5th International Conference on

PLASMA CHEMISTRY AND PLASMA PROCESSING

November 13-14, 2017 Paris, France

Posters

Renato Perillo et al., J Biot Phyt 2017

The influence of N_2 in high density low temperature H_2 plasma by means of magnum-PSI and numerical simulations

Renato Perillo, IGJ Classen, TW Morgan, WAJ Vijvers, HJN Van Eck, W Lu, R Chandra, R Barrois and **MR de Baar**

Dutch Institute for Fundamental Energy Research, Netherlands

Experiments have shown that impurity seeding in the tokamak's divertor region leads to a net reduction of power loads onto the targets. Nitrogen is currently the leading candidate for impurity seeding in ITER. Volume processes such as molecular-activated-recombination (MAR) and electron-ion recombination (EIR), together with impurity radiation losses, may all contribute to achieve a detached plasma regime, in which the heat and particle fluxes are greatly reduced before reaching the surface. Little is known on the detailed plasma-chemical processes occurring in such scenario in the presence of nitrogen. To study this complex system, an extensive global plasma model of H_2+N_2 chemistry has been set up on using PLASIMO code. The model has generated qualitative results highlighting new molecular-assisted reactions paths, suggesting N_2H+ as principal ion mediator and NH as main electron donor in charge exchange with H^+. The resulting primary mechanisms are being implemented in Eunomia, a 3D Monte-Carlo code based on the test particle approximation method. All the 14 vibrational states of H_2 are included, together with a large set of chemical reactions and species, namely H, H_2, N, N_2 and related ions. Dedicated experiments on plasma-surface-interactions in relevant conditions with nitrogen seeding have been carried out, providing qualitatively the predicted results. Magnum-PSI is a unique linear plasma generator, located at DIFFER, capable of reproducing ITER-relevant plasma conditions.

Biography

Renato Perillo is a PhD student at the Dutch institute for fundamental energy research (DIFFER) among the group plasma edge physics and diagnostics (Nuclear fusion branch). He carried out his studies in Padova, Italy, obtaining a master's degree in environmental chemistry in 2014 (final mark 9/10). His thesis is focused on advance oxidation of volatile organic compounds (VOCs) by means of non-thermal plasma applications. From january to september 2015 he worked as guest researcher in computational plasma physics with the EPG group at the Eindhoven University of Technology, where he developed an extended global plasma model of low temperature hydrogen plasma. Since November 2015 he is employed at differ institute, working on plasma detachment and impurity seeding using numerical simulations and the linear plasma device magnum-PSI, a unique machine capable to mimic the plasma-surface interactions foresee to occur in ITER.

R.Perillo@differ.nl

Notes:

Dry etch profile of contact hole in inductively coupled plasma

Nomin Lim[1], Changmok Kim[1], Ki Han[2], Yeon-Ho Im[3], Hyun woo Lee[4] and **Kwang-Ho Kwon[1]**

[1]Korea University, Republic of Korea

[2]Nanophotonics Research Center-Korea Institute Science & Technology, Republic of Korea

[3]Chunbuk National University, Republic of Korea

[4]Hanseo University, Republic of Korea

Plasma is widely used in semiconductor device processes. Among them, the plasma etching process is a patterning method for removing a substrate material by using ions, reactive gases or radicals generated by plasma, and it is an indispensable process to provide the precision of process, miniaturization, and low damage. There is an increasing need to form fine contact holes for solving the problems caused by distortion and tilting of the etched profile. On the other hand, the tilted etched profile had got a big attention by etching process engineers. However, this phenomenon was not evaluated in detail. Any detailed researching results on the tilted etched profile have not been suggested, yet. Accordingly, in this work, the phenomenon of the tilted etched profile was studied in detail. In this work, the photoresist (PR) was used as a mask and plasma-enhanced chemical vapor deposited silicon oxide (SiO_2) of 2 μm thickness was used as a dielectric material. In order to analyze the tilting phenomenon, a dielectric (plastic) block and a metal (aluminum) block were used and the sample was put on the material blocks. For this work, the material blocks were fabricated with various height (T = 0, 0.25, 0.5, 1 cm). After the contact hole sample was placed on the prepared blocks, contact hole etching was performed. We performed the inductively coupled $C_4F_8/CH_2F_2/O_2/Ar$ plasma to etch SiO_2 films. The total gas ratio was 120 sccm. The source power, bias power, and process pressure were 50W, 400W, and 10mTorr, respectively. Scanning electron microscope (SEM) was used to identify the contact hole angle and etching profile after contact hole etching. The higher the block height, the larger the degree of contact hole tilting. Finally, we discuss How the behaviour of plasma ions and electric field at the edge affected the contact hole etching characteristics.

Biography

Nomin Lim is from Korea University belongs to the department of control and instrumentation engineering. His research is on the semiconductor process using plasma under the guidance of professor Kwang Kwang-Ho. He is conducting research to systematically identify the mechanism of etching through analysis. His content of the study was published in Japanese Journal of Applied Physics, Journal of nano science and nanotechnology, and thin solid films etc.

nomin_lim@korea.ac.kr

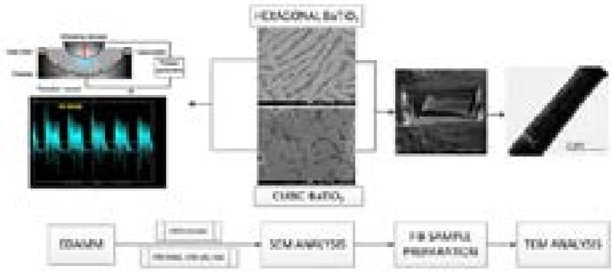
Notes:

Monika Wyszomirska, J Biot Phyt 2017

$BaTiO_3$ powders prepared by electric discharge assisted mechanical milling (EDAMM) method

Monika Wyszomirska
University of Wollongong, Australia

Over the years electric discharge assisted mechanical milling device had proven to be fast and extremely effective method for powders processing and synthesis . Thus, as a next step an in-depth analysis of the products was performed to define the processes that govern specific compounds formation. In this work we present low and high temperature $BaTiO_3$ perovskite phases depending on processing conditions used. As characterization techniques scanning electron microscope was used to visualize grains morphologies of prepared disc-shaped samples and to define the regions of final and intermediate products. elemental analysis using backscattered electron detector and aztec software was also performed. EBSD system being part of the abovementioned Microscope was utilized to prove the crystallographic structure and quantify the constituent phases. additionally, transmission electron microscopy was performed to observe the grain boundaries of specific regions on the samples prepared by focused ion beam instrument. Described procedures are meant to provide extensive crystallographic information which will be used to define the growth mechanism of specific phases in $BaTiO_3$ under different EDAMM conditions.



