, and the eventually width of the band gap of a nanomaterial gets narrower when compared to bulk crystal (this means that there will be

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Structural and optical characterization of titanium–carbide and polymethyl methacrylate based nanocomposite

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Abstract

The rich chemistries and unique morphologies of titanium carbide MXenes, made them strong candidates for many applications like sensors and electronic device materials. During the synthesis procedure, chemical etching, oxidation occurs and residual materials, like titanium-dioxide nanocrystals and nanosheets are often present in resulting material. As titanium-carbide MXenes are suggested to be used as additive in organic polymer matrices for production of nanocomposites, it is essential to consider the presence of the oxides and other residuals together with MXene flakes in synthesis results, and consequently in produced nanocomposite. In this study we present structural and optical characterization of such polymer nanocomposite titanium carbide/PMMA (Polymethyl methacrylate) consisting of Ti_3C_2, TiC_2 MXenes and TiC, and TiO_2 residues of synthesis in PMMA matrix, as a multicomponent nanocomposite. Using XRD, infra-red and Raman spectroscopy, followed by comparative study on the vibrational properties using density functional theory calculations, we characterize this nanocomposite. Further, the SEM measurements are performed, demonstrating the produced titanium-carbide-based flakes in nanocomposite are well defined and separated to nanosized grains, allowing us to use Maxwell–Garnet model to analyse infrared spectrum. This enables us to determine the presence of the optical modification of polymer matrices corresponding to a volume fraction of 0.25.

Keywords Titanium-carbide nanoparticles · PMMA composite · Multicomponent nanocompostite

This article is part of the Topical Collection on Photonics:Current Challenges and Emerging Applications.

Guest edited byJelena Radovanovic, Dragan Indjin, Maja Nesic, Nikola Vukovic andMilena Milosevic.

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Advanced Ceramics and Applications

Edited by
Rainer Gadow and Vojislav V. Mitic

DE GRUYTER

Zorica Ž. Lazarević, Martina Gilić, Aleksandra Milutinović, Nebojša Romčević, Hana Ibrahim Elswie, Vesna Radojević, Dalibor L. Sekulić

15 Growth and characterization of calcium fluoride single crystals

Abstract: The calcium fluoride (CaF_2) single crystals were grown using the Bridgman technique. By optimizing growth conditions, <111>-oriented CaF_2, crystals up to 20 mm in diameter were grown. Number of dislocations in CaF_2 crystals was 5×10^4–2×10^5 per cm^2. Selected CaF_2 single crystals is cut into several tile diamond saw. The plates were polished, first with the silicon carbide, then with the paraffin oil and finally with a diamond paste. The obtained crystals were studied by X-ray diffraction, Raman spectroscopy, far-IR reflectivity and by the measurement of transmission in the mid-IR range. The crystal structure is confirmed by XRD. One Raman and two IR optical modes predicted by group theory are observed. In the transmission spectra, except modes originated from vibration of $-CH_2$ groups, hydroxyl groups -OH and KBr, is visible a peak at 671 cm^{-1} assigned to the Ca-F stretching vibrations. A low photoluminescence testifies that the concentration of oxygen defects within the host of CaF_2 is small. The electrical and dielectric properties of CaF_2 single crystal were studied.

Keywords: goptical materials, CaF_2, Raman spectroscopy, IR spectroscopy, photoluminescence

15.1 Introduction

Crystals are the unacknowledged pillars of modern technology. Without crystals, there would be no electronic industry, no photonic industry, no fiber optic communications, which depend on materials/crystals such as semiconductors, superconductors,

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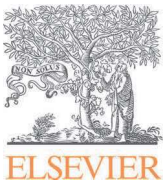

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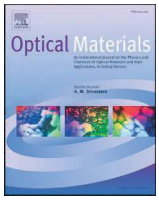

Research Article

Phonon assisted charge transfer in complexes of Zn(II) and Cd(II) with 2-acetylpyridine-aminoguanidine

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Keywords:
Metal complexes
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ABSTRACT

Metal complexes with some Schiff bases, as one of the most widely used groups of ligands, have a wide field of application. In order to find a material with the required optical properties, it is very important to examine the material characteristics as a function of the type of chelating ligand, metal, and the ions present as coligands. In this paper, the synthesis of two new complexes of 2-acetylpyridine-aminoguanidine (L) with zinc(II) and cadmium(II), viz. $[Zn(L)(NCO)_2]$ and $[\{Cd(L)Cl(\mu\text{-}NCO)\}_2]$ is described. Their structural characterization was provided by using SC-XRD. Spectroscopic characterization of these two new complexes and two previously synthesized complexes - $[Zn(L)(NSC)_2]$ and $[Cd(L)Cl_2]$ are performed. Their phonon structure was determined based on the IR transmission and Raman spectra. The range of Raman modes with significantly increased intensities was registered (1000-1700 cm^{-1}), the same range for all four samples. Also, the registered photoluminescence and energy transfers were analyzed and three photoluminescence peaks (E_1, E_2, E_3) were determined. It was concluded that phonons with significantly increased intensities participate in transitions from the E_1 state to the energy levels in the range from E_2 to E_3. The strength of the peaks was significantly affected by replacing one $[Cl]^-$ with the $[NCO]^-$ ligand. The addition of the second $[NCO]^-$ ligand increases the photoluminescence over the entire measured range. The analysis performed helps to understand the issues related to the electron-phonon interaction. Also, the perspectives for the application of metal complexes with various ligands are expanding.

1. Introduction

During the last decades, d-block metal complexes attract great attention not only because of their application in medicine but also due to their optical properties. Although some of these compounds were originally synthesized for medical purposes [1,2], their luminescence properties provide the opportunity for the application as organic light-emitting diodes (OLEDs) [3–9], sensors, light-emitting electrochemical cells [10,11], etc. Literature data show that complexes with iridium, platinum, ruthenium, and other rare transition metals showed very pronounced luminescence properties [3,7–9,12].

Schiff bases, compounds with the general structure $R_1R_2C = NR'$ ($R' \neq H$), are one of the most widely used groups of ligands. Schiff bases of aminoguanidine, as well as 2-acetylpyridine, are widely studied since their biological activity was proven [13].

The optical properties, i.e., the luminescence of d-block metal complexes with some Schiff bases are well known [14]. When we consider the possible application in medicine, the toxicity of the synthesized compounds is a very important characteristic. Due to the biological significance and biocompatibility of zinc, complexes with this 3d-metal are widely examined. But, for the application in optical devices, the limitations are not so strict and it is possible to consider some other d-metals.

In order to find a material with the best possible properties, it is very important to examine the material characteristics as a function of the type of chelating ligand, metal, and ions present as coligands. For that purpose, we have previously synthesized and investigated the optical properties of the first compound of Zn(II) containing pyridoxylideneaminoguanidinium $(PLAGH)_2[ZnCl_4]$ [15], where PLAGH is the cation of the Schiff base of aminoguanidine and pyridoxal. Also, two complexes of Zn(II) and Cd(II) with 2-acetylpyridine-aminoguanidine (L) $[Zn(L)(NSC)_2]$ [16] and $[Cd(L)Cl_2]$ [17] were synthesized and

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Република Србија
МИНИСТАРСТВО ПРОСВЕТЕ, НАУКЕ И ТЕХНОЛОШКОГ РАЗВОЈА
Комисија за стицање научних звања

Број: 660-01-00001/1398
08.07.2020. године
Б е о г р а д

На основу члана 22. став 2. члана 70. став 5. Закона о научноистраживачкој делатности ("Службени гласник Републике Србије", број 110/05, 50/06 – исправка, 18/10 и 112/15), члана 3. ст. 1. и 3. и члана 40. Правилника о поступку, начину вредновања и квантитативном исказивању научноистраживачких резултата истраживача ("Службени гласник Републике Србије", број 24/16, 21/17 и 38/17) и захтева који је поднео

Институт за физику у Београду

Комисија за стицање научних звања на седници одржаној 08.07.2020. године, донела је

ОДЛУКУ
О СТИЦАЊУ НАУЧНОГ ЗВАЊА

Др Мартина Гилић

стиче научно звање

Виши научни сарадник

у области природно-математичких наука - физика

О Б Р А З Л О Ж Е Њ Е

Институт за физику у Београду

утврдио је предлог број 1677/1 од 05.11.2019. године на седници Научног већа Института и поднео захтев Комисији за стицање научних звања број 1691/1 од 07.11.2019. године за доношење одлуке о испуњености услова за стицање научног звања ***Виши научни сарадник***.

Комисија за стицање научних звања је по претходно прибављеном позитивном мишљењу Матичног научног одбора за физику на седници одржаној 08.07.2020. године разматрала захтев и утврдила да именована испуњава услове из члана 70. став 5. Закона о научноистраживачкој делатности ("Службени гласник Републике Србије", број 110/05, 50/06 – исправка,18/10 и 112/15), члана 3. ст. 1. и 3. и члана 40. Правилника о поступку, начину вредновања и квантитативном исказивању научноистраживачких резултата истраживача ("Службени гласник Републике Србије", број 24/16, 21/17 и 38/17) за стицање научног звања ***Виши научни сарадник***, па је одлучила као у изреци ове одлуке.

Доношењем ове одлуке именована стиче сва права која јој на основу ње по закону припадају.

Одлуку доставити подносиоцу захтева, именованој и архиви Министарства просвете, науке и технолошког развоја у Београду.

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Effect of Deposition Cycles on the Properties of Copper Sulfide Thin Films Deposited by CBD

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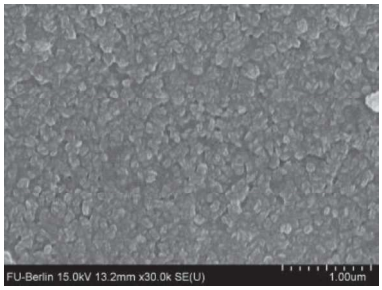
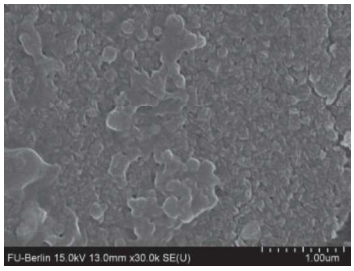
The deposition of copper sulfide as a thin layer onto the surface of the polymer is a promising approach to obtain electrically conductive films. Flexible, transparent polymer substrate coated with copper sulfide is expected to be useful in many fields, for example, as reflectors for concentrating collectors, heat mirrors, and solar control coatings [1], as conductive substrates for deposition of metal and semiconductors [1, 2], as gas sensors functioning at temperatures close to room temperature [3].

The chemical bath deposition (CBD) technique has been used for the deposition of copper sulfide thin films on polypropylene (PP) substrates. The Cu_xS thin film deposition was carried out at room temperature using a mixture of 0.05 M $CuCl_2$ and 0.05 M $Na_2S_2O_3$ solutions for 16 h. The CBD process was carried out by varying cycles (1, 2 and 3 cycles) of deposition. The formed samples were annealed at 80 ºC for 30 min.

The structure, surface morphology, and optical characterization of the deposited thin film indicated a strong relationship between the number of deposition cycles. The scanning electron microscope (SEM) showed a uniform morphology with randomly oriented nano-grains of the copper sulfide film at varying deposition cycles (Fig.1). The thin film morphology uniformly covers the PP substrate and shows a smooth surface. Additionally, the films prepared by CBD with 3 cycles were found quite dense with good crystallinity and no holes, homogenous surface, adhesion to the substrate, compact, and improved in grain size compared to copper sulfide films prepared with 2 cycles (Fig. 1.).



2 cycles



3 cycles

Fig. 1. Surface morphology of Cu_xS thin films prepared at different cycles

Analysis of Cu_xS thin films also was performed using X-ray diffraction analysis, ultraviolet-visible (UV-VIS) spectroscopy, and Raman after each deposition cycle. The electrical result of the thin films shows that resistivity decreases, while conductivity increases as the CBD cycle increases.

References

1. J. Cardoso et al, Semicond. Sci. Technol., **16** (2001) 123-127.
2. M. T. S. Nair and P. K. Nair, Semicond. Sci. Technol., **4** (1989) 191-199.
3. A. Galdikas et al, Sensors Actuators B Chem., **67** (2000) 76-83.

BOOK OF ABSTRACTS

JELGAVA, LATVIA

SEPTEMBER 20-22, 2023

RAMAN ANALYSIS OF Cu_xS THIN FILMS DEPOSITED ON the SURFACE OF POLYPROPYLENE

Edita Paluckiene[1], Martina Gilić[2,3], Neringa Petrasauskiene[1]

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Polypropylene (PP) is one of the most widely used thermoplastic polymers with great chemical, physical and mechanical properties. In this work, the preparation of electrically conductive Cu_xS/PP films by deposition of copper sulfide from an aqueous solution onto a polypropylene film surface r via chemical bath deposition method (CBD). Copper sulfide layers were deposited using a mixture of 0.05 M $CuCl_2$ and 0.05 M $Na_2S_2O_3$ solutions. The CBD process was carried out from 1 to 3 cycles at room temperature. The duration of each cycle was 16 hours.
In order to find the optimal technological conditions for the Cu_xS deposition process, the influence of deposition cycles was studied. Analysis of this material included studies of structure, morphology and electrical surface conductivity.

