ПРИЛОЖЕНИЕ 2

РЕЗЮМЕТА НА НАУЧНИТЕ ТРУДОВЕ
на
д-р Анна Петрова

BULGARIAN ACADEMY OF SCIENCE
SPACE RESEARCH AND TEHNOLOGY INSTITUTE
Department "Space material science"

Anna Petrova Petrova

STRUCTURE, PROPERTIES AND APPLICATIONS OF DETONATION NANODIAMONDS

ABSTRACT of Ph. D. THESIS

The subject of the current Ph. D. thesis is related to detonation nanodiamond particles obtained in a phase transition of the free carbon contained in explosives with negative oxygen balance (S. Stavrev et al., 1991). The processing conditions are the following: pressure - 22 GPa; temperature - 4500 K; time-frame of the process - a few milliseconds.

The parameters of the detonation wave and phase diagram of carbon shows that diamond crystallizes from microscopic drops of carbon. Nanodiamonds synthesized by detonation (DND) with monocrystalline structure and a particle size around 4 ÷ 6 nm, are particularly important for the nanotechnology application. DND has high specific area 300 ÷ 400 m2/g and in the same time DND has a high surface activity. Nanodiamond crystals, which are obtained at the front of a detonation wave in an extremely varying regime and in a very short period of time, have many surface defects. Therefore, the carbon atoms on the surface of the nanodiamond crystals cannot stabilize their electron shell. DND has a three-layer structure. The third layer consists of different functional goups (oxygenic, carboxylic, carbonylic and others) around the diamond nucleus. They determine the hydrophilic properties of the nanodiamond surface.

The conditions of the nanodiamond synthesis determine the distinguishing characteristics of the nanodiamond produced, which differ considerably from these of the natural diamond and the nanodiamond obtained by static or dynamic synthesis. These characteristics determine the specific properties of the detonation nanodiamond, which make it suitable for biological and industrial applications.

Nanoscience & Nanotechnology, **14**
eds. E. Balabanova, E. Mileva, Sofia, 2014

SURVEY OF CARBON NANOSTRUCTURES SYNTHESIZED BY DETONATION METHOD IN BULGARIA

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Abstract: The past two decades were characterized by a huge development of explosives technology as a way to synthesize and modify nanomaterials. The creation of new powerful explosive mixtures, technologies for their preparation and methods to implement explosive processes lead to deeper understanding of the phenomena that accompany these processes (shock waves, detonation, impact velocity, accumulation, phase transitions, etc.). The rapid development of computer technology enabled accurate modeling of the complex explosive processes. Dynamic methods for synthesis of nanoparticles represent one of the most interesting changes of the energy of the shock-wave. For development of nanotechnologies detonation nanodiamonds are of special interest. Applications of detonation nanodiamonds in industry and science are diverse. They have the thermal stability typical of a natural diamond. They are suitable for various industrial applications both in the form of powder and as mechanically stable compacts. Detonation nanodiamonds are used to create high-quality materials with nanocrystalline structure (with particle size up to 100 nm). In some applications it is permissible to use chemically untreated detonation nanodiamonds – initial suspension, which is almost two times cheaper. It is necessary to make preliminary studies of powder to determine the size, particle shape and surface conditions.

Keywords: detonation nanodiamonds, aqueous suspension, electron microscopy.

quantities. The base is formed by knowledge developed over the past 30 years, which is a guarantee for technical superiority on the European market. The complete set of features of the nanodiamonds has been studied. Goals are achieved by combining nanotechnology and intellectual production in the synthesis of detonation nanodiamonds, by creating new applicable knowledge and radical innovations in advanced materials and multifunctional products.

The object of the present study are nanodiamond samples in the form of an aqueous suspension (sample 1) and dry powder (samples 2 and 3). Samples were prepared by the shock-wave method. Output explosives are TNT+hexogen in suitable proportions. The weight of the charge is 0,580 kg. The cooling environment is water. The samples were analyzed in TISNUM, Troitsk, Russia.

The interaction of X-rays with matter can be reduced to two processes: absorption, that is, transformation of the energy of the X-rays into other types of energy, and scattering, that is, change of the initial propagation direction of the X-rays.

The composition and the structure of the samples were determined by X-ray diffraction using a TETA ARL X'TRA diffractometer. Particle size was measured on a JEM-2010 electron microscope with acceleration voltage

Nanoscience & Nanotechnology, **9**
eds. E. Balabanova, I. Dragieva, Sofia, 2009

PROJECT I-STONE FROM FP6 „RE-ENGINEERING OF NATURAL STONE PRODUCTION CHAIN THROUGH KNOWLEDGE BASED PROCESSES, ECO-INNOVATION AND NEW ORGANIZATIONAL PARADIGMS"

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PRIORITY 3 - Nanotechnologies and nano-sciences, knowledge-based multifunctional materials and new production processes and devices
Project Coordinator: Giuseppe Gandolfi, Dr. Ing., Pedrini SPA ad unico socio, Italy
Coordinator for Bulgaria: Prof. d-r Sc. Stavri Stavrev – Space Research Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria, tel: +359/2/753443, e-mail: sstavrev@phys.bas.bg
Duration: 45 months (2005-2008)
Participants: 42 from 17 Countries: Italy (7), Spain (5), Sweden (4), Netherlands (2), Belgium (1), Portugal (1), Germany (3), Greece (6), Romania (3), Bulgaria (1), Austria (1), Ukraine (1), Russia (2), Argentina(2), Denmark (1), Czech Republic (1), Poland (1).

Abstract: The need for an IP (I-STONE) to address the current problems and the future requirements of the European Stone Sector originates from the ever increasing need of the EU *Construction industry* for more and higher quality stone products and the fact that despite its economic importance, the Stone Sector has not made any significant technological progress the last decades. The aim of the proposed IP is the re-engineering of the stone production chain, in order to considerably increase its efficiency and productivity, minimize the amount of stone wastes disposed in the environment, produce a new generation of multifunctional products based on stone wastes and safeguard the quality in stone application and use. The ultimate target of the project is to transform the rather traditional Stone Sector into a modern, competitive and knowledge-based industry and ensure a lasting technological superiority of EU over its competitors.

Keywords diamond, metallization, composites, coating, tools

1. Project summary

Among all the raw minerals (energy, metallic and industrial) the Stone Sector is the most significant in terms of

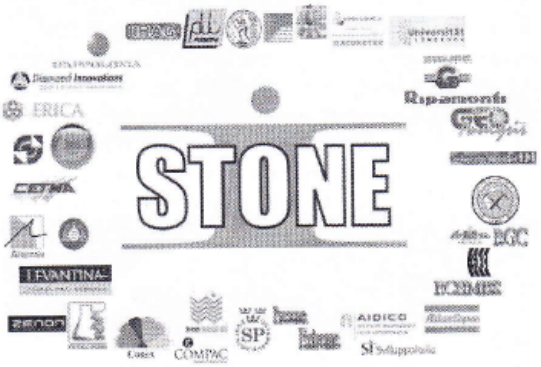

Figure 1. I-Stone logo

These objectives will be achieved with the incorporation of nanotechnology and intelligent manufacturing in stone processing and through the creation of new applicable knowledge and radical innovations in advanced materials and multifunctional products [1].

Пленарные доклады

Международная интеграция в области нанотехнологий: участие в европейских программах и соглашений о сотрудничестве с научными подразделениями в России - задачи, проблемы, перспективы

Анна Петрова Петрова, Ставри Янев Ставрев
ИКИ-БАН

Последствия развития нанотехнологий – это быстрое развитие всех отраслей науки и техники.

Предмет исследования секции "Космическое материаловедение и нанотехнологии" в ИКИ-БАН: научные и научно-прикладные исследования; синтез и модификации кубических наноструктур углерода и на основе нитрида бора; создание технологий для их применения в космических исследованиях, промышленности, медицине и безопасности страны.

Секция "Космическое материаловедение и нанотехнологии" является предпочитаемым партнером в комплексных проектах V, VI и VII Рамочных программ ЕС.