Biography

Monika Wyszomirska graduated from a master's of materials engineering degree at Warsaw University of Technology, Poland in 2013. Since then she has been involved in doctoral studies at University of Wollongong, Australia. Monika is presently working on plasma processing of ceramic powders with special interest placed on phase transformations during pulsed plasma processing. Her aim is to broaden then understanding of the processes occurring during Electric discharge assisted mechanical Milling (EDAMM) therefore leading to more efficient and optimization of the processing parameters. She is also heavily involved in materials characterization by X-ray diffraction, secondary and transmission electron microscopy and especially interested in sample preparations by FIB-SEM.

mw966@uowmail.edu.au

Notes:

Young Dae Jung et al., J Biot Phyt 2017

Ion-wake field effects on the dust-acoustic surface wave in a semi-bounded Lorentzian complex plasma

Young Dae Jung and **Myoung Jae Lee**
Hanyang University, South Korea

The growth rate of the dust-acoustic surface wave in the semi-bounded complex plasma with an ion streaming passing through the plasma at rest is analytically derived. We have adopted the Lorentzian distribution for electrons to investigate the nonthermal property of plasma on the growth rate. We find that the growth rate of the surface wave increases as the wave number increases and it is always larger than that of bulk wave, especially in the realm of large wave numbers. The nonthermal effect of Lorentzian electrons in the high-energy tail is found to enhance the growth rate. It is also found that the density and speed of streaming ion would increase the growth rate. The growth rate of surface wave is compared with that of bulk wave for various physical parameters

Biography

Young Dae Jung received his B.S. degree in physics in 1984 from Hanyang University, Seoul, South Korea, and the PhD degree in theoretical physics in 1990 from the University of California, San Diego. After his PhD, he held the National academy of sciences/National research council research fellowship at NASA/Marshall Space Flight Center. Since 1992, he has been at Hanyang University, Ansan, South Korea, where he is Professor of Applied Physics. His research deals with theoretical atomic physics, plasma physics, and astrophysics. At various times, he has been associated with NASA/Marshall Space Flight Center, U.S.A. and National Institute of Fusion Science, Japan. In addition, he held the visiting professorship at National Institute of Fusion Science in 2008. He is a member of the Korean Physical Society and the American Physical Society.

ydjung@hanyang.ac.kr

Notes:

5th International Conference on

PLASMA CHEMISTRY AND PLASMA PROCESSING

November 13-14, 2017 Paris, France

e-Posters

Plasma Chemistry 2017

Mid-infrared emission spectroscopy of laser generated carbon plasmas

Laszlo Nemes
Science adviser, Hungary

Mid infrared time-resolved emission (IrLIBS) spectra were recorded from laser-induced carbon plasma at Hampton University, Virginia, USA. These spectra constitute the first report of carbon materials LIB spectroscopy in the mid infrared range. The plasma was induced using a Q-switched Nd: YAG laser. The laser beam was focused to high purity graphite pellets mounted on a translation stage. Mid infrared emission from the plasma in atmospheric pressure background gases was detected by a cooled MCT detector in the range 4.5-11.6 micrometer, using long-pass filters. The spectra were taken in argon, helium and also in nitrogen and were background corrected and noise filtered. A 0.15 m spectrometer with gratings blazed at 8 micrometer was used. Spectral resolution was around 80 nm. Several spectral runs were averaged using a boxcar averager. Even though a gate delay of 10 to 20 microseconds was used there were strong backgrounds in the spectra. Superimposed on this background broad and noisy emission bands were observed, the form and position of which depended somewhat on the ambient gas. In argon, for instance strong bands were observed around 4.8, 6.0 and 7.5 micrometer. Using atomic spectral data by NIST it could be concluded that carbon and argon lines from neutral and ionized atoms are very weak in this spectral region. The width of the infrared bands also supports molecular origin. The infrared emission bands were thus compared to vibrational features of carbon molecules (excluding C_2) and clusters of various sizes on the basis of previous carbon cluster infrared absorption and emission spectroscopic analyses in the literature and quantum chemical calculations. Applications of these results are expected in materials science, environmental chemistry and also in astrophysics.

Biography

Laszlo Nemes is graduated and certified chemical engineer in 1959 from the Technical University of Budapest. He joined at the research network of the Hungarian Academy of Sciences and he have been associated ever since with that organization. His main fields are molecular spectroscopy, laser and plasma spectroscopy. He got his Ph D degree from the Technical University of Budapest (1965), a DSc.degree from the Hungarian Academy of Sciences (1982), and posses "venia legendi" as a habilitated, titular professor in physical chemistry at the Technical University of Budapest (1995). He held several grants and stipends to do research and teaching abroad. He also visited Great Britain in the years 1964-65. In 1972-73 he had a Dozentenstipendium from the German Alexander von Humboldt-Stiftung for work at the University of Kiel , later he was reactivated in 1982 as humboldt-fellow at the Justus-Liebig-University, Giessen. In 1985 he was visiting scientist at the Herzberg institute of astrophysics, National Research Council of Canada, Ottawa and in 1986 a state professorship in France at Villeneuve d'Ascq (Universite de Lille). In 1990 he spent time at the Catholic University of Nijmegen, Laboratory of Molecular and Laser Physics (The Netherlands). In 1991 he was visiting research scientist at the chemistry department, University of Michigan, Ann Arbor, USA. He worked at the University of Waterloo, Canada in the Center for Molecular Beams and Laser Chemistry in 1992 and 1993 and he have spent a year as guest research professor of the Academia Sinica, Taipei, Taiwan at the Institute of Atomic and Molecular Sciences. Then In 1996 he was W F James professor of pure and applied science at the St. Francis Xavier University in Nova Scotia, Canada. Since 1980 he have been active in the field of laser induced chemistry and the emission spectroscopic studies of laser generated plasmas. In 2006 he retired but remained active at my former institute, the Central Research Institute of Chemistry as science advisor emeritus. Since 3 years he associated with the Research Center of Natural Sciences of the Hungarian Academy of Sciences, Budapest, as emeritus science advisor. His CV has been published by several international biographical organs, first in 1981 in the Who's Who in the World, , USA, then in several other published works, e.g. in the UK. A compilation of about 80 of his scientific papers are available at research gate.