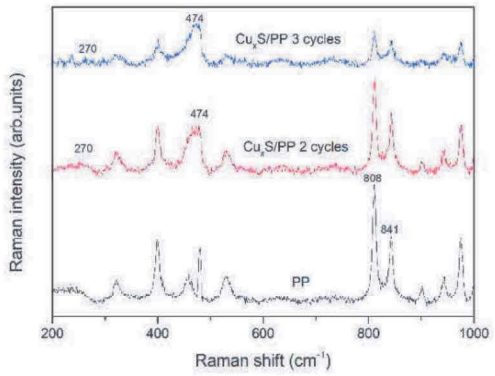

Fig. 1. Raman spectra of the Cu_xS/PP thin films

Raman Spectroscopy is a non-destructive chemical analysis technique which provides detailed information about chemical structure, phase and polymorphy, crystallinity and molecular interactions of materials. Raman spectrum of PP 6 (Fig. 1) shows *C–C* stretching at 808 cm^{-1} and 972 cm^{-1}, band at 841 cm^{-1} is related to rocking CH_2, rocking at 972 $cm^{-1}$and 998 cm^{-1} corresponds to CH_3 vibrations [1]. As shown in Fig. 1, the typical Raman spectra copper sulfide film samples (deposited at 2 and 3 cycles) exhibit similar peak positions. The spectrum reveals a pronounced peak at 474 cm^{-1}, which is assigned to vibrational (stretching) modes from the covalent S–S bonds [2] and a much weaker peak at about 270 cm^{-1} attributed to the Cu–S bond vibration [2]. Therefore, the main attention was paid to the analysis of the intensity of the most intense Raman mode at 474 cm^{-1}. Raman analysis confirms the composition of the copper sulfide on the surface of PP films.

References

1. *H. Tadokoro, M. Kobayashi, M. Ukita, K. Yasufuku, S. Murahashi.* Normal Vibrations of the Polymer Molecules of Helical Conformation. V. Isotactic Polypropylene and Its Deuteroderivative // J Chem Phys. – 1965. – Vol. 42, P.1432.
2. *Ishii M.; Shibata K.; Nozaki H.* Anion Distributions and Phase Transitions in $CuS_{1-x}Se_x$(x = 0-1) Studied by Raman Spectroscopy // J. Solid State Chem. – 1993. – Vol. 105 – P. 504–511.

ANALYSIS OF CuxS THIN FILM DEPOSITED ON SURFACE OF POLYAMIDE – RAMAN SPECTROSCOPY

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The preparation of electrically conductive CuxS/PA films by deposition of copper sulfide from an aqueous solution onto a polyamide film surface is reported in this paper.
Copper sulfide (CuxS) layers were deposited on the surface of polyamide via the chemical bath deposition method (CBD) at room temperature using a mixture of 0.05 M $CuCl_2$ and 0.05 M $Na_2S_2O_3$ solutions for 16 h. The CBD process was carried out by varying the number of cycles (1, 2 or 3 cycles) of deposition. The influence of deposition cycles was studied to determine the optimum condition for the deposition process. The analysis of this material included studies on the structure, morphology and electrical surface conductivity.

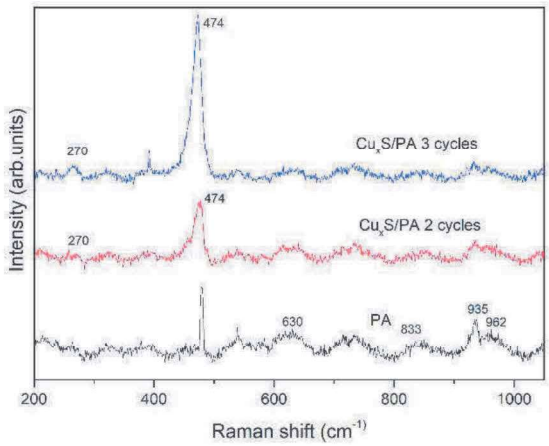

Fig. 1. Raman spectra of the CuxS/PA thin films

Raman spectroscopy is a useful spectroscopic technique to study the crystal phase, crystallinity and vibrational properties of the films. Raman spectrum of pure PA 6 (Fig. 1) shows *C–C* deformation mode at 630 cm^{-1}, band at 833 cm^{-1} is related to rocking CH2, while stretching mode of CH_2 is at 935 cm^{-1}, and 962 cm^{-1} corresponds to *CO–NH* vibrations [1]. As shown in Fig. 1, the Raman spectra of copper sulfide film samples (deposited at 2 and 3 cycles) exhibit similar peak positions. The spectrum reveals a pronounced peak at 474 cm^{-1}, which is assigned to vibrational (stretching) modes from the covalent S–S bonds [2] and a much weaker peak at about 270 cm^{-1} attributed to the Cu–S bond vibration [2]. Therefore, the main attention was paid to the analysis of the Raman intensity of the most intense mode at 474 cm^{-1}. Raman analysis confirms the composition of the copper sulfide on the surface of PA films.

References

6. Ferreiro V., Depecker C., Laureyns J., Coulon G. Structures and morphologies of cast and plastically strained polyamide 6 films as evidenced by confocal Raman microspectroscopy and atomic force microscopy // Polymer. – 2004. – Vol. 45, – P. 6013–6026.
7. Ishii M.; Shibata K.; Nozaki H. Anion Distributions and Phase Transitions in CuS1-xSex(x = 0-1) Studied by Raman Spectroscopy // J. Solid State Chem. – 1993. – Vol. 105 – P. 504–511.

Boosting Surface-Enhanced Raman Scattering by Ultrathin Golden Film on Bio-Photonic Crystals

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Abstract: Hybrid substrates based on three structurally distinct diatom biosilica coated with ultrathin uniform gold were utilized in SERS. The comparative analysis showed that substrates containing cylindrical *Aulacoseira sp.* valves achieved the enhancement up to 8-folds. © 2022 Gilic et al.

1. Introduction

Surface-enhanced Raman spectroscopy (SERS) is an outstanding tool for qualitative and quantitative analysis, with a sensitivity that enables the analyte detection down to a single-molecule level. In the core of this technique are the plasmonic active substrates that could couple the incoming laser light and free electrons within, which launches surface plasmon polaritons in case of a planar surface or localized surface plasmon resonance in case of nanoparticles [1,2]. Additional enhancement could be obtained through utilizing hybrid substrates that include photonic crystals (PCs) or resonant gratings, which leads to the coupling, *for instance*, of guided-mode resonance (GMR) with the surface plasmonic resonance and thus additionally increases SERS [2]. Diatoms are unicellular aquatic algae whose exoskeleton represents one of the exquisite examples of natural 2D photonic crystals. To the best of our knowledge, a few diatom species, mainly *Pinnularia*, have been used to fabricate hybrid substrates for SERS coated with either silver or gold NPs or rarely non-uniform thin films [3]. It has been suggested that diatom valves mainly contribute to the SERS through GMR [3, 4], but also with concentrating analyte molecules as well as nanoparticles on their surface and pore rims. However, coating the valves with nanoparticles or non-uniform golden films creates the hotspots without homogeneity for the SERS signal over the entire valve surface.

In this work, we aim to experimentally evaluate SERS enhancement and homogeneity obtained by hybrid substrates consisting of ultrathin uniform golden film (10 nm) coating the biosilica valves of three different diatom species of distinct structural features. The obtained results were supplemented by theoretical calculations.

2. Experimental work

The diatom monolayers of *Coscinodiscus radiatus* (CR), *Gomphonema parvulum* (GP), and *Aulacoseira sp.* (Aula) on glass substrates were coated with 10 nm golden film via physical vapor deposition, after applying a self-assembled monolayer of 3-mercaptopropyl trimethoxy silane to assure the thickness homogeneity. Scanning electron microscopy was obtained with Hitachi SU8030. Raman measurements were obtained on Horiba XploRA with 638nm laser line. Theoretical calculations were done with COMSOL 5.5 using the frequency domain method.

3. Main results and discussion

The uniformity of Au layer and fine structure of hybrid substrates were characterized with SEM. As can be seen from Fig.1a, the gold is evaporated uniformly over the sample creating a smooth film with no signs of dewetting or voids. The 3 chosen valves differ significantly in terms of size, shape, and parameters. The GP (Fig.1b) has small 7 µm long oval valves, with rows of 0.1 µm pores with spacing 0.2 µm within a row. Aula has cylindrical valves of 15 µm diameter with a flat top surface, pore size of 0.3 µm, and pore spacing within a range of 0.6 – 1 µm (Fig.1c). Finally, CR has large circular valves of 100 µm and 3 pore layers, where the largest pore size is 1.2 µm (Fig.1d).

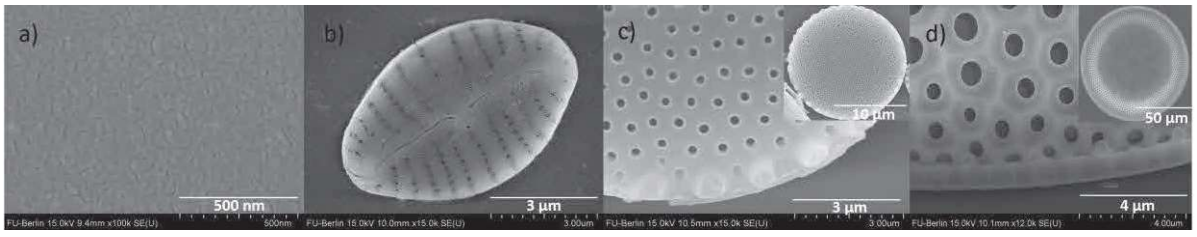

Fig. 1. SEM of the valves with the golden thin film. a) gold, b) *Gomphonema parvulum*, c) *Aulacoseira sp.*, d) *Coscinodiscus Radiatus*. Insets in (c) and (d) show the whole valve.

The SERS spectra of a dried drop of 10^{-3} M Rhodamine 6G (R6G) in ethanol obtained on different substrates are presented in Fig 2a. All three diatom valves give a significant enhancement compared to golden film without biosilica - the signal enhancement of the spectrum obtained on GP was 5.5x, on CR 6.8x, and finally on Aula 8.4x. Raman mapping of intense mode of R6G at 1360 cm^{-1} (marked with *) obtained on the golden coated Aula valves is shown in Fig.2b. The mapping image corresponds the optical image and no doubt the signal is homogeneously stronger on the valve than the surrounding substrate. The pore size and spacing are the key parameters in considering the valve as a photonic crystal-like structure, and within the three valves they are comparable to the laser λ_{exc}. In such dielectric structures, the occurring of GMR is expected at specific wavelengths and can be coupled to the plasmonic resonance to enhance electromagnetic (EM) fields close to the surface. In case of Aula valve, pore spacing partially matches the λ_{exc}, while pore size approximates $\lambda_{exc}/2$.

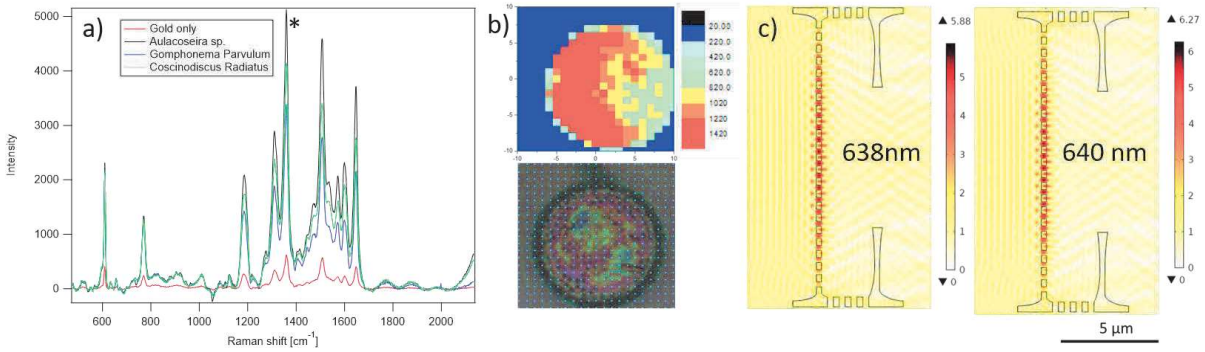

Fig. 2. a) Raman spectra of R6G obtained on four different substrates; b) Raman mapping of 1360 cm^{-1} mode on *Aulacoseira sp*. valve; c) The EF enhancement in 2D CS in Aula valve model coated with 10 nm gold on the top at λ_{exc} and λ_{GMR} . The EF was initiated from the left with an input strength of 1 V/m.

The theoretical calculations were carried out on statistically representative selected 2D cross-sections (CS) to investigate the possible contribution of GMR in the three hybrid substrates to the observed enhancement in SERS with the presence of the gold thin film. The observed GMR of 2D CS in GP valve model was studied extensively in our previous work [5], however no modes were observed at λ_{exc} under normal incidence in the air. The same conclusion was obtained for the 2D CS of CR valves. For Aula 2D CS, GMR maximum on 640 nm is found for the pore spacing set to be 0.61 µm, and on 638nm (λ_{exc}) electromagnetic field (EF) intensity insignificantly drops from 6.27 to 5.88 V/m (Fig. 2c). During the GMR, a higher EF intensity was observed within the pores. However, the λ_{GMR} shows a red shift with increasing pore spacing, and for instance, for spacing of 0.75 µm λ_{GMR} appears at 778nm. Thus, it requires more effort in future work to find out the possible explanations besides the GMR for the enhancement, including the concentration of analyte on the hybrid substrates.

4. Conclusion

The ability of the obtained hybrid structures to significantly and uniformly enhance SERS was proved experimentally and showed different enhancements depending on the fine structure of the substrates. The theoretical analysis suggests that, in case of some diatom species, GMR might be partially responsible for the SERS enhancement.

REFERENCES

[1] R.R. Jones, D. C. Hooper, L. Zhang, D. Wolverson, and V.K. Valev, "Raman techniques: Fundamentals and frontiers," Nanos. Res. Lett. **14**, 231 (2019).

[2] A. Wang and X. Kong, "Review of recent progress of Plasmonic Materials and nano-structures for surface-enhanced Raman scattering," Materials **8**, 3024–3052 (2015).

[3] E. De Tommasi and A. C. De Luca, "Diatom biosilica in plasmonics: Applications in sensing, diagnostics and therapeutics [invited]," Biom. Opt. Express **13**, 308-3101 (2022).

[4] F. Ren, J. Campbell, D. Hasan, X. Wang, G.L. Rorrer, A.X. Wang, Enhancing surface plasmon resonances of metal nanoparticles by diatom biosilica, Opt. Express **21**, 15308-15313 (2013).