Благодаря высокому бэкграунду, секция стала желанным партнером в проектах: SMART WIRE, OSNET, ESINET, I-STONE, X-GEAR, NAVOBS , NAVOBS PLUS.

Участие в рамочных программах ЕС и совместные проекты с Россией очень перспективны. ЕС приветствует участие России в совместных проектах. Это направление отличается очень высоким потенциалом, а Болгарии является связывающим звеном.

вопросом метрологии является также создание и аттестация стандартных образцов.

Состояние синтеза наноструктур в Болгарии, перспективные технологии и их применение

Анна П. Петрова, Здравка К. Карагьозова, Ставри Я. Ставрев
ИКИ-БАН

В предлагаемой работе сделан анализ развития синтеза наноструктур в Болгарии вообще, и детонационный синтез кубических наноструктур в частности. Определены причины и условия, позволяющие развивать данные методы синтеза наноструктур в БАН и в ИКИ-БАН. Подчёркнуты созданные и поддерживаемые узкие связи с Институрами РАН и рядом университетов, как основы для развития данного направления в Болгарии.

В работе рассмотрены исследования, позволяющие создать технологии синтеза шести модификаций детонационного наноалмаза: фулереновых структур; нанотрубок; четвертых алотропных модификаций углерода и ряда других. Показаны, созданные для этих целей технологии и технологическая оснастка для промышленного производства.

Nanoscience & Nanotechnology, 4
eds. E. Balabanova, I. Dragieva, Heron Press, Sofia, 2004

METALLIZATION OF DIAMOND POWDER

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Abstract. The paper has studied the wear resistance and the microhardness of composite diamond coatings, made in a solution "EFTTOM NICKEL" with a metallized Ultra Dispersed Diamond Powder – UDDP. The obtained coatings are with a good adhesion with the base of the samples. The best wear resistance is obtained in the case with the electroless grasping of a metalized UDDP.

Keywords: diamond, metallization, coating, superabrasives, tools

the use of diamonds with coatings, particularly titanium or chromium [4].

In electroplated bonds a single layer of diamond crystals is attached to a grinding wheel by means of a layer of metal, typically nickel that is electroplated on top of the diamonds [5]. Usually pill-out ratio of coated grits can be reduced by 20–40% compared to that of uncoated ones. Moreover, most of crystals can be used to their full potential [6].

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI.
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
N^0. 4 – 2010, ISSN 1453 – 083X

PHYSICO-MECHANICAL AND PHYSICO-CHEMICAL PROPERTIES OF BIO-INERT COMPOSITE CERAMICS

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ABSTRACT

Bio-inert ceramics are non-toxic, non-allergenic and non-carcinogenic materials which explain why these are frequently used as orthopedic and dental implants. Unfortunately, these are chemically inert and do not naturally form a direct link with the bone. The research carried studies micro/nanostructure properties and the porosity of the TiO_2-Nb_2O_5 ceramics, used as biocompatible polymer matrix, prepared by different technological regimes. The morphology of the composite samples of TiO_2-Nb_2O_5 was studied using scanning microscopy. The phase identification of the composites was carried by metallographic microscopy. Results obtained show the chemical composition, the technological parameters and the porosity determined, favors formation of sufficiently strong bond between the studied materials and vitreous carbon layers.

KEYWORDS: bio-inert ceramics, physico-mechanical, physico-chemical properties

S E S 2 0 1 7
Thirteenth International Scientific Conference
SPACE, ECOLOGY, SAFETY
2 – 4 November 2017, Sofia, Bulgaria

METHODS FOR ANALYSIS OF SURFACE MODIFIED METAL ALLOYS

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Keywords: *Microstructure, morphology, roughness, electroless Ni coatings, aluminum alloy, stainless steel*

Abstract: *In the last decades, there is interest in the fabrication of nanostructures suitable for different applications. Physical and mechanical properties of the nanoscale particles are novel, different from those in the bulk materials.*

This review deals with the latest techniques developed to perform the analysis of coatings on alluminium alloys or steel, classical and novel measurements for complementary characterization of the surfaces.

The topography of the surfaces of the metals and applied coatings are tested using atomic force microscopy (AFM), scanning electron microscope (SEM) and optical microscopy (OM) analysis. Coating defects and pores are demonstrated on 2D and 3D images.

S E S 2 0 1 7
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2 – 4 November 2017, Sofia, Bulgaria

АНАЛИЗ НА НАНОСТРУКТУРИ ЧРЕЗ СКАНИРАЩА МИКРОСКОПИЯ

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Ключови думи: *Микроструктура, морфология, грапавост*

Резюме: *Текущите изображения предоставят допълнителна информация за свойствата на повърхността. Техниките за изследване при сканираща сондова микроскопия (SPM) са безразрушителни и осигуряват измерване на механичните свойства на изследваните образци. Микроскопът позволява измерване на грапавостта на повърхността. Трудно е да се сканира, когато има пори, големи образования и драскотини върху повърхността на пробата.*

Морфологията на повърхността се наблюдава с микроскоп NanoScan.

S E S 2 0 1 5
Eleventh Scientific Conference with International Participation
SPACE, ECOLOGY, SAFETY
4 – 6 November 2015, Sofia, Bulgaria

DISPLACEMENT (IMMERSION) TIN PLATING

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Keywords: *Electroless immersion coatings, tin coatings, printed circuit boards, etching, wet angle*

Abstract: *The metal layering on the metal surface flowing without the presence of the reducing agents or an external source of electricity is called immersion plating. The salt solution of the noble metal and less noble metal substrate are needed the process to take place. The deposition of the noble metal on the plated surface is observed due to displacement process.*

The immersion plating of Tin on Copper is too popular in the production of printed circuit boards. The displacement of copper with tin in the solution of tin salt becomes. The achieved layer is characterized with better solder wettability, corrosion and oxidation protection of the surface.

The morphology observation, hardness and elasticity measurements are carried out of the Tin and Tin-DND coatings.

INNOVATIVE NANOSTRUCTURED COMPOSITE COATINGS

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1. Introduction

The past two decades were characterized by a huge development of nanotechnologies as a way to synthesize and modify nanomaterials. Dynamic methods for synthesis of nanoparticles represent one of the most interesting changes of energy. Nanodiamonds (ND) are of special interest for the development of various technologies. They are used to create high-quality materials with nanocrystal structure and particle size up to 100 nm. The nanostructured composite coatings are usable in the production of new generation of multifunctional products based on innovative materials, which safeguard the quality in application and use.

The gear industry has to implement major changes in gear design, mechanical transmission systems and fabrication techniques. The production of new gears, using new materials steel-coated with innovative surface treatments, based on nanodiamonds, has been analysed.

This survey relates to samples with ND synthesized by the methods [1], [2], [3]. A detailed study of the characteristics and the properties was performed in [4].

Financial support by „X-GEAR" project EC Framework 6 - Development of Gear Drive-Trains Based on New Materials and Novel Gear Systems, Contract Number 030433 is gratefully acknowledged. The participants are 22 structures from 8 countries: Italy (6), Netherlands (1), Belgium (3), Portugal (2), Bulgaria (4), Poland (4), England (1), Finland (1).