nemesl@comunique.hu

Vladislav Zyn, J Biot Phyt 2017

Mechanisms of a glow discharge polymerization

Vladislav Zyn
Samara State Pedagogical University, Russia

Introduction & Aim: A classical glow discharge has the well-known non-uniform structure. Several lights and dark bands zones are visible clearly in a discharge gap independently of the chemical nature of a gas used. Every zone has its own mechanism of electrical processes. In the case of a molecular gas, these local primary electrical processes initiate further chemical reactions and determine their kinetics. So, it is natural to formulate the purposes of this work as to determine whether the above-mentioned zonal structure of the discharge is reproduced in the spatial distribution of the polymerization products, identify the local polymerization mechanisms, and determine their productivity and influence of each local electrical mechanism on properties of the products.

Method: The objectives were achieved by means of a joint analysis of various databases formed by different experimental techniques. The films were grown on various surfaces, such as electrodes, quartz probe of a microbalance, metalized glass plates, and thin quartz filaments having been stretched through the discharge in various directions. *In-situ* thickness measurements were carried out with an ellipsometer. The gas phase during the polymerization was monitored with the help of a mass spectrometer and laser probe. Plasma processed samples with grown films were studied by means of optical and electron microscopy, interferometry, IR spectrometry, ESR, ESCA, atomic scanning microscopy, analytical weighing.

Results: Identified at least five principally different polymerization mechanisms: Cathodic, anodic, surface chemical reactions, the formation of aerosols and their deposition on the substrate. It was traced, how and through which mechanism the identity of each local activation stage passes through all stages of the polymerization and appears in the properties of the film grow. The most powerful local mechanism is the cathodic one. The ion bombardment of the cathode surface provides the most rate of the synthesis and is responsible for creation peculiar structure and internal stresses of the film which have shock nature and are formed by the ion bombardment. The anodic mechanism is activated by an electron bombardment mainly responsible for the film growth at the surface of an anode. The energetic spectrum of the anodic polymerization rate demonstrates thresholds and peaks.

Conclusion: The information obtained allows one to choose one or another mechanism depending on the problem being solved and organize the process accordingly

Biography

Vladislav Zyn is from Samara State Pedagogical University, Russia

zyn37@mail.ru

A I Saifutdinov, J Biot Phyt 2017

Self-organization of current structures on electrodes of glow and arc micro-discharges at atmospheric pressure

A I Saifutdinov
Kazan Federal University, Russia
Saint Petersburg State University, Russia

For gas discharges of direct current at high pressures, including atmospheric pressure, a violation of spatial homogeneity is characteristic. This is due to the fact that a uniform distribution of the current density over the cross section is unstable and current structures are formed. In addition, at high pressures, in cases of sufficient heating of the electrodes, the glow discharge passes into an arc. In this transition was simulated and various scenarios of current-voltage characteristics (CVC) were shown. However, without due attention, the study of the formation of various current structures in the entire range of currents corresponding to the independent discharge remained. In the work presented, numerical studies of the formation of current spots on the cathode and anode in micro discharges of direct current in an argon atmosphere were carried out. A hybrid discharge model based on the continuity equations for charged and excited particles, heat balance equations for the electronic and heavy plasma components, Poisson's equation for describing the electric field, and the heat balance equations for describing the thermal fields in the cathode and anode was considered. On the solid-plasma boundaries, self-conjugate effect, taking into account the heating of the electrodes, were considered. As a result, the onset of thermionic emission was taken into account at the cathode. Transport coefficients, as well as inelastic processes involving electrons, were determined from the local boltzmann kinetic equation. The formulated model described the main parameters of a gas discharge (glow and arc discharges) in a wide range of discharge currents and to obtain its classical current-voltage characteristic. In this case, violation of the radial uniformity of the plasma parameters of the discharge, which are noticeable near the surface of the electrodes, appeared across all sections of the CVC through a characteristic time. Perturbations occurred randomly both on the axis of the computational domain, forming a classical current spot, and at an arbitrary distance from the axis, forming a ring. It is worth noting that the ring current structures appeared on the CVC section corresponding to a normal glow discharge. In certain cases, the ring formed was unstable, its radius decreased and the formation of a stationary spot occurred, as in the first case. At high values of the discharge current characteristic of the arc discharge, the dynamics of the formation of a contracted current spot was obtained. The study was carried out with the financial support of the Russian Foundation for Basic Research in the framework of the scientific project No. 16-38-60187 Mol_a_dk.

Biography

A I Saifutdinov is postdoctoral fellow from Sain Petersburg State University, SPbGU.

as.uav@bk.ru

5th International Conference on

PLASMA CHEMISTRY AND PLASMA PROCESSING

November 13-14, 2017 Paris, France

Accepted Abstracts

Plasma Chemistry 2017

J Biot Phyt 2017

Cold plasma treatment to support healing of chronic wounds

K Masur[1], **Th von Woedtke**[1], **H R Metelmann**[2], and **K D Weltmann**[1]
[1]Leibniz Institute for Plasma Science and Technology – INP Greifswald, Germany
[2]Greifswald University, Germany

