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Charged Dust Particles Confinement by Electrodynamic Traps in Gas Medium

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The purpose of this work is to study the possibility and conditions of the dust structure confinement in quadrupole traps at an atmospheric pressure in corona discharge plasma in gas flows. For simulation of dust structures we consider potential forces acting on dust particles. The influence of the buffer gas is taken into account by viscosity and random forces. The motion of dust particles is described by Brownian dynamics that takes into account the stochastic forces acting on dust particles from the neutral and plasma particles. The equations of motion of dust particles are described by the Langevin equations. The results of the simulations allow us to find the regions of the dust particle confinement, the influence on these regions the particle masses and charges, applied to the trap electrodes voltages and its frequency. The results of the simulations agree with results of dust particle confinement obtained in our experiments for the linear Paul trap.

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Influence of Substrate Distance on Diffuse Coplanar Surface Barrier Discharge properties

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Interaction between sample surface and plasma during the surface modification of solids can influence character and plasma parameters of discharge. This work reports on modification Diffuse Coplanar Surface Barrier Discharge (DCSBD) properties as a function of adjusted distance between conductive or dielectric substrate and discharge electrode. Plasma parameters were studied in particular by means of electrical measurements, i.e. the time dependence of current and voltage for different power densities and different thicknesses of the used discharge electrode dielectrics. Discharge was generated in laboratory air and power density was in the range $1 – 3$ W/cm^2. Constant electrode temperature 50 °C was kept in all cases. Images of discharge were recorded by digital camera to analyse the character of discharge.

This research has been supported by the project R&D centre for low-cost plasma and nanotechnology surface modifications CZ.1.05/2.1.00/03.0086 funded by European Regional Development Fund.

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Chemistry of amine-containing plasma polymers

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Deposition of thin films containing amine groups was carried out in low pressure capacitively coupled radio frequency (13.56 MHz) discharges using two monomers, tert-butylamine and cyclopropylamine, mixed with argon. Two plasma reactors were applied for the plasma polymerization, with horizontally or vertically oriented electrodes. Plasma was investigated by optical emission spectroscopy that reveal the presence of CN, NH and CH molecular bands, OH impurities and atomic lines related to the dissociation of monomer. Deposited thin films were characterized by Fourier transform infrared spectroscopy, X-ray photoelectron spectroscopy and ion beam methods (Rutherford backscattering spectroscopy and elastic recoil detection analysis). The complex investigation of the chemistry of the deposited plasma polymers was related to the plasma conditions and plasma chemistry.

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Inactivation of Candida albicans by Corona Discharge in System with Rotating Electrode

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The inhibition effect of the non-thermal atmospheric pressure plasma generated by a negative corona discharge on the *Candida albicans* yeast growth was studied. An ion conducting semi-liquid cultivating medium (Sabouraud agar) surface contaminated with yeast suspension was treated for 3 minutes. The point to plane electrode configuration was used. A rotating plane electrode was realized directly by the agar surface. The point electrode was placed at distances 0, 1, 2 or 3 cm from the plane electrode axis. The inoculum concentration 10^6 cfu/cm^2 was used. A modification of the diffuse disc method (standard for antibiotics testing) was used to evaluate inhibitory effect.

This study follows our previous results focused on the treatment effect in outlying area during the direct plasma treatment. Significant inhibitory zone enlargement was observed, especially for paraxial positions of the point electrode. A subsequent exposition at various distances dramatically augments the inhibitory effect.

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A New Plasma Surface Modification Source for Roll-to-roll Vacuum Deposition Machines to Prevent Defects Due to Dust Particles

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Various dust particles formation and removal have been studied in a DC plasma surface treatment system of a web plasma sputter machine. The dusts` formation results in polymerization of C, H, O, Ni, Fe, and Cr which come from sputtering of SUS elements and physical etching of polyimide films in the system. The ballistic deposition and flaking of deposited layers on the walls are main mechanisms of the dust formation in the system. It is important regularly to remove and clean the dusts prior to causing defects, since they can cause various defects, such as scratches, dents, pin-holes, creases, and so on. In this presentation, a new feature of the plasma surface treatment system for a web plasma sputtering machine, which has no dust deposition on the walls, will be introduced. The new system consists of the linear ICP plasma source and dust travelling electrode arrays. The effects and experimental results of the introduced system will be also discussed.

This research has been supported by the Ministry of Education, Science, Republic of Korea

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Tungsten Erosion with Noble Ions at High-Flux and High-Fluence Bombardment

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The W samples were irradiated with keV He and Ar ions. The beam has been generated by FALCON ion source with typical particle fluxes of $0.4 – 1.0 \times 10^{22}\ m^{-2}s^{-1}$ and the heat fluxes of 0.3 – 1 MWm^{-2}. The heat fluxes elevate the temperature of the samples up to 770 – 970 K. The long exposure with intense particle flux allowed to reach fluence above $10^{26}\ m^{-2}$. Erosion yield of W with He ion beam is in a good agreement with data for physical sputtering. Erosion yields produced by Ar ion beam is below yields for physical sputtering by factor of two. The morphology of the surface exposed to He ion beam has been found to be typical. Bombardment of the W surface with Ar ion beam produces pores and cracks with typical dimension of 1 μm. High-flux and high-fluence exposure of the W with Ar ions may involve the effects, which decrease the erosion, while He ion flux does not demonstrate this kind of effects limiting its influence within the physical sputtering.

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The Device for Matching Electrical Pulse Generator with Plasma as a Load

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The construction has been developed and working peculiarities have been studied as to the device for matching electro-physical parameters of the output stage of the high voltage pulse source with E-type electric-discharge system for exciting the glow-discharge plasma in low vacuum conditions. The matching device includes a wide-range adjustable inductive element and a microprocessor control system. The device is provided with the analog feedback circuit with capability of digital threshold regulation of physical matching parameters. Using the matching device as a part of the equipment for modification of solid structures with non-equilibrium gas discharge plasma makes it possible to improve energy efficiency of the treatment process by means of compensation of plasma load reactivity.

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Immobilisation of Humic Substances Using Plasma Modification

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This paper is focused on the way humic substances are immobilized on polypropylene (PP) nonwoven fabrics. In order to fixate humic substances, the PP nonwoven fabric was modified in a volume of nonthermal atmospheric pressure dielectric barrier discharge (DBD) under defined conditions. Unmodified PP fabric was used as a reference sample. Both modified and unmodified samples were dipped in aqueous solution of potassium humate, dried and consequently acidified in 7 % acetic acid. Then the samples were washed in water and dried. Aqueous solution of cadmium salts was filtrated through the treated fabric, the content of cadmium in the solution was monitored using ICP-OES analysis. Efficiency of the PP plasma modification was proved by the XPS analysis and adhesion of humic substances to fibers using SEM analysis.

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Investigation of Influence of Plasma Power on the Geometric Parameters of Carbon Nanotubes Formed by Plasma Enhanced Chemical Vapor Deposition

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Carbon nanotubes were formed by plasma enhanced chemical vapor deposition. The influence of process parameters on the growth of the geometric properties of CNTs. Found that when the plasma power 2W array of vertically aligned CNT has a greater height and the lowest

dispersion in the parameters for both structures . Just shows that the experimental dependence of the rate of growth characterize CNT array structures on Ni/Cr/Si and Ni/V/Si. The resulting dependence of growth has two sections. It is shown that the method of plasma enhanced chemical vapor deposition allows to form array of vertically aligned carbon nanotubes with given parameters , which can later be used as sensing elements in ioniza-tion sensors gases, as well as field emission structures.

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Plasma Modification of Polymeric Foils by Dielectric Barrier Discharge in Air at Atmospheric Pressure

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Treatment of polymers by atmospheric plasma is an effective method for improvement of their surface properties. Many studies proved that atmospheric plasma is capable to induce required changes of surface properties of various polymers. However, comparison of results reached for different polymers is rather difficult, since different authors use different sources of atmospheric plasma as well as different treatment conditions (e.g. power, frequency or working gas). Therefore, we report in this study on changes induced by plasma generated by means of coplanar DBD reactor operated in air at constant conditions (applied power 30 W, interelectrode distance 1.5 mm) on different polymers (LDPE, PET, PP, PTFE, Nylon, Kapton, PEEK, PLLA). The main attention is devoted to the determination of alterations of chemical structure, morphology, optical properties and surface energy of plasma treated polymers that were studied by means of XPS, AFM, UV-Vis spectrophotometry and sessile droplet method.

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Electron Temperature of $CuInSe_2$-Based Spark Discharge Plasma at Various Interelectrode Distances

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The emission characteristics of the plasma of nanosecond spark discharge with $CuInSe_2$ electrodes were carried out to monitor the process of the synthesis of nano-structures based on copper indium diselenide compound. The radiation spectrum from the plasma of spark discharge obtained at 3 and 4 mm interelectrode distances, which includes the spectral lines of excited atoms of copper and indium. The dependence of the population logarithm of the excited atoms of copper (510.6; 515.3; 521.8 nm) of their energy is constructed at 3 and 4 mm interelectrode distances. The electron temperature is determined, which values amounted 0.63 and 0.62 eV at 3 and 4 mm interelectrode distances respectively. These results can be used for a deeper understanding of the processes in spark discharge

and to select the optimal conditions for the synthesis of nanoparticles of different sizes based on copper indium diselenide compound by pulsed nanosecond discharge.

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High Rate Removal of Photoresist Films in the Microwave Discharge Afterglow in Oxygen

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The results of experimental investigation of the process of removing protoresistive protection layers in oxygen microwave discharge afterglow are presented. The process demonstrated good characteristics and may be successfully used in very-large-scale integration circuits (VLSI) processing with substrates diameter 150, 200 and 300 mm in automated manufacture conditions. The performed experiments showed that the process of photoresist protective coating removal in the zone of plasma microwave discharge afterglow has high quantitative and qualitative characteristics. It makes it very perspective for application in IC and VLSI manufacturing technologies using 150, 200 and 300 mm diameter substrates especially in automated production.