[5] M. Ghobara, C. Oschatz, P. Fratzl, and L. Reissig, "Light modulation by a small pennate diatom valve: The case of *Gomphonema Parvulum*," in IEEE Photonics Conference (2021).

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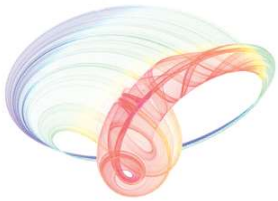

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Belgrade, 2021

Boosting surface plasmon resonances of thin golden film by bio photonic crystals

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Diatoms are unicellular biomineralized algae which possess a biosilica shell with a 2D periodic pore structure. Due to their unique physical, chemical and photonic properties, diatoms found numerous application in biochemical sensors contributing to their ultra-high sensitivity [1, 2].As substrates for Surface Enhanced Raman Spectroscopy (SERS) they proved to be capable of concentrating analyte molecules on their surface as well as assembling metal nanoparticles at pore rims which lead to more controllable hot spot creation.Ithas beensuggested that diatoms enhance the SERS signal additionally with guided mode resonance due to their photonic crystal – like properties. However, current studies are limited to coating diatoms with noble nanoparticles or non-uniform golden films, which hampers interpretation regarding their photonic structure contribution and leads to unsatisfactory reproducibility. Here we present biosilica substrates based on diatom frustules coated with a uniform 10nm thick layer of gold as a candidate for highly reproducible SERS substrates with high enhancement factors. The uniform films spread over theperiodic frustule structure enable the study of photonic properties of periodical pore arrays and their role in enhancing optical sensitivity. Rhodamine 6Gis used as a typical Raman probe molecule. Our results show that substrates with a gold film over diatom monolayers improveSERS detection of R6G by several times compared to substrates with a gold film on glass.The reproducibility of the measurement was verified with Raman mapping. Surface morphology and the fine structure of the diatoms were investigated with Scanning Electron Microscopy, confirming structural integrity for an expanded analytical study.

REFERENCES:
[1] K. Squire, K.Sivashanmugan, B. Zhang, J.Kraai, G. Rorrer, A. Wang,ACS APPLIED NANO MATERIALS 3,1656 (2020).
[2] S.Manago, G. Zito, A.Rogato, M.Casalino, E. Esposito, A. De Luca, E. De Tommasi, ACS Appl. Mater. Interfaces 10, 12406 (2018).

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On behalf of the Organizing Committee of the **"15th Photonics Workshop 2022"** we are pleased to invite you to the workshop scheduled from **March 13-16, 2022 in Kopaonik, Serbia**. This conference will be organized by the **Institute of Physics Belgrade** and **Optical Society of Serbia**.

It is our special pleasure to invite you to attend the meeting and present an **invited lecture (20 min).** The lecture is expected to contain an introduction to be appreciated by graduate students and offer a review and up-to-date progress in your field of research.

Should you have any question please don't hesitate to contact us by e-mail.

Yours sincerely,

Dr Marina Lekić
Chair of the Organizing Committee
email: lekic@ipb.ac.rs, fotonika@ipb.ac.rs

Publ. Astron. Obs. Belgrade No. 99 (2020), 79 – 82 *Contributed Paper*

RATE COEFFICIENTS FOR Ar^+ IN Ar/BF_3 MIXTURES

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Abstract. In this paper we present most probable reactions of Ar^+ ion with Ar/BF_3mixtures. Appropriate gas phase enthalpies of formation for the products were used to calculate scattering cross section as a function of kinetic energy. These data are needed for modeling in numerous applications of technologically important BF_3discharges. Results for transport coefficients as a function of *E/N* (*E* -electric field; *N*-gas density), specially rate coefficients were obtained by using the Monte Carlo technique.

1. INTRODUCTION

Cold plasmas are frequently used in new technologies where they open up the possibilities of non-intrusive production or modification of various substances (Makabe et al. 2006.). These plasmas have a high electron temperature and low gas temperature so non-equilibrium behavior of a large number of species becomes important (Robson et al. 2005.). Current computer resources allow studies of complex global models (Murakami et al. 2013.) which describe the behavior of such plasmas by taking into account a very large number of particles. The knowledge of ion-neutral reactions is generally available (see https://nl.lxcat.net/data/set_type.php) although the effects of reactions on transport parameters of particular ions are much less studied due to non-detectability of rapidly vanishing ionic fluxes. This especially holds for ions whose transport is affected by fast reactions (Stojanović et al. 2014. andNikitović et al. 2016.).

In this paper we firstly selected the most probable reactions of Ar^+ with BF_3 gases for thermodynamic threshold energies below about 15 eV.

2. CROSS SECTION SETS

Complete cross section sets for ion transport are scarce in spite of a broad range of specific methods relevant for quantification of particular cross sections. The main problem in heavy particle scattering, easily and precisely selecting the state of the projectile and target before the collision, is still very complicated for a range of conditions, so databases for ion scattering (Murakami et al. 2013. and https://nl.lxcat.net/data/set_type.php) are still devoid of such data. Phelps established the first worldwide accessible database with cross section sets (see https://nl.lxcat.net/cache/5b33772b61cf9/) tested for each particular case either for swarm conditions of spatially resolved measurements of emission or ion mobility values. In order to focus on effects of reactive processes introduced by BF_3 we neglected all but these two components of the Ar^+ + Ar cross section set. Complete cross section sets used in this work are shown in Figure 1.

Appropriate gas phase enthalpies of formation for the products (Table 1) were used to calculate thermodynamic thresholds.

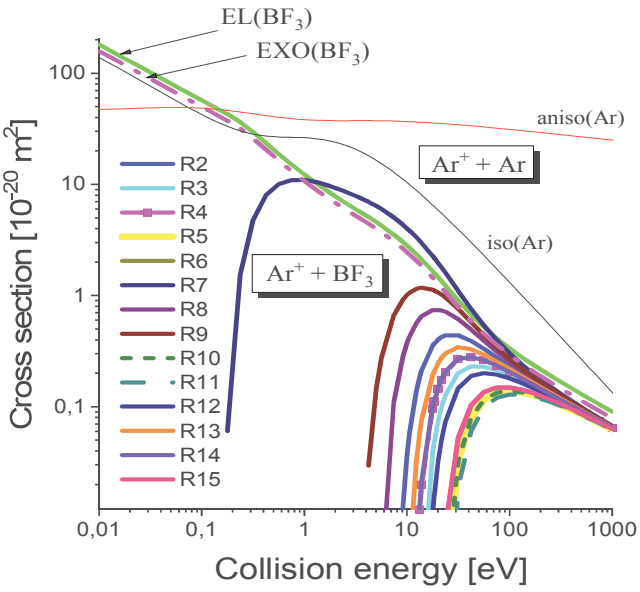

Figure 1: Cross section sets for Ar^+in BF_3.

Ion/neutral	ΔH_f(ion) kJ/mol (room temperature)	ΔH_f(neutral) kJ/mol (room temperature)
Ar^+/Ar	1520.57	0
Ar_2^+/ Ar_2	1398.1	-1.01
B^+/B	1363.3	562.7
BF^+/BF	957	-115.8
BF_2^+/BF_2	314	-589.9
BF_3^+/BF_3	364.3	-1137.0
F^+/F	1760.2	79.4
F_2^+/F_2	1514.5	0

Table 1: Heats of formation $\Delta_f\mathbf{H}^0$ at 298 K (kJ/mol).

3. DISCUSSION AND RESULTS

Monte Carlo Simulations (MCS) have many applications for analysis of the transport of charged particles in plasmas. MCS provide swarm data with the only the uncertainty due to statistical fluctuations and uncertainties in the cross sections. In addition, MCS is the basis of hybrid models of plasmas allowing easy and accurate representation of the end effects and of the non-local high energy groups of particles which are essential in production of plasmas and treatment of surfaces.The MC code used in our analysis is based on the null collisions method.

In Figure 2 we show rate coefficients for reactions of Ar^+ ions with Ar/BF_3 mixtures at T=300K, calculated by Monte Carlo simulations. Rate coefficients are important for applications of the global model to Ar/BF_3 mixtures. We are presenting reaction products and thermodynamic thresholds for Ar^+ + BF_3(Nikitović et al. 2019.)formation a) total attachment and b) attachment for endothermic and exothermic reaction products.

4. CONCLUSION

In addition to presenting the data we show here the effects of non-conservative collisions to ion transport. Data for swarm parameters for ions are needed for hybrid and fluid codes and the current focus on liquids or liquids in the mixtures with rare gases dictates the need to produce data compatible with those models.

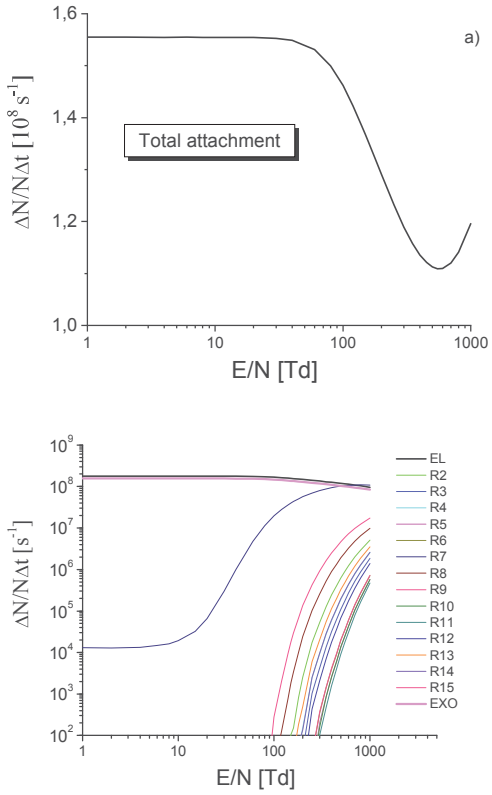

Figure 2: Rate coefficients of Ar^+ in Ar/BF_3 mixtures.

References

Makabe, T., Petrović, Z. : 2006, *Plasma Electronics: Applications in Microelectronic Device Fabrication Taylor and Francis*, New York: CRC Press.

Murakami, T., Niemi, K., Gans, T., O'Connell, D., Graham, W. G. : 2013, *Plasma Sources Sci. Technol.,***22,** 015003.

Nikitović, Ž.,Gilić, M., Raspopović, Z.,Stojanović, V. : 2016,*EPL*,**116,** 15002.

Nikitović, Ž., Raspopović, Z., Stojanović,V. : 2019, *EPL*, **128**, 15001.

Robson, R. E., White, R. D., Petrović, Z. Lj. : 2005, *Rev. Mod. Phys*., **77,** 1303.

Stojanović, V., Nikitović., Ž., Raspopović, Z., Jovanović, J. : 2014, *Acta Physica Polonica,***A125,** 46.

Photonic crystal behavior of biosilica – influence of frustule's morphology on SERS sensitivity

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Abstract. Hybrid substrates for Surface Enhanced Raman Spectroscopy (SERS) based on diatom biosilica frustules covered with thin uniform gold films have been investigated. The observed increased sensitivity has been linked to the resemblance of diatom frustules to 2D photonic crystals and associated unique optical properties, such as guided mode resonance (GMR) [1, 2]. In this work the enhancement of three structurally distinct diatom biosilica species were compared – *Aulacosira sp.*, *Coscinodiscus sp.* and *Gomphonema Parvulum*. Uniform and well controlled thin layers of gold could be deposited onto the biosilica utilizing physical vapour deposition and a self-assembled (SAM) monolayer adhesion layer leading to accurate and reproducible SERS enhancement factors without creating artificial hot-spots. Those could hamper interpretation regarding the contribution of the frustules intrinsic photonic structure and lead to unsatisfactory reproducibility. The in the samples occurring distinct structural parameters, obtained from scanning electron microscope (SEM) analysis, such as pore size, spacing and other lattice parameters, allow us to study the influence of chosen laser excitation lines on coupling of GMR and Surface Plasmon Resonance (SPR), theoretically (using COMSOL multiphysics) as well as experimentally. We demonstrate that SERS enhancement strongly depends on the frustules morphology, and thus its photonic properties. The greatest SERS enhancement factor (of more then 3, compared to gold on flat glass) of Rhodamine 6G was obtained on frustules from *Coscinodiscus sp.*, with dominant structural parameters in the range of the excitation line. The reproducibility of the measurements was verified with Raman mapping. The results suggest that high emphasis should be given to the detailed analysis of lattice parameters of the several 100k diatom species and increasing our understanding of the structural relationship of the enhancement, for selecting best target materials for future bio-sensor application.

REFERENCES

[1] J. Kraai, A. Wang, G. Rorrer, Adv. Mater. Interfaces 7 (2020) 2000191.

[2] G. Perozziello, P. Candeloro, M. Coluccio, G. Das, L. Rocca, S. Pullano, A. Fiorillo, M. De Stefano, E. Di Fabrizio, Appl. Sci. 8 (2018) 668.

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Optical properties of CuSe thin films-band gap determination M Petrović, M Gilic, J Ćirković, M Romčević, N Romčević, J Trajic, I Yahia Science of Sintering 49 (2), 167-174	33	2017
Structural and optical properties of CuSe2 nanocrystals formed in thin solid Cu–Se film M Gilić, M Petrović, R Kostić, D Stojanović, T Barudžija, M Mitrić, ... Infrared Physics & Technology 76, 276-284	27	2016
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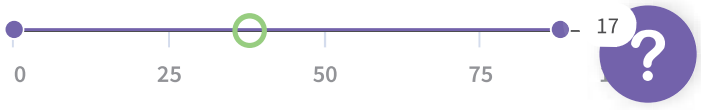

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01.09.2023

Arbeitszeugnis

Frau Dr. Martina Gilic war vom 25.09.2020 bis zum 31.07.2023 in der AG Reissig am Institut für Experimentalphysik der Freien Universität Berlin als erfahrene wissenschaftliche Mitarbeiterin (senior Postdoc) tätig. AG Reissig ist eine Nachwuchsgruppe, die sich mit der Implementierung biologischer Materialien in opto-elektronischen und photonischen Bauteilen beschäftig und diese mit herkömmlichen Materialen vergleicht. Um die Materialen optimal einzusetzen beruht die Forschung zum einen auf einer genauen Untersuchen der optischen und strukturellen Eigenschaften, aber auch einem fundiertem Verständnis des Aufbaus der anvisierten Bauteile, sowie ihrer Anpassung und Optimierung, mit dem Ziel von dem Einsatz der biologischen Materialen bestmöglich zu profitieren. Dr. Gilic war eine wichtige Mitarbeiterin für die erfolgreiche Durchführung des DFG Projektes "Die Frustule der Diatomeen als Natur-gestaltete Bauscheine in photonischen Anwendungen", war aber auch an anderen Forschungsprojekten beteiligt.