During the past decade the new interdisciplinary field of research plasma medicine has been established. Applying cold atmospheric pressure plasma may provide numerous future applications in medicine, ranging from wound care support, to blood coagulation, or medical device disinfection, and even cancer treatment. Cold plasma consists of partially ionized gas and contains several biological active components including reactive oxygen and nitrogen species (ROS and RNS), mild heat and UV-radiation. The challenge hereby is to proof that plasma treatment can have lethal effects on bacteria, whereas eukaryotic cells can be promoted to grow and proliferate under the same conditions. Our aim was to investigate the impact of cold plasma on the stimulation of mammalian cells with respect to chronic wound healing. Therefore, human cells from cell culture and from biopsies were treated with the atmospheric pressure plasma jet kINPen MED and other plasma sources to compare their effects on treated cells. However, the underlying processes still need to be identified to modulate the plasmas for future applications – especially with respect to clinical application (including patient diversity) and comparison of different plasma sources. Our results indicate that for an optimal plasma treatment for each plasma source the control of ambient conditions, as well as a careful plasma treatment harmonized to the respective cell line, or respectively the patients is of tremendous importance for a successful approach of plasma therapy. Nevertheless, future plasma applications *in vivo* demand for thorough investigation on plasma-cell and plasma-liquid interactions ensuring safety and reliability of devices in advance of its clinical use. For future progression in the development of medical devices, the standardization of plasma generating processes as well as the biological tests is needed. This work will provide some aspects on how to compare different plasma treatment regimes, but also will give some hints what still need to be investigated regarding patient treatments.

kai.masur@inp-greifswald.de

J Biot Phyt 2017

Laser-induced plasma spectroscopy for applications in analytical chemistry

Christian Parigger
Center for Laser Applications - University of Tennessee Space Institute, USA

The generation of plasma has served well in diagnostics applicable to analytical chemistry. Laser-induced plasma shows various applications in determining species composition of materials, parameters such as electron density and temperature, or dynamics of processes, to name a few research areas. Of particular interest are the characterization of hydrogen plasma and selected diatomic molecular spectra or 'fingerprints' that can be measured with temporally and spatially resolved emission spectroscopy. Recorded high-speed photography images particularly in gaseous environments are associated with spectral data sets by use of computed tomographic methods that include integral transforms of line-of-sight data.

cparigge@utsi.edu

J Biot Phyt 2017

Remote plasma assisted vacuum deposition: A plasma approach for the development of advanced organic and hybrid multifunctional materials

Francisco J Aparicio[1], Maria Alcaire[2]
[1]Institute of Materials Science of Seville, Spain
[2]Spanish National Research Council-University of Seville, Spain

Plasma polymerization represents a solvent-free, room-temperature, and competitive alternative for the development of organic nanometric films with surface chemical functionalities which are appealing for different fields such as biomedicine and electronics. Due to the inherent complexity of plasma polymerization processes, the synthesis of these materials typically addresses the incorporation of rather simple chemical functionalities present in a volatile precursor which is dosed into a plasma discharge. During the last years we have developed a "remote plasma assisted vacuum deposition (RPAVD)" technique intended to expand the scope of the plasma polymerization field. The process is conceived for the controlled incorporation, into plasma polymer films, of integer complex molecules of interest for functional applications. The RPAVD technique is based on the fine regulation of the interaction between a remote microwave plasma and the functional molecules sublimated in the afterglow region. To illustrate the possibilities and versatility of the technique we present results about photonic plasma nanocomposites hosting different organic dyes, such as perylenes, xanthenes, and flavonols; as well as their integration as active media in photonic structures (ring resonators, and photonic crystals). The optical properties of the films (light absorption, refractive index luminescence, optical sensor response, etc.) can be tailored and optimized thanks to the accurate control that the technique provides over the aggregation state of the dye within the plasma polymer matrix. We also show the advantageous use of co-polymerization processes to control the chemical and optical properties of the plasma polymer matrix. In the present communication, we pay especial attention to recent results about the development of luminescent photonic sensors and laser gain nanomaterials. Ongoing studies about the synthesis of bactericide, dielectric and nanostructured optoelectronic materials will be also presented. Finally, we discuss the synthesis of hybrid and heterostructure nanomaterials by combining the sublimation of metalorganic molecules and remote plasma techniques.

fjaparicio@icmse.csic.es

J Biot Phyt 2017

DBD plasma chemistries in aqueous solutions

Hai-Feng Ji[1], Arben Kojtari[1], Utku K Ercan[2], Josh Smith[1], Gary Friedman[3], Alex Fridman[4], Richard B Sensenig[2], Somedev Tyagi[5], Suresh G Joshi[2] and **Ari D Brooks[2]**
[1]Drexel University, USA
[2]Drexel University College of Medicine, USA

Plasma has found a variety of applications recently in clinical, agriculture, and environmental fields. In order to understand the unique applications, the chemical composition and characterization of plasma-treated water or solutions need to be studied. We intend to report our studies on plasma chemistries in solutions. A variety of water-containing solutions with various organic compounds, including sugar, amino acids, lipids, antibiotics, and pure water have been tested.

HJ56@DREXEL.EDU

J Biot Phyt 2017

Phase space path integral simulations of momentum distribution functions and thermodynamics of strongly coupled quantum plasmas

Filinov V S[2] and **Larkin S A**[1]
[1]Joint Institute for High Temperatures RAS, Russia
[2]Moscow Institute of Physics and Technology, Russia

Quantum effects may affect equilibrium momentum distribution functions making them non-maxwellian. For example, exchange effects lead to Fermi-Dirac or Bose-Einstein distributions in systems of non-interacting particles. On the other hand, interaction between particles restricts available for particle volume and could result in broadening of momentum distribution due to Heisenberg principle. This effect may strongly influence the reaction rates and may be important in studies of combustion, detonation and even nuclear fusion. Under extreme conditions systems of particles are usually strongly coupled and perturbative approaches are not applicable. Therefore, ab initio non-perturbative methods for calculation of momentum distribution functions are required. In our work we use path integral representation for Wigner function and propose two Monte Carlo methods for studies of momentum distribution functions of degenerate non-ideal Fermi systems. In the first method to obtain explicit expressions for Wigner functions we take into account pair exchange interaction of fermions and linear or harmonic local approximations of interparticle potential. The second method (single-momentum) is based on reduced Wigner function, integrated over all momenta except several few. Both methods have been tested on simple models: one particle in different external potential fields and ideal Fermi gas. Results are in good agreement with available analytical and numerical data. Then momentum distribution functions for a two component degenerate plasma media have been investigated. Quantum corrections to Fermi and Maxwell distributions in form of "power - low tails" have been found.