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Effect of Plasma Treatment on Corrosion Layers of Bronze

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Plasma chemical process for conservation of metallic objects is a relatively new way of effective and fast treatment of corroded objects. Removal of corrosion products is based on plasma chemical reduction of corrosion layers by radio-frequency (RF) low pressure hydrogen plasma. Model corrosion layers on bronze were studied. SEM/EDX analyses on corroded and treated samples were performed. Our experiment was realized in different power regimes. The duty cycle was varied from continuous to 66 % pulsed. The SEM/EDX analyses on corroded and treated samples were performed. The analyses showed that the decrease of chlorine and oxygen was achieved by hydrogen plasma. This method is a part of a plasmachemical approach to conservation of original artifacts. The main advantage is its non-destructivity and no contact with aggressive chemicals.

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The Investigation of Thermal Processes in Plasma-Chemical Reactor Designed for Waste Treatment

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The management of organic sludge produced by the industry, farms, water purification plants and other sources raises major issues worldwide as traditional waste repositories become less and less available. The use of plasma for treatment of wastes has had a fascination for many years because of the ability of the plasma to melt and vaporize anything and destroy any chemical bonds. High energy densities and high temperatures are the main advantages that a plasma offers to treatment processes. Therefore, it is very important to control the thermal processes in the plasma-chemical reactor during the waste treatment. It can be done only after the detailed investigation and determination of the main factors that influence the plasma flow temperature distribution and heat losses in the reactor channel. In this work, the thermal processes in the plasma-chemical reactor with up to 100 kW power plasma torch designed for gasified sludge treatment are investigated.

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Improvement of the Well Logging Neutron Tube's Penning Ion Source

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Penning ion sources as parts of neutron tubes have long been used for neutron generation. The ion source key performance metrics – power efficiency, lifetime and stability can be significantly improved by the wall materials optimization. The effects of different plasma-facing materials on discharge characteristics were earlier observed.

Coatings are reasonable alternatives for bulk materials, especially in the case of nonmagnetic coatings on the magnetic substrates. For instance the influence of the Pd-Ba coating of the ion source electrodes on the atomic ion fraction, stability and lifetime is described (RU Patent №138346). The atomic ion fraction is rise approximately up to 15 %, while the neutron yield up to 40 % after activation procedure. Other metrics, including time-dependent ones are also described.

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Glancing Angle Deposition over Metal and Plasma Polymer Particles

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Glancing angle deposition (GLAD) is known to be versatile technique for deposition of columnar structures. The method is based on a shadowing effect which occurs when the substrate is tilted with respect to the direction of flux of the incoming material. When

deposited on a smooth substrate, the deposit has to form islands first which then grow into columns as a result of the area behind the islands being shielded from the incoming flux due to self-shadowing effect. The size and the spacing of the columns are determined by the substrate temperature and also by the substrate and deposit material. In this work we investigate the possibility of using preformed islands in form of (nano)-particles of different sizes to influence the final width of the columns.
Two types of particles have been investigated: smaller (relative to the mean diameter of the column) copper particles and bigger C:H plasma polymer particles. The particles have been first deposited on a smooth silicon substrate and then over-deposited by silver and titanium in GLAD arrangement. The resulting films are compared to the GLAD films deposited on smooth substrate.

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Natural Rubber - Polyethylene Composites: Is Plasma Treatment an Effective Surface Modification for Polyethylene?

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Plasma treatment is an environment friendly process which alters the surface properties without changing the intrinsic bulk properties. In the present work we have tried to incorporate plasma modified PE in natural rubber matrix by various methods such as melt mixing and two roll mill mixing. The cure characteristic, morphology, mechanical properties and cross link density of these composites has been systematically studied. Comparative study with untreated polyethylene was also done. It was found that two roll mill mixing was found to be more beneficial in improving the properties of the composites. Plasma modified polyethylene showed poor polymer-filler interactions, which can be improved by the incurporation of compatibilizers.

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Optical Emission Spectroscopy during a Controlled Reactive High-Power Impulse Magnetron Sputtering Of Densified ZrO_2 Films

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We report on the results of the optical emission spectroscopy (OES) with a temporal and a spatial resolution carried out during the reactive high-power impulse magnetron sputtering (HiPIMS) with a pulsed reactive gas flow control (RGFC) system. The RGFC makes it possible to utilize exclusive benefits of the HiPIMS discharges (an intense sputtering

of the target, a high dissociation degree of reactive gas molecules and highly-ionized and energetically-enhanced fluxes of particles to the substrate) and to achieve high deposition rates of densified stoichiometric ZrO_2 films (up to 120 nm/min at the deposition-averaged target power density of 52 Wcm^{-2}, the voltage pulse duration of 200 μs, the repetition frequency of voltage pulses of 500 Hz and the Ar partial pressure of 2 Pa). The results of the OES show that the sputtering process remains near the optimum point between a more and less metallic mode for alternating O_2 fluxes adjusted by the RGFC during the deposition.

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High Power Impulse Magnetron Sputtering of CIGS Thin Films for High Efficiency Thin Film Solar Cells

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In this work $CuIn_{1-x}Ga_xSe_2$ (CIGS) thin films with three different values of *x* (0; 0.28; 1) were prepared by nonreactive sputtering of Cu, In and Ga in HiPIMS (High Power Impulse Magnetron Sputtering) or DC magnetron and subsequently selenized in an Ar+Se atmosphere. Optical emission spectroscopy (OES) was used to monitor some basic plasma parameters during sputtering of metallic precursors. CIGS thin film characteristics were measured using X-ray diffraction (XRD), scanning electron microscopy (SEM), Raman spectroscopy, energy-dispersive X-ray spectroscopy (EDX) and other techniques.

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Electrical Discharge above the Surface of the Water Solution of Uracil

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This work is dedicated to the spectroscopy study of cluster formation of uracil molecules in mixtures with water vapor when it is excited by electrical discharge. In the course of the research we have obtained spectra of glow in wavelengths from 200 to 600 nm. In the analysis of these spectra were found two spectral bands in the region 430 – 475 nm and 510 – 560 nm. We think that, molecules of uracil in water solution form clusters. The shape of the cluster is defined by the formation of links between the molecules of uracil, when the total energy of the formed cluster will be less than total energy of the source molecules. This may be a sandwich form, where the molecules of uracil, which are planar, packed in layers. There are hydrogen links between the layers which provide the relative strength of this new formed object − cluster.

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Combination of PECVD and Gas Aggregation Source as a Tool for Fabrication of a C:H/Cu Nanocomposites

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PECVD of a-C:H coatings is well established process in many areas of industry and technology due to the hardness and tribological properties of the coatings. It was also shown that a-C:H coatings with the thickness of several tens of nanometers serve as an excellent barrier for gases which makes them suitable for use in food packaging industry. Incorporation of Cu NPs in such films allows a production of antibacterial coatings.
In the present study is shown a technology how to produce hard polymeric coatings containing metal (Cu) NPs and there is shonwn the characterization of the films in terms of chemical composition, morphology, optical and mechanical properties. The a-C:H matrix was deposited in a mixture of Ar and n-hexane on the substrates placed on the RF electrode. Cu NPs were produced by means of gas aggregation cluster source (GAS). It was possible in this arrangement to control the hardness of the films and by pulsing the RF discharge also the amount of the NPs in the film.

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Increase in Reflectivity of the Aluminum Films in UV Range by Means of Change of Microstress in the Coating

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Thin aluminum films were prepared using the method of magnetron sputtering with and without argon ion beam assistance. The influence of argon ion beam on the reflectivity in the UV range and the structure of aluminum films was studied. The structure of the films was studied by transmission electron microscopy (TEM), X-ray diffractometry (XRD) and atomic-force microscope (AFM). The study has shown that the films deposed with the assistance of the argon ion beam have more significant microstresses associated with an increase of crystallites microstructure defects as compared to the films deposed without ion assistance. Comparison of the measured reflectivity of aluminum films deposed without and with the assistance of the ion beam has shown that the films characterized by a higher level of microstructure defects have increased reflectivity in the UV range. The studies suggest that the defects of thin aluminum films crystal structure influence its optical properties.

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Plasma Assisted Fabrication of Zinc Oxide Based Nanostructures

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ZnO/Ag nanocomposite structures were prepared by using a discharge with an atmospheric-pressure mi-croplasma cathode and a solid metal anode immersed in an electrolyte solution and their optical proper-ties were studied. The effect of Ag on the microstructure and optical properties of ZnO has been dis-cussed.

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Melanoma Cells Exposed to Singlet Oxygen Generated by RF/DC Discharge

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Singlet oxygen is the lowest electronically excited state of molecular oxygen. Its energy is about 1 eV. In medicine it is mainly used in the photodynamic therapy. In our study singlet oxygen is generated by fast mixing of hybrid Ar+He plasma jet of DC electric arc sustained by an RF discharge with an injected neutral O_2+He+NO gas stream. The yield of gaseous singlet oxygen is about 5 %. Mouse melanoma cells (primary melanoma, ascites melanoma and circulating tumour melanoma cells) were exposed to gaseous singlet oxygen. Evaluation methods were the MTT test (for comparison of the singlet oxygen therapy and the singlet oxygen therapy combined with a chemotherapy), the xCELLigence system (for online monitoring of cells viability). The gene expression of exposed melanoma cells was also carried out. Results of these methods are presented.

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Diagnostics of Neon Plasma by Optical Emission Spectroscopy and Collisional-Radiative Modelling

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Combining collisional-radiative (cr) modelling with optical emission spectroscopy a method of electron temperature or electric field determination was developed for low-pressure neon plasma. Measured intensities of 27 neon spectral lines from 3p and 3d states were compared

with a result of the cr model using a least squares method. Maxwellian electron distribution function or Boltzmann kinetic equation were used to calculate rates of electron collisional processes. Densities of neon metastables were analyzed independently using self-absorption. The method was applied to a surface-wave sustained microwave discharge burning in a coaxial tube configuration at pressure 300 – 700 Pa. The axial profile of the electron temperature was found approximately constant around 1.5 eV. The reduced electric field strength decreased along the plasma column ranging 16.5 – 6.0 Td. A large influence of the gas cooling along the plasma column on the determined reduced electric field strengths was observed.