Das Aufgabengebiet von Frau Dr. Gilic umfasste u.a. folgende Tätigkeiten:

- Planung der Forschungsstrategien zur Umsetzung der Projektziele
- Herstellung der Proben als dünne Schichten (Rotationsbeschichtung, Arbeiten mit Vakuum und inerter Atmosphäre).
- Charakterisierung der optischen und strukturellen Eigenschaften (u.a. SERS Raman-Spektroskopie, UV-Vis-Spektroskopie, Rasterelektronenmikroskopie REM, optische Nahfeldmikroskopie SNOM))
- Analyse und Interpretation der erhaltenen Forschungsergebnisse (u.a. mit Hilfe von Software IGOR Pro und Origin)
- Ergänzung der experimentellen Ergebnisse durch Simulationen (COMSOL Multiphysics)
- Umfangreiche Literaturrecherche
- Veröffentlichung wissenschaftlicher Ergebnisse in renommierten Zeitschriften
- Präsentation der Ergebnisse auf internationalen Konferenzen und internen Seminaren
- Unterstützung bei der Organisation der Arbeitssicherheit in den Bereichen Erste Hilfe, Chemikalieninventur und Erstellung der Chemikaliensicherheitsblätter.
- Vertretung der Teamleitung bei Bedarf (auch längerfristig) mit Übernahme der Leitung der Gruppenseminare und Anleitung der übrigen MitarbeiterInnen.
- Etablierung interner und externer Kollaborationen
- Lehre als Tutorin in der Nebenfachvorlesung Physik (Bachelorstudium, Deutsch)

Dr. Martina Gilic ist eine erfahrene Wissenschaftlerin mit hervorragenden Kenntnissen experimenteller Techniken der physikalischen Chemie und einer fundierten Erfahrung wissenschaftliche Studien systematisch durchzuführen und Teilstudien anzuleiten. Sie besitzt ein hervorragendes Grundwissen in den Bereichen der physikalischen Chemie, und exzellente Voraussetzungen dieses auch in modernen interdisziplinären Bereichen der Wissenschaft einzusetzen. Sie war stets bereit ihr Wissen mit anderen zu teilen, und auch in Themen, an denen sie selbst nicht gearbeitet hat, mit Rat und Erfahrung beiseite zu stehen. Frau Dr. Gilic zeigte gleichzeitig eine sehr große Bereitschaft sich in neue Themengebiete einzuarbeiten, und den Austausch mit anderen WissenschaftlerInnen in unserem Team, innerhalb der Universität aber auch extern zu suchen, eine Voraussetzung für die erfolgreiche Bearbeitung interdisziplinärer Themengebiete.

Dr. Matrina Gilic ist eine sehr zuverlässige und gewissenhafte Wissenschaftlerin, die gestellte Aufgaben stets erfolgreich zu Ende bringt, sowie sich mit Neugier und Begeisterungsfähigkeit mühelos in neue Gebiete auch unter Zeitdruck einarbeitet. Dies gelingt ihr vor allem durch ihr sehr gutes und effektives Projektplanungstalent und ihre beeindruckende Fähigkeit effektiv zu priorisieren und klar zu kommunizieren. Durch ihr großes Durchhaltevermögen, auch bei unerwarteten Schwierigkeiten, hält sie Abgabetermine stets ein, oder bietet frühzeitig einen gut durchdachten und unterlegten Alternativplan. Auch in Zeiten äußerer erschwerter Bedingungen (wie während der Corona-Pandemie oder Übernahme längerer Vertretungsaufgaben) fand Frau Dr. Gilic stets einen Lösungsweg. Ihre Positivität, Flexibilität und Bodenständigkeit erlaubten es ihr sich auf neue Situationen ideal einzulassen, um die erwarteten Aufgaben zu erledigen. Sie scheute sich nie Verantwortung zu übernehmen und erfüllte alle Aufgaben stets zur vollsten Zufriedenheit.

Ihr Verhalten gegenüber Vorgesetzen, Gruppenmitgliedern, KollegInnen und Externen war stets ausgezeichnet. Martina wurde für ihre umsichtige und respektvolle Art von allen MitarbeiterInnen der FU sowie externen BesucherInnen unserer AG geschätzt. Sie war, von Anfang an, ein wichtiger Faktor für den Zusammenhalt unserer kleinen AG, war den jüngeren Gruppenmitgliedern ein Vorbild und stand immer mit Rat zur Seite. Als Tutorin war sie bei den Studierenden aufgrund ihrer offenen und ermutigenden Art und ihrer stets ausgezeichneten Vorbereitung, sowie ihrer Bereitschaft zur Anwendung modernen Lehrmetoden sehr geschätzt.

Obwohl Englisch an der FU im Wissenschaftsbereich die Lingua Franca ist, war Martina bereit auch in ihrer privaten Zeit ihre Deutschkenntnisse stets zu verbessern (auch über den Besuch an Kursen), um die Kommunikation mit den sonstigen Mitarbeitern am Fachbereich und in der Verwaltung zu erleichtern, und ihren Einsatz in der Lehre zu ermöglichen.

Mit dem Projektende zum 31.07.2023 lief der befristete Vertrag von Dr. Gilic aus. Wir danken Frau Dr. Gilic für den hervorragenden Einsatz, sowohl im wissenschaftlichen als auch lehrenden Bereich. Wie bedauern es sehr sie als wissenschaftliche Mitarbeiterin und Kollegin in unserer AG zu verlieren. Mit Interesse werden wir ihren weiteren wissenschaftlichen und beruflichen Werdegang verfolgen, und würden uns freuen, wenn sich wieder eine Art der Zusammenarbeit bietet. Auf jeden Fall, wünschen wir ihr für ihren weiteren Berufs- und Lebensweg alles Gute und viel Erfolg.

L. Dalgleish

Prof. Louisa Reissig (verheiratet Dalgleish)

Optics of Diatom Frustules

Toward Applications and Photobiology

Dissertation

zur Erlangung des Grades eines
Doktors der Naturwissenschaften
(Dr. rer. nat.)

am Fachbereich Physik
der Freien Universität Berlin

vorgelegt von

Mohamed Ghobara

Berlin
2024

Acknowledgments

First, I would like to thank **Prof. Dr. Louisa Reissig**, who supervised, encouraged, and helped me a lot during the first three years of my PhD. She also helped me a lot while transitioning from biology to physics and gave me the proper training on experimental and numerical techniques, enabling me to conduct the research work successfully. I would also like to thank her for the countless fruitful discussions, comments, and positive criticism that encouraged me to make more effort. Thanks also for her helpful comments and suggestions on earlier versions of my thesis.

I would like to express my sincere gratitude to my supervisor **Prof. Dr. Paul Fumagalli** for accepting me as a PhD student in his group upon the recommendation of Prof. Dr. Louisa Reissig. I am really grateful for his kindness, wisdom, knowledge, and unlimited support, and for guiding me through difficult times to reach the final steps in my thesis. Without his help, this thesis will not be there. He also helped me develop more toward physics. On a personal level, I learnt from his wisdom and leadership many lessons. I would also like to thank him very much for his helpful comments and suggestions on different versions of my thesis.

I would like to appreciate and thank **Prof. Dr. Stephanie Reich**, my second supervisor, for her help, understanding of the challenges I faced during my PhD journey, and the fruitful discussions and suggestions at different stages of my thesis.

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I am really grateful to **Dr. Yasser Shokr** for all the mental support, discussions, and advice he offered during my PhD. He was more than a brother and helped me settle in Berlin.

I would like to thank all my colleagues from **AG Fumagalli** and **AG Reissig**, whom I enjoyed discussions with. I would also like to thank people from other research groups in the department who gave me access to their labs and equipment during my PhD time, including **AG Heberle**, **AG Bolotin**, and **AG Reich**. My sincere thanks also go to the administrative members of the department, **Mrs Badow**, **Mrs Endrias**, and **Mrs Cech** for their unlimited help and support.

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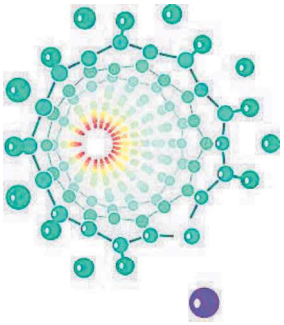
Универзитет у Београду

Факултет за физичку хемију



Јелена М. Митрић

СТРУКТУРНА И ОПТИЧКА СВОЈСТВА ПОЛУПРОВОДНИЧКИХ НАНОМАТЕРИЈАЛА: ГАДОЛИНИЈУМ – ЦИРКОНАТА И ИТРИЈУМ – ВАНАДАТА ДОПИРАНИХ ЕУРОПИЈУМОМ, КАДМИЈУМ – ТЕЛУРИДА И ЦИНК – ОКСИДА МОДИФИКОВАНОГ РУТЕНИЈУМОВИМ КОМПЛЕКСИМА

Докторска дисертација

Београд, 2020.

ЗАХВАЛНИЦА

Велику захвалност дугујем својим менторима,

др Ивани Стојковић Симатовић, ванредном професору, на несебичној помоћи и свим корисним саветима и сугестијама током израде ове дисертације;

а посебно др Небојши Ромчевићу, научном саветнику, из чијих идеја је и настала ова докторска дисертација. Хвала Вам на великој подршци, свим саветима и дискусијама током протеклих година.

Такође, искористићу прилику да се посебно захвалим својим колегама из Института за физику:

Др Маји Ромчевић, за свако прво читање радова које сам написала и за све сугестије које су их учиниле квалитетнијим; др Мартини Гилић, за бројна тумачења добијених резултата и заједничке месеце проведене у лабораторији за раманску спектроскопију; др Бранки Хаџић, експерту за цинк – оксид, за помоћ око тумачења добијених резултата и бројне дискусије; др Бориславу Васићу и др Урошу Ралевићу за помоћ при мерењима на микроскопу атомских сила; др Новици Пауновићу, за исцрпна мерења инфрацрвених спектара.

Хвала и др Данијелу Доброволском, са Института за физику Пољске академије наука и др Ибрахиму С. Јахии, са Кинг Калид Универзитета у Саудијској Арабији, на заједничком раду на танким филмовима кадмијум – телурида; као и колегама Фернандез – Искјердо и Хименез – Хернандез из Лабораторије за неорганску и општу хемију Универзитета у Хавани, Куба, на заједничком раду на наноплочицама цинк – оксида.

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На крају, желим да се захвалим мојој породици, мом брату, мајци и оцу, за најчвршћи ослонац и највећу подршку коју сам имала током свог школовања. Ову докторску дисертацију посвећујем вама.

Subject [Biosensors] Manuscript ID: biosensors-2806696 - Acknowledgement - Review Received
From biosensors@mdpi.com
To Martina Gilić
Cc biosensors@mdpi.com
Reply-To Lottie Wang, Biosensors Editorial Office
Date Fri 12:22

Dear Dr. Gilić,

Thank you for submitting your review of the following manuscript:

Manuscript ID: biosensors-2806696
Title: A 3D hydrophobic SERS sensor by silver-coated PTFE membrane for direct trace-detection of molecules in water
Authors: Guanwei Tao, Jiajun Li, Yunyun Mu, Xinping Zhang *

We are continuously working to improve the services we offer and would greatly appreciate receiving feedback about your experiences through the short survey below.
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Kind regards,
Ms. Lottie Wang
Assistant Editor
Email: lottie.wang@mdpi.com
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Subject [Coatings] Manuscript ID: coatings-2703809 - Acknowledgement - Review Received
From coatings@mdpi.com
To Martina Gilić
Cc Coatings Editorial Office, Anna Krzykawska
Reply-To Anna Krzykawska, Coatings Editorial Office
Date 2023-10-31 19:40

Dear Dr. Gilić,

Thank you for submitting your review of the following manuscript:

Manuscript ID: coatings-2703809
Title: Optimalization of the Electrophoretic Deposition Parameters and Mechanism of Formation of Ag-TiO2 Nanocoating on a NiTi Shape Memory Alloy: Part I
Authors: Karolina Dudek *, Mateusz Dulski *, Jacek Podwórny, Magdalena Kujawa, Patrycja Rawicka

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We also invite you to contribute to Encyclopedia (https://encyclopedia.pub), a scholarly platform providing accurate information about the latest research results. You can adapt parts of your paper to provide valuable reference information for others in the field.