vladimir_filinov@mail.ru

J Biot Phyt 2017

Food industry waste energy recovery by thermal plasma process

Mario G. Garcia
Energy Department of ABC Federal University, Brazil

This paper presents the experimental results of food industry waste processing for energy recovery using thermal plasma technology. The thermal plasma is a technology where a gas is superheated and temperatures up of 15,000 ° C can be reached . In this temperature range, the superheated gas does not meet any of the properties of the solid, liquid or gaseous, which causes the plasma is called the "fourth state of matter." The heating of this gas occurs through an electric arc in operation in controlled conditions to achieve greater energy efficiency. Energy is applied to a reactor where, under controlled conditions, gasification of the waste occurs. In these temperatures, there is a molecular disassociation of all gaseous materials, which increases the extractable energy of the gasification process, as compared to other known processes such as incineration, pyrolysis or gasification by other thermal processes. A very important feature and inherent thermal plasma process is the total destruction of the processed material, not generating, after processing, any type of waste requiring a specific disposal. processes. A very important feature and inherent thermal plasma process is the total destruction of the processed material, not generating, after processing, any type of waste requiring a specific disposal. Typically, the process residue with the thermal plasma, we gas production, generation of a metal layer (if any metals in the waste) and generating a vitrified phase material not all gassing. These metal and glazed phases are totally inert and may have specific disposal. The metallic phase may be marketed for the metalworking industry and the vitrified phase can be discarded or used as gravel for paving filling or other uses in the construction area. The energy released by the process gas can be utilized for generating steam, with the use of a combustion chamber and a boiler. Depending on the need of energy matrix where the processing is occurring, it is also possible to use a system with a steam turbine and an electrical generator to provide electrical energy.

mario@raeelectric.com.br

J Biot Phyt 2017

Superior functional plasma coating from protonated precursor ions via the plasma α-γ transition

Solmaz Saboohi[1], **Bryan R Coad**[1], **Hans J Griesser**[1], **Andrew Michelmore**[1,2] and **Robert D Short**[1, 3]
[1]Future Industries Institute - University of South Australia, Australia
[2]University of South Australia, Australia
[3]University of Lancaster, UK

Chemically functionalized surfaces may be produced via plasma polymerization; however, a high degree of functional group retention is often difficult to achieve. Here, the plasma polymerization of three structurally related ester precursors, ethyl isobutyrate (EIB), methyl isobutyrate (MIB) and ethyl trimethylacetate (ETMA) is compared at low and high pressure. In moving from a low pressure to higher pressure regime, significant changes in the plasma chemistry and resulting plasma polymer deposit were observed with much higher retention of chemical functionality at the higher pressure observed. Until now these changes would have been attributed to a decrease in the energy/molecule, however we show by direct measurement of the chemistry and physics of the plasma that there is fundamental shift in the properties of the plasma and surface interactions which explain the results. At low pressure (α regime) precursor fragmentation and neutral deposition dominate resulting in poor functional group retention. Increasing the pressure such that the sheath region close to surfaces becomes collisional (γ regime) favours production of protonated precursor ions which retain functionality and dominate the deposition process rather than radical species.

Solmaz.Saboohi@unisa.edu.au

J Biot Phyt 2017

Synthesis of hybrid, carbon-based magnetic, hybrid nanoparticle systems using dense-medium, atmospheric pressure plasma approaches

Ferencz S Denes
University of Wisconsin Biological Systems Engineering, USA

Magnetic nanoparticles embedded in non-magnetic host materials, including carbon structures are of special interest due to the fact that embedding provides encapsulation and prevents grain grow and agglomeration. A combination of magnetic and electrical properties and the accessibility to chemical modification of particles open up significant ways for biotech applications. It has been suggested that the size of the immunizing antigen particles controls their interaction with specific Antigen Presenting Cells (APCs). Bacterial sized (> 1μm) uptake is favored by macrophages, while viral-sized (< 100 nm) are preferentially engulfed by DCs. Using an original Dense Medium Plasma (DMP) technologies and plasma reactors provided with iron electrodes, C and C/N based uniformly sized (40-80nm) hybrid iron and iron oxide containing magnetic nanoparticles (CMNP) were synthesized by starting from benzene and acetonitrile. Based on ESCA results, Fourier transform IR spectroscopy, Raman spectroscopy, AFM and SEM it was shown that the nanoparticles are composed of graphitic carbon or graphitic carbon containing nitrogen atoms and small amounts of iron and iron oxide. Thermal gravimetry/differential thermal gravimetry analysis indicates that these particles are stable up to temperatures as high as 600 oC. Ferromagnetic resonance spectroscopy (FMR) and extended x-ray absorption fine structure spectroscopy suggest that most of host structures is related to metallic Fe. Magnetite and maghemite is also present in the structure of the metallic particles. It was also demonstrated that part of the nitrogen atoms included into the acetonitrile-based structures are in the form of primary amine functionalities. In this presentation based on "*in vitro*" and "*in vivo*" experimental data, the potential use of functionalized plasma-synthesized nanoparticles in future immunotherapy applications is also discussed.

denes@engr.wisc.edu

J Biot Phyt 2017

Molecular dynamics simulations of plasma-surface and plasma chemistry processes

P Brault
GREMI - University d'Orléans, France

Due to the atomic/molecular nature of the plasma surface interactions and the reactivity of the plasma core, molecular dynamics simulations are suitable for understanding the associated basic mechanisms. This is mainly due to availability of interaction potentials of high quality, especially many body and /or reactive potentials. A wide variety of processes can be thus rigorously investigated: Atomic and molecular collisions in the gas phase, nano cluster/soot growth in the gas phase, Plasma wall interactions and surface and subsurface (nano) structuration, plasma (nano) cluster and thin-film growth on materials, Direct treatment of materials surface: nitridation, carbidization, oxidation, plasma grafting, functionalization, plasma reactivity on surfaces including supported nano catalysts. Beside the availability of the interaction potentials, careful modelling of the initial conditions for simulations, hopefully closed to experiments, is required. Moreover, there now exist strategies for including process long time dynamics in molecular dynamics simulations. Due to the high fluxes encountered in molecular dynamics simulations, caution should be paid to the treatment of energy release during bond formation, unphysical collisions, heating. The present lecture will illustrate the different methodological approaches in considering various contexts, in line with experiments, as: plasma (reactive) sputtering and deposition, plasma – catalysis, plasma chemistry, including involving biological media and radicals and plasma irradiation of materials.