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Solution Plasma Process and Its Applications in Biomedicine

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Solution plasma process (SPP), a liquid-phase plasma, has been accepted as a capable technology to treat waste water and synthesize carbon materials, nanoparticles, as well as metal-supported catalyst. Presently, this technology has been broadening to utilize for biomedical application. For example, it is used to depolymerize biopolymers such as chitosan and sodium alginate to produce low-molecular weight polymers which possess good biological activities and can act as medicine or supplement for patients with several type of problems. A one-step synthesis of gold nanoparticles in an alginate gel matrix was also studied. This lecture conveys an idea of the SPP fundamental and focuses on its applications in biomedicine. The key success factors and competitive advantages of the SPP in biomedical field are the chemical free with fast production rate. Therefore, the SPP might represent an effective method to be extended to numerous applications in biomedicine.

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From Target to Substrate – Fundamental Aspects of High Power Pulsed Magnetron Discharges

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High power impulse magnetron sputtering (HiPIMS) plasmas generate energetic metal ions at the substrate as a major difference to conventional direct current magnetron sputtering (dcMS). The origin of these very energetic ions in HiPIMS is still an open issue, which is unraveled by using two fast diagnostics: time resolved mass spectrometry with a temporal resolution of 2 µs and phase resolved optical emission spectroscopy with a temporal resolution of 1 µs. To explain the presence of energetic ions, a potential hump given by the hot plasma inside localized ionization zones is proposed: if an atom becomes ionized inside the spokes region it is accelerated because

of the ambipolar field along the density gradients to higher energies whereas its energy remains unchanged if it is ionized outside. In applying this model to our measurements the observed phenomena as well as several measurements from other groups can be explained.

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Polymer Chain Ends in Polymer Surfaces Modified by Plasma and Surface Functionalities Relevance to Adhesion

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Plasma surface modification of polymeric materials is grafting process of functional groups such as C-OH, C(O)-OH, C=O, NH_2, NH-C(O), etc. ontosurfaces of the polymeric materials by chemical actions of plasma. As a result, surface properties suchas hydrophilicity, bio-compatibility, etc. as well as chemical composition are drastically changed. The modification is restricted at a topmost layer (a few nanometers) of the surface of polymeric materials, and never occur at deep layers (a few micrometers or more) from the surfaces. Therefore, only polymer chains which locate near the surface of polymer materials take part in the plasma modification, and polymer chains locating at deep layers from the surface never contribute to the modification.

The surface of polymeric materials is the topmostlayer which is extended from bulk polymers and which contacts with air. Is the surface is the same in physical and chemical properties as the bulk polymer? Polymer chain ends tend to aggregate at the surface rather in the bulk of polymers, due to large free volume at the surface. As a result, chain ends concentrate at the surface is higherthan that in the bulk. Therefore, we believe that polymer chain ends take mainly part in plasma modification.

Aromatic polyesteris often called one of the third-generation engineering plastics because of its excellent electrical and thermal properties as well as mechanical properties. The dielectric constant and dissipation factor for aromatic polyesterfilmsis comparable to those for polyimide film (Kapton H), and theirwater absorption (0.04 %) is much lower than that for Kapton H film (2.9 %). From a viewpoint of electrical properties, aromatic polyesterfilm is expected as a new material in application such as flexible printed circuit board (FPCB) for microelectronics. Two aromatic polyester films, (VecstarFA and OC) having different concentration of chain end groups at film surfaces (47 and 40 % of the total of carbon atoms, respectively) were used as base films of PPCBto investigate the contribution of chain end groups to adhesion with copper metal.The plasma modification bylow pressure plasmas was effective in Vecstar FA, but was never effective in Vecstar OC. The peel strength for the copper metal/Vecstar OC film systems was less than twotens compared with Vecstar FA.

Vecstar OC surface was irradiated by electron beam radiation at nitrogen atmosphere or hydrolyzed in supercritical carbon dioxide containing methanolat 200 °C, in order to make polymer chain ends on the surface. These pretreatment could improvethe adhesion, indicating that polymer chain ends modified by plasma contribute to the adhesion. XPS spectra at a take-off angle of 20 degrees which corresponds to an analysis depth of 3 nm showed that O=C(O) and O-C groups, when the films contacted with hydrophilic surface such as glass,appearedat the topmost layer fromthe inner layer. On the other hand, suchoxygen groups, when heated in N_2 atmos-phere, escaped from the topmost layer to the inner layer. We believe that such movement of oxygen groups may be related closely to adhesion with copper metal. This movement mainly may be inducedbychain end groups.

* * *

Antibacterial Plasma Polymers: Different Approaches, Same Goal

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Undesirable biofouling of surfaces caused by bacteria and microorganisms creates a substantial financial loss in various industrie. Plasma polymerization is a process which is already being used on an industrial scale, reliably modifying materials to confer desirable surface properties to them. First, we present an overview of different approaches used to render surfaces antibacterial utilizing plasma polymerisation as well as their mode of action against the pathogens in question. Second, we report the most current project; the use of chlorinated monomers for plasma polymerization to generate "one step" non-biofouling plasma polymer surface coatings. The resulting surfaces coatings show excellent activity against the clinically relevant bacteria strain Staphylococcus epidermidisas well as the eukarotic cell lines m3T3 and KG1a. Furthermore, these chlorinated surfaces retain their antimicrobial properties even after numerous washes with water or saline.

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* * *

Modernization Features of Vacuum Installation Based on Low-Pressure Arc Category for Composite TiN(Cu) Layers Formation.

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The hybrid technology of composite TiN(Cu) layers formation in the conditions of coordinated action the vacuum arc evaporator and the planar magnetron is developed. Possibility of a combination of different growth processes (evaporation in the arc vacuum category, accompanied by ionic bombing, and magnetron sputtering) in one installation opens new receptions of cultivation layers. The generator's plasma basic electro physical and technological parameters are studied and technological modes of sedimentation TiN(Cu) layers are completed.

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Operation Modes and Characteristics of Plasma Dipole Antenna

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Some new results of the computer simulation and experiments studies on plasma antennas are presented in this work. Numerical simulation was done in KARAT code [User's Manual for Code KARAT, V.P. Tarakanov, Springfield, VA, 1992]. Two models of the plasma were

used: the Drude's model and the PiC-method. The plasma antenna operation was studied by the numerical simulation. In the course of simulation the plasma density value in the discharge tube was changed, but the output signal frequency remained constant. As a result of the simulation it has been found that surface wavelength and plasma antenna operation mode depend on the ratio plasma frequency to signal one. It has been obtained diagrams of space distribution of electromagnetic wave components in the plasma, in near and far field zones. We did experimental studies of radiation pattern and frequency characteristics of antennas. Plasma and metal antennas were compared in the numerical simulation and experimental measurements.

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Plasma Deactivation of Microorganisms on the Surface of Grains

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Sterilization process using nonthermal plasma was presented as an alternative to common seed disinfection methods. Proposed solution enabled to obtain uniform treatment (even for complicated structures), high activity at low temperature with relatively short processing times, and without damage of seeds. The presence of toxic residues was not observed during the experiment. Treatment of seeds was carried out using packed-bed non-thermal plasma reactor at atmospheric-pressure in the ambient air. The discharge was powered by 30 kHz sinusoidal voltage with amplitude up to 10 kV. Electrical parameters and temperature of the sterilization process were monitored. The plasma treatment (in duration of 10 seconds) reduced the amount of microorganisms below 10 % of the initial content while preserving germination quality of the seeds. Evaluated energy consumption of the plasma sterilization process was several times lower in comparison to the current method used in agriculture.

This research has been supported by the grant no. B30029 realized at Wroclaw University of Technology.

* * *

Generation of Electron Beam Plasma inside the Dielectric Tube

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The results of experimental study of electron beam plasma inside the dielectric tube are presented. Beam plasma was generated by the fore-vacuum plasma electron source at 2 – 10 Pa in DC mode. It is shown, that the dependence of the plasma potential on gas pressure inside the tube is completely different in compar-ison with similar dependence without a tube. Monotonic dependence of the insulated beam collector potential in the tube on beam energy has two stages: slow and fast growth.

This research has been supported by the the Russian Foundation for Basic Research (Grant No. 12-08-00074).

Formation of Superhard Boride Layers MeB_2 on Carbon Steels under the Influence of Powerful Electron Beams in a Vacuum

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Formation of borides layers of iron, titanium and zirconium carbon steels investigated. The new method is applied for obtain superhard borides under the influence of powerful electron beam in a vacuum. This method uses the self-propagating high-temperature synthesis (SHS), and its products are fused to the surface of carbon steel under the influence of powerful electron beam. As the initiator of the SHS acts electron beam. In this paper, we used the stoichiometric reactionary daubs based on metals oxide, boron and carbon. Studies have shown that the use of electronic heating allows to reduce friability and to increase ductility of superhard layers. Microhardness layers reaches 2500 – 3000 MPa.

This research has been supported by the Russian Foundation for Basic Research, project no: 14-08-31412.

* * *

Study of Physical and Chemical Processes and the Development of Technologies for Complex Plasma Processing of Coal

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One of the promising methods for the processing of solid fuels is a complex plasma processing coal by using modular plasma systems that allow a single process to obtain highly reactive (activated) coal syngas and displace gas and fuel oil from the fuel mix boiler and by plasma gasification of low-grade coal, improve environmental and economic performance of boiler. Experiments were carried out with the following coals: Tugnuisky, Okino – Klyuchevskii (Buryatia), Baganursky, Aduunchulunsky (Mongolia), Ureysky (Transbaikal region). Studies were conducted on a two-stage modular plasma unit. Experimental studies obtained high-quality, environmentally friendly synthesis gas (CO and 45 %, H_2 45 %, caloric 2300 – 2500 kkal/kg) and activated carbon with high sorption properties.Industrial tests of activated carbon were carried out in the water system Gusinoozersk where positive results are obtained by the use of it as a sorbent for wastewater treatment. Carbon sorbents obtained by an arc plasma have high sorption properties, which makes them comparable to the parameters with industry produces sorbents. These data are consistent with the known data from the literature. Using of plasma arc significantly intensify heat treatment processes coals to increase the yield of desired products of synthesis and thereby reducing manufacturing costs and significantly improved environmental performance. In addition, the plasma system is reliable and easy to operate.