Kind regards,
Dr Anna Krzykawska
Assistant Editor, MDPI Poland
E-Mail: krzykawska@mdpi.com
al.Jana Pawła II43a, 31-864, Krakow, Poland
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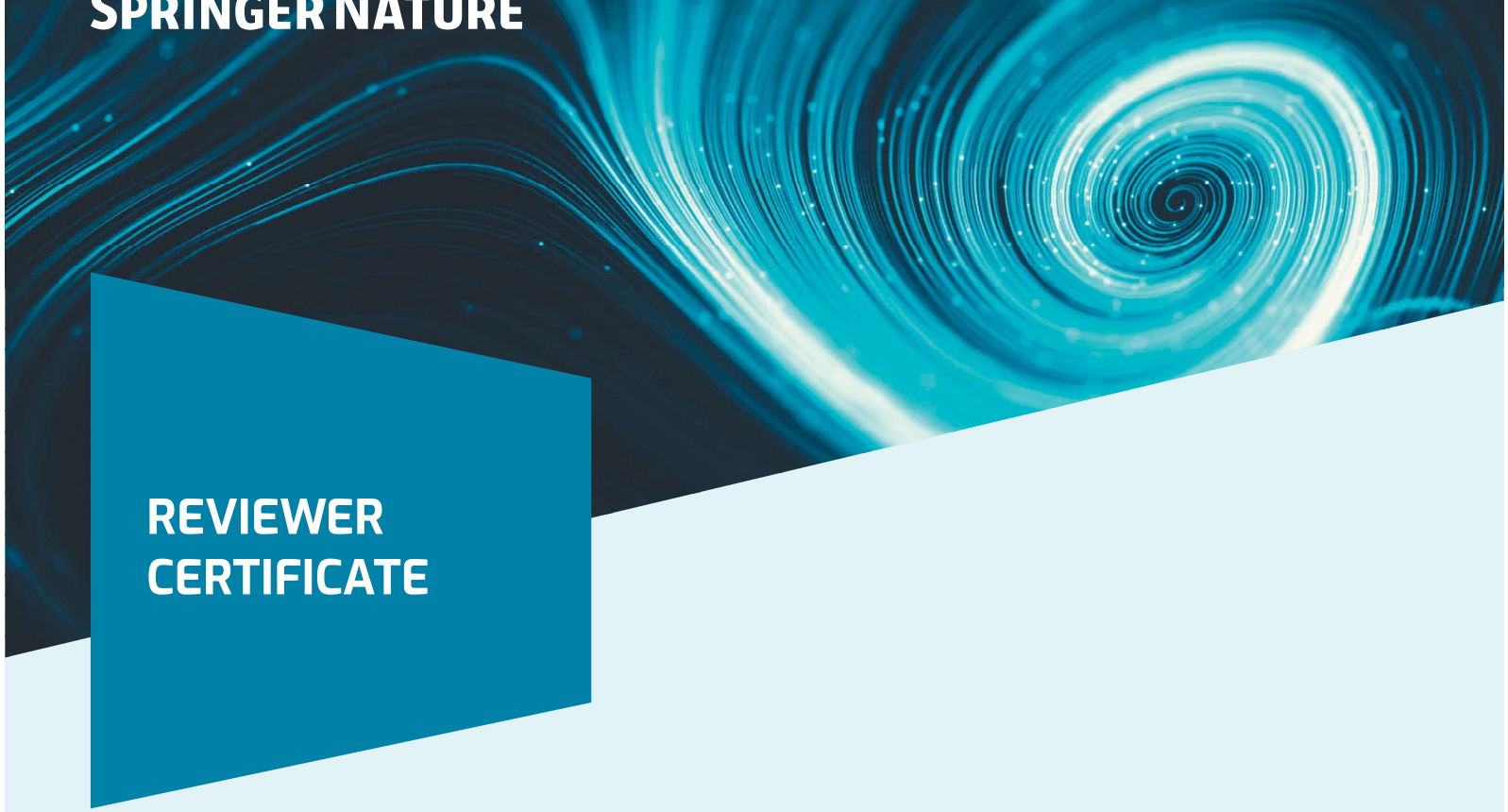

REVIEWER CERTIFICATE

This certificate is awarded to

M. Gilić

in recognition of their contribution to

1 manuscript in 2024 for

Plasmonics

04 November 2024

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REVIEW CONFIRMATION CERTIFICATE

We are pleased to confirm that

Martina Gilić

has reviewed 2 papers for the following MDPI journals in 2023:

Biosensors, Coatings

Shu-Kun Lin

Dr. Shu-Kun Lin, Publisher and President
Basel, 2 January 2024

MDPI is a publisher of open access, international, academic journals. We rely on active researchers, highly qualified in their field to provide review reports and support the editorial process. The criteria for selection of reviewers include: holding a doctoral degree or having an equivalent amount of research experience; a national or international reputation in the relevant field; and having made a significant contribution to the field, evidenced by peer-reviewed publications.


CERTIFICATE
We have honor to certify that
Martina Gilic
has been invited lecturer at the
Advanced Ceramic and Application Conference VII
СРПСКО КЕРАМИЧКО ДРУШТВО
THE SERBIAN CERAMIC SOCIETY
President
Belgrade
September 17-19, 2018.
Serbian Ceramic Society

Serbian Ceramic Society Conference

ADVANCED CERAMICS AND APPLICATION VII

New Frontiers in Multifunctional Material Science and Processing

Serbian Ceramic Society
Institute of Technical Sciences of SASA
Institute for Testing of Materials
Institute of Chemistry Technology and Metallurgy
Institute for Technology of Nuclear and Other Raw Mineral Materials

PROGRAM AND THE BOOK OF ABSTRACTS

Serbian Academy of Sciences and Arts, Knez Mihailova 35
Serbia, Belgrade, 17-19. September 2018.

Serbian Ceramic Society Conference

ADVANCED CERAMICS AND APPLICATION VII

New Frontiers in Multifunctional Material Science and Processing

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/ Institute for Testing of Materials / Institute of Chemistry Technology and Metallurgy /
/ Institute for Technology of Nuclear and Other Raw Mineral Materials /

PROGRAM AND THE BOOK OF ABSTRACTS

Serbian Academy of Sciences and Arts, Knez Mihailova 35
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INV-OGE 3

Detection of high pressure phase transitions in RE^{3+} doped Y_2O_3 and Y_2MoO_6 through luminescence measurements

Marko G. Nikolić[1], Ana Vlašić[1], Mihailo Rabasović[1], Branka Murić[1], Vladan Čelebonović[1], Nadežda Stanković[2], Branko Matović[2] and Branislav Jelenković[1]

[1] *Institute of Physics, Belgrade University, Belgrade, Serbia*
[2] *Institute of Nuclear Sciences "Vinča", Belgrade University, Belgrade, Serbia*

Rare earth ions (RE^{3+}) are highly sensitive to local symmetry so changing the symmetry is reflected in their luminescence spectra. In this work we investigated the high pressure photoluminescence properties of cubic and monoclinic Y_2O_3, as well as, monoclinic Y_2MoO_6, doped either with Eu^{3+} or Sm^{3+} ions.

Photoluminescence emission of cubic Y_2O_3:Sm^{3+} and Y_2O_3:Eu^{3+} phases were recorded up to the pressure of 20 GPa and 15 GPa, respectively. With varying pressure, the intensity ratio of $^4G_{5/2} \rightarrow {}^6H_{7/2}$ and $^4F_{3/2} \rightarrow {}^6H_{7/2}$ Sm^{3+} emission shows three distinct regions. Furthermore, the intensity ratio of $^5D_0 \rightarrow {}^7F_1$ and $^5D_0 \rightarrow {}^7F_2$ Eu^{3+} emission of the cubic matrix has similar pressure dependence as Sm^{3+} doped phase. A steep pressure dependence evident in the range of 9.2-13.1 GPa could be used for detecting a pressure induced cubic to monoclinic phase transition of Y_2O_3 matrix. It matches well the behavior of the pressure sensitive Sm^{3+} spectra in the range of 9.1-11.6 GPa, which is proven to appear due to a phase transition at ~ 11 GPa.

The monoclinic Y_2O_3:Eu^{3+} also has a pressure-sensitive intensity ratio of $^5D_0 \rightarrow {}^7F_1$ and $^5D_0 \rightarrow {}^7F_2$ emission lines. Measurements for the monoclinic Y_2O_3:Eu^{3+} matrix were recorded up to 8 GPa. The dependence is unambiguous, without any phase transitions in the measured region. The nature and high sensitivity suggests that this dependence can be used as an efficient high pressure sensor.

Photoluminescence emission measurements of Y_2MoO_6:Sm^{3+} and Y_2MoO_6:Eu^{3+} phases were recorded up to 12 and 11.5 GPa, respectivelly. Intensity ratio variation of $^4G_{5/2} \rightarrow {}^6H_{5/2}$ and $^4G_{5/2} \rightarrow {}^6H_{7/2}$ Sm^{3+} emission lines, as well as of $^5D_0 \rightarrow {}^7F_1$ and $^5D_0 \rightarrow {}^7F_2$ Eu^{3+} emission lines as a function of pressure can be also used for detection of the Y_2MoO_6 phase transition. The accomplished results demonstrate the properties of Y_2MoO_6:Sm^{3+} and Y_2MoO_6:Eu^{3+} inorganic phosphors, with emmision linear dependance of the intensity ratio on the pressure up to 8 GPa, could be used as an efficient high pressure sensor.

INV-OGE 4

Optical and stryctural properties of nanostructured semiconductors

Martina Gilić and Milica Ćurčić

Institute of Physics Belgrade, University of Belgrade, 11080 Belgrade, Serbia

Science and technologyof nanostructures is a broad and interdisciplinary area of research and development activity that has been growing explosively worldwide in the past decade. Ongoing studies cover not only basic research but also the broad applications range.

The properties of materials at the nano scale differ from the ones at corresponding bulk materials. These differences depend on particle sizes, shape and surface characteristics. Nanomaterials have a much greater surface area to volume ratio than their conventional forms, which can lead to greater chemical reactivity and affect their strength. The enhanced surface area increases surface states, which change the activity of electrons and holes, and affects the chemical reaction dynamics. Also at the nano scale, quantum effects can become much more important in determining the materials properties and characteristics, leading to novel optical, electrical and magnetic behaviours.

We discuss recent advances in understanding the nanostructure and optical properties of semiconductor nanocrystals. Spectroscopic methods can provide a great deal of information about the electronic and spatial structure of the nanocrystals. As consequence of miniaturization, we expect bulk modes to be shifted and broadening. Linking these characteristics with the synthesis methods will play key roles in the further development of these particles for optoelectronic and biomedical applications.

INV-OGE 5

Forensic Science and Fractal Nature Analysis

Goran Lazović[1], Vojislav V. Mitić [2,3], Ana S. Radosavljević-Mihajlović[4], Dragan Simeunović[5]

[1] *University of Belgrade, Faculty of Mechanical Engineering, Belgrade, Serbia*
[2] *University of Nis, Faculty of Electronic Engineering, Nis, Serbia;*
[3] *Institute of Technical Sciences of SASA, Belgrade, Serbia;*
[4] *Institute for technology nuclear and other raw materials. Franshe D EPERE 86, 1100 Belgrade, Serbia*
[5] *Academy of Nacional Security Republic of Serbia*

The forensic photography**,** also referred to as crime scene photography, is an activity that records the initial appearance of the crime scene and physical evidence, in order to provide a permanent record for the court. Now a day, we can imagine the crime scene investigation without photography evidence. Crime or accident scene photographs can often be re-analysed in cold cases or when the images need to be enlarged to show critical details. Fractals are rough or fragmented geometric shape that can be subdivided in parts, each of which is a reduced copy of the whole Fractal dimension (FD) is an important fractal geometry feature. There are many applications in various fields including image processing, image analysis, texture segmentation, shape classification and identifying the image features such as roughness and smoothness of an image. The damage image can be reviewed, analyzed and reconstructed by fractals.

ФАКУЛТЕТ ТЕХНИЧКИХ НАУКА
Број 01-209/ 405-1
25.4- 20 18. год.
НОВИ САД

Анекс IX Уговора о реализацији Пројекта ИИИ 45003 у периоду април - децембар 2018. године

На основу чл. 10, 97. став 1. и 104. Закона о научноистраживачкој делатности („Службени гласник РС", бр. 110/05, 50/06-исправка, 18/10 и 112/15) - у даљем тексту: Закон), сагласно Акту о избору, вредновању и финансирању Програма ОИ/ТР/ИИИ број 451-01-967/2010-01 од 20. маја 2010. године (у даљем тексту: Акт), у пројектном циклусу истраживања од 2011. године, чије финансирање се наставља до 31. децембра 2018. године, по Решењу Владе 05 број: 021-162/2018 од 11.01.2018. године („Службени гласник РС", број 3/18), а у вези са тачком 4. Одлуке о распореду средстава за финансирање истраживања по пројектима одобреним у оквиру програма ОИ/ТР/ИИИ у периоду од 1. априла до 31. децембра 2018. године, број: 451-03-1283/2018-14 од 04.04.2018. године, **уговорне стране:**

1) РЕПУБЛИКА СРБИЈА – Министарство просвете, науке и технолошког развоја, Београд, Немањина 22-26, ПИБ 102199748, матични број: 17329235 (у даљем тексту: Министарство), које представља министар просвете, науке и технолошког развоја,
и
2) РЕАЛИЗАТОРИ ИСТРАЖИВАЊА - учесници у реализацији научноистраживачког пројекта:

2. 1) Криминалистичко-полицијска академија у Београду, ПИБ 104629251, матични број:17672355, рачун КЈС број 840-0000001751660-26, кога заступа проф. др Горан Бошковић , в.д. декана
2. 2) Универзитет Џон Незбит, Факултет за пословне студије у Београду, ПИБ 100035467, матични број:17241117, рачун КЈС број 840-0000014505763-46, кога заступа др Татјана Цветковски , декан
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2. 5) Универзитет у Београду, Институт за нуклеарне науке 'Винча', ПИБ 101877940, матични број:7035250, рачун КЈС број 840-0000000011723-73, кога заступа др Милица Марчета Канински , директор
2. 6) Универзитет у Београду, Институт за физику, ПИБ 100105980, матични број:7018029, рачун КЈС број 840-0000000020723-39, кога заступа др Александар Богојевић , директор
2. 7) Универзитет у Београду, Машински факултет, ПИБ 100209517, матични број:07032501, рачун КЈС број 840-0000001876660-28, кога заступа др Радивоје Митровић , декан
2. 8) Универзитет у Београду, Стоматолошки факултет, ПИБ 100125119, матични број:07001991, рачун КЈС број 840-0000001122660-85, кога заступа др Мирослав Вукадиновић , декан
2. 9) Универзитет у Београду, Технолошко-металуршки факултет, ПИБ 100123813, матични број:07032552, рачун КЈС број 840-0000001441660-87, кога заступа др Ђорђе Јанаћковић , декан
2. 10) Универзитет у Новом Саду, Факултет техничких наука, ПИБ 100724720, матични број:08067104, рачун КЈС број 840-0000001710660-30, кога заступа др Раде Дорословачки , декан

2. 11) Универзитет Унион у Београду, Факултет за пословно индустријски менаџмент у Младеновцу, ПИБ 102520146, матични број:17434977, рачун КЈС број 840-0000009329763-92, кога заступа ,

2. 12) Универзитет Унион, Рачунарски факултет у Београду, ПИБ 102971356, матични број:17489453, рачун КЈС број 840-0000013144763-25, кога заступа Др Драган Милетић , декан

закључују

Анекс IX

основног уговора о реализацији Пројекта ИИИ у периоду април - децембар 2018. **године у циклусу истраживања од 01.01.2011. до 31.12.2018. године**

Члан 1.