S E S 2 0 1 4
Tenth Anniversary Scientific Conference with International Participation
SPACE, ECOLOGY, SAFETY
12 – 14 November 2014, Sofia, Bulgaria

ПЕРСПЕКТИВНИ МАТЕРИАЛИ ЗА РАБОТА В ЕКСТРЕМНИ УСЛОВИЯ

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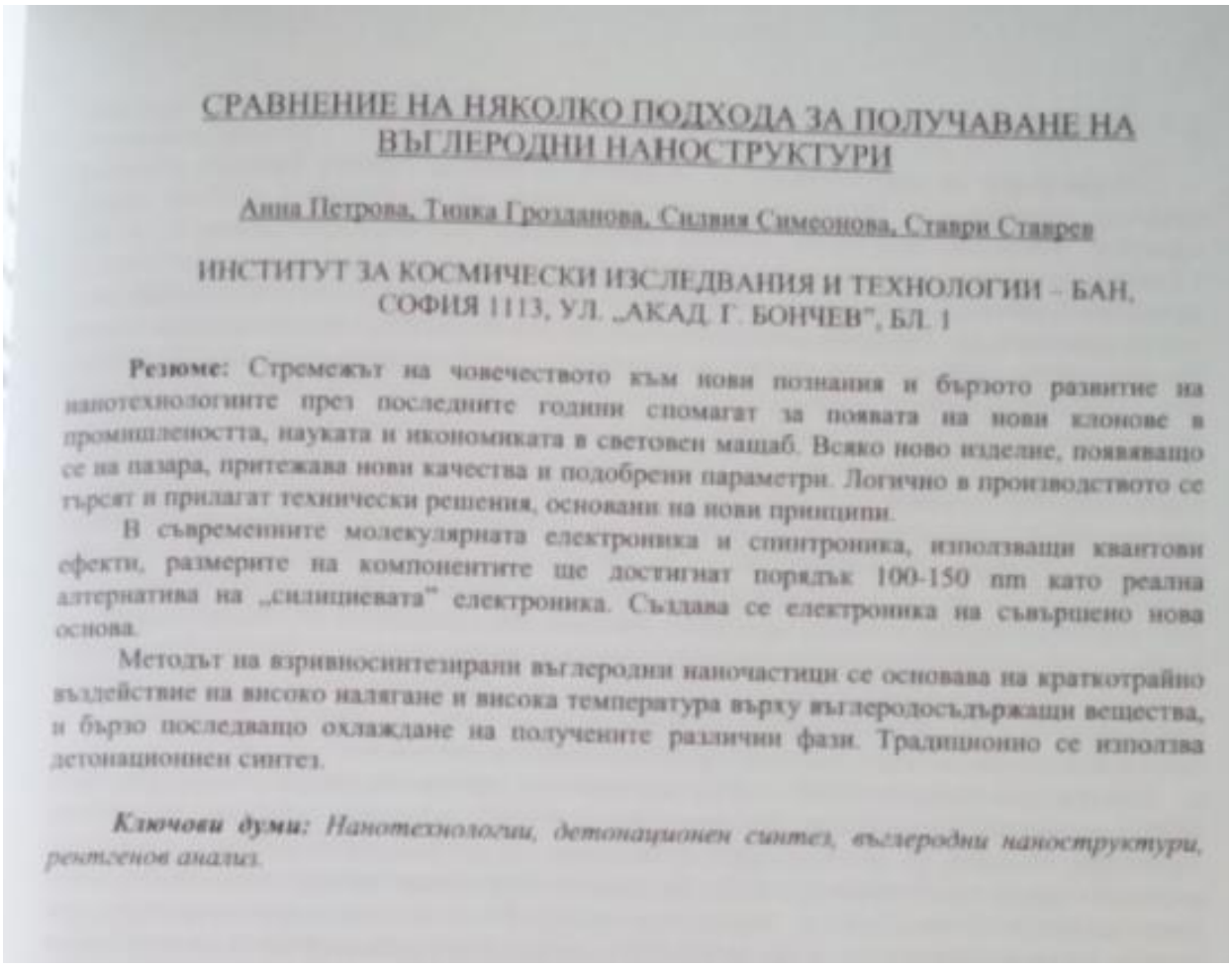
Ключови думи: *Трибология, нанотехнологии.*

Резюме: *В статията са представени самосмазващ се композиционен антифрикционен материал, съдържащ молибденов дисулфид, предназначен за работа във вакуум и космически условия, и материали с повишена твърдост и износоустойчивост от стомана и лят чугун, с нанесени композитни, наноструктурирани, никелови покрития.*



СРАВНЕНИЕ НА НЯКОЛКО ПОДХОДА ЗА ПОЛУЧАВАНЕ НА ВЪГЛЕРОДНИ НАНОСТРУКТУРИ

Анна Петрова, Тинка Грозданова, Силвия Симеонова, Ставри Ставрев

ИНСТИТУТ ЗА КОСМИЧЕСКИ ИЗСЛЕДВАНИЯ И ТЕХНОЛОГИИ – БАН, СОФИЯ 1113, УЛ. „АКАД. Г. БОНЧЕВ", БЛ. 1

Резюме: Стремежът на човечеството към нови познания и бързото развитие на нанотехнологиите през последните години спомагат за появата на нови клонове в промишлеността, науката и икономиката в световен мащаб. Всяко ново изделие, появяващо се на пазара, притежава нови качества и подобрени параметри. Логично в производството се търсят и прилагат технически решения, основани на нови принципи.

В съвременните молекулярната електроника и спинтроника, използващи квантови ефекти, размерите на компонентите ще достигнат порядък 100-150 nm като реална алтернатива на „силициевата" електроника. Създава се електроника на съвършено нова основа.

Методът на взривносинтезирани въглеродни наночастици се основава на краткотрайно въздействие на високо налягане и висока температура върху въглеродосъдържащи вещества, и бързо последващо охлаждане на получените различни фази. Традиционно се използва детонационен синтез.

Ключови думи: *Нанотехнологии, детонационен синтез, въглеродни наноструктури, рентгенов анализ.*

ТРИБОЛОГИЧНИ ХАРАКТЕРИСТИКИ НА САМОСМАЗВАЩ СЕ КОМПОЗИЦИОНЕН АНТИФРИКЦИОНЕН МАТЕРИАЛ, СЪДЪРЖАЩ МОЛИБДЕНОВ ДИСУЛФИД

Тинка Грозданова, Анна Петрова, Силвия Симеонова

ИНСТИТУТ ЗА КОСМИЧЕСКИ ИЗСЛЕДВАНИЯ И ТЕХНОЛОГИИ – БАН, СОФИЯ 1113, УЛ. „АКАД. Г. БОНЧЕВ", БЛ. 1

Резюме: Твърдотелните смазващи материали (твърдотелни смазки) са високоефективни антифрикционни материали, осигуряващи нисък коефициент на триене на трибосистемите. Нанасят се върху работните повърхности, подложени на триене в екстремни условия – висока температура, лъчения, отсъствие на окисляваща атмосфера, сухо триене (без смазка) и др. В статията е разгледан антифрикционен самосмазващ се материал, съдържащ молибденов дисулфид.

Ключови думи: *Самосмазващ композитен материал, вакуум, молибденов дисулфид.*

THIRD INTERNATIONAL SCIENTIFIC CONFERENCE
SCIENCE, EDUCATION, INNOVATION
DEDICATED TO THE 145TH ANNIVERSARY OF
BULGARIAN ACADEMY OF SCIENCES AND TO THE
35TH ANNIVERSARY OF GEORGI IVANOV'S FLIGHT

Original Contribution

ISBN 978-954-577-970-1

NANOTECHNOLOGIES – THE REALISTIC FUTURE

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ABSTRACT: *Nanotechnology is one of the key technologies of the 21st Century. Nanotechnological products and processes hold an enormous economic potential for the markets of the future. The production of ever smaller, faster and more efficient products with acceptable price-to-performance ratio has become for many industrial branches an increasingly important success factor. Due to its interdisciplinary cross-sectional character, nanotechnology will affect broad application fields of chemistry, materials, electronics, medicine, information technology, environmental and energy engineering. Also in space technology a high potential for nanotechnological applications is postulated. The increasing commercialisation of manned and unmanned space travel as well as ever more ambitious missions for the scientific investigation of the solar system and far space, require the development of more efficient, more economical and more resistant space technologies and systems in the future. Nanotechnology could contribute significantly to solutions and technological breakthroughs in this area (nano-spin-on).*

KEY WORDS*: Nanotechnologies, detonation nanodiamond, scanning probe microscopy.*

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DEDICATED TO THE 145TH ANNIVERSARY OF
BULGARIAN ACADEMY OF SCIENCES AND TO THE
35TH ANNIVERSARY OF GEORGI IVANOV'S FLIGHT