* * *

The Angular Distributions of Neutrons Emitted from the PF-1000 Device

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The PF-1000 device is a powerful source of neutrons. The set of indium samples was used for angular neutrons distribution determination. The samples architecture was the subject of optimization. The reaction ^{115}In(n,n')$^{115m.}$ In has a threshold for $E_n \approx 340$ eV. Because of that it is most sensitive for neutrons emitted from the pinch. The ^{115m}In has a $T_{1/2}$ = 4.5 h that allows measure of many samples after activation. For the vertical distribution the set of 8 samples were used. They were put regularly on the external surface of device, on the plane that crossing its axis. The set of 9 samples were used to measure of the horizontal distribution. The samples were put on the device surface on the plane containing its axis. The experiment was supported by MCNP calculation that show character of neutron emission and allowed calculate anisotropy coefficient.

* * *

Neutron Production at the Compression of the Puffing Gas in Plasma Focus Discharge

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The experimental research of fusion DD reaction was provided on the plasma focus device at the current of 2 MA in the approach with the MagLIF conception. The deuterium or neon injected from the gas-puff in the axis of the anode and compressed by deuterium or neon plasma sheath was studied with the multiframe x-ray and interferometry diagnostics. The total neutron yield at the level of $10^{10} - 10^{11}$ per shot was registered at the presence of the deuterium in the load. The registered soft X-ray emission neutron production and interferometric images can be explained by separation of the neon and deuterium in the central structures during their formation and transformation. The separation of both gases should be caused by internal closed currents magnetizing the plasma. The neutrons were produced both at the initial phase of stagnation, as well as at a later time during the evolution of instabilities.

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* * *

Bright EUV Light Source for Metrology Based on Pulsed-Power Technology

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The actinic metrology tools in EUVL deployment require stable high-brightness EUV sources with moderate power output in 2 % spectral band around 13.5 nm wavelength. We report

on a new compact EUV light source development through extensive computational modelling. The source is based on a pulsed gas-filled capillary discharge triggered through transient hollow cathode mechanism. Nanosecond scale of the discharge is provided by high-voltage pulsed power technology with energy storage line imbedded in the source structure. Computational modelling of discharge dynamics and plasma emission is carried out by means of the code ZENITH being a next generation of RMHD codes Z* and ZETA. The energy storage line is charged to joule range of electric energy at 20-30 kV voltage that provides up to 20 kA current during 20 ns pulse. Pulsed xenon plasma heated up to 30-50eV temperature has 150 nm diameter. It emits up to 7 sW/kHz of in-band radiation power averaged at high frequency operation mode into 2πsr.

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Deuterium Gas-puff Z-pinch Experiments on the GIT-12 Pulse Power Generator

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An investigation of the implosion of a deuterium gas-puff Z-pinch was carried out on the GIT-12 generator at IHCE in Tomsk during several Czech-Russia experimental campaigns from 2011 to 2013. We diagnosed 70 Z-pinch shots with deuterium linear mass of about 0.1 mg/cm with different configurations and with a slow or fast current rise time. The configurations were as follows: double or triple gas-puff (D2/D2, D2/D2/D2 or Ne/D2/D2), plasma shell on double or single gas-puff (D2/D2 or D2). In these experiments, the current at stagnation reach the value of about 3 MA. The most interesting results were obtained in 2013 with an outer plasma shell, where we observed (i) DD neutron yield up to 3×10^{12} (ii) energy of neutrons from DD reaction up to 15 MeV in radial direction and 22 MeV on axis and (iii) track in CR-39 that corresponded to energies up to 51 MeV deuterons (or 38 MeV protons) on the z-pinch axis. Besides these values, other experimental results will be presented.

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Studies on Dynamic Pressure of Compression Plasma Flow

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The temporal evolution of dynamic pressure of a compression plasma flow, generated by a magnetoplasma compressor, was investigated in a range of initial voltages from 2 to 4.5 kV

by an interferometric method. The main advantages of the method are that it is insusceptible to electromagnetic noises and mechanical vibrations, requires no calibration procedures and ensures local readings from small areas. Depending on the initial voltage, the pressure values varied from 0.7 to 16 atm.

* * *

Perfluorocarbons Destruction by Thermal Plasma Torch at Atmospheric Pressure

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Perfluorocarbons (PFCs) gas is among the six listed greenhouse gases in Kyoto Protocol required emission reduction. PFCs are extremely stable due to their inert, non-toxic and non-flammable properties, and being used heavily in both alumina and semiconductor manufacturing industries. In Taiwan, the issue of PFCs emission reduction for the semiconductor industries is an urging matter that requires an applicable solution. The traditional PFCs decomposition methods, like combustion, absorption, and catalytic conversion etc., are proven to have limited abatement capabilities. Thermal plasma is being regarded as a romising tool for effective PFCs destruction. In this paper we present the studies of using thermal plasma torch for the decomposition of various PFCs gases such as CF_4, CHF_3, C_2F_6, NF_3, and SF_6. The results show the NF_3 is the easiest species to remove, and $CF_4$is the least one. As the inlet concentration of PFCs decreases, the destruction removal efficiency drops too, except SF_6.

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A Study on a Microwave Steam Plasma Torch for Low Grade Coal Gasification

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High power microwave plasma torch for coal gasification has been studied. For steam plasma generation, high pressure and temperature water vapor input to the three 2.45 GHz microwave plasma torches. Fine coal powder (~70 μm) was mixed with the steam plasma at the exit of the torch and supplied into the gasifier. The steam plasma and coal with additional oxygen were mixed and make a partial oxidation reaction at the high temperature (> 1500 ^oC) to generate the synthetic gas, such as CO and H2, in the gasifier. While the conventional coal gasification (IGCC: Integrated Gasification Combined Cycle) converts the high quality coal (> 6,000 kcal/kg) into the synthetic gas at a high temperature and high pressure, use of the low grade (< 4000 kcal/kg) coal and operation at atmospheric pressure are an advantages of the plasma gasification. In this presentation, the developed 25 kWe steam plasma gasification system and numerical results for the design the gasifier will be discussed.

This research has been supported by the Korea Research Council of Fundamental Science and Technology.

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Optical Emission Spectroscopy and Electrical Study of High Power Thermal Arc Plasma Switching Device

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An atmospheric thermal plasma arc generated from a laboratory scale high power arc switching device was investigated. In the presented study the typical voltage and current profiles from the arc switching device were measured by a high voltage probe and a Rogowski coil. It was shown that the volt-ampere characteristic of the arc plasma is directly related to the distance between electrodes. This switching device has a pulse width range of approximately 120 ns. Furthermore, the optical emis-sion spectroscopy techniques were used to measurement of the arc temperature and to identify the plasma active species. The calculated arc temperature is about 28,400 K.

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Diagnostics and Modeling of Atmospheric Pressure Microwave Plasma Torch Operated in Argon and Argon/Hydrogen

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Atmospheric pressure microwave plasma torch at 2.45 GHz was previously used for the synthesis of carbon nanotubes in the mixture of argon with methane and hydrogen. This work concentrates on the underlaying physics of the torch in the mixture of argon with hydrogen. Spatially resolved internal plasma parameters such as electron density, electron and gas temperatures were determined using a combination of plasma diagnostics methods, namely Thomson scattering, Stark broadening, Rayleigh scattering and laser Schlieren deflectometry for varied microwave power and gas flow rates. The model of 2D axisymmetric turbulent gas flow in the torch was coupled with the electromagnetic field model. It provided spatial distribution of gas temperature, velocity of neutral species and their relative concentrations.

* * *

Evolution of the Small Ball-like Structures in the Plasma Focus Discharge

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The experiments were carried out on the PF-1000 plasma focus device at the current of 2 MA with the deuterium injected from the gas-puff nozzle placed in the axis of the anode face. The diagnostics included interferometric measurements with a Nd:YLF laser operated at the second harmonics (527 nm) and XUV pinhole camera. The laser with a pulse duration of less than 1 ns was split by a set of mirrors into fifteen separated beams which passed through a Mach-Zehnder interferometer. These beams were used for investigating the plasma region

with a mutual 10 – 20 ns delay ranging during 210 ns. The ball-like structures were clearly visible in interferometric and XUV pinhole camera images. The life-time of the ball-like structures with a diameter of several mm was usually longer than 200 ns and they did not change initial locations. Later, ball-like structures were absorbed inside the expanded column and/or expired in surrounding plasma.

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Plasma Target Density Profile Effects on Proton Energy Loss

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Laser-accelerated proton beams are used to analyze plasma foils [F. Abitch et al., Proc. SPIE 8779, 87790V (2013)]. The protons deposit their energy through their stopping with plasma bound and free electrons [D. Casas, M. D. Barriga-Carrasco, J. Rubio, Phys. Rev. E, 88 (2013) 033102]. For this, it is necessary to take in account the distribution of temperature, density and ionization of the plasma target. First, we start to study a simplistic model, where temperature and ionization are constant, and density profile of the plasma [A. A. Andreev et al., Phys. Plasmas, 16, (2009), 013103] is characterized. This density profile is approximated by various piecewise functions that conserve the number of particles. Then, we put this density profile into MBC-ITFIP code [M. D. Barriga-Carrasco, G. Maynard, Y. K. Kurilenkov, Phys. Rev. E, 70 (2004) 066407] to calculate the proton energy loss.

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Radiation Anisotropy of Z-pinch Tungsten Multiwire Arrays on the Angara-5-1 Facility

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Power and spectral composition of soft X-ray pulse of multiwire tungsten arrays were investigated in the axial and radial directions in the photon energy range 0.02 – 2 keV using the diagnostic complex of Angara-5-1. The spectral characteristics of the radiation source in the Z-pinch implosion studied using grazing incidence diffraction spectrometer and a set of x-ray diodes. The results obtained by independent methods showed a significant coincidence. It is found that in the radial direction most of the energy is emitted in the range of 70 – 300 eV, whereas in the axial direction the emitted energy is distributed more uniformly across the range of 20 – 70 and 70 – 300 eV. Thus, the radiation emitted in the axial direction, characterized by a soft spectrum than in the radial direction.