Овим анексом се мења и допуњује основни Уговор о реализацији Пројекта ИИИ, тако што се уређују међусобна права и обавезе уговорних страна и Руководиоца Пројекта у реализацији и финансирању научноистраживачког пројекта: "Оптоелектронски нанодимензиони системи - пут ка примени", евиденциони број ИИИ 45003 (у даљем тексту: Пројекат ИИИ) у периоду април - децембар 2018. године у текућем циклусу истраживања од 01.01.2011. до 31.12.2018. године.

Финансирање реализације Пројекта ИИИ у периоду јануар-март 2018.године извршено је у складу са одлуком број: 451-03-496/2018-14 од 29. јануара 2018. године. Реализатори истраживања на Пројекту ИИИ по овом анексу су правна лица из члана 104. став 1. Закона.

Члан 2.

Укупан обим истраживања на Пројекту ИИИ износи 342 истраживачких месеци.

Руководилац Пројекта ИИИ је др Небојша Ромчевић, научни саветник запослен у научноистраживачкој организацији: Институт за физику у Београду (у даљем тексту: Руководилац Пројекта).

Одлуку о одређивању другог лица за Руководиоца Пројекта доноси министар, уз прибављено образложено писано мишљење руководилаца свих Реализатора истраживања. Уколико реализатор, на писани захтев, не достави мишљење у року од 8 дана, сматраће се да је мишљење о предлогу за одређивање другог руководиоца позитивно.

Пројекат ИИИ чине следећи потпројекти:

- Потпројекат 1: "Синтеза наноматеријала и структура", чији је руководилац Мартина Гилић, научни сарадник
- Потпројекат 2: "Теорија оптичких особина наноструктура", чији је руководилац Милан Тадић, редовни професор
- Потпројекат 3: "Електронски принципи формирања и функционисања наноструктура ", чији је руководилац Ивана Радисављевић, виши научни сарадник
- Потпројекат 4: "Примена рачунара у повезивању теоријских, експерименталних и примењених истраживања", чији је руководилац Стеван Милинковић, редовни професор
- Потпројекат 5: "Карактеризација нанаочестица и наноструктура", чији је руководилац Милица Ћурчић, научни сарадник
- Потпројекат 6: "Испитивање електричних карактеристика нових материјала и пројектовање сензора са оптичким влакнима", чији је руководилац Бранка Хаџић, научни сарадник

- Потпројекат 7: "Наноструктурни оптоелектонски сензорски системи", чији је руководилац Пеђа Михаиловић, ванредни професор

Члан 3.

Овим анексом се утврђује следећи износ и структура буџета Пројекта ИИИ до 31. децембра 2018. године и то:

1) Накнаде за рад истраживача, односно сарадника ангажованих на Пројекту ИИИ (у даљем тексту: истраживач) у бруто износу, одређене су множењем одобрених истраживач-месеци за сваког истраживача, са одговарајућом ценом истраживач-месеца која се утврђује посебном одлуком министра (Прилог 2).

У складу са одредбама члана 7.4. Основног Уговора о реализацији Пројекта ИИИ и члана 36. Акта, истраживачима који почев од датума објављивања Јавног позива (23. маја 2010. године), нису наводили пуну афилијацију приликом публиковања радова на начин утврђен Одлуком министра број 451-03-3558/2011-14 од 18.10.2011. године, накнада за научноистраживачки рад ће од априла 2018. године бити умањена, и то: са износом од 5 уместо 8 истраживач месеци за истраживаче запослене на високошколским установама, односно, са износом од 10 уместо 12 истраживач месеци за истраживаче запослене у институтима и у регистрованим иновационим организацијама из члана 104. Закона. Умањен износ, у складу са чланом 3.2. горе наведене Одлуке, истраживачи ће примати све док Министарству не доставе потписану изјаву да ће при будућем објављивању научних радова писати пуну афилијацију из члана 36. Акта;

2) Директни материјални трошкови истраживања (ДМТ) који су у функцији обављања научноистраживачког рада на Пројекту ИИИ у 2018. години а који су по структури:

2) 1. ДМТ I / режија, трошкови рада лица запослених код реализатора истраживања на стручним, административним и техничким пословима, као и трошкови електричне енергије, воде, грејања, комуналних услуга и сличних трошкова реализатора програма пројектног финансирања.

2) 2. ДМТ II - трошкови који су у функцији обављања научноистраживачког рада на Пројекту ИИИ у 2018. години, а односе се на: набавку потрошног материјала, ситне опреме и ситног инвентара, трошкове службених путовања чланова пројектног тима, трошкове дисеминације резултата истраживања, трошкове услуга истраживачима и сличних трошкова реализатора програма пројектног финансирања у функцији обављања пројектних активности.

Члан 4.

Саставни делови овог анекса су следећи прилози:

Прилог 1. Опис, очекивани кључни резултати и значај истраживања Пројекта ИИИ до 31. децембра 2018. године, програм са динамиком и планом рада, планираним резултатима и роковима реализације истраживања;

Прилог 2. Цене истраживач-месеци утврђене за период април-децембар 2018. године у складу са категоријом и истраживачким, научним и сарадничким звањем истраживача из члана 69. Закона, кога су Реализатори истраживања укључили на пројектно финансирање у складу са Законом и чл. 22-24. Акта. Висину утврђене цене истраживач-месеца Министарство може мењати у току реализације Пројекта ИИИ у складу са расположивим буџетским средствима;

Прилог 3. Списак истраживача ангажованих код Реализатора истраживања са ознаком категорије у коју су разврстани сагласно чл. 11-18. Акта, са утврђеном накнадом за научноистраживачки рад у бруто износу, која садржи: нето износ за исплату и износ припадајућег пореза и доприноса. Бруто накнада за научноистраживачки рад истраживача који су запослени

Члан 13.

Овај уговор је сачињен у 16 (шеснаест) истоветних примерака, од којих по један за сваког Реализатора истраживања, један за руководиоца Пројекта, а три за Министарство.

У Београду, дана 19. 04. 2018. године

УГОВОРНЕ СТРАНЕ

1. **за Универзитет у Београду, Институт за физику**

   др Александар Богојевић, директор _____

   Ев. број уговора код учесника
   у реализацији Пројекта: ИИИ45003

2. **за Универзитет у Београду, Институт за нуклеарне науке Винча**

   проф. др Милица Марчета Канински, декан

   _____

   Ев. број уговора код учесника
   у реализацији Пројекта: ИИИ45003

3. **за Универзитет у Београду, Електротехнички факултет**

   проф. др Мило Томашевић, декан _____

   Ев. број уговора код учесника
   у реализацији Пројекта: ИИИ45003

4. **за Универзитет у Новом Саду, Факултет техничких наука**

   проф. др Раде Дорословачки, декан _____

   Ев. број уговора код учесника
   у реализацији Пројекта: ИИИ45003

5. **за Универзитет у Београду, Грађевински факултет**

   проф. др Бранко Божић, декан _____

   Ев. број уговора код учесника
   у реализацији Пројекта: ИИИ45003

6. **за Универзитет у Београду, Машински факултет**

   проф. др Радивоје Митровић, декан _____

   Ев. број уговора код учесника
   у реализацији Пројекта: ИИИ45003

7. **за Универзитет у Београду, Медицински факултет**

   проф. др Радивоје Митровић, декан

   _____

   Ев. број уговора код учесника
   у реализацији Пројекта: ИИИ45003

8. **за Универзитет у Београду, Стоматолошки факултет**

   проф. др Мирослав Вукадиновић, декан _____

   Ев. број уговора код учесника
   у реализацији Пројекта: ИИИ45003

9. **за Универзитет у Београду, Технолошко-Металуршки факултет**

   проф. др Ђорђе Јанаћковић, декан _____

   Ев. број уговора код учесника
   у реализацији Пројекта: ИИИ45003

10. **за Универзитет Унион, Рачунарски факултет**

    проф. др Драган Милетић, декан _____

    Ев. број уговора код учесника
    у реализацији Пројекта: ИИИ45003

11. **Криминалистичко-полицијска академија у Београду**

    проф. др Горан Бошковић, декан _____

    Ев. број уговора код учесника
    у реализацији Пројекта: ИИИ45003

12. **за Универзитет Џон Незбит, Факултет за пословне студије у Београду**

    проф. др Татјана Цветковски, декан _____

    Ев. број уговора код учесника
    у реализацији Пројекта: ИИИ45003

13. **РУКОВОДИЛАЦ ПРОЈЕКТА**

    др Небојша Ромчевић, научни саветник _____

    запослен у Универзитет у Београду, Институт за физику

UNIVERZITET U BEOGRADU
TEHNOLOŠKO-METALURŠKI FAKULTET

Nikola B. Tasić

SINTEZA I PROCESIRANJE NANOSTRUKTURNOG TITAN(IV)--OKSIDA ZA PRIMENU U SOLARNIM ĆELIJAMA SA FOTOOSETLJIVOM BOJOM

Doktorska disertacija

Beograd, 2017.

UNIVERSITY OF BELGRADE
FACULTY OF TECHNOLOGY AND METALLURGY

Nikola B. Tasić

SYNTHESIS AND PROCESSING OF NANOSTRUCTURED TITANIA FOR APPLICATION IN DYE-SENSITIZED SOLAR CELLS

Doctoral Dissertation

Belgrade, 2017

Mentori:

dr Jelena Rogan, vanredni profesor
Tehnološko-metalurški fakultet, Univerzitet u Beogradu

_____

dr Goran Branković, naučni savetnik
Institut za multidisciplinarna istraživanja, Univerzitet u Beogradu

_____

Članovi komisije:

dr Aleksandar Radojković, naučni saradnik
Institut za multidisciplinarna istraživanja, Univerzitet u Beogradu

_____

dr Aleksandra Dapčević, docent
Tehnološko-metalurški fakultet, Univerzitet u Beogradu

_____

***Datum odbrane*: _____**

Zahvalnica

Doktorska disertacija „Sinteza i procesiranje nanostrukturnog titan(IV)-oksida za primenu u solarnim ćelijama sa fotoosetljivom bojom" urađena je na Odseku za Nauku o Materijalima Instituta za Multidisciplinarna Istraživanja (IMSI) u okviru projekta III45007, pod nazivom „0–3D nanostrukture za primenu u elektronici i obnovljivim izvorima energije“, Ministarstva prosvete, nauke i tehnološkog razvoja Republike Srbije.

Zahvaljujem se mentoru i rukovodiocu projekta, dr Goranu Brankoviću, naučnom savetniku Instituta za multidisciplinarna istraživanja Univerziteta u Beogradu za veliko angažovanje tokom svih faza u izradi ove disertacije, za smernice, dragocene stručne savete, veliko strpljenje i prijateljsku pomoć.

Takođe, želeo bih da se zahvalim dr Jeleni Rogan, vanrednom profesoru Tehnološko-metalurškog fakulteta Univerzita u Beogradu, na nesebičnoj pomoći, prenešenom znanju i savetima tokom izrade disertacije.

Dr Aleksandri Dapčević, docentu na Tehnološko-metalurškom fakultetu Univerziteta u Beogradu, i dr Aleksandru Radojkoviću, naučnom saradniku na Institutu za multidisciplinarna istraživanja Univerziteta u Beogradu, dugujem ogromnu zahvalnost na uloženom trudu tokom pisanja i konačnog oblikovanja doktorske disertacije, kao i iskrenoj prijateljskoj podršci.

Posebnu zahvalnost dugujem kolegama sa Projekta, pre svih dr Zorici Marinković Stanojević, na izuzetnom strpljenju i uloženom vremenu tokom mnogobrojnih mikroskopskih analiza uzoraka, kao i dr Zorici Branković na vrednim sugestijama i podršci. Ostalim kolegama sa Projekta i Odseka za nauku o materijalima IMSI, zahvaljujem na svesrdnoj podršci i kreiranju prijatne radne atmosfere u radnim prostorijama Instituta.

Istraživanje nije bilo moguće bez pomoći kolega iz drugih laboratorija i naučno-istraživačkih ustanova. Stoga bih se zahvalio dr Milanu Žuniću, sa Koledža za Inženjerstvo i Informacione Tehnologije u Dždedi (Saudijska Arabija), dr Tatjani Novaković, sa Instituta za Hemijsku Tehnologiju i Metalurgiju (Univerzitet u Beogradu), dr Matejki Podlogar, sa Instituta Jozef Štefan (Ljubljana) i dr Martini Gilić, sa Instituta za fiziku (Univerzitet u Beogradu).

Na kraju bih se zahvalio svojoj porodici, koja me je uvek motivisala i podržavala.