Original Contribution

ISBN 978-954-577-970-1

TRIBOLOGY AND ECOLOGY

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ABSTRACT: *Ecological and economical aspects of frictional interactions must be taken into account in product design and in the operation of machines. Tribology is the study of friction, wear and lubrication. The concept of „Green tribology" (environment-friendly tribology) as „the science and technology of the tribological aspects of ecological balance, as well as the environmental and biological impacts" was introduced by Prof. P. Jost. There are a number of problems that can be addressed by Green tribology. The specific field of tribology emphasizes on the aspects of interacting surfaces in relative motion, which are of importance for energical or environmental sustainability. It is necessary not only to expect novel development but also to create realistic solutions by conventional technologies. Ecotribology is an engineering technology that can contribute a lot to the development of the modern society.*

KEY WORDS: *Tribology, vacuum conditions, self-lubricating composite materials, molybdenum disulfide (MoS_2), nanotechnologies.*

S E S 2 0 1 3
Ninth Scientific Conference with International Participation
SPACE, ECOLOGY, SAFETY
20 – 22 November 2013, Sofia, Bulgaria

ФИЗИКО-МЕХАНИЧНИ СВОЙСТВА НА ОБРАЗЦИ ОТ ТИТАНОВА КЕРАМИКА ПОКРИТИ СЪС СТЪКЛОВЪГЛЕРОД ЗА ПРИЛОЖЕНИЕ В МЕДИЦИНАТА

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Ключови думи: *Биокерамика, ендопротези, стъкловъглерод.*

Резюме: *При имплантирането на различни стави в човешкото тяло, като най-целесъобразен е установен модулния принцип за изграждане на ставните протези, позволяващ вариации във вида на използвания материал за отделните компоненти на феморално-ацетабуларната става. Това позволява избор на оптимална комбинация от материали за артикулиращите повърхнини на импланта съобразно специфичните данни на пациента. За изработване на различни видове протези се използват както метални (стоманени и титанови) сплави, така и различни видове керамики. Биоинертните керамики са нетоксични и не предизвикват алергии. Това обеснява голямото им приложение като материали за ортодонни и ставни импланти.*

В настоящата работа са изследвани образци от титанова керамика (титанов диоксид и добавки), направени по проект 02-234/17.12.2008 с НФНИ при МОМН.

Анализирани са микро и макроструктурата - повърхност, среден размер на частиците, еластичност, микротвърдост по Викерс, Кнуп и NanoScan за образци, на основата на която са изработени ставни импланти за бъдещо медицинско приложение. Получените резултати са сравнени с характеристиките на други, известни в литературата материали, използвани за различни видове импланти в човешкия организъм.

ISSN 1310-3946

НАУЧНИ ИЗВЕСТИЯ на НТСМ
SCIENTIFIC PROCEEDINGS

Year /Година XX ❐ Number/ Брой 1 (130) June/Юни 2012

MICROSTRUCTURAL AND MECHANICAL STUDY OF COMPOSITE CERAMIC MATERIAL INTENDED FOR HIP JOINT PROSTHESIS

ИЗСЛЕДВАНЕ НА МИКРОСТРУКТУРАТА И МЕХАНИЧНИТЕ СВОЙСТВА НА КОМПОЗИТЕН КЕРАМИЧЕН МАТЕРИАЛ С ПРИЛОЖЕНИЕ ЗА ПРОТЕЗА НА ТАЗОБЕДРЕНА СТАВА

ИССЛЕДОВАНИЕ МИКРОСТРУКТУРЫ И МЕХАНИЧЕСКИХ СВОЙСТВ КОМПОЗИЦИОННОГО КЕРАМИЧЕСКОГО МАТЕРИАЛА ДЛЯ ПРИМЕНЕНИЯ КАК ПРОТЕЗ ТАЗОБЕДРЕНОГО СУСТАВА

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Abstract *We investigated the mechanical properties of the composite material in the Al_2O_3 - ZrO_2 system with different content of the two oxides and the influence of the temperature treatment. Preliminary synthesis is made aiming partial stabilization of the ZrO_2 with Y_2O_3. The sintering of the composite material is carried out at temperature up to 1680^0C. The obtained composite ceramic possesses high hardness – 90 HRA, compressive strength - 1650 MPa and bending strength - 260 MPa. We studied four compositions with different content of the two basic oxides. The mechanical properties – compressive and bending strength of the compositions are determined.A method for coating of the described ceramic with vitreous carbon is developed. For this purpose the ceramic substrate, in our case the sintered Al_2O_3 - ZrO_2 samples, are covered with polymer organic material, with complex structure of the type (CnHm). During the heating the polymer decomposes to: carbon, which subsequently forms the desired carbide structure; hydrogen (H_2) and organic radicals (CxHy). The presence of H_2 in the furnace environment favours the reduction of the oxides at the ceramic surface by extracting and chemically bonding the labile oxygen O^{2+} ions. The obtained free chemical bonds are lately saturated by the carbon atoms from the decomposition of the polymer organic material, thus forming the desired carbide layer on the substrate surface.*

KEYWORDS: BIO COMPATIBLE CERAMIC, AL_2O_3 - ZRO_2, VITREOUS CARBON, PHYSICO-MECHANICAL, PHYSICO-CHEMICAL PROPERTIES

UDC 621.983

Teodosiev D., Valov R., Petkov V.,
Simeonova S., Petrova A., Tabakova B.

MICROSTRUCTURAL AND MECHANICAL STUDY OF COMPOSITE CERAMIC MATERIAL INTENDED FOR HIP JOINT PROSTHESIS

The mechanical properties of the composite material in the Al_2O_3 - ZrO_2 system with different content of the two oxides and the influence of the temperature treatment have been investigated. Preliminary synthesis is made aiming partial stabilization of the ZrO_2 with Y_2O_3. The sintering of the composite material is carried out at temperature up to 1680^0C. The obtained composite ceramic possesses high hardness – 90 HRA, compressive strength - 1650 MPa and bending strength - 260 MPa. Four compositions with different content of the two basic oxides have studied. The mechanical properties – compressive and bending strength of the compositions are determined.A method for coating of the described ceramic with vitreous carbon is developed. For this purpose the ceramic substrate, in our case the sintered Al_2O_3 - ZrO_2 samples, are covered with polymer organic material with complex structure of the type (C_nH_m). The polymer is decomposing during heating to: carbon, which subsequently forms the desired carbide structure; hydrogen and organic radicals (C_xH_y). The presence of hydrogen in the furnace environment favours the reduction of the oxides at the ceramic surface by extracting and chemically bonding the labile oxygen O^{2+} ions. The obtained free chemical bonds have saturated lately by the carbon atoms from decomposition of the polymer organic material, thus forming the desired carbide layer on the substrate surface.

Keywords: *biocompatible ceramic, Al_2O_3 - ZrO_2 system, vitreous carbon, physico-mechanical properties, physico-chemical properties.*

ВЛИЯНИЕ НА ТЕРМИЧНАТА ОБРАБОТКА НА ОСНОВНИЯ МАТЕРИАЛ ВЪРХУ ФИЗИКО-МЕХАНИЧНИТЕ ПОКАЗАТЕЛИ НА ХИМИЧЕСКИ ПОКРИТИ ЗЪБНИ КОЛЕЛА

Здравка Карагъозова, Крис Айлот, Лиляна Александрова,
Ирен Дрангажова, Анна Петрова, Силвия Васева, Ставри Ставрев

Използването на покрития върху стоманени изделия, подложени на триене и износване е широко разпространено в машиностроенето. С развитието на нанотехнологиите се разкриват нова възможности за повишаване на механичните показатели и най-вече на износоустойчивостта на детайлите. Физико-механичните показатели на изделията, подложени на триене и износване, заедно с натоварвания на натиск, опън и огъване зависят в голяма степен от качествата на материала, от който на направени. Свойствата на материала се определят от неговата структура, а тя от своя страна се определя от предварителните обработки, на които е подлаган материала. В случаите, когато става дума за стоманени изделия, определяща роля в това отношение има термичната обработка.

Синтез карбид титана с применением нового донора углерода

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Потребность в расходо- и энергоэффективных материалах и технологиях, щадящих одновременно с этим окружающую среду, непрерывно возрастает. Все более широкое применение в машиностроении и медицине находит новый класс таких материалов, разработанных или на основе аморфного стеклоуглерода, или на базе карбидов бора, титана или вольфрама.

Карбид характеризуются высокими: температурой плавления, твердостью электропроводимостью, химической и тепловой устойчивостьями, а также высоким сопротивлением износу. По этим качествам они являются основой для керамики с широким спектром применения в ключевых высоких технологиях.

Карбид титана можно использовать и как заместитель карбида вольфрама [1-4]. На сегодвяшний день 10% мирового потребления дорогостоящего кобальта используются в качестве связки в изделиях из карбида вольфрама. В керамике на основе карбида титана в роли связующего вещества употребляют никель, который стоит в два раза дешевле. Карбид и карбонитрид титана также находят применение в производстве композитов SiC - TiC, Si_3N_4 - TiC, Al_2O_3 - TiC, ZrO_2 -Ti(CN).

Поскольку вышеупомянутые материалы применяют главным образом в виде порошков, большое значение приобретает разрабатывание технологий синтеза микронных порошков, гомогенных по химическому составу и имеющих минимальный разброс по размерам.

Nanoscience & Nanotechnology, 9
eds. E. Balabanova, I. Dragieva, Sofia, 2009

PROJECT X-GEAR "DEVELOPMENT OF GEAR-DRIVE TRAINS BASED ON NEW MATERIALS AND NOVEL GEAR SYSTEMS" EC FRAMEWORK 6 COLLECTIVE RESEARCH PROJECT

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PRIORITY 3 - Nanotechnologies and nano-sciences, knowledge-based multifunctional materials
and new production processes and devices
• EC Framework 6 Collective Research project
COLL-CT-2006, Contract Number 030433
• Full title
–Development of Gear-Drive Trains Based on New Materials and Novel Gear Systems
• Project leader -D'Appolonia, Italy
• EC Contract signed 28 August 2006 and Consortium Agreement signed by all Members
• Coordinator for Bulgaria: Prof. D.Sc. Stavri Stavrev – Space Research Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria,
tel: +359-2-9753443, e-mail: sstavrev@phys.bas.bg
Duration: 42 months (2006-2010)
Total Request for the project: 2 697 094,60 Euro
EC Contribution for the project: 1 872 586,00 Euro
EU Contribution for Bulgaria (SRI-BAS): 119 498,00Euro
Participants: *22 from 9 Countries*: Italy (6), Netherlands (1), Belgium (3), Portugal (2), Bulgaria (4), Poland (2), England (1), Finland (1), Poland (2) (Figure 1).

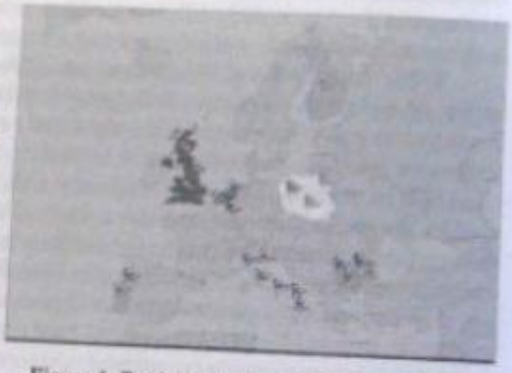

Figure 1. Participants Geographyc distribution

Abstract: European mechanical transmission sector producers of gears and gearing products rely on traditional technologies and are characterised by a general conservatism. However over the years the end products in which the gears are used have become more complex and are pushing the state of the art in new technology. Thus the requirement for more sophisticated and reliable gears become extremely important. The gear industry has to implement major changes in gear design and gear fabrication techniques just to keep up with the changing needs of the end product. In line with the strategic objectives of the associations of manufacturers of gears and mechanical transmission systems, the objective of X-gear is the diffusion and the standardisation of novel technologies and new materials for a new generation of gears characterised by higher accuracy, resistance, reliability, and tribology properties. In this context X-GEAR plays a role in the competitiveness of European industry since aims to comply with the tighter and tighter requirements being put on the gear industry for lighter weight, higher torque transmissions and quieter, more efficient gear trains.

Keywords: diamond, metallization, composites, coating, tools

1. Project summary

lect and develop new materials and novel surface treatments for high performance gears.

- **The Main Innovations:**
  - **Development of new materials** starting from the analysis of new direct hardening and air quenching steels, of advanced sintered steels and nanopowders.
  - **Development of new processes** integrating the most recent advances in material properties, tooling design and tooling materials, automation, heat treatment, hard machining, innovative post-processing and the application of different modes and grades of powder forging.
  - **Design Tool Development** for realising the full benefit of nanostructured coatings.
  - **Produce Novel Helical Gears** manufactured in new materials steels coated with innovative surface treatments for application in the **automotive and wind energy sectors** defined in terms of manufac-
turing routes and

JOURNAL OF OPTOELECTRONICS AND ADVANCED MATERIALS, Vol. 11, No. 9, September 2009, p. 1351 - 1354

Structural characterization and photoluminescence of ZnSe nanolayers

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Single layers of ZnSe (30, 40, 50, 70, 100 nm and 1 μm thick) are deposited at room substrate temperature by thermal evaporation of ZnSe powder in vacuum. The film surface morphology and structure are investigated by Atomic Force Microscopy (AFM). The as-deposited films are smooth and homogeneous while the relaxed ones show pits on the surface and a root mean square roughness of 2 - 4 nm. It is assumed that as-deposited films are highly strained and the strain relaxation with time creates pits and increases the surface roughness. Optical transmission measurements on relaxed films (≤ 100 nm thick) show an energy dependence of the absorption coefficient typical of amorphous materials, but the AFM data indicate the presence of nanocrystals (apparent grain size 25 - 30 nm). Therefore, it is assumed that the layers contain two phases, amorphous and crystalline, and the portion of the crystalline phase decreases with decreasing thickness. Photoluminescence (PL) measurements carried out at various temperatures in the range 20 – 300 K reveal two bands in the spectra of all films, centred at ~ 500 and ~ 550 nm. The bands are related to radiative recombination in the crystal phase, via two kinds of deep acceptors which are not discrete but have certain energy distributions in the forbidden gap.

(Received November 5, 2008; accepted December 15, 2008)

Keywords: Thin films, ZnSe, Thermal vacuum evaporation, Atomic force microscopy, Photoluminescence

JOURNAL OF OPTOELECTRONICS AND ADVANCED MATERIALS, Vol. 11, No. 9, September 2009, p. 1347 - 1350

Photoelectrical characterization of nanocrystalline $AgBiS_2$ thin films

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The photoelectric properties of chemically produced nanostructured $AgBiS_2$ thin films are investigated. Atomic force microscopy is used to prove the nanocrystalline structure of the films, and a value of ~ 10 nm is obtained as an upper limit for the average grain size. The temperature dependences of the photocurrent measured in the range 77 – 390 K do not display high photosensitivity at low temperatures. This observation is related to a high density of fast recombination centers created at the interfaces between the nanocrystals. Persistent photoconductivity is measured at low-temperatures after turning off the light, and a high voltage polarization is observed on light illumination of the films. Both effects are related to trapping of photoexcited carriers in deep defect states, and are considered as responsible for the rather low value (< 0.5) of the exponent in the photocurrent intensity dependence. Constant photocurrent method measurements, carried out at energies higher than the optical band gap, reveal fine structure in the absorption spectra of the films, which could be assigned to higher excitons in $AgBiS_2$ quantum dots, and be considered as an indication of a narrow size distribution of the nanocrystals in the layers.