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* * *

Plasma of the Pulse Discharge in Aerosol

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Study of the pulse discharge in various environments is the one of the priorities research in modern plasmachemistry. Impulse discharge in water aerosol is often observed in experiments with electric discharge on air-liquid border due to dispersion of liquid drops. Other applications of aerosol discharge are fuel efficiency improvement and natural long-life plasmoid research. The observation of this phenomenon suggests the existence of a mechanism of energy storage in aerosol drops during discharge. The aerosol source is a nozzle through which the stream of water and air is fed. The nozzle placed in a quartz tube. Construction of aerosol system allows varying the root-mean-square (RMS) radius of the aerosol particles. The discharge is caused by reservoir capacitor charged with a high-voltage generator. The capacitor and copper electrodes were separated by air gap. The discharge area was filmed with a digital camera with frame rate of 30 frames-per-second.

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The Neutron Source Calibration of Plasma Focus Device

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In the IPPLM is operated plasma focus (PF) device – PF-1000 that is the huge source of neutrons. They are generated in results of D-D fusion and beam-target reaction respectively. The neutron source calibration (NSC) supported by MCNP calculations is the process that fulfill us with calibration coefficient for neutron diagnostics which are in use for the total neutron Yield (Yn) determination. To allow safety and precision operation with Am-Be neutron source a specially designed automatic system was constructed. That system pick up the Am-Be source form the shielding container and put in inside the PF-1000 for the time that is need for particular diagnostic calibration. The silver activation counter, beryllium monitor, yttrium fusion neutron monitor and indium activation detector will be the subject both MCNP simulation and NSC. Combined results of numeric simulation and experimental data provide us with precision information that will be used in future plasma research.

* * *

Measuring of Parameters of Neutron Radiation in Condensed Deuterated Z-pinch on the Angara-5-1

Aleksandrov V.V.[2], Frolov I.N.[2], Grabovskii E.V.[2], Gritsuk A.N.[2], Kalinin Yu.G.[1], Kazakov E.D.[1], Korolev V.D.[1], Lauhin J.I.[2], Medovshchikov S.F.[2], Mitrofanov K.N.[2], Olejnik G.M.[2], Pimenov V.G.[3], Ustroev G.I.[1], Shevelko A.P.[4], Volobuev I.V.[4]

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Measuring of the neutron radiation from the condensed Z-pinch were performed on the Angara-5-1 (3.5 MA). Central part of load was produced from deuterated polyethylene

with density of $0.1 – 0.5$ g/cm^3, with a diameter of 1 mm and the total mass of $250 – 1000$ μg. Parameters of Z-pinch plasma were determined by a diagnostic set. The electron temperature determined from EUV spectra of Fe diagnoctical admixture. Neutron energy data were obtained by time of flight method. The neutron radiation bigan in moment of formation of bright points and appearance of short pulses of soft x-ray. The neutrons flux is emitted of the time when the current achieved maximal value of 3.5 MA. The mean energy of neutron was 2.4 MeV. The neutron yield of 3×10^{10} was reached by using the load from deuterated polyethylene with 300 mg/cm^3 density.The same neutron yield was obtained in previous experiments with more homogeneous distribution of density and lower current 1.8 MA.

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Correlation between Shockwave and Wire Properties in the Wire Initiated Electrical Discharges in Water

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Pulsed spark discharges in water have been applied in various fields using strong shockwave. However, the significant uncertainty originated from the random duration of the prebreak-down period and the unpredictable formation of the spark channel made it difficult to analyze the phenomena. In this study, we have employed an initiating metal wire between the electrodes so as to generate the uniform and well-defined cylindrical spark channel. Several metal wires made of aluminum, copper, and tungsten with different diameters have been tested to correlate the wire properties with the pressure wave. The pressure wave is measured for various stored energy in the capacitor bank up to 1 kJ. The energy delivered to the spark channel was calculated from the current and voltage waveform and the efficiency of the energy transferred to the compressed water flow is estimated. The importance of each control parameter is verified and their relations to the effective pressure development are addressed.

This research has been supported by the Defense Research Laboratory Program of the Defense Acquisition Program Administration and the Agency for Defense Development of Republic of Korea.

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Breakthrough of Magnetic Flux inside Wire Array

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In the experiments on wire array implosion at the Angara-5-1 facility the characteristics of the magnetic flux breakthrough phenomenon inside the array volume had been experimentally investigated. It was shown that the breakthrough develops in the final stage of wire ablation. The spatial distribution of the azimuthal magnetic field inside the wire arrays of tungsten, molybdenum, copper and aluminum was measured using magnetic probes. Azimuthal magnetic field distribution was registered along the height of the array $B\varphi(z,t)$ at different times of implosion. We determined the characteristic dimensions of the inhomogeneous

magnetic field regions, which occur during the development of magnetic flux breakthrough on the outer boundary of the wire array plasma. A comparison of the size of these regions was carried out with the spatial dimensions of the regions of reduced plasma emission registered in time-frame and time-integrated X-ray images.

This research has been supported by the This work was supported in part by the State Atomic Energy Corporation ROSATOM under Contract H.4X.44.90.13.1108 and in part by the Russian Foundation for the Basic Research under Project 13-02-00013.

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Shock Wave Propagation in Neutral Gases and Weakly Ionized Plasma

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Shock Wave (SW) dynamics under subatmospheric pressure in neutral gases and weakly ionized low temperature plasma is investigated experimentally. Spherical and plane SW are studied. Weakly ionized low temperature plasma is created by electric discharge. SW excitation and propagation characteristics are studied in the region 1 Torr < p < 760 Torr. It is shown that when p = 3 Torr it is possible to register successfully the SW appearance and propagation. When pressure decreases the SW amplitude decreases and Mach number increases. In case of plane SW Much number reaches the value M = 5.2 under the pressure p = 3 Torr. As for SW propagation in weakly ionized low temperature plasma our experiment showed significant decrease of wave amplitude and simultaneous increase of its velocity up to 35 %. Increase of the SW velocity is related to the heating of neutral gas in plasma. Besides, decrease of the wave amplitude is related to the increase of SW dissipation in plasma.

This research has been supported by the Shota Rustaveli National Science Foundation (Georgia) Grant FR/443/6-140/11.

* * *

Plasma Piston in Two-Channel Compact Railgun for Synchronous Acceleration of Bodies to Hypersonic (4 – 5 km/s) Speeds

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The problem of acceleration and high-speed (more than 1 km/s) flight of a group of bodies along adjacent trajectories is topical in many areas of science and technology. They include, for example, thermonuclear reactor core fuelling, hypersonic exterior ballistics, and studies of specific features of crater formation and target destruction at group high-speed collisions. The paper reports the solution of the problem of synchronous high-speed acceleration of two bodies by using compact railguns developed at Ioffe Institute as accelerators. These railguns are capable of accelerating plastic cubes of the mm size to speeds higher than 5 km/s. The possibilities to use a plasma piston for acceleration of bodies and to overcome the erosion

of electrodes by applying an external magnetic field are demonstrated. An original configuration that allows launching of two 2 mm bodies with a speed of higher than 4 km/s along the same trajectory after each other is described.

This research has been supported by the RFBR 12-08-01050-a.

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Plasma Gasification of Municipal Solid Waste

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Gasification of municipal solid waste was performed in the reactor equipped with a DC plasma torch. Produced thermal plasma features outstanding parameters such as very high temperature (approx. 18,000 K) together with low mass flow rate (around 0.3 g/s of H_2O + 0.2 g/s of Ar). The plasma torch is mounted to a water cooled reactor that has ceramic 400 mm insulation and inner volume of 0.22 m^3. There is the inlet of gasified material in the top part of the reactor and the outlet of produced gas in the side of the reactor. Wall temperatures ranged between 900 °C and 1,500 °C during experiments. Municipal solid waste (plastics 47 %, wood + paper 24 %, textiles 10 %, fines 18 %) was gasified at the rate of 20, 40 and 60 kg/h. The sum of hydrogen and carbon monoxide formed roughly 90 % (vol.) of produced gas (the rest was mainly composed of argon, carbon dioxide, methane).

* * *

MCNP Calculations for Neutron and Hard X-ray Diagnostics at PALS and GIT-12 Devices

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TOF waveforms of neutrons may provide the information about the neutron energy, therefore energy of fusion ions may be determined. However, neutron is inevitably scattered by materials which it has to fly through. As a result, a very distorted information about plasma may be calculated. The neutron scattering rate is not easily predictable by the experiment. Thus, the MCNP computer simulation is used for this purpose. The PALS (Prague, CR) and GIT-12 (Tomsk, Russia) devices are the subject of MCNP simulations. Transport of 2.45 MeV D-D neutrons and high energy (from 0.2 MeV to 20 MeV) photons is observed. The GIT-12 simulations show that there is a great neutron scattering in the axial direction, caused by the gas puff hardware. The MCNP results for PALS device refer that there is an abundance of photons with energy > 1 MeV in the experiment. The MCNP simulations of transport of ions in strong magnetic field are also the subject of interest in the research.

This research has been supported by the Research Program under Grants MSMT No. LG13029, LH13283, GACR P205/12/0454, IAEA RC-16115, RC-16954, RC-16956, RC-17088 and SGS 13/194/OHK3/3T/13.

* * *

Emission Parameters of the Cathode Spot Plasma during the Metal-to-Plasma Transition

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The initial stage of explosive electron emission represents is of most interest in the case of production of subnanosecond and picosecond electron beams in devices with explosive-emission cathodes. In this work we have developed, based on the electron density functional theory, a self-consistent model that allows one to calculate the emission parameters of the cathode spot plasma in the range from the metal density to a density of $\sim 10^{18} - 10^{20}$ cm^{-3} in the interval of electron temperatures from zero to ~5 eV. Calculations have been performed for a copper cathode. It has been shown that as the concentration of free charge carriers at the front the cathode flare is decreased from 10^{23} to 10^{20} cm^{-3}, the work function of the plasma decreases to about one fifth. Thus, as the free carrier density decreases due to the expansion of the cathode spot plasma, the potential well for electrons practically disappears at $n_e \sim 10^{20}$ cm^{-3}.

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* * *

Development of a Pulse Vacuum Arc Discharge in the Gap Containing an Insulator Sputtered with Electrode Material

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Based on the conducted experiment a mechanism of arc burning in the vacuum gap with an insulator sputtered with electrode material was developed. It was established that at the moment of ignition two discharges are burning between the electrodes and the areas of the sputtered layer adjacent to the electrodes, which can explain why the voltage value of arc burning in the experiment exceeds the voltage of arc burning on the electrodes of similar materials.

* * *

Electric Probe Diagnostic Supersonic Thermal Plasma Jet

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Recent years have seen increased interest in technology developments based on thermal plasma dc arc jets, such as plasma spraying, deposition of thin films or plasma synthesis. In our experiments we used electric probes for investigation of low-pressure (1 – 10 kPa) DC arc plasma jets generated in water/argon-stabilized arc. In this pressure range a transfer of flow regime takes place from the subsonic turbulent jet controlled dominantly by an entrainment of cold ambient gas to the supersonic jet. In the experiments the positively

biased probes were applied to measurement of plasma potential and electron saturation currents.
Basic information about structure and shape of supersonic thermal plasma jet were evaluated from measurements with moving electric probes. The probes were used in a regime of minimum probe current for determination of distribution of potential in the jet and in a regime of electron saturation current for characterization of distribution of plasma electric conductivity.

* * *

Degradation of Toxic Organic Waste Using Thermal Plasma Method

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There are large quantities of various hazardous organic wastes accumulated in the world. A lot of those materials contains Cl, F, P, Hg combinations that gradually degrade and form new harmful substances. During the inactivation of a various organic wastes by conventional thermal methods (distillation, desorption), the process temperature is lower than the 1,300 – 1,500 °C. This is not sufficient for proper decomposition of the waste materials. In order for complete decomposition of such materials, the reaction temperature must be raised up to 1,800 °C. The plasma is a unique environment where all the chemical reactions that are not available in conventional flue gas environments can be achieved. The temperature in the plasma electric arc zone reaches up to 50,000 °C, and the temperature of outgoing plasma flow is in the 3,000 – 8,000 °C range, which provides the possibility to achieve the necessary conditions to realize the neutralization process of the organic contaminants.

This research has been supported by the B. Postdoctoral fellowship is being funded by European Union Structural Funds project "Postdoctoral Fellowship Implementation in Lithuania".

* * *

Characterization of Thermal Arc Plasma by Means of Emission Spectra of Atoms and Molecules

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Thermal plasmas produced by arc plasma torches at atmospheric pressure have several typical features. One of them is strong mixing with ambient air which causes fast changes in properties along the plasma flow. Because of intensive radiation of excited species, optical emission spectroscopy is an efficient tool in analysis of this plasma. It is possible to observe emission lines of various components, ions, atoms and diatomic molecules. In this work we study plasma torches used for gasification of biomass. For this application it is important to know properties and composition of plasma flow in the regions where interaction with supplied material takes place. Therefore we concentrate on investigation of outer regions of the plasma flow which are characterized by mixing with ambient atmosphere and where emission spectra of molecules dominate over atomic and ionic species. As a result, we obtain temperature and distribution of various species, for example reactive OH radical.

* * *

Modelling of Energy Exchange between Electric Arc and Its Surrounding

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The contribution deals with mathematical modelling of intensively blasted electric arc burning in a cylindrical anode channel of an arc heater. The model is based on mass and energy conservation laws and Ohm's law. In comparison with previous versions of the model, some improvements have been made in the model itself (preliminary computation of some terms, individual terms in the energy equation) and in preparation of its input data (necessary corrections of measured arc voltage and corresponding power loss distribution along the device). Input data of the model are the results of numerous measurements carried out on an experimental arc heater in various experimental arrangements and under different conditions (working gas, its flow rate, input power, arc current and voltage). Attention is focused on mechanisms of energy exchange between the electric arc, the heated gas around and the cooled wall of the anode channel. The computed results are given in figures and discussed.

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* * *

Charging of Dust Grains in Plasma within Cell Model

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We consider dusty (or complex) plasmas. It is the low-temperature plasma consist of monodisperse spherical particles of the same size (dust grains) and electrons and ions (plasma itself). Under such conditions dust grains gain huge charges (thousands of electron charge) due to emission processes.The average dust grain charge is determined by Saha equation (we used the analogy between process of charging of dust grains and ionization of atoms). We took into account electrostatic effects within the cell model. This model represents plasma as the ensemble of electroneutral cells (each cell contains one dust grain) of equal radius. The radius of a cell in mean field approximation is determined as a half of average inter-grain distance. The investigation of fluctuations of the charge density into a cell and its surface allows us to go beyond standard mean field approach. Thus, the radius of stable electroneutral cell is obtained.

* * *

Non-Local Thermodynamic Equilibrium Effects on Sound Speed in Argon, Helium and Argon-Helium Thermal Plasmas

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In the present work, non-local thermodynamic equilibrium effects on sound speed in argon, helium and argon-helium thermal plasmas have been investigated at atmospheric pressure in the temperature range from 1,000 K to 30,000 K. It has been observed that sound speed is always less than the frozen sound speed at high temperatures. In argon, helium and argon-helium thermal plasmas, the maximum deviation between the frozen sound speed and sound speed increases with augmentation of non-equilibrium parameter θ. The addition of helium to argon plasma decreases these deviations for all values of non-equilibrium parameter θ. The sound speed in helium plasma is always greater than its value in the argon plasma at temperature above 6,000 K. In the initial stages of the ionization when the degree of the ionization is small, the ratio of sound speed in helium to that in argon plasma is 3.16 and at high temperatures this ratio reduces to 2.74.

* * *

The Calculations of Electronic Transport Coefficients and Pressure in Plasmas of Semiconductors

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The equation of states, conductivity etc. are important in many theoretical tasks and applications. Up to recently the plasma state of metals and semiconductors (i. e. T > 10 kK) was inaccessible for measurements. So the considered properties can be studied only theoretically. But corresponding experiments have appeared during last years. In particular, there are corresponding measurements for plasma of semiconductors. Earlier we have developed the model for calculation of electronic transport coefficients for various substances in plasma state within the relaxation time approximation. The ionic composition, necessary for this calculation, has been obtained within the generalized chemical model, which produces the pressure too. Here, we have calculated the pressure, conductivity, thermal conductivity and thermal power forB, SiandCin low-temperature plasma. Our data are in good agreement both with experimental results and calculations of other researchers.

This research has been supported by the RFBR grants 13-08-12248, 14-08-00536.

* * *

Ion Acceleration from Self-similar Expansion of a Non-quasi Neutral Plasma into Vacuum

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We obtain a new self-similar solution which describes the expansion of a finite plasma mass into vacuum with a full account of charge separation effects. The solution exist only when

the ratio $\Lambda = R/\lambda_D$ of the plasma scale length R to the Debye length $\lambda_D$is invariant under the condition $T_e(t) \propto [n_e(t)]^{1-2/\nu}$, where ν = 1, 2, 3, corresponds respectively, to the planar, cylindrical and spherical expansion geometries. The ion fluid is assumed to have a finite radial extension $0 \leq r \leq R\xi_f$. The functions N_i and v_i/R are defined only inside the interval $0 \leq \xi \leq \xi_f$. The electron fluid, on the contrary, extends to infinity and the functions ϕ, $N_e$and v_e/R are defined for all $0 \leq \xi < \infty$. For $\Lambda \gg 1$ the position of the ion front and the maximum energy $\varepsilon_{imáx}$of accelerated ions are calculate: in particular, for ν=3 one finds $\varepsilon_{imax} = 2ZT_{eo}W(\Lambda^2/2)$, where W is the Lambert function.

* * *

Composition and Thermodynamic Properties of Fe-containing High-temperature System

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The equilibrium composition together with the thermodynamic properties of the system containing possible reaction products of oxygen and hydrogen with iron for temperatures up to 10,000 K is presented. The computational method is based on the free energy minimization, while the total thermodynamic functions of the system are given by standard thermodynamic functions and corresponding standard enthalpies of formation of individual substances forming the system. The temperature dependences of the standard thermodynamic functions for the iron-containing molecules in the temperature range from 298.15 K to 50,000 K at standard pressure 1 bar have been evaluated mainly on the basis of theoretical and, often incomplete, experimental data. The estimation of structure, energetics and missing molecular characteristics as geometry and harmonic frequencies has been obtained by quantum chemistry methods. The standard functions for many substances of interest have not been published yet.

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* * *

Magnetized Pre-sheath in an Oblique Magnetic Field: Some Effects of the Source Terms

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A fluid model of the sheath formation in an oblique magnetic field is presented. In the continuity equation three different source terms are taken into account: the zero source term, the constant source term and the exponential source term. The continuity equation and the equation of motion are transformed into a system of 4 differential equations for 4 unknown functions. For the boundary conditions the magnetic field aligned ion flow is selected. When V_x reaches unity the system becomes singular and respective *x* is identified as the sheath edge position x_{SE}. It turns out that for the exponential and constant source terms the choice of initial ion velocities between 10^{-6} and 10^{-8} has almost no effect to the solutions. But

for the zero source term the initial ion velocity has strong influence on the pre-sheath length. In order to sobtain the x_{SE} of the same order as for the previous two source terms the initial ion velocity must be increased by 7 orders of magnitude.

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* * *

Wave-particle Interaction as a Possible Source of Electron Heating in E × B Fields Driven Instabilites

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An anomalous electron heating in the **E** × **B** fields driven instabilities is usually studied under the Farley-Buneman (FB) instability conditions. Using PIC simulations, we study how the electron heating evolves out of the FB limit for different types of ion-neutral collisions. Electron temperature is easily determinable in our simulations: because of Maxwellian velocity distribution of electrons, their temperature relates to the second moment of the velocity distribution. We observe the strongest electron heating for the ion-neutral elastic collisions, while the largest electrostatic potential fluctuations are for the ion-neutral charge exchange collisions. Wave spectra, obtained from the Fourier transform of electrostatic potential, suggest wave-particle interaction around electron thermal veloci to which can provide energy transfer between the wave and electrons and heat them up. Our results can be useful for explaining some ionospheric observations and measurements.

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Nonelinear Study of Electron Plasma Oscillation on Dense Magnetized Electron-hole Dusty Quantum Plasma

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The nonlinear properties in quantum electron-hole-dust magnetoplasmas are investigated by employing quantum hydrodynamic equations QHD along with Poisson equation. For this purpose, reductive pertur-bation method is applied and quantum Kdv equation is derived. It is

found that Kdv equation is modified under quantum Bohm potential term and soliton dispersive part is purely quantum mechanical.

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* * *

Glow Discharge Mixture of Ar/He

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Glow discharge mixture of Ar/He at a pressure of 266.66 Pa is experimentally investigated by optical emission spectroscopy and double Langmuir probe at various mixture compositions. The principal lines observed were of He I and Ar I. The electron temperature was found in the range of 2.07 to 4.70 eV, and the ion concentration in the order of 1,010 cm^{-3}. The electron temperature displays a decreasing behavior as a function of the increase in the Ar concentration, whereas the ion density clearly increased. This behaviour may be explained because if Argon concentration increases in the mixture, there are more electrons in the system which leads to an increase in the density of generated ions, this increase requires lower electron temperatures to provide the required ionization rate.

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* * *

Quantum Mechanical Calculation of the Mobility of the C+ Ion in a Cooled He Gas at 4.3 K

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On the light of the suggestion mentioned in a recent paper of Matoba et al., we have performed full quantum mechanical calculations of the mobility of C^+ ions moving in a cooled buffer helium gas. Hence, this work is realized by the means of the calculated interaction potentials corresponding to ground C^+ (^{2}P) – He(^{1}S) state and the metastable C^+ (^{4}P)-He(^{1}S) state which are achieved with morplo. Then we use the computed quantum-mechanical transport cross sections in the Viehland gramchar Fortran code as to get the mobility of C^+ ions at 4.3 K gas temperature. A good agreement is acquired with the experiment.

Exact Kinetic Theory for Beam-Plasma Instabilities in Arbitrarily Oriented Magnetic Fields

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Collective beam-plasma interaction plays an important role in different astrophysical phenomena and in laboratory fusion experiments. One of the most important characteristics of beam-plasma interaction is the linear growth rate of oscillations. To calculate it we use the numerical code that allows to analyze the full unstable spectrum taking into account both kinetic and relativistic effects without using of any simplifying assumptions.
In the present study, we investigate how the finite angle between the beam velocity vector and the magnetic field vector can affect the instability growth rate. We focused on the questions if oblique instabilities can play the dominant role under the influence of obliquely injected electron beam and how efficiently such a beam can drive electromagnetic modes. These questions are important for identification of processes responsible for generation of electro-magnetic radiation observed in the beam-plasma experiments at the open trap GOL-3.

This research has been supported by the Russian Foundation of Basic Research (Grant Nos. 14-02-00294).

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Electron Dynamics in Non-ideal Clusters Plasma

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Irradiation of nanosized metallic clusters by femtosecond laser pulses of moderate intensities (10^{13}–10^{16}W/cm^2) has been considered recently in both experiments and computer simulations [Deppner T. et al.: Phys. Rev. A. 2006. V. 73. P. 031202R; Belkacem M. et al.: Phys. Rev. A, 73, 051201R (2006)]. Electron plasma oscillations, electron-ion collisions, relaxation rates in such nanoplasma are of particular interest in view the size effects essential for the cluster plasma [Belkacem M. et al.: Phys. Rev. A, 73, 051201R (2006), 3; Raitza T. et al.: CPP. 2009(49), 496-506]. Using the GPU-accelerated molecular dynamics simulation code the frequencies and damping of different collective plasma oscillation modes including Mie and Langmuir oscillations are studied. Dependence of the electron oscillation spectra on the choice of the interaction potential, the shape and crystallo-graphic group of ionic structure clusters are presented.

* * *

Coheretes Stuctures in Plasma Reactor

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The basic purpose of this paper was the investigation of coherent structure's occurrence in multi-component plasma. The emphasis was on the possibility of generation of soliton and double layer by means of Sagdeev-potential and reductive perturbation technic. We found that in four component plasma there are remarkable changes in the nonlinear

properties of the acoustic wave. Indeed, the presence of negative ions produces solitons as well as double layer. This study can be suitable in studying collective process in plasma reactor, which is deemed useful in understanding plasma-surface interactions, and thin films properties.

* * *

Electric Arc (Thermal) Plasma Simulation

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Eaton is a global technology leader in power management solutions and offers a broad range of equipment like circuit breakers, switchgear, arc fault detection devices, etc. In some of these devices electric arcs are used as the switching element, in other devices electric arcs occur as fault events. Virtual prototyping capabilities have been developed to predict arcing, in order to reduce expensive time-consuming prototype test, develop new products with enhanced performance, safety, reduced size and cost, and to enhance the understanding of physical processes.
The plasma model presented here is based on the MHD approach, describing the plasma as one fluid. The equations are a combination of Navier–Stokes flow equations and Maxwell equations for the electric and magnetic field. Two simulation examples are given: the current interruption in a single-break low-voltage miniature circuit breaker (MCB) and in a low-voltage double-break molded case circuit breaker (MCCB).

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Optimal Pre-ionization for Nitrogen XUV - Capillary Source

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The goal of this work is to study pre-ionization of nitrogen filled capillary plasma column for XUV source in water window region (especially l = 2.88 nm). We used specific exponent-tially damped sinusoidal main pulse current and different pre-ionization currents. The optimal conditions for XUV emission also depends on the plasma radial distribution before the main pulse. The plasma radial distribution in a capillary is caused namely by pre-ionization current. The optimal time delays of the main current pulse and optimal pre-ionization current for the best plasma conditions and maximal value of radiation intensity are determined. The available Npinch and RMHD Z* codes were used for modeling of both plasma pre-ionization and also for pinching plasma driven by main pulse current.

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Coupling of Ballooning Instability with Thermal Instability under Fusion Reactor Conditions

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We consider the ballooning instability in specific Snow-Flake (SF) topology of magnetic field in the vicinity to X-point. Ballooning modes appear to be the most unstable in this region due to an increase of potential magnetic well. It is shown that the ballooning perturbations inside the closed magnetic surfaces are much weaker, than outside owing to the stabilizing effect of a favorable magnetic curvature in inner side. The upper attainable density exhibits almost linear dependence on the plasma current similar to the Greenwald limit. However it differs from the Greenwald value: at low temperatures (< 100eV) this limit is less restrictive. A weak dependence on impurity content was obtained. The influence of impurities can emerge through the resistive modes, which in turn can trigger the ideal MHD modes.

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Large-eddy Simulation of Subsonic-supersonic Plasma Flow in a Hybrid-stabilized Argon-water Arc Discharge

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This paper focuses on numerical simulation of the turbulence effect in the nozzle region and upstream from a rotating disc anode in the worldwide unique type of thermal plasma generator with combined stabilization of electric arc by axial argon flow and tangential water vortex. We assume two-dimensional, axisymmetric, unsteady, compressible, radiating and turbulent plasma flow with homogeneous mixing of water and argon species. Turbulence is treated by Large-Eddy Simulation with the Smagorinsky subgrid-scale model. The complete set of conservation equations is being solved numerically with the plasma properties dependent on temperature and pressure. Results of simulation for 300 – 600 A and argon mass flow rates of 22.5 – 40 slm indicate quasi-laminar flow. The maximum space-averaged relative difference between laminar and turbulent models for each of the monitored physical quantities is less than 2 % within the volume of the discharge and less that 6 % for the outlet region.

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Modeling of Bright EUV Source Based on Specially Prepared Plasma

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EUV-lithography requires bright EUV source with a wavelength of 13.5 nm. Such materials as Li, Sn, Xe can be the candidates for laser produced plasma emitting at this wavelength. For detailed description of the processes in the target irradiated by laser the model of nonstationary non-equilibrium radiative plasma with account of level kinetics and radiative transport in spectral lines is constructed. This model is included in the 2D Eulerian RHD-code, named RZLINE. This code allows to carry out simulation of the radiation and evolution of the plasma resulting from the impact of the laser pulse. Influence of various methods with account of detailed level kinetics and radiation field self-consistently also has been studied with the two-temperature 1D Lagrangian RHD-code SND_RUSAM. This report presents the results of specific calculations (variants with different types of the target, laser pulse and plasma geometry), that give high conversion efficiency in EUV band.

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Prediction of the Post-arc Current in a SF_6 Self-blast Interrupter Using a CFD-arc Modeling

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Due to the complexity and not-well knowingness of an interruption process, it is difficult to analyze the characteristics of a SF_6 self-blast interrupter experimentally and theoretically. The computation cannot cover the testing satisfactorily because all the real processes arc not taken into account. But the knowledge of the arc behavior and the prediction of the thermal-flow inside an interrupter by numerical simulations are more useful than those by experiments. In this paper, in order to get further information into the interruption process of a SF_6 self-blast interrupter, which is based on a combination of thermal expansion and the arc rotation principle, gas flow simulations with a CFD-arc modeling are performed during the whole switching process such as high-current period, pre-current zero period, and current-zero period. Through the complete work, the plasma turbulent viscosity and intensity for three different periods were analyzed, especially during current-zero phase.

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Production of High Energy Electrons in Microwave Plasma

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It was investigated how high energy electrons were produced through PIC-MCC simulations. The results show that the high energy electrons gain their energy when they pass the E-field of a resonantly excited electron plasma wave by a microwave around cutoff density, and the acquisition energy depends on the timing and their velocity of electrons entering into a resonant region. The maximum energy of the electrons would be determined by the limited value due to a sheath potential and an energy gain when passing through a resonant region again on the way back to bulk plasma.

This research has been partially supported by JSPS KAKENHI Grant Number 25340073. We would like to express our deep appreciation to Plasma Theory and Simulation Group of University of California at Berkeley for their public distribution of the PIC code (xpdp1).

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Atmospheric Argon Free-burning Arcs with the Energy Flux Going into the Cathode Using CFD-arc Modeling

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Electrode erosion is indispensable for atmospheric plasma systems, as well as for switching devices, due to the high heat flux transferred from arc plasmas to contacts, but experimental and theoretical works have not identified the characteristic phenomena because of the complex physical processes. The metallic vapors with high electrical conductivities change the hermodynamic and transport properties of working gas and its insulating properties through the diffusion process. To the previous study, we have investigated atmospheric argon free-burning arcs with the energy flux going into the anode using the computational fluid dynamics (CFD) analysis. At this time, our investigation is concerned with another electrode, cathode, erosion argon free-burning arcs by the similar approach. We are also interested in the energy flux and temperature transferring to the cathode with a simplified unified model of arcs and their electrodes.

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Numerical Simulation of Low Pressure Inductively Coupled Plasma Sources for Nanostructured Carbon Deposition

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Numerical study on low pressure inductively coupled plasma used for nanostructured carbon deposition has been performed with direct simulation Monte Carlo method and electron Monte Carlo simulation. Spatial distributions of electron density, electron temperature, and plasma

potential are obtained. The electron energy distribution functions (EEDFs) are compared with the experimental results obtained with a Langmuir probe. The EEDFs of an Ar and a CH_4/H_2 plasma obtained from the simulation agree well with the measured data. The calculated EEDF of a CH_4/H_2 plasma at 50 mTorr exhibits a hump around 6 eV, which corresponds to a hump around 6 eV in the measured EEDF at the same pressure. It can be attributed to the resonant peak of the vibrational excitation cross section of CH_4 molecule. The complex hump structure appeared in the EEDF of a CH_4/H_2 plasma is discussed by considering different inelastic interaction channels between electrons and heavy particles in molecular plasmas.

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Particle-in-cell code and Poisson equation solver parallelisation

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Numerical simulations based on PIC technique like the SPICE2 model developed at IPP ASCR are often used in tokamak plasma physics to investigate the interaction of edge plasma with plasma-facing components. The SPICE2 model has been parallelised with the exception of the Poisson equation solver, which considerably slows down the simulations. It is now being upgraded to a parallelised version to be efficient enough to perform more demanding tasks like the ITER tokamak baseline scenario edge plasma, which is characterized by very high density (up to 10^{20} m^{-3}) and low temperature (1 – 2 eV). This leads to extremely small Debye length (10^{-7} m) and enormous grids (thousands of cells in each direction). This in combination with a shallow magnetic field inclination (1 – 2 deg.) results in simulations taking several months to compute. Performance and scaling are compared for different solvers using the Helios IFERC supercomputer in order to choose the optimal candidate for specific conditions.

* * *

Charging of Macroparticles in a High-voltage, Vacuum Arc Sheath

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The charging of macroparticles (MPs) in front of the negatively biased metal surface emitted the secondary electrons due to bombardment by multiply charged ions with low impact energies (below 1 keV) has been investigated. The numerical calculations are carried out assuming that the MPs have no effect on the sheath. The MP potential relative to the sheath, MP charge have been calculated as a function of the MP position in the sheath. It is established that the the MP charge is considerably governed by the bias of the substrate. When the substrate is more negatively biased, the MP charge increases. The control of the MPs by modifying the bias of the substrate and selecting the materials of the cathode is possible.

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Microwave Dual-polarization Diagnostics in Toroidal Plasma

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O-mode phase shift is proportional to average plasma density along the hord of probing. However for extraordinary X-mode phase shift depends not only on plasma density but also on confining magnetic field. For torsatron-type devices confining magnetic field is known. Thus, additional information as to plasma density profile may be inferred from the X-mode phase shift measurements. First measurements of phase shifts were performed and plasma density profiles were established for Uragan-3M. The one-chord O-mode multifrequency (frequency sweeping) reflectometry was developed in detail up to now and successfully applied in tokamaks for this purpose. Here we offer the simulteneous using of O- and X-mode plasma reflectometry as the way for reconstruction of plasma density profile and poloidal magnetic field profile, too. The original algorithm was created to solve the integral equation for X-mode phase shift. It allows us to solve the inverse problem of poloidal field reconstruction.

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The Influence of Topological Defects on Processes of Mass Transfer in Two-dimensional Systems

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Study of structural properties of non-ideal systems is of great interest from a fundamental point of view. Special focus is on two-dimensional (2D-) systems, where phase transitions may qualitatively differ from those in 3D-systems. One of the reasons for this fact is the possibility of direct experimental verification of existing analytical and numerical results, for example, in experiments with monolayer dust structures in plasma of radio frequency capacitive discharge. In this work we present the results of numerical studies of influence of topological defects on processes of mass transfer in two-dimensional systems. Calculations have been performed in a wide range of parameters, corresponding to the experimental conditions in the laboratory dusty plasmas. A relation between a number of topological defects, a coupling parameter of the system and a diffusion coefficient for particles in two-dimensional non-ideal systems with various isotropic potentials was found for the first time.

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Low-pressure Plasma Sources with Localized Power Absorption Operating from 0.35 to 2.45 GHz

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The operational performances of the plasma sources are commonly considered in terms not only of pressure and absorbed power but also of excitation frequency, especially in terms of coupling efficiency to the plasma when it comes to the high frequency discharges. In this

frequency range numerous studies are already performed in the RF (13.56 to 200 MHz) as well as in the MW (0.2 to 2.45 GHz) discharges, this last in particular concerning the well known surface wave discharges. Our study focuses on the compact microwave plasma sources (few cm in diameter) consisting of a coaxial line from the generator up to the plasma coupling plane. The coupling modes and conditions required for the capacitive-inductive transition are investigated over a large pressure and power range for two frequencies 3.5 and 2.45 GHz. This comparative study is carried out through the characteristics of the plasma, notably electrical parameters (impedance, electrical permittivity, plasma density).

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How Can Plasmas Create 1D or 2D Nanostructures?

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Plasma might play important role for nanotechnologies in the near future, since the plasma is the only method that can produce large scale and abundant quantities of 1D or 2D nanostructures like nanowires and nanotubes or nanowalls and nano-thin sheets, respectively. The advantage of plasma growth is not only abundant quantity, but short time-scales of synthesis and many other advanced properties of materials, e.g. single-crystallinity of materials, superstructure of crystal lattices, pureness, etc. Moreover, such materials show improved performance to others nanomaterials synthesized by other methods when tested in devices. Growing different nanostructures, especially more complex ones like 1D or 2D depends significantly on plasma parameters of interacting plasmas and surface conditions during the growth. The selectivity criteria of plasmas is based mostly on fluxes of charged species and neutral atoms to the surface as well as potential at the surface.

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Plasma-based Growth and Functionalization of CNT from First Steps to Technological Applications

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Carbon nanotubes are important building blocks for novel applications in science and technology. They can be used for example for chemical or biological sensors as in connection microelectronics devices. In this contribution we report experiments performed in low-pressure capacitively coupled RF C_2H_4 in H_2 or NH_3 mixing gasplasma which is used to grow densely packed vertically aligned CNTs on different sets of substrates and catalysts.Depending on the catalyst/substrate nature the CNT morphology presents multi-walled graphene or bamboo-like structures. Important parameter for the future applications concerns the surface modification of CNT. We focus on the controlled functionalization of CNT carpets by low temperature nitrogen plasmas. The effect of the plasma is analyzed by NEXAFS and XPS, and surface properties of materials by contact angle measurements. Electrical and thermal characterrization of CNT films has been achieved to determine their potential use in microelectronics devices.

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Cold Atmospheric Plasmas for Medical Applications

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Intense research efforts in low-temperature (or cold) atmospheric plasma (CAP) applications in bioengineering led to the foundation of a new field, plasma medicine. Varieties of novel plasma diagnostic techniques were applied in a quest to understand physics of cold plasmas. In particular it was established that the streamer head charge is about 10^8 lectrons, the electrical field in the head vicinity is about 10^7 V/m, and the electron density of the plasma column is about 10^{19} m^{-3}. We have demonstrated the efficacy of CAP in a pre-clinical model of various cancer types (lung, bladder, breast, head, neck, brain and skin). Both in-vitro and in-vivo studies revealed that CAPs selectively kill cancer cells. It was shown that reactive oxygen species (ROS) metabolism and oxidative stress responsive genes are deregulated. Simulations of the cold plasma interaction with tumor performed showed reasonable agreement with experimental evidence.

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On the Dynamics and Active Species of Room Temperature Plasma Plume

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This paper focuses on one of the fundamental phenomena, namely the formation and propagation of ionization waves - streamers. Plasma bullets are guided ionization waves moving in a thin column of a jet of plasma forming gases (e.g., He or Ar) expanding into ambient air. In contrast to streamers in a free (unbounded) space that propagate in a stochastic manner and often branch, guided ionization waves are repetitive and highly-reproducible and propagate along the same path - the jet axis. This property of guided streamers, in comparison with streamers in a free space, enables many advanced time-resolved experimental studies of ionization waves with nanosecond precision. This paper introduces the recent advances on the experimental and computational studies of guided streamers, in particular related to the propagation dynamics of ionization waves and the various parameters of relevance to plasma streamers.

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Fluorine-free Super-hydrophobic Coatings Prepared Using Gas Aggregation Sources

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Superhydrophobic surfaces are of long-term interest that is connected with wide range of their possible applications. The most often materials used for fabrication of highly hydrophobic films are, due to their extremely low surface energy, fluorocarbons. However, fluorocarbons are in some

cases undesirable and thus alternative materials need to be used. From this point of view C:H or C:H:O:Si plasma polymers are considered as promising candidates to replace fluorocarbons. In order to enhance water repellent character of C:H or C:H:O:Si coatings, they have to be nanostructured. In this study we present an approach that combines PECVD with deposition of nanoparticles produced by gas aggregation sources. It is shown that this allows independent adjustment of chemical composition and surface roughness of coatings including possibility of production of surfaces with dual-scale roughness. Optimization of the deposition process enables production of fluorine-free superhydrophobic surfaces.

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Fusion Technology Research in Rez, Czech Republic

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Research Centre Rez (CVR) has carried out a number of testing and R&D activities in the fusion technology research of the ITER and the DEMO nuclear components. These contributions have led to the development of numerous experimental facilities, especially HHFTF BESTH device and in-pile TW3 rig, in-pile CHOUCA rig, in-pile LiPb rig or Meliloo LiPb loop. CVR cooperates with the European Agency F4E on the development of new HHFTF and is a member of the European Consortium TBM-CA, in which is involved in the development of TBMs. Three new facilities are under construction: the 14 MeV neutron generator, the HHFTF HELCZA and the TBM Platform. Within the framework of the European Consortium EUROfusion CVR performs research in the areas of breeding blanket, divertor and safety in accordance with Fusion Roadmap of the EFDA. The paper provides an overview of research activities and experimental facilities CVR, in part focused on the HHF testing of PFC.

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