P 12: Atmospheric-pressure plasma and applications 3

Time: Wednesday 11:00–12:45 Location: b305

Invited Talk P 12.1 Wed 11:00 b305

Surface modification with atmospheric-pressure plasmas - applications and challenges — •Claus-Peter Klages, Lars Bröcker, Andreas Czerny, Stefan Kotula, Meret Leonie Lehner, Andris Martinovs, and Vitaly Raev — Institute for Surface Technology, Technische Universität Braunschweig, Braunschweig, Germany

Since the early 1990, soon after demonstration of stable uniform dielectric-barrier discharges by a group at Sophia University in Tokyo, the number of scientific papers concerning applications of atmospheric-pressure plasmas for surface treatment has been increasing rapidly up to between 150 and 200 per year in the recent decade. In the industry, so-called *corona treatment* was introduced much earlier - already around 1950 to render polymer surfaces wettable or, in the 1960, to degrease aluminum surfaces. In spite of a long and successful technical history of applications, fundamental mechanisms of the interactions between discharges and organic or inorganic surfaces and products of these interactions are to a large extent still unknown. The lecture will give an account of recent work at Fraunhofer IST or at IOT/TUBS on applications of barrier discharges for treatment of inorganic surfaces such as silicon, silica, aluminum or silver, and on recent studies on the plasma-nitrogenation of polymer surfaces and low-molecular-weight model compounds, utilizing flowing post-discharges as well as single-filament discharges in nitrogen. Results of infrared-spectroscopic investigations of plasma-nitrogenated samples are compared with densities of reactive nitrogen species in the gas phase.

P 12.2 Wed 11:30 b305

Experimental Investigation of a Plasma Electrolytic Polishing Process for the Pretreatment of Cemented Carbide — •Sehoon An[1], Rüdiger Foest[1], Katja Fricke[1], Luka Hansen[2], Thorben Kewitz[1], Hendrik Riemer[3], Maik Fröhlich[4], Holger Kersten[2], and Klaus-Dieter Weltmann[1] — [1]Leibniz Institute for Plasma Science and Technology, Greifswald, Germany — [2]Institute of Experimental and Applied Physics, CAU, Kiel, Germany — [3]Technical University, Berlin, Germany — [4]University of Applied Sciences, Zwickau, Germany

Plasma electrolytic polishing (PEP) has gained much attention owing to the significant improvement of surface properties within short time, but also because of its ecological benefits. We report on PEP processes for the pretreatment (cleaning) of cemented carbide, a typical material for tools. Depending on electrolyte temperature, concentration and process voltage, optimum operating conditions could be identified. Beneficial conditions for cleaning are between 100 V and 150 V for current densities in the range of 0.2 to 0.8 A/cm2. Investigations on the energy flux towards the workpiece were conducted by employing a thermocouple and monitoring the temperature. Distinct heating phases are observed and discussed in relation to different contributing factors to the total energy flux. In addition, the surface status of the cemented carbide after PEP was examined using SEM and AFM. For tribological assessment, the samples were coated with an AlTiSiN layer. Tool lifetimes comparable to conventional pre-treatment could be achieved but with less consumption of harmful chemicals.

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Electric field behaviour of a micro cavity plasma array measured by Stark shift of helium — •Sebastian Dzikowski[1], Sylvain Iseni[2], Marc Böke[1], and Volker Schulz-von der Gathen[1] — [1]Ruhr-University, Bochum, Germany — [2]GREMI, Orleans, France

Micro-structured array devices get more and more interest for gas reformation and plasma catalysis. In case of devices where cavities are integrated in the dielectric the applied electric field can strongly influence the interaction between plasma and catalyst.

Here we present a metal-grid array device consisting of a powered metal-grid, a dielectric foil and a grounded magnet. The grid contains uniformly arranged cavities with dimensions in the one hundred micrometer scale. This sandwich-like structure allows disassembling and exchange of the dielectric foil with catalytic properties. Typically, the metal-grid array operates close to the atmospheric pressure and is applied with a bipolar triangular voltage waveform with an amplitude up to 800 V at 15 kHz.

To measure the internal electric field, we use the 492.19 nm helium line that gets split in an allowed and forbidden counterpart. The distance between the two components is proportional to the electric field.

We present and discuss time-averaged and time resolved measurements depending on typical operation parameters such as applied voltage, cavity diameter and frequency.