pascal.brault@univ-orleans.fr

J Biot Phyt 2017

Direct photoelectric conversion of the focused solar radiation on the base of low-temperature plasma

Gorbunov Nikolay
Admiral Makarov State University of Maritime and Inland Shipping, Russia

A model of the direct photoelectric conversion of concentrated solar radiation in a plasma ignited in a heat pipe filled with a mixture of sodium vapor and krypton is developed. The model considers the non-homogeneous distribution of the alkali atom density in the heat-pipe volume and the thermionic effect of a cathode. The model treats a hot plasma core in a local thermal equilibrium (LTE) state and takes into account non-equilibrium layers near the converter walls. The model is employed to calculate an open-circuit voltage, a plasma resistance, a short-circuit current, an energy flux of positive ions directed toward the cathode, and a conversion efficiency of the solar radiation. We found within the framework of a two-temperature model that the reduction of the electron temperature by 20% compared with the LTE plasma temperature took place at the outer boundary of the ionization layer near the cathode. This non-isothermal model predicts a rather high value (approximately 33%) for the conversion efficiency for a 300x solar radiation concentration ratio. We analyzed the impact of chemical reactions on the plasma conductivity in the external cooling loop region. Two possible explanations for an abnormal high conductivity in an oversaturated vapor of alkali metals are considered. First, the reduce of the effective ionization potential takes place because of the high concentration of alkali metal molecules. Second, a high concentration of micro drop components in the vapor may serve as an additional source of free electrons through the thermal emission effect. The increase of the ambipolar electric field strength in the near-anode region due to non-equilibrium shape of electron energy distribution function (EEDF) is considered. Thus, the formation of the non-equilibrium EEDF in the photo plasma may play a significant role in the problem of attainment of maximal possible values of the converter efficiency.

Nikolay_gorbunov@mail.ru

J Biot Phyt 2017

Pulsed laser ablation in liquids: what can we learn from the bubble diagnoses?

D Amans[1,2]
[1]Institut Lumière Matière-Université Lyon 1-CNRS, France
[2]Université de Lyon, France

Pulsed laser ablation in liquids (PLAL) is a versatile technological approach to producing nanoparticle colloids with ligand-free or functionalized surfaces. Therefore, PLAL has aroused a lot of commercial interests recently. Despite this widespread use, the underlying mechanisms of PLAL are not fully understood yet. In a first step, a liquid confined plasma is created by the laser ablation. Then, numerous authors reported the formation of an expanding bubble from which nanoparticles are released. According to small angle x-ray scattering (SAXS) measurements and laser-light scattering measurements the bubble cavity should support nucleation and growth of nanoparticles. However, two fundamental features remain largely unknown: the chemical composition and the thermodynamic properties within the bubble. Using time-resolved plasma spectroscopy and ultrafast imaging, we address both issues. We then develop theoretical approaches. From a Rayleigh-Plesset based model, we demonstrated that (i) inertial forces drive the bubble dynamics, (ii) vapor evolution is adiabatic, and (iii) the bubble is mainly composed of evaporated solvent. Moreover, we present a fully microscopic approach based on a first-principle study, and propose a scenario of composition gas evolution leading to the first seeds. This approach is illustrated in the framework of alumina. These results will be discussed in the framework of the state of the art (diagnoses and models).

david.amans@univ-lyon1.fr

J Biot Phyt 2017

Determining the thickness and the sub-structure details of the magnetopause from MMS data

R Manuzzo, G Belmont and L Rezeau
[1]Laboratoire de Physique des Plasmas, France

The magnetopause thickness, like its mean location, is a notion that can have different meanings depending which parameters are considered magnetic field or plasma properties. In any case, all the determinations have been done, up to now, considering the magnetopause boundary as a structure strictly stationary and 1D (or with a simple curvature). These determinations have shown to be very sensitive to the accuracy of the normal direction, because it affects the projection of the quantities of interest in studying geometrical sensitive phenomena such as the magnetic reconnection. Furthermore, the 1D stationary assumptions are likely to be rarely verified at the real magnetopause. The high-quality measurements of MMS and their high time resolution now allow investigating the magnetopause structure in its more delicate features and with an unequal spatio-temporal accuracy. We make use here of the MDD tool developed by which gives the dimensionality of the gradients from the four-point measurements of MMS and allows estimating the direction of the local normal when defined. Extending this method to various quantities, we can draw their profiles as functions of a physical abscissa length instead of time along a sensible normal. This procedure allows answering quantitatively the questions concerning the locations and the thicknesses of the different sub-structures encountered inside the "global magnetopause".

roberto.manuzzo@lpp.polytechnique.fr

J Biot Phyt 2017

Low-pressure plasma-etching of organic materials for optical applications

U Schulz
Fraunhofer Institute for Applied Optics and Precision Engineering, Germany

Direct plasma etching is a powerful method for producing antireflective nanostructures on transparent organic materials. The nanostructure formation depends on the chemical composition of the substrates and as well on the plasma conditions applied. The chemical composition of several organic materials modified using plasma was studied with infrared reflection absorption spectroscopy (IRRAS). The investigations indicate a change of chemical composition even during the first few seconds of plasma etching. It is assumed that the modified surface layer is essentially involved in the structure formation process. The most sophisticated optical application is a curved lens in which the antireflection function is maintained throughout the visible spectral range and over an extended range of incident light angles. A multiple etching process for polymer substrates and organic layers will be introduced. By depositing and etching of organic layers step-by-step on etched polymer substrate a broadband antireflective performance was achieved.