Beograd, 2017. *Nikola Tasić*

Izvod

Solarne ćelije sa fotoosetljivom bojom predstavljaju profitabilnu alternativu konvencionalnim i komercijalizovanim uređajima na bazi kristalnog i amorfnog silicijuma, kadmijum-telurida i pseudo-ternarnih jedinjenja bakra, indijuma, galijuma i selena. Osnova ovih ćelija jeste poluprovodni film titan(IV)-oksida (TiO_2) na koji je adsorbovan monosloj fotoosetljive boje. Boja i TiO_2 zajedno predstavljaju tzv. fotoaktivnu elektrodu. Uloga boje jeste da apsorbuje zračenje, dok TiO_2 osim mehaničke potpore boji obezbeđuje i protok fotogenerisanih elektrona. U cilju izrade efikasne fotoelektrode neophodno je obezbediti visoku poroznost i veliku specifičnu površinu filma TiO_2, kao i optimizovati optička, morfološka i strukturna svojstva materijala.

U ovoj doktorskoj disertaciji primenjena su dva istraživačka pravca za dobijanje elektrodnih filmova, čija optimizacija je vršena na osnovu fotonaponskih parametara pripremljenih solarnih ćelija. Prvi istraživački pravac bio je priprema filmova polazeći od komercijalnog nanočestičnog praha TiO_2, uz upotrebu polietilen-glikola (PEG) različitih molarnih masa (1000–20000 g mol^{-1}), prema do sada neobjavljenim recepturama za paste. Paste su deponovane na transparentne provodne supstrate tehnikom nanošenja sečivom i kalcinisane na temperaturi od 475 °C. Paste pripremljene sa vezivnim agensima PEG4000, PEG6000, PEG8000 rezultovale su poroznim filmovima bez pukotina i sa odličnom adhezijom. Efikasnosti fotokonverzije ćelija sa ovim elektrodama kreću se do 4,31% pri halogenom osvetljenju solarnog simulatora od 100 mW cm^{-2}, a korišćene su kao referentne vrednosti za ocenu kvaliteta filmova dobijenih iz drugog istraživačkog pravca.

Drugi istraživački pravac bio je sinteza nanostrukturnog TiO_2 hidrotermalnom metodom i procesiranje proizvoda sinteze u funkcionalne filmove. Sinteza je podrazumevala upotrebu kompleksirajućeg agensa (Na_2EDTA) i nejonskog surfaktanta (Triton X100), prema do sada neobjavljenoj eksperimentalnoj proceduri, polazeći od titan(IV)-izopropoksida. Ovom metodom dobijene su čestice „pirinčastog“ izgleda i malih dimenzija (<20 nm), organizovane u submikronske micelarne strukture. Intenzivnim ultrazvučnim procesiranjem (60 minuta, 70 W) proizvoda sinteze uz dodatak organskih agenasa, depozicijom pripremljene paste i kalcinacijom na 500 ºC, dobijeni su uniformni monolitni filmovi (uni-TiO_2) visoke

specifične površine od 158 m^2g^{-1}. Kratkotrajnim i blagim ultrazvučnim tretmanom (3 minuta, 7 W) proizvoda sinteze uz dodatak organskih agenasa, pripremljena je pasta sa očuvanim micelarnim strukturama. Depozicijom ove paste i kalcinacijom na 500 ºC, dobijeni su nanostrukturni trodimenzionalni filmovi sa sfernim arhitekturama (3D-TiO_2), specifične površine 135 m^2g^{-1}. U oba slučaja vrednost specifične površine višestruko je veća od specifične površine referentnog komercijalnog praha (55 m^2g^{-1}).

Sistematična optimizacija konfiguracije ćelija sa uni-TiO_2 filmovima, sastava paste, temperature kalcinacije filmova i koncentracije titan(IV)-hlorida, tokom tretmana koji je primenjen sa ciljem poboljšanja fotonaponskih parametara, rezultovala je reproduktivnom efikasnošću fotokonverzije od 5,04%, uz vrednost napona otvorenog kola 0,72 V, gustine struje kratkog spoja 11,336 mA cm^{-2} i faktora idealnosti 0,616. S druge strane, ćelije sa 3D-TiO_2 elektrodama imale su do 3,20% efikasnosti, uz napon otvorenog kola 0,69 V, gustinu struje kratkog spoja 7,656 mA cm^{-2} i faktor idealnosti 0,606.

Uzorci iz različitih faza eksperimenata okarakterisani su u potpunosti u cilju utvrđivanja morfoloških (SEM, FE-SEM, TEM), strukturnih (XRD, SAED, Raman), optičkih (UV-VIS-NIS spektroskopija) i teksturalnih (BET) svojstava. Osim toga, fenomeni transporta nosilaca naelektrisanja u ćelijama ispitani su metodama EIS i OCVD, a dobijeni rezultati detaljno su diskutovani.

Ključne reči: titan(IV)-oksid, hidrotermalna sinteza, fotoelektroda, solarna ćelija sa fotoosetljivom bojom.
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UNIVERSITY OF BELGRADE
FACULTY OF TECHNOLOGY AND METALLURGY

Hana Ibrahim Elswie

SYNTHESIS AND CHARACTERIZATION OF OPTICAL POLYMER COMPOSITES BASED ON SINGLE CRYSTALS

Doctoral Dissertation

Belgrade, 2017.

UNIVERZITET U BEOGRADU
TEHNOLOŠKO-METALURŠKI FAKULTET

Hana Ibrahim Elswie

SINTEZA I KARAKTERIZACIJA OPTIČKI AKTIVNIH KOMPOZITA SA POLIMERNOM MATRICOM NA BAZI MONOKRISTALA

Doktorska Disertacija

Beograd, 2017.

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SINTEZA I KARAKTERIZACIJA POLIMERNIH KOMPOZITA NA BAZI MONOKRISTALA POLUPROVODNIČKIH MATERIJALA

Rezime

Kompoziti sa polimernom matricom na bazi monokristala imaju veliki potencijal u oblasti optičkih komunikacionih sistema gde su aktivni mikro do nano kristali dispergovani u optički transparentnu matricu. Predmet ove doktorske disertacije obuhvata istraživanja u oblasti funkcionalnih optoelektronskih kompozitnih materijala s polimernom matricom za primenu u elektronskim tehnologijama kao i u oblasti komunikacijskih i navigacionih tehnika i mogućnosti razvijanja integralne optike i fotonike. U toku izrade ove disertacije izvedena je sinteza polimernih optoelektronskih kompozitnih materijala kontrolisanih optičkih svojstava. Dobijanje visoko transparentnih kompozita moguće je s jedne strane korišćenjem neorganskih punilaca dimenzija čestica manjih od talasne dužine elektromagnetnog zračenja, da ne bi došlo do rasejavanja. Drugi način je ugradnja materijala sa sličnim vrednostima indeksa refrakcije. U okviru ove disertacije izbor materijala pao je na poli (metil-metakrilat) sa indeksom refrakcije n_{600}= 1.49 i kalcijum-fluorid sa n_{600}= 1.43.

Istraživanja su išla u dva pravca: a) sinteza monokristalnog CaF_2 kao funkcionalnog nosioca u kompozitu i ugradnja u polimernu matricu; b) sinteza i karakterizacija kompozita sa polimernom matricom ugradnjom kvantnih tačaka CdSe. Na ovako organizovan način istraživanja može se pratiti i uticaj organizacije i dimenzija kristala na optička i mehanička svojstva dobijenog kompozita.

Modifikovanom metodom vertikalni Bridžman u vakumu dobijen je visoko kvalitetni monokristal CaF_2. Dobijeni kristal je ispitivan metodam Raman i IC spektroskopijom. Kristalna struktura je potvrđena rendgensko strukturnom analizom. U skladu sa teorijom grupa primećen je jedan Raman i dva infracrvena optička moda. Niska fotoluminiscencija svedoči o tome da je koncentracija defekata kiseonika u CaF_2 mala. Sva obavljena istraživanja pokazuju da dobijeni monokristal CaF_2 ima dobar optički kvalitet. Nakon

mlevenja čestice monokristala su ugrađene u polimernu matricu poli (metil-metakrilata). Ugradnjom monokristalnog CaF_2 dobijen je kompozit sa očuvanim optičkim svojstvima monokristala, dok su termička i mehanička svojstva poboljšana.

Kvantne tačke (*quantum dots*-QD) predstavljaju poluprovodne monokristalne nanostrukture, čiji su nosioci naelektirisanja prostorno ograničeni u sve tri dimenzije. Materijal od koga su tačke izrađene definiše njihove karakteristične energijske vrednosti, međutim tačne vrednosti energijskog procepa su određene veličinom tačke. Posledica ovoga je činjenica da kvantne tačke izrađene od istog materijala, ali različitih veličina emituju zračenje različitih talasnih dužina. U okviru ovog rada izvedeno je ispitivanje uslova dobijanja tankog filma od poli(metil metakrilat)-a dopiranog kvantnim tačkama CdSe metodom livenja iz rastvora. Termička svojstva kompozita ispitana su metodom DSC. Optička svojstva ispitivana su analizom emisionog spektra pikosekundnim mernim sistemom za merenje vremena života luminescencije. Mehanička svojstva su ispitana primenom metode nanoindentacije. Rezultati DSC Apokazuju da je za kompozitni film PMMA dopiranog s QD dobijena je nešto niža T_g u odnosu na čist PMMA. Razlog za ovo sniženje T_g je interakcija QD sa osnovnim polimernim lancem PMMA. Rezultati ispitivanja nanoindentacijom pokazuju da dodatak QD povećava redukovani modul elestičnosti i tvrdoću. I ovakvo ponašanje kompozitnog filma ukazuje na interakciju nanočestica QD i osnovnog polimernog lanca PMMA. Ove čestice sprečavaju pokretanje polimernog lanca i na taj način poboljšavaju mehanička svojstva kompozita.Rezultujući fluorescentni spektar kompozitnog filma pokazao je da su QD zadržale svoja optička svostva i da odlično reaguju u PMMA matrici na pobudu.

***Ključne reči*:** Kompozitni materijali, monokristal, kvantne tačke, fluoroscencija, nanoindentacija

Naučna oblast: Inženjerstvo materijala

UDK: 66.017:548.55

UNIVERZITET U BEOGRADU
TEHNIČKI FAKULTET U BORU

Stevan P. Dimitrijević

ELEKTROHEMIJSKA I POVRŠINSKA KARAKTERIZACIJA TROKOMPONENTNIH LEGURA SISTEMA Ag-Cu-Zn U BLISKO NEUTRALNIM HLORIDNIM RASTVORIMA

doktorska disertacija

BOR, 2015. godine

UNIVERSITY OF BELGRADE
TECHNICAL FACULTY IN BOR

Stevan P. Dimitrijević

ELCTROCHEMICAL AND SURFACE CHARACTERIZATION OF TERNARY ALLOYS OF THE SYSTEM Ag-Cu-Zn IN NEAR NEUTRAL CHLORIDE SOLUTIONS

Doctoral Dissertation

BOR, 2015.

Komisija za pregled i odbranu:

Mentor:	redovni profesor, dr Mirjana Rajčić-Vujasinović, Univerzitet u Beogradu, Tehnički fakultet u Boru
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	docent, dr Vesna Grekulović, Univerzitet u Beogradu, Tehnički fakultet u Boru
	redovni profesor, dr Zoran Stević, Univerzitet u Beogradu, Tehnički fakultet u Boru

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Bor, 2015. godine

Stevan Dimitrijević, dipl.inž.teh.

Elektrohemijska i površinska karakterizacija trokomponentnih legura sistema Ag-Cu-Zn u blisko neutralnim hloridnim rastvorima

REZIME

Predmet istraživanja disertacije bile su legure sistema Ag-Cu-Zn sličnog sastava faza u širokom opsegu sadržaja srebra. Metali za sve ispitivane legure dobijeni su reciklažom elektronskog otpada. Nakon dobijanja dvostrukim topljenjem i homogenizacionog žarenja u trajanju od 24h u atmosferi azota izvršena je površinska i elektrohemijska karakterizacija ovih legura. Kao legure za uporednu analizu korišene su legure sistema Ag-Zn i Cu-Zn, sastava sličnog fazama ispitivanih legura i legura Ag40Cu30Zn30 čiji se fazni sastav značajno razlikuje od preostale tri trokomponentne legure istog sistema.

Termodinamička analiza Ag-Cu-Zn sistema izvršena je korišćenjem faznih dijagrama i Pandat softvera. Za površinsku karakterizaciju homogenizovanih legura korišćena je skenirajuća elektronska mikroskopija sa rentgenskom analizom (SEM/EDS) i rentgenskom difrakcijom (XRD).

Elektrohemijsko ponašanje legura sistema Ag-Cu-Zn ispitivano je u deaerisanim i prirodno aerisanim neutralnim rastvorima NaCl koncentracije 3,5% (masenih), sintetičkoj morskoj vodi, prirodnim filtriranim morskim vodama i boratnom puferu (pH=8.1) sa (masenih) 3,5% NaCl, korišćenjem potenciodinamičkih merenja, linearne polarizacije, ciklične voltametrije i potenciostatskih merenja.

Anodni film formiran na ispitivanim legurama hronoampermetrijski na 0,0 V i +0,25 V (vs. ZKE) je ispitivan: rentgenskom difrakcijom, FE SEM/EDS metodom, Raman spektroskopijom i MALDI masenom spektrometrijom.

Utvrđen je isti mehanizam korozije prilikom anodne polarizacije za sve legure u svim hloridnim rastvorima, osim u puferisanom rastvoru NaCl. Naročito je slično ponašanje legura Ag43Cu37Zn20 i Ag25Cu52,5Zn22,5. Legura sa 25% (mas.) srebra ima sličnu otpornost na koroziju u 3,5% rastvoru NaCl kao legura sa 40% (mas.) srebra, što je nedvosmisleno uticaj faznog sastava. Pri sličnom faznom sastavu legura koroziona otpornost raste sa većim udelom srebra (faze bogate srebrom). Sve ispitivane legure sistema Ag-Cu-Zn nemaju pasivnu oblast u svim rastvorima osim puferskog, gde se javlja pseudo-pasivna oblast na polarizacionim krivama.

Faza bogata bakrom (Cu) je kritična za korozionu otpornost legura. Ona se pri anodnoj polarizaciji prva rastvara što je utvrđeno analizom polarizacionih krivih, hemijskim analizama, XRD analizom i SEM snimcima.