(Received November 5, 2008; accepted December 15, 2008)

Keywords: $AgBiS_2$ thin films, Nanocrystals, Photocurrent

S E N S 2 0 0 8
Fourth Scientific Conference with International Participation
SPACE, ECOLOGY, NANOTECHNOLOGY, SAFETY
4–7 June 2008, Varna, Bulgaria

ВЛИЯНИЕ НА ДОБАВКА ОТ НАНОДИАМАНТ ВЪРХУ СВОЙСТВАТА НА НИКЕЛОВО ПОКРИТИЕ

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Ключови думи: *диамант, метализация, покритие, абразиви, NanoScan*

Резюме: *Изследвано е влиянието на наноразмерен уякчаващ материал (нанодиамант) върху някои свойства на безтоково никелово покритие.*

Проведени са сравнителни тестове на композиционни никелови покрития, включващи микроразмерни усилващи частици (cBN).

Получените резултати за физико-механичните и експоатационни характеристики за покритие никел-нанодиаманд потвърждават уникалността на свойствата характерни за наноразмерните частици, използвани като подисващ елемент: висока износо- и корозо-устойчивост, повишена твърдост, нисък коефициент на триене, подобрена адхезия.

Проведените експерименти са етап от тестови изследвания във връзка с работа по Проекта X-Gear по VI РП в секция «КМ и НТ» при ИКИ-БАН.

Nanoscience & Nanotechnology, 8
Eds. E. Balabanova, I. Dragieva, Prof. Marin Drinov Academic Publishing House, Sofia, 2008

PREPARATION OF NANOCRYSTALLINE CdSe SINGLE LAYERS BY THERMAL EVAPORATION IN VACUUM

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Abstract. Nanocrystalline single layers of CdSe (20–100 nm) have been prepared by thermal evaporation under high vacuum on a room temperature substrate, using (i) one-step (uninterrupted) and (ii) step-by-step (periodically interrupted) deposition techniques. The effect on crystallite size and layer structure was investigated by atomic force microscopy and transmission electron microscopy. In the case of one-step deposition a decrease in grain size is observed with decreasing layer thickness. A size decrease is also seen when step-by-step deposition is used but it is more pronounced than in the one-step layers. Moreover, a more compact grain packing, with smaller pores between the grains, is evident in the step-by-step layers. The difference in the film microstructure appears related to the combination of low substrate temperature and very low average deposition rate (0.04 nm/s) during step-by-step deposition. These results explain the good periodicity previously reported for step-by-step deposited amorphous and nanocrystalline/amorphous multilayers, and are consistent with the improved gas sensitivity of the dark- and photo-conductivity of 50 nm thick step-by-step CdSe layers when compared with one-step deposited layers of the same thickness.

such as reactive and magnetron sputtering, glow discharge, plasma- and photochemically-enhanced chemical vapor deposition, thermal evaporation in vacuum etc. Most frequently, when using the latter techniques non-epitaxial layer growth is applied in the preparation of nanosized and nanostructured thin films, which allows deposition at low substrate temperatures and places much less stringent requirements on substrates than epitaxial growth. However, in order to be used for preparation of nanostructured materials, non-epitaxial layer growth techniques must enable fabrication of nanosized materials with the desired geometry, cost-effective production of large quantities of nanoscale materials, easy process control and good reproducibility.

In the case of thermal evaporation in vacuum, atoms reaching the substrate have a low kinetic energy. Consequently, the surface temperature is very important since it significantly affects the grain size of the polycrystalline films that normally grow. In particular, there is no appreciable surface diffusion and adatoms (atoms that

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Journal of Physics and Chemistry of Solids 68 (2007) 675–680
JOURNAL OF PHYSICS AND CHEMISTRY OF SOLIDS
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Thin film semiconductor nanomaterials and nanostructures prepared by physical vapour deposition: An atomic force microscopy study

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Abstract

Amorphous/nanocrystalline SiO_x/CdSe, GeS_2/CdSe, SiO_x/ZnSe and Se/CdSe amorphous multilayers (MLs) were grown by consecutive physical vapour deposition of the constituent materials at room substrate temperature. A step-by-step manner of deposition was applied for the preparation of each layer (2–10 nm thick) of MLs. Surface morphology has been investigated by atomic force microscopy (AFM) in order to get information about ML interfaces. For a scanned area of $3.4 \times 4\,\mu m^2$ SiO_x/CdSe and GeS_2/CdSe MLs showed surface roughness which is around three times greater than the roughness of SiO_x/ZnSe MLs. This observation has been connected with effects of both film composition and deposition rate. For a scanned area of $250 \times 250\,nm^2$ the roughness determined in all MLs displayed close values and a similar increase with the ML period. The latter has been related to the flexible structure of amorphous materials. The AFM results, in good agreement with previous X-ray diffraction and high resolution electron microscopy data, indicate that the application of step-by-step physical vapour deposition makes possible fabrication of various amorphous/nanocrystalline MLs with smooth interfaces and good artificial periodicity at low substrate temperatures.

Keywords: A. Nanostructures; A. Chalcogenides; B. Vapour deposition; D. Surface properties

JOURNAL OF OPTOELECTRONICS AND ADVANCED MATERIALS Vol. 9, No. 1, January 2007, p. 240 - 243

Osteoblast cell activity on calcium phosphate layers grown on glass by a laser-liquid-solid interaction

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A calcium phosphate layer was grown on glass by a laser-liquid-solid interaction (LLSI) process in simulated body fluid (SBF). Glass samples with a layer grown by simple soaking in the SBF (i.e. without laser irradiation) were prepared for comparison. Formation of an inhomogeneous calcium phosphate (CaP) layer on both laser-treated and non-treated samples was observed. The results showed that the laser irradiation did not change the layer structure and morphology but yielded the growth of a thicker CaP layer. With increasing load the elasticity and the hardness increased for both laser-treated and non-treated samples. Furthermore, we tested the osteoblast cell activity of the CaP layers grown on the laser-treated and non-treated samples. Toxicity test showed that the viability of the cells on the layer grown by the LLSI process was over 95%. A permanent increase in the cell number was observed for both groups of samples, and it was more stable on the laser-treated surfaces. The latter showed a higher cell number after 7 days of cell culturing. A slower increase, resulting in a lower cell numbers was observed for the samples untreated with laser irradiation.

(Received November 28, 2006; accepted December 21, 2006)

Keywords: Calcium phosphate, Simulated body fluid, Laser-liquid-solid interaction, Osteoblast cells

JOURNAL OF OPTOELECTRONICS AND ADVANCED MATERIALS Vol. 9, No. 1, January 2007, p. 229 - 232

Mechanical properties of extracellular matrix/hydroxyapatite composites

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An increasing interest in biomimetics – design of materials based on natural biological structures - has led to the nanomechanical characterization of biomaterials. In this regard, nanoindentation has been used in conjunction with the determination of the mechanical properties of the extracellular matrix (ECM) proteins that are known as ligands in reactions with cell surface receptors involved in bone physiology. The aim of the presented work is to investigate the - and nano-scale mechanical properties of laser designed extracellular matrix/hydroxyapatite composites. The osteoblast-like cell line SAOS-2 synthesised and assembled its own ECM on the solid substrates under standard cell culture conditions. After selective removal of cells, thin films of ECM on substrates of stainless steel (SS), silicon (S) and silica glass (SG) were obtained. One group of samples was soaked in simulated body fluid (SBF) and another was obtained by simultaneous immersion in the SBF and treatment by laser irradiation. As a result, a hydroxyapatite (HA) crystal layer was grown on the surfaces. The mechanical properties of the obtained composites, such as elastic modulus (E) and indentation hardness (H), were analysed. It was observed that by applying a typical working force in the range 200 μN to 600 μN and a displacement range of 0-60 μm, E increased for all composites obtained by the laser process (for samples immediately removed from the SBF). Surface scanning along the direction centre of the sample to the laser treated area showed a decrease in the Young's modulus, to values similar to those in the human bone.

