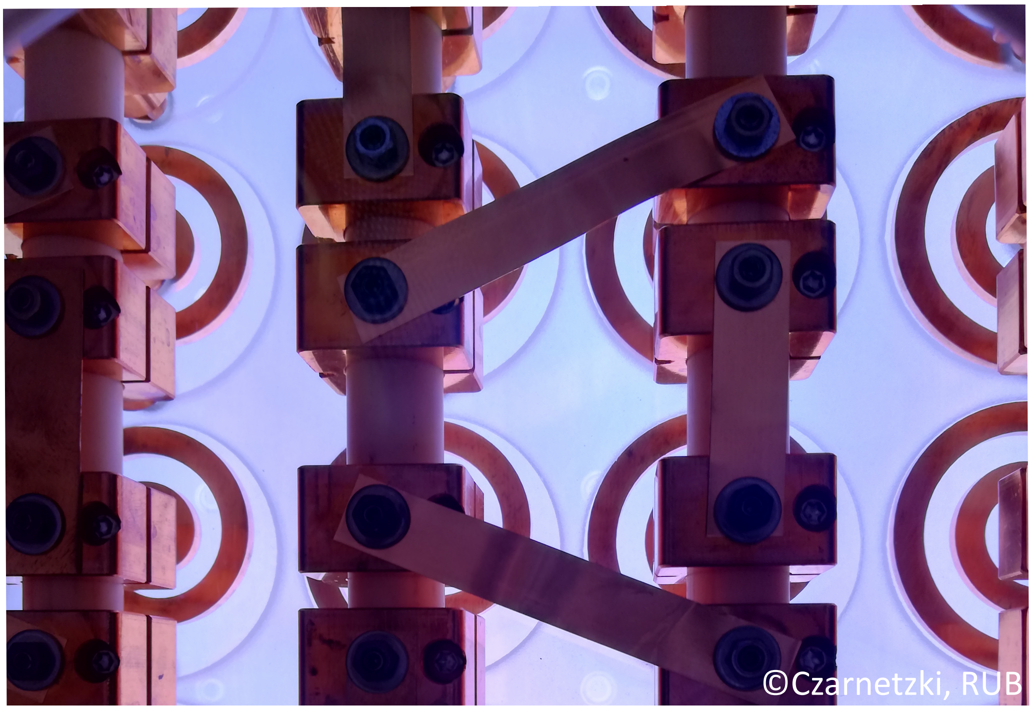
SFB-TR 87

SFB 1316

NEWSLETTER

EDITION 7



Foreword

Challenge to handle expectations on the newsletter

The focus of a research consortium has different aspects depending on the person who is asked. As a central administration project, the public relations should address different target groups with their work. Naturally, the target groups are people from outside the research consortia, which is very intuitive. Here, the research activities should be communicated in an informative way regarding recent scientific work. However, research communication also within the research consortia is a main aspect, which should be achieved. This also includes the scientists within the projects themselves, who are addressed by this newsletter.

Regarding, the structure of a research consortium, the newsletter has to fulfil a wide range of expectations from the spokespersons of the CRCs over the project leaders, from scientific staff to Bachelor students and also from external partners. Thus, the job of the team members of the project public relations, who select the articles for the newsletter, is not as easy is it might seem. Therefore, we would first like to thank the people within the collaborative research centers for their feedback and support in the different articles.

The content of the recent newsletter of the SFB-TR 87 and CRC 1316 should mirror this diversity of people. We present recent research activities as well as students within the CRCs. Furthermore, joined meetings beside the 'daily' business will be represented. Each of the presented articles is well selected and should show the different working aspects within the research centers.

As the work within the public relations is essentially supported by students, the team of public relations changes every now and then. I would like to thank Katharina Nösges and Simon Kreuznacht for their past work within the team. They are now starting to work in their scientific projects and will not be able to support the team for public relations any more. Thus, the team of public relations is now looking for a new candidate (with our without Bachelor degree in one of the CRCs). The team public relations is now looking for one motivated, communicative, self-dependent student, who would like to work with us. Please tell us if you are interested to work in this project or if you know someone who might be.