Anodni film dobijen potenciostatskom metodom na potencijalu od 0,0 V vs. ZKE se sastoji pretežno od CuCl. Površinski film dobijen na potencijalu od +0,25 V vs. ZKE je kompleksnog sastava i sastoji se iz: CuCl (nantokita), cink hidroksihlorida (β-Zn(OH)Cl i simonkolajt – $Zn_5(OH)_8Cl_2 \cdot H_2O$) i Cu_2O, kako je utvrđeno XRD metodom. To je potvrđeno Raman spektroskopijom i MALDI masenom spektrometrijom a ove dve metode su ukazale i na prisustvo AgCl i $CuO/Cu(OH)_2$.

Korozioni mehanizam prilikom anodne oksidacije u 3,5% (mas.) NaCl u boratnom puferu se značajno razlikuje od ostalih ispitivanih rastvora. Iz polarizacionih krivih i hemijskih analiza rastvora zaključeno je da se površinski film sastoji od oksida/hidroksida bakra (Cu_2O, $Cu(OH)_2/CuO$) a da se cink rastvara i ostaje u obliku rastvornih hidratisanih jona.

Ključne reči: Ag-Cu-Zn, legure, hloridni rastvori, morska voda, boratni pufer, anodni film, elektrohemija, korozija, Tafel, Polarizacija, Ciklična voltametrija, Rentgenska difrakcija, Raman spektroskopija, masena spektrometrija, MALDI, SEM/EDS.

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ФАКУЛТЕТ ТЕХНИЧКИХ НАУКА НОВИ САД

КОНГРЕС МЕТРОЛОГА 2015

Златибор, 12.-15. октобар 2015. године

ЗБОРНИК РАДОВА

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I M P R E S U M

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П Р Е Д Г О В О Р

Ове године се одржавање Конгреса поклапа са 140. годишњицом потписивања Метарске конвенције и Годином светлости, проглашеном од стране Уједињених нација, тако да ће се ова два догађаја посебно обележити кроз два уводна предавања.

Управни одбор Друштва Метролога је, због поклапања са годишњицом Метарске конвенције, одлучио да организатор Конгреса буде неко ко се бави мерењем дужина, а то је Метролошка лабораторија за еталонирање мерила угла и дужине. Лабораторија већ 30 година успешно ради у оквиру Института за геодезију и геоинформатику на Грађевинском факултету Универзитета у Београду. Оранизатор се потрудио да окупи већи број стручњака из области метрологије са факултета, из научно-истраживачких института, метролошких лабораторија...

Традиционално, Конгрес има за циљ размену информација, научних и стручних сазнања и побољшање квалитета у свим областима метрологије. Радови на Конгресу су груписани у секције према класификацији IMEKO (International Measurement Confederation, www.imeko.org). Радови, њих тридесетак, су штампани у електронској форми, на USB меморији.

Организацију Конгреса и штампање Зборника радова је помогло Министарство просвете, науке и технолошког развоја Републике Србије.

У Београду,
Октобар, 2015.

Председник Научног одбора
В. проф. др Синиша Делчев, дипл. геод. инж.

Program Kongresa metrologa 2015

PONEDELJAK, 12.10.2015.

KOKTEL DOBRODOŠLICE: 12^{00} - 12^{45}	
Otvaranje Kongresa i radovi po pozivu - Banket sala: 12^{45} - 14^{00}	
Vida Živković	METARSKA KONVENCIJA I PREDLOŽENA REDEFINICIJA OSNOVNIH JEDINICA SI
Ljiljana Brajović	SVETLOST I METROLOGIJA

Pauza za ručak

Sesija 1 - Konferencijska sala I: 15^{00} - 16^{30}

TC4: Measurement of Electrical Quantities/Merenje električnih veličina	
Predsedavajući: dr Zoran Mitrović	
Zoran Knežević	METODE ETALONIRANJA KALIBRATORA KEITHLEY 263 I REFERENTNIH ETALONA, FLUKE 510A PRI INTERLABORATORIJSKOM POREĐENJU PREMA PROTOKOLU PT-E-DCACR-1-2014
Milana Nikolić	ANALIZA PRORAČUNA MERNE NESIGURNOSTI ETALONIRANJA ELEKTRIČNE OTPORNOSTI OTPORNIKA DC STRUJE DIGITALNIM MULTIMETROM AGILENT 34420A
Slavko Vukanić	METODA ETALONIRANJA HARMONIJSKIH IZOBLIČENJA DIGITALNOG MULTIMETRA KEITHLEY 2015 U TEHNIČKOM OPITNOM CENTRU
Marjan Urekar, Marina Bulat, Nemanja Gazivoda, Zoran Mitrović, Jovan Mitrović	ESTIMACIJA PERFORMANSI REFERENTNOG NAPONSKOG IZVORA ZA KALIBRACIJU 3 ½ CIFARSKIH DIGITALNIH MULTIMETARA VAN LABORATORIJE
Dusan Radivojevic, Nenad Milosevic	UTICAJ SOFTVERSKOG POVEĆANJA REZOLUCIJE NA STATISTIČKE KARAKTERISTIKE A/D KONVERZIJE DC NAPAJANJA RAZVIJENOG U INSTITUTU VINČA

Sesija 2 - Konferencijska sala II: 15^{00} - 16^{30}

TC9 - Flow Measurement/Merenje protoka; TC12 - Temperature and Thermal Measurements/Merenje temperature i toplote	
Predsedavajući: dr Dušan Prodanović	
Marijana Terzić, Nenad Milošević, Nenad Stepanić	PROJEKTOVANJE, IZRADA I VALIDACIJA APARATURE ZA ODREĐIVANJE TOPLOTNE PROVODNOSTI SLABO PROVODNIH ČVRSTIH MATERIJALA PO METODI JEDNOSTRANE ZAŠTIĆENE TOPLE PLOČE
Miroslav Benišek, Dejan Ilić, Đorđe Čantrak, Novica Janković	INSTALACIJA ZA KALIBRACIJU PROTOKOMERA VISOKE TAČNOSTI
Nenad Stepanić, Marijana Terzić, Nenad Milošević	UTICAJ ASIMETRIJE IZVORA TOPLOTE NA NESIGURNOST ETALONIRANJA TOPLOTNIH FLUKSMETARA METODOM AKSIJALNOG TOPLOTNOG TOKA SA ZAŠTITNOM OBLOGOM
Mirjana Mladenović, Vitomir Mrvaljević, Dragan Lazić	ETALONIRANJE DIGITALNIH TERMOHIGROMETARA

Sesija A - Konferencijska sala I: 17^{00} - 18^{30}

Radionica I - Međulaboratorijska poređenja
Predsedavajući: Predstavnik DMDM

UTORAK, 13.10.2015.

Sesija 3 - Konferencijska sala I: 9^{00} - 11^{00}

TC3 - Measurement of Force, Mass and Torque/Merenje sile, mase i torzije; TC8 - Traceability in Metrology/Sledivost u metrologiji; TC14 - Measurement of Geometrical Quantities/Merenje geometrijskih veličina	
Predsedavajući: dr Branislav Tanasić	
Drago Bijelić, Nedeljko Bencuz, Ranko Ljepojević	CALIBRATION PROCEDURE OF HORIZONTAL CYLINDRICAL FIXED TANK USING LASER SCANNING AND SURVEY OF THE RESULTS IN RELATION TO THE VOLUMETRIC METHOD
Vitomir Mrvaljevic, Dragan Lazic, Jasminka Jelisavac	ETALONIRANJE CENTRIFUGE ZA TESTIRANJE PILOTA
Vitomir Mrvaljević	ETALONIRANJE CENTRIFUGE ZA SELEKCIJU PILOTA
Vlastimir Gluhovic, Srdjan Damjanovic, Biljana Petric	ANALIZA PERIODA ETALONIRANJA MJERNIH INSTRUMENATA U METROLOŠKOJ LABORATORIJI ORAO A.D.

Sesija 4 - Konferencijska sala II: 9^{00} - 11^{00}

TC9 - Flow Measurement/Merenje protoka; TC12 - Temperature and Thermal Measurements/Merenje temperature i toplote	
Predsedavajući: dr Ljiljana Brajović	
Želimir Nedović	ISPITIVANJE DIFERENCIJALNIH UNIDIREKCIONALNIH PRETVARAČA PRITISKA.
Milica Mirković, Goran Todorović, Radovan Gospavić, Željko Jovanović, Ljiljana Brajovic	EKSPERIMENTALNO ODREĐIVANJE FAKTORA PRIGUŠENJA I KAŠNJENJA OSCILACIJA TEMPERATURE GRAĐEVINSKIH OBJEKATA
Branko Zivkovic, Predrag Kolarz	ANEMOMETRIJSKI METROLOŠKI USLOVI ZA AEROTUNELE I NJIHOVA ZADOVOLjENOST U METEOROLOŠKOJ LABORATORIJI RHMZ SRBIJE

Skupština Društva metrologa - Konferencijska sala I: 12^{30} - 14^{00}

Pauza za ručak

Sesija 5 - Konferencijska sala I: 15^{00} - 16^{30}

TC4: Measurement of Electrical Quantities/Merenje električnih veličina; TC8 - Traceability in Metrology/Sledivost u metrologiji; TC14 - Measurement of Geometrical Quantities/Merenje geometrijskih veličina	
Predsedavajući: dr Siniša Delčev	
Jelena Gučević, Siniša Delčev, Vukan Ogrizović, Stefan Miljković	VALIDATION OF NON-STANDARD METHODS FOR CALIBRATING TERRESTRIAL LASER SCANNERS
Žarko Nestorović	PROVERA PRECIZNE PANTLJIKE IZRAVNANJEM OPAŽANIH PRAVACA I DUŽINA MERENIH TOTALNOM STANICOM
Ankica Milinković	SIMULACIJA PT PROVAJDERA ZA ISPITIVANJE OSPOSOBLJENOSTI TOU DIMENZIONALNIH MERILA PRIMENJENIH U GEODEZIJI
Miša Markuš, Neda Spasojević, Ivica Milanović	SISTEM ZA MERENJE BRZINE PROJEKTILA I BRZINE PALJBE VFR-2 I POSTUPAK NJEGOVOG ETALONIRANJA
Sanja Tucikešić, Ankica Milinković, Kornelija Ristić	ODREĐIVANJE NAGIBA I SAVIJENOSTI RAVNI KOJU OPISUJE ZRAK ROTACIONOG LASERSKOG NIVELIRA

Sesija 6 - Konferencijska sala II: 15^{00} - 16^{30}

TC3 - Measurement of Force, Mass and Torque/Merenje sile, mase I torzije; TC4: Measurement of Electrical Quantities/Merenje električnih veličina; TC8 - Traceability in Metrology/Sledivost u metrologiji	
Predsedavajući: dr Platon Sovilj	
Ivica Milanović, Neda Spasojević, Miša Markuš	MERENJE KRATKOTRAJNE STABILNOSTI FREKVENCIJE - MOGUĆNOSTI LABORATORIJE TEHNIČKOG OPITNOG CENTRA I DALJI RAZVOJ
Platon Sovilj, Dragan Pejić, Bojan Vujičić, Marjan Urekar, Nemanja Gazivoda	METROLOŠKA VERIFIKACIJA 2-BITNOG STOHASTIČKOG INSTRUMENTA ZA MERENJE EFEKTIVNE VREDNOSTI UNIFORMNOG ŠUMA
Rajko Spasojevic, Bojan Sekularac, Vladimir Martinovic	THE PROJECT ON LINE MONITORING METHODS IN PROAKTIVE MAINTENANCE IN OPEN PIT KOLUBARA
Dragan Lazic	PRIKAZ OSNOVNIH MODELA GREŠAKA INERCIJALNIH SENZORA

SREDA, 14.10.2015.

Izlet 9 - 14^{00} (Šarganska osmica)

Sesija B - Konferencijska sala I: 17^{00} - 18^{30}

Radionica II: Normativna dokumenta (direktive) DMDM i standardi
Predsedavajući: dr Branislav Tanasić

20^{00} - ?? SVEČANA VEČERA

ČETVRTAK, 15.10.2015.

Sesija 7 - Konferencijska sala: 9^{00} - 10^{30}

TC3 - Measurement of Force, Mass and Torque/Merenje sile, mase i torzije; TC12 - Temperature and Thermal Measurements/Merenje temperature i toplote	
Predsedavajući: dr Jelena Gučević	
Mladen Mirić, Miloš Đorđević	LEGURE ZLATA ZA IZRADU NAKITA – OD PRE 140 GODINA DO DANAS
Oleg Odalovic, Sanja Grekulovic, Miljana Todorovic Drakul	ANALIZA TAČNOSTI PODATAKA SATELITSKE MISIJE GOCE NA TERITORIJI REPUBLIKE SRBIJE
Sofija Naod, Ljiljana Brajović, Oleg Odalović, Miodrag Malović, Goran Todorović, Radovan Gospavić	GRAVITACIONI GRADIOMETRI KOJI SE KORISTE U SATELITSKIM MISIJAMA - PRINCIP RADA I MERNE KARAKTERISTIKE
Srdjan Damjanovic, Predrag Katanic. Borislav Drakul	SISTEM ZA MJERENJE I OBRADU PODATAKA O KVALITETU VAZDUHA

11^{00} - 12^{00} Zatvaranje Kongresa

Povratak

РЕПУБЛИКА СРБИЈА

Завод за интелектуалну својину

Београд, Кнегиње Љубице 5

ИСПРАВА О МАЛОМ ПАТЕНТУ

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по пријави МП - 2018/0028, поднетој 19.06.2018. године.

Мали патент је уписан у Регистар малих патената 03.04.2019. године,
и објављен у Гласнику интелектуалне својине број 4/2019 дана 30.04.2019. године.

Мали патент важи до 19.06.2028. године, под условом
да се годишње таксе за његово одржавање редовно плаћају.

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("Службени гласник РС", бр. 99/11).

Београд, 03.05.2019. годинс

Директор
Владимир Марић