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The spatial distribution of HO2 in a cold atmospheric pressure plasma jet investigated by cw cavity ring-down spectroscopy — •S.-J. Klose[1], M. Gianella[2], K. Manfred[2], H. Norman[2], G. A. D. Ritchie[2], and J. H. van Helden[1] — [1]Leibniz Institute for Plasma Science and Technology (INP), Greifswald, D — [2]Department of Chemistry (PTCL), University of Oxford, UK

In order to tailor the impact of cold atmospheric pressure plasma sources on biomedical or semiconductor targets, a profound understanding of the chemical reaction network is pivotal. One big open question in the field of plasma-liquid interaction is still, where the reactive species come from: Are they produced in the gas phase and diffuse into the liquid or are they formed via secondary reactions inside the liquid? We investigate the gas phase reactions of the cold atmospheric pressure plasma jet kINPen, already used for wound healing and in cancer research, in order to understand the reaction kinetics of H2O2, which is a key species in the plasma to cell interaction. The small diameter of these plasma jets, which is usually in the order of mm's, makes diagnostics challenging. A common approach to obtain absolute species densities are absorption spectroscopy techniques. To increase the absorption path length, cavity-enhanced spectroscopy methods can be applied. However, with these techniques often line-of-sight densities without any spatial information are obtained. Nevertheless, with cw cavity ring-down spectroscopy, we were able to determine the spatial distribution of the HO2 radical that is involved in the formation and destruction of H2O2.

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Loss processes of plasma-generated atomic oxygen in phenol solutions — •Kerstin Sgonina[1], Giuliana Bruno[2], Kristian Wende[2], and Jan Benedikt[1] — [1]Institute of Experimental and Applied Physics, Kiel University, Kiel, Germany — [2]Leibniz Institute for Plasma Science and Technology, Greifswald, Germany

Aqueous solutions treated by cold atmospheric pressure plasma jets contain high amounts of reactive species. It has already been shown that atomic oxygen produced by a cold atmospheric pressure plasma jet effectively reacts with organic molecules like phenol dissolved in water without any intermediate reaction steps [1]. However, it is unknown whether the reactions with atomic oxygen are liquid-surface or liquid-volume dominated.

To investigate the loss processes of atomic oxygen in liquid solutions, experimental results are combined with simulations of the reaction kinetics. Phenol solutions were treated with the effluent of a He/O_2-plasma ignited in the COST-Jet which provides well-known densities of reactive oxygen species [2]. Variation of the phenol concentration allows an insight into the competing O-loss reactions in gas phase, liquid phase or at the liquid surface. The comparison to simulations of the reaction kinetics and transport from gas into liquid should reveal the up-to-now unknown absolute reaction rates of atomic oxygen in liquid phase and at the liquid surface.

[1] J. Benedikt *et al.*, Phys. Chem. Chem. Phys. 20 12037, 2018.
[2] G. Willems *et al.*, New J. Phys. 21 059501, 2019.

P 12.6 Wed 12:30 b305

Plasma Medical Investigations for Disinfection of Different Surfaces and Their Modifications Caused by Cold Atmospheric Plasma Treatment — •Sandra Moritz[1], Alisa Schmidt[1], Joachim Sann[2], and Markus Thoma[1] — [1]1. Physikalisches Institut, Justus-Liebig University, Gießen, Germany — [2]Physikalische Chemie, Justus-Liebig University, Gießen, Germany

Inactivation of microorganism on sensitive surfaces by cold atmospheric plasma is one major application in the field of plasma medicine, because it provides a simple way to sterilize heat-sensitive materials. Therfore, one has to know whether plasma treatment affects treated surfaces. In this contribution, the effect of cold atmospheric surface micro-discharge (SMD) plasma on plasma-treated surfaces was investigated. Hence, different material samples (stainless steel, different polymers and glass) were plasma-treated for 16 hours using an SMD plasma device. Furthermore, the device was used to investigate the behaviour of Bacillus atrophaeus inoculated on the material samples at different treatment times. Afterwards, the material probes were analysed using surface analysis methods such as laser microscopy, contact angle measurements and X-ray photoelectron spectroscopy. The results show in case of the treated bacteria that a log reduction in bacterial number between 3.0 and 6.0 can be achieved within only 15 min of plasma treatment. In accordance to this results, surface analysis revealed, that there were three different types of reactions the probed materials showed to plasma treatment, ranging from no changes to shifts of the materials' free surface energies and oxidation.