Ulrike.Schulz@iof.fraunhofer.de

J Biot Phyt 2017

China's surface modification of metallic bipolar plates of PEMFC: from basic materials to the application technology development

Aimin Wu, Guoqiang Lin, Hao Huang and **Chuang Dong**
Dalian University of Technology, China

The proton exchange membrane fuel cells (PEMFC) can be considered as an ideal power source for stationary cogeneration systems and for fuel cell vehicles (FCV). The bipolar plate is the most important component and major part in PEMFC stack manufacturing, and it contribute 60%-80% of the total components of PEMFC stack. The bipolar plates are typically made from conductive metallic, carbon and polymeric materials. The measurements obtained for electrical conductivity (>100 Scm-1), impact strength (>40.5 Jm-1), thermal conductivity (>10 Wm-1 K-1), interfacial contact resistance (<10 mΩ cm2) and current densities for corrosion resistance (<1 μA cm-2) are based on DOE targets. Although graphite has excellent chemical stability and good electrical conductivity, but the high processing cost of graphite bipolar plates inhibits its use for PEMFC. Metallic materials, such as stainless steel (SS) with surface coated have been used in fabricating bipolar plates for PEMFC to achieve specifications that are low cost, safer and highly stable. This work will introduce the research and application of the surface modification technology of the metal bipolar plate for PEMFC in China. Continuous Supported by the National High-tech R&D Program (863 Program) of China, a series of modified films on commercial SS316L plates with different chemical compositions and structures, such as NiCr, CrN, CrC single layer, and NiCr/(NiCr)N, Cr/CrNx/Cr multilayer, were carried out. The research result showed that, coating of SS bipolar plates can improve the corrosion resistance of metallic bipolar plates. Excellent performance of bipolar plates was recorded by using Cr0.23C0.77 coating for SS materials. The ICR value was 2.8 mΩ cm2 with a low current density (Icorr) 0.091 μA cm-2. And the Cr0.50N0.50 coating also shows well performance with ICR value 5.8 mΩ cm2 and Icorr value 0.59 μA cm-2. The criteria for both current densities (<1 μA cm-2) and electrical conductivity (<10 mΩ cm2) met the DOE's 2020 technical targets. The PEMFC stack assembled with this Cr0.23C0.77 coated SS bipolar plate was successfully applied to the fuel cell vehicles and used as the designated VIP car in 2010 Shanghai World Expo.

aimin@dlut.edu.cn

J Biot Phyt 2017

Plasma chemical processes in cold atmospheric-pressure plasma jets for biomedicine

George Naidis
Joint Institute for High Temperatures, Russian Academy of Sciences, Russia

Cold atmospheric-pressure plasmas have recently attracted a great interest owing to their high efficiency in production of reactive species for biomedical applications. Among most widely used sources of such plasmas are atmospheric-pressure plasma jets (APPJs) formed by pulsed corona or barrier discharges inside thin dielectric tubes in flows of various plasma forming gases typically noble gases, pure or with molecular admixtures, emerged from the discharge tubes into ambient air. At pulse repetition frequencies in the kilohertz range the APPJs are typically composed of bullet-like plasma plumes - streamers travelling along the jets. Reactive species excited atoms and molecules, radicals, charged species in these APPJs are produced by streamers not only in discharge regions inside the tubes but along the whole jets. Due to this property, the APPJs operating in the plasma bullet mode are capable to deliver fluxes of various reactive species, including those with short lifetimes e.g., oxygen atoms, directly to treated objects. Composition of produced reactive species is rather complex, including several tens of various sorts, so that it is a very difficult task to obtain it in experiment typically, densities of only several sorts of species are measured. In this respect, for evaluation of the whole set of reactive species densities the use of computational methods is of high importance. In the talk, results of computational studies on the production of reactive species by APPJs operating in the plasma bullet mode are summarized.

gnaidis@mail.ru

J Biot Phyt 2017

Direct photoelectric conversion of the focused solar radiation on the base of low-temperature plasma

Gorbunov Nikolay
Admiral Makarov State University of Maritime and Inland Shipping, Russia

A model of the direct photoelectric conversion of concentrated solar radiation in a plasma ignited in a heat pipe filled with a mixture of sodium vapor and krypton is developed. The model considers the non-homogeneous distribution of the alkali atom density in the heat-pipe volume and the thermionic effect of a cathode. The model treats a hot plasma core in a local thermal equilibrium (LTE) state and takes into account non-equilibrium layers near the converter walls. The model is employed to calculate an open-circuit voltage, a plasma resistance, a short-circuit current, an energy flux of positive ions directed toward the cathode, and a conversion efficiency of the solar radiation. We found within the framework of a two-temperature model that the reduction of the electron temperature by 20% compared with the LTE plasma temperature took place at the outer boundary of the ionization layer near the cathode. This non-isothermal model predicts a rather high value (approximately 33%) for the conversion efficiency for a 300x solar radiation concentration ratio. We analyzed the impact of chemical reactions on the plasma conductivity in the external cooling loop region. Two possible explanations for an abnormal high conductivity in an oversaturated vapor of alkali metals are considered. First, the reduce of the effective ionization potential takes place because of the high concentration of alkali metal molecules. Second, a high concentration of micro drop components in the vapor may serve as an additional source of free electrons through the thermal emission effect. The increase of the ambipolar electric field strength in the near-anode region due to non-equilibrium shape of electron energy distribution function (EEDF) is considered. Thus, the formation of the non-equilibrium EEDF in the photo plasma may play a significant role in the problem of attainment of maximal possible values of the converter efficiency.

Nikolay_gorbunov@mail.ru

J Biot Phyt 2017

Dry cleaning of polymeric residues from graphene with high density hydrogen plasma: the issue of plasma purity

Hasan-al Mehedi
[1]LTM/CNRS, France
[2]Leti-Minatec, France
[3]CEA Centre de Grenoble, France

Graphene consists of two exposed sp2-hybridized carbon surfaces and has no bulk. Therefore, graphene surface contamination by adsorbed polymer residues have a critical influence on its electrical properties and can drastically hamper its widespread use in device fabrication. Therefore, graphene-based technology requires "soft" and selective surface cleaning process to suppress this surface contamination. However, polymeric contamination is resistant to cleaning due to p-stacking and is problematic because it originates from typical technological processes used to fabricate graphene devices. Since solvents are not efficient to clean these residues, other strategies based on reactive plasmas have been proposed. Here, we investigated a high density H2 plasma cleaning process of graphene monolayer in an industrial ICP plasma reactor designed to etch 300mm diameter wafers. Firstly, we show that there is a considerable issue associated with the use of H2 plasmas to treat graphene and other 2D materials: H atoms and H3+ ions reduce the surface of all the materials exposed to the plasma, which include the reactor walls and the substrate holder (i.e. the 300-mm diameter wafer on which the graphene sample is stuck). As a result, metallic and O atoms are released in the H2 plasma, resulting respectively in graphene metallic contamination and damages, Si stick on graphene while O atoms etch it spontaneously. We investigated various coating of the reactor walls to prevent this phenomenon. We concluded that the only solution to get rid of parasitic O is to use a wafer holder made of Aluminum and to fully fluorinated the reactor walls and the wafer with a F rich plasma prior the H2 process. Under such controlled conditions, we show that H2 plasmas can provide an infinite etching selectivity between sp2 and sp3 hybridized form of carbon, i.e. H2 plasma can clean polymer residues from graphene. The quality of the cleaning is characterized by various surface diagnostic techniques, including k-PEEM to measure its band structure. We show that the cleaned graphene lattice remains undamaged by H2 high density ICP plasma. This dry-cleaning has the advantage to be an industrially mature technology adapted to large area substrates and to other 2D materials.

hasan-al.mehedi@cea.fr

J Biot Phyt 2017

Experimental study of the characterization of the main properties of DC- Glow discharge plasma experiment in ASU

Ashraf Yahia[1], A A Talab[2], M A Saudy[1] and M E Ali[1]
[1]Ain Sham University, Egypt
[2]Atomic Energy Authority-Nuclear Research Center, Egypt

The (DC-GDPAU) is a DC glow discharge plasma experiment which was built and operated in Ain Shams University. It consists of discharge chamber, vacuum system, DC electrical circuit and digital storage oscilloscope. The cylindrical discharge chamber is made of stainless steel inside it there are two movable parallel circular copper electrodes (cathode and anode). The working data measured at (d) from 3 to 7 cm respectively. The minimum breakdown voltage () for each gap length from Paschen curves occurred at the pressure P of Ar gas 0.3 Torr. So, this is the operating pressure which used to get plasma at V in the range from 400 to 1800 volts. The plasma electrical parameters (Ip, Vp, Rp and Wp) are measured and calculated to produce complete characterization to the plasma. The and are measured by using double electric probe at radial distances r = 2, 4, 6, 8 cm to each gap length while the operating plasma current was 20 mA. The electron temperatures were in range from 7.96 eV to 10.44 eV at d = 3 cm, 6.58 eV to 7.65 eV at d = 5 cm and 7.33 eV to 7.99 eV at d = 7 cm. The ion density was in range from 0.91 × 1010 cm-3 to 1.79 × 1010 cm-3. From these results, it is clear that at gap length 7 cm the plasma temperature was almost constant at all radial distances. While at 3 cm this difference was bigger. So, as application, the samples which exposed to the plasma put at d = 7 cm. After studying the characterization of the plasma in this system, a PCB (printed circuit board) samples exposed to this plasma to study improving some properties of it. Digital optical microscope was used to show the changing in the shaping of the samples surfaces. From the images, there is change in the surfaces. It was studied in this paper to explain it. This is as part of the collaboration between EAEA and ASU. Also, the conductivity of the samples studied as collaboration between electronic unit and central physics laboratory unit in ASU, and the results showed that the resistance of copper decreased from Ω to Ω, this means that the conductivity of the samples increased. The hardness of this sample will study in the collaboration between Central Metallurgical Research & Development Institute and ASU.

azza_talab@yahoo.com

J Biot Phyt 2017

Energy and environment: plasma processes for decarbonization

P I John
Institute for Plasma Research, India

It is obvious that our energy resources for the foreseeable future will continue to be based on fossil-derived hydrocarbon fuels. CO2 emissions associated with fossil fuel burning and correlated to global warming trends have many negative consequences across the globe. In the climate challenge to reduce carbon dioxide emissions by decarbonisation, Plasma based techniques are emerging to play a significant role. Coal gasification using steam plasma at ultra-high temperatures (T>1200K) can increase the proportion of lighter hydrocarbons. Methane dissociation to remove the carbon content requires energy input in the form of high-temperature (>1200↔C) may benefit from the use of plasma catalysts. Direct conversion of methane to solid carbon using AC plasma torches has been recently successful. Plasmolysis of CO2 to useful products is another very active area of research as many ideas are being pursued. Vibrational excitation is the most effective means for CO2 dissociation because the process requires the least amount of energy. Tailored plasmas to achieve this is a challenge. Another method for CO2 conversion is the partial oxidation reaction which results in the production of hydrogen and solid poly carbon sub-oxide. The concepts of 'Solar Fuels' to produce Carbon neutral energy and the ingenious combination of electricity and gas grids for energy storage may lead to totally carbon neutral fuel systems.

john.pucadyil@gmail.com

J Biot Phyt 2017

Glow discharge plasma brazing of Ti-45Al-2Nb-2Mn-1B titanium aluminide with Ti-Ni-Cu alloys

Ahmad Reza Rastkar
Shahid Beheshti University, Iran

TiAl intermetallics are considered as promising materials for high-temperature application especially in advanced automobile and aero engine components because of their low density and high melting temperature and high-temperature strength. Practical application of γ-TiAl alloys depends on the proper joining of these alloys as a key factor in aircraft and automobile technology. It has been reported that sound joints could be achieved by solid-state diffusion bonding and reaction-assisted diffusion bonding. A pulsed DC plasma in the highest amperage range of glow discharge was employed to join the parts of Ti-45Al-2Nb-2Mn-1B titanium aluminide at 900° C for 15 min at 10 mbar pressure with Ti-Ni-Cu (wt.%) alloys. The glow discharge surrounded the whole volume of the joint assembly and the brazing was performed like conventional furnace heating. The cross-section of the joints was analyzed by using optical and SEM microscopy, EDX and XRD spectroscopy and microhardness and shear fracture tests. Microscopy of the joints showed a different irregular type of particles in the interfacial regions with a chemical composition of Ti2AlNi, TiAlNi and NiAl3 enriched with Cu and Mn in matrices composed of TiAl, Ti3Al, and TiAl3. The microhardness of the interfacial regions was approximately slightly harder than the base metal and a good matching was observed between the joint and the base metals. Cracking was not observed in the joints. The maximum shear strength of the joints was approximately 400 MPa for the specimen brazed with Ti-30% Ni filler metal in comparison with the base metal with the strength of 500 MPa.

a-rastkar@sbu.ac.ir