(Received November 28, 2006; accepted December 21, 2006)

Keywords: Extracellular matrix, Mechanical properties, Hydroxyapatite, Laser-liquid-solid-interaction process

JOURNAL OF OPTOELECTRONICS AND ADVANCED MATERIALS Vol. 9, No. 2, February 2007, p. 394 - 397

The role of high-energy electron irradiation induced defects in some mechanical properties of Si-SiO_2 structures

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The mechanical stress produced by 23 MeV energy electron radiation in both n- and p-type Si-SiO_2 structures is studied as a function of the dose. Low dose electron irradiation (2,4 – 4,8x10^{14} cm^{-2}) increases significantly the yield stress for n-type Si-SiO_2 samples, but to a much lesser extent for p-type ones. The nanohardness of irradiated structures is measured using the sclerometry method. Our results show that the nanohardness increases with the dose in the same manner for both groups studied. The values are very close, but for p-type samples are consistently higher. The variations of both the stress and nanohardness are remarkable at low doses. These mechanical properties of the irradiated samples are discussed on the basis of radiation induced defects.

(Received November 1, 2006; accepted December 21, 2006)

Keywords: Thin films, Electron irradiation, Mechanical stress, Nanohardness

Proc. ILLA/LTL, 4-7 October, Smolyan, 2006 Bulgaria

Detonation generated nanodiamond reinforced calcium phosphate composites grown through laser-liquid-sold-interaction process

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Abstract

Recently, hydroxyaptite (HA) has received increasing attention as a bone implant material to promote the ability to bond chemically with living bone tissues owing to its similar chemical composition and crystal structure as apatite in the human skeletal system. On the other hand detonation generated nanodiamond (DND) has become an attractive candidate for fundamental research studies since it has been shown that it can play the organic part, imitating the role of collagen in bones. Inclusion of DND in a ceramic matrix is expected to produce composites possessing high stiffness and improved mechanical properties compared to the single phase ceramic material. In the presented study, DND reinforced HA composite coatings have been successfully fabricated by the method of laser-liquid-solid interaction (LLSI) process. The morphology, elemental composition and structure of the composite coatings have been studied using SEM/EDX, coherence probe microscopy and Raman spectroscopy. Additionally, measurement of the elastic modulus and the hardness of the composite coatings by nanoindentation tests (Nanoscan), have indicated that the mechanical properties are affected by the DND in the starting precursor material of simulated body fluid . Therefore, DND reinforced hydroxyapatite composites are promising coating materials for high-load-bearing implants.

Keywords: reinforced calcium phosphate composites, detonation generated nanodiamond, laser-liquid-sold-interaction process

S E S ‘ 2 0 0 5
Scientific Conference “SPACE, ECOLOGY, SAFETY” with International Participation
10–13 June 2005, Varna, Bulgaria

МЕТАЛИЗАЦИЯ НА ДИАМАНТ

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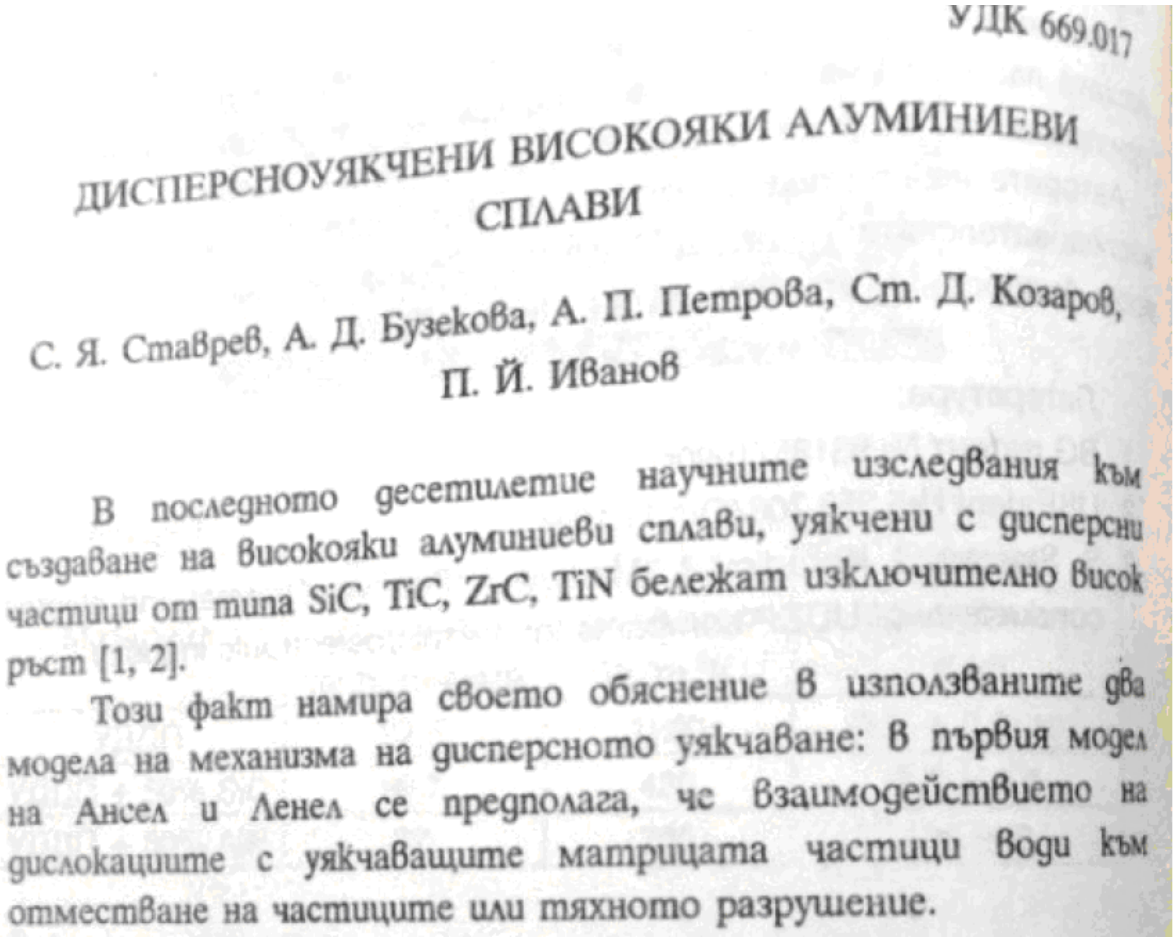
Ключови думи: диамант, метализация, покритие, абразиви, NanoScan

The paper has studied the wear resistance and the microhardness of composite diamond coatings, made in a solution “EFTTOM-NICKEL” with a metallizated Ultra Dispersed Diamond Powder - UDDP. The obtained coatings are with a good adhesion with the base of the samples. The best wear resistance is obtained in the case with the electroless grasping of a metallizated UDDP.

Керамики,карбиди като волфрамов карбид, твърд камък като гранит, и стъкло са все по-важни промишлени материали през последните няколко десетилетия. В много случаи диамантът е предпочитан за направата на инструменти за рязане, точене и полиране на тези материали. Поради свръхвисоката твърдост на диаманта, степента на отстраняване на материала е значително по-висока от тази при инструментите с конвенционални абразиви. Това при диамантените покрития поевтинява процеса в сравнение с този при работата с инструменти, направени с абразиви като алуминиев и силициев карбид [1].

За направата на диамантен инструмент, диамантените кристали се смесват с материала на матрицата. Един от големите проблеми е трудното задържане на диаманта на определено място в матрицата.

Няколко различни материала се използват за свързване на диаманта към матрицата.



УДК 669.017

ДИСПЕРСНОУЯКЧЕНИ ВИСОКОЯКИ АЛУМИНИЕВИ СПЛАВИ

С. Я. Ставрев, А. Д. Бузекова, А. П. Петрова, Ст. Д. Козаров, П. Й. Иванов

В последното десетилетие научните изследвания към създаване на високояки алуминиеви сплави, уякчени с дисперсни частици от типа SiC, TiC, ZrC, TiN бележат изключително висок ръст [1, 2].

Този факт намира своето обяснение в използваните два модела на механизма на дисперсното уякчаване: в първия модел на Ансел и Ленел се предполага, че взаимодействието на дислокациите с уякчаващите матрицата частици води към отместване на частиците или тяхното разрушение.

УДК 620.22

Изследвания на свойствата на взривно синтезиран ултрадисперсен диамантен прах

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През последните години получаването на диамантени частици по взривен метод и тяхното приложение привлича все по-голямо внимание. Експерименталното решение на проблема се базира на предположението, че при взривяването на взривни вещества (ВВ) с отрицателен кислороден баланс, освободеният въглерод се превръща в диамант, при съответни стойности на налягането и температурата.

Детонационната вълна представлява комплекс от ударна вълна, на фронта на която започва разлагане на ВВ, следвана от зона на химичната реакция, завършваща в точката на Чепмен-Жуге. Изчислените стойности на p и T в детонационната вълна за някои ВВ съпоставени с фазовата диаграма на въглерода (фиг. 1) показват, че свободният въглерод се кондензира в диамант. Например, за заряди от ТХ 50/50 (тротил/хексоген с плътност $\rho_0=1,67 g/cm^3$) точката на Жуге лежи в областта на течния въглерод, следователно диамантът кристализира от микрокапките С и при разширението на продуктите от взрива, той се превръща в графит.

Количеството

Nanoscience & Nanotechnology
eds. E. Balabanova, I. Dragieva, Heron Press, Sofia, 2001

THE "OSNET" No GTC1 – 2000 – 2820. PROJECT OF THE FIFTH FRAMEWORK PROGRAMME

S. Stavrev, J. Karadjov, L. Markov, A. Petrova, Z. Karagyozova

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1. Introduction

The "OSNET" project is of the "Development" Programme has key activities "Innovationproduct, processes and organization". In itself it's a network, and covers allimportant branches of output, working up and utilization of the decorative stones, equipment, environment and safety.

The Network covers a wide range of experts in investor's technologies, stones producers, equipment producers, consumers, national organizations, trading agencies and it has pointedly industrial orientations. There is significant participation of small companies.

As a result of its transnational character, the offered Network will give assistance to get over the geographical

Nanoscience & Nanotechnology
eds. E. Balabanova, I. Dragieva, Heron Press, Sofia, 2001

THERMAL AND ELECTRIC CONDUCTIVITY OF UDDP COMPACTS FOR THE MICROELECTRONIC INDUSTRY

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Abstract. Compacts were made from ultradisperse diamond powder (UDDP) alone, and with the addition of 50% AlN, or SiC. Compacts made from pure UDDP are most prom-ising as a non metallic material for the production of pads. They combine good mechanic stability with high ther-mocon-ductivity and a very low electric conductiv-ity, and can be used as pads in microelectronics.

Keywords: nanodisperse diamond, silicon carbide, aluminium nitride

Highest thermoconductivity is typical for natural diamond and precious metals, especially silver. Their high price either and necessity of electric isolation limit their application only to unique, expensive appurtenances.

A widely used material with good isolating properties is BeO. It has a relatively high thermoconductivity, but its extreme toxicity limits its use.

In the last decade, many attempts were made to solve the heat dissipation problem by the use of pads made from synthetic diamond compacts.

Nanoscience & Nanotechnology
eds. E. Balabanova, I. Dragieva, Heron Press, Sofia, 2001

THERMAL STABILITY AND DENSITY MEASUREMENT OF A NEW ALLOTROPIC FORM OF CARBON

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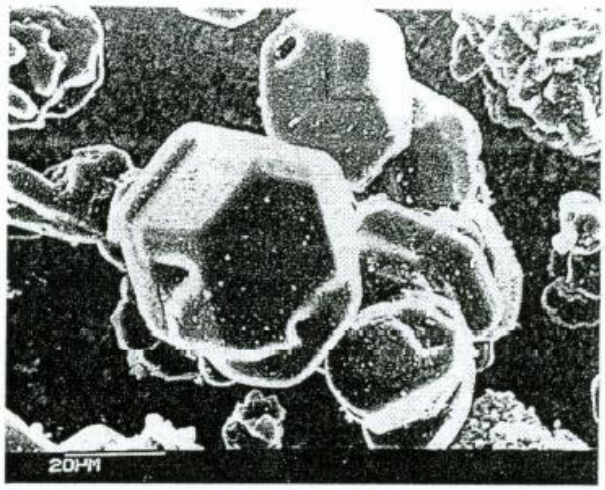
Abstract. A new carbon phase was obtained from ultradisperse diamond powder by the action of a shock wave. Thermal analysis shows that in an inert atmosphere the new material is stable in the tempera-ture range up to 1500°K. Raman and X-ray spectra of the new mate-rial are surprisingly similar, but not identical, to the corresponding spectra of boron carbide. Our hypothesis is that under the action of the shock wave on dia-mond a new carbon phase is formed which contains carbon icosahedres.

Keywords: diamond, carbon



The new material was obtained during experiments with ultradisperse diamond powder (UDDP) [1] in an attempt to increase the size of diamond particles under the action of a shock wave. When a very high pressure was applied, diamond was transformed into a new carbon phase.

ГОДИШНИК НА СОФИЙСКИЯ УНИВЕРСИТЕТ „СВ. КЛИМЕНТ ОХРИДСКИ"
ХИМИЧЕСКИ ФАКУЛТЕТ
Том 92–94, 2001

ANNUAIRE DE L'UNIVERSITE DE SOFIA „ST. KLIMENT OHRIDSKI"
FACULTE DE CHIMIE
Tome 92–94, 2001

EXTREMELY HARD AND NEW CARBON MATERIALS – SYNTHESIS AND POSSIBLE APPLICATIONS

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Since the first successful conversion of graphite into diamond in 1955 [1], the use of synthetic diamond has now become commonplace in many industrial cutting, grinding, polishing, and lapping operations. However, the synthesis of diamond requires pressures in the order of 100 kbar and high temperatures, and these conditions can be realized statically only in specially constructed vessels inserted in very powerful presses.

Diamonds are occasionally found in meteorites. Much of the evidence suggests that most meteoritic diamond was formed by solid state conversion of graphite under the action of the shock wave caused by the impact of the meteorite on earth. Explosive shock synthesis of diamond from graphite was first reported in 1961 [2]. This process yields very small pieces of diamond (in the order of 10 nm) aggregated in small particles (50 to 100 nm). Most of the researchers believe that shock wave synthesized diamond is formed by a diffusionless conversion from graphite.

10 години космически проект "Шипка " ✦ 10th anniversary of the Shipka Space Project
Институт за космически изследвания – БАН ✦ Space Research Institute – BAS
София ✦ 1998 ✦ Sofia

Увеличаване ресурса на инструменти за обработване на материалите след отлагане на слой никел – УДП

*З. Карагьозова, И. Иванова, А. Петрова, Я. Желязова**

ИКИ – БАН,
** ЦЛ СЕНЕИ – БАН*

Подобряването на повърхностните свойства на инструментите и детайлите придобива особено значение на съвременния етап от развитието на техниката. В това отношение нарастващ интерес предизвикват комбинираните (композиционни) материали. В практиката съществуват различни примери за съчетаване на метали, керамика, неорганични съединения за получаване на нови материали. По свойствата си комбинираният материал превъзхожда съставните си части или рязко се отличава от тях. Прието е комбинираните материали да се разглеждат като получени посредством физическо присъединяване на две или повече фази. Първата фаза – матрицата е по еластична, докато втората – дисперсиода – притежава висока якост, твърдост, износоустойчивост. Фазите могат да бъдат метали, неметали, хомогенни и хетерогенни сплави, неорганични или органични съединения. В новия материал те се съединяват като структурно цяло. Между компонентите е възможно взаимодействие чрез адхезионни сили. В много отношения композицията превъзхожда сумарните свойства на отделните компоненти, т.е. наблюдава се ефект на усилване.