Marina Prenzel, public relations

Graduate

Dr.-Ing. Frederik Schmidt

Recently the SFB-TR 87 member Frederik Schmidt from project C4 finished his PhD with summa cum laude. His PhD thesis has the title "Technische Hochfrequenzplasmen und ihre Wechselwirkung mit externen elektrischen Netzwerken" (*High frequency technical plasmas and their interaction with external electrical networks*).

In detail, to understand plasma processes in detail, simulations can provide additional insights. Often, however, the nonlinear interaction of the plasma with the external electric network, e.g. generator or impedance matching, is neglected or strongly simplified in these simulation frameworks. In this work several methods are introduced, which allow the user-friendly simulation of the plasma with external circuits simultaneously.

Katharina Nösges, public relations

Recent research activities

Fueling biocatalytic reactions with non-thermal plasmas

Non-thermal plasmas have gained significant interest in various fields of biology, including cancer treatment, wound healing, surface sterilization and enhancement of plant growth [1]. In many of these applications, the plasma-induced production of reactive oxygen and nitrogen species (RONS), both in the gas phase as well as in the liquid phase, is crucial. Numerous studies have shown that RONS are toxic for virtually all biomolecules, including lipids, DNA and enzymes [2]. Nevertheless, one of the RONS, hydrogen peroxide (H_2O_2), is produced in high amounts in plasma-treated liquids and has recently emerged as a valuable oxidant to drive enzymatic conversion of hydrocarbons into value-added products [3].

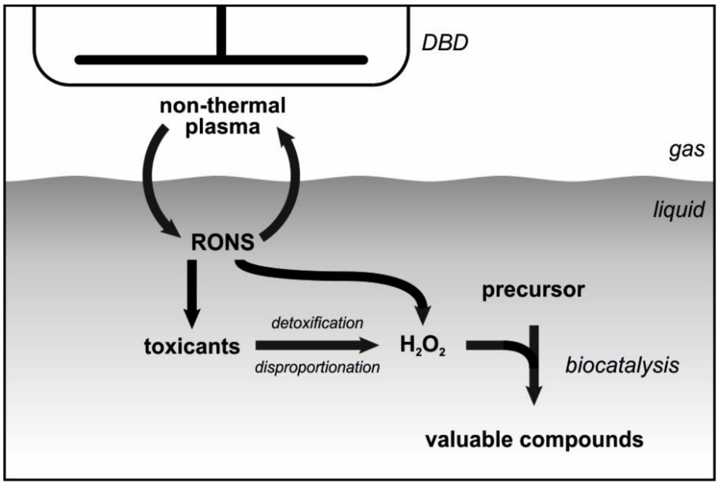


Figure 1: ***Proposed scheme for plasma-driven biocatalysis.*** *Non-thermal plasma, preferably generated by a DBD device, interacts with the aqueous phase and produces reactive oxygen and nitrogen species (RONS), e.g. peroxynitrite ($ONOO^-$), superoxide (O_2^-), or H_2O_2. While some of these RONS present toxic or undesired side products, H_2O_2 can be used by biocatalysts to convert precursor molecules into more valuable compounds.*

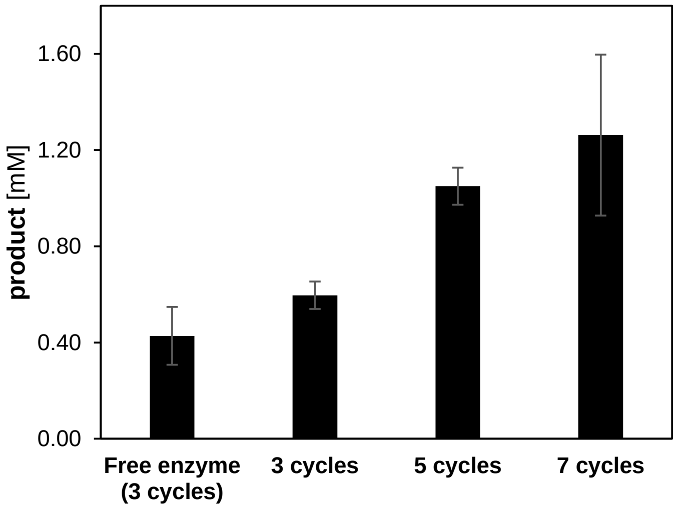


Figure 2: ***Biocatalysis with immobilized enzyme and buffer treated for several cycles.*** *Buffer was treated with a DBD and subsequently added to a reaction vessel containing precursor and immobilized enzyme. After conversion was allowed to complete, the buffer was re-treated with the DBD and the next cycle of biocatalysis initiated.*

We therefore set out to investigate whether non-thermal plasmas can drive reactions using enzymes as biocatalysts (Fig. 1). Indeed, when a solution containing substrate and enzyme was treated, conversion of the precursor was observed.

However, enzyme activity decreased plasma-dependently. The enzymes used in this work belong to the classes of peroxidases and peroxygenases which are known to be inactivated by excess H_2O_2 [3]. Therefore, inactivation of enzymes by exposure to plasma was investigated. Generally, all tested enzymes where inactivated on a time scale of minutes with the tested DBD source. However, when enzyme and precursor were added after plasma-treatment was completed, no activity loss was observed and biocatalysis was successful. In order to extend the lifetime even further and enable recycling, enzymes were immobilized on solid supports. Immobilization resulted in a ≈ 20 fold lifetime increase after plasma exposure. As shown in Fig. 2, with the immobilized enzyme, no catalyst poisoning was observed for several cycles of plasma-driven biocatalysis, indicating that other long-living, plasma-induced RONS other than H_2O_2 do not significantly contribute to enzyme inactivation. Most importantly, plasma-exposure did not alter the specificity of the enzyme, yielding a highly-pure solution of product after biocatalysis. Currently, further protection measures and other enzyme systems are being investigated to explore the applicability of this approach.

[1] I. Adamovich, S. D. Baalrud, A. Bogaerts, P. J. Bruggeman, M. Cappelli, V. Colombo, U. Czarnetzki, U. Ebert, J. G. Eden, P. Favia et al., J. Phys. D: Appl. Phys. 2017, 50, 323001.

[2] J.-W. Lackmann, J. E. Bandow, Appl. Microbiol. Biotechnol. 2014, 98, 6205.

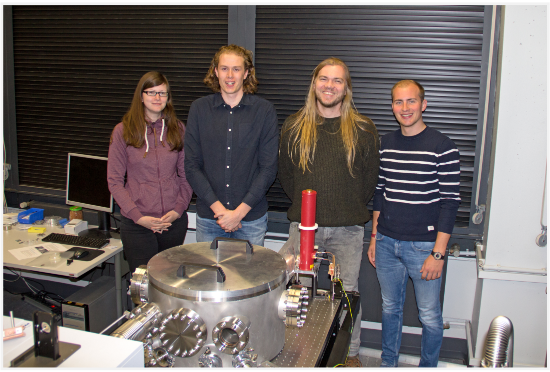
[3] Y. Wang, D. Lan, R. Durrani, F. Hollmann, Curr. Opin. Chem. Biol. 2017, 37, 1.

Abdulkadir Yayci & Julia Bandow, project B8 of the CRC 1316

Mercator activities

Erasmus student joins CRC 1316 project

Between March 25th and July 19th, 2019 the Erasmus student **Roel Michiels** visits the research group EP2 of Prof. von Keudell at Ruhr University Bochum. He joins project A3 from the CRC 1316 "Excitation transfer between molecules in transient atmospheric pressure plasmas and its impact on plasma chemistry".



From left to right: Theresa Urbanietz, Roel Michiels, Christoph Stewig, and Steffen Schüttler from the project A3 of the CRC 1316.

Roel Michiels is associated with the group of Annemie Bogaerts from the Department of Chemistry at the University of Antwerp. He finished his Bachelor thesis last year and prepares now for his Master degree. The topic of his Master thesis is micro kinteic modelling of plasma catalysis. The modelling is done via Density functional theory (DFT) and Molecular Dynamics (MD).

Together with Theresa Urbanietz, Christoph Stewig, and Steffen Schüttler he tries to gain experience in experimental work in Bochum. His work here focuses on the measurement as well as on the analysis of FTIR spectra gained in the project.

Marina Prenzel, public relations

Young researcher interests

Interview with two students from the SFB-TR 87

The outcome of the research results in the collaborative research centers SFB-TR 87 as well as CRC 1316 is mainly being made by PhD students from the different projects. However, also Bachelor and Master students in the sub projects are essential for the general scientific outcome. Furthermore, students get a deep insight into the work within a project. This leads to a better understanding and prepares for future tasks.

Therefore, we would like to present two positions from students who did their Bachelor thesis within a collaborative research center, here the SFB-TR 87. David Schulenberg works in projects C1 of the SFB-TR 87 and Jan Löwer is member of project A5.

Dear David, dear Jan, thank you for giving this interview. We would like to learn something about your perspective on the work of a collaborative research center.

What is your recent role in the SFB-TR 87?

David: I'm a Hiwi working in the C1 project of the SFB-TR 87. My task is to build a symmetric CCP reactor which will help to determine surface coefficients of different materials.

Jan: After my bachelor thesis I focused more on the rotation velocity of spokes in HiPIMS discharges. In this context I build up new experiments and try to use new measurement techniques.

What was the topic of your Bachelor thesis?

David: Spatial and time-resolved investigation of electron heating dynamics in a symmetrical capacitive radio frequency discharge.

Jan: My Bachelor thesis had the title "Statistical analysis of spokes in HiPIMS plasmas". Within this work, I observed two methods that had been used already in order to determine the mode number of spokes in 'High Power Impulse Magnetron Sputtering' plasmas. I compared both methods and developed a new one in order to automate the determination of the mode number by simply using images of the discharge taken with an ICCD camera. In addition, I also examined the rotation velocity of these structures within the plasma.

What was your picture about physics before your Bachelor thesis and how did it change?

David: I didn't know how much of industry related physics is still not well understood, and I'm often surprised about how much there is still left to discover. I also was not aware about how much engineering work it takes to set up an experiment, before actual research on the topic can begin.

Jan: Since my thesis was the first contact with actual research, it surely gave me new insights in the world of physics. One interesting part was to read papers that were published in the last few years. Before I started with my Bachelor thesis, I wondered how real life research questions are connected with absolute fundamentals of physics in lectures.
Furthermore, I also thought that methods I learned in the first four semesters could never be really used in today's fields of research. This changed throughout my thesis since I was able to experience how detailed today's research actually is and how much patience it requires, but that it is accessible even from my point of knowledge.

How much was the connection between your thesis topic and the scope of your project?

David: *My thesis was a logical part of the project itself.*

Jan: *From my perspective both were fully linked, and I had a good feeling about actually contributing to the project. As the objective is to learn more about the inner structure and processes during the discharges and especially inside these spokes, it is important to know more about the structure and its dependency on the discharge parameters.*

What is your mind about the advantage of doing your bachelor thesis within a large consortium?

David: *It's a good chance to get support from a lot of different people and it's also nice to know that the results of the project possibly help significantly in a bigger context.*

Jan: *The main advantage clearly is the possibility to talk about every problem, challenge, question, or result that occurs during my Bachelor thesis with the members of this consortium. Furthermore, the meetings always give you an idea about the latest research progress and also the possibility to actively take part in group discussions or in planning the next steps. So, you don't work only for yourself but as part of team in a bigger project.*

Do you have any demand on the SFB, which is not fulfilled at the moment?

David: *No.*

Jan: *No.*

Marina Prenzel, public relations

Conference report

10th International Workshop on Microplasmas in Kyoto

This year, the 10th edition of the International Workshop on Microplasmas took place in Kyoto between May 20th and 24th, 2019. The scope of the workshop are the generation/sources of microplasmas, modelling, and applications (material processing, biomedical material treatments, environmental devices etc.). Around 70 participants from all over the world joined the meeting. A group of nine people from Bochum, especially from the CRC 1316 joined the conference. Finally, two oral presentations and six poster presentations were given by them.

In detail, an oral presentation was held by Sebastian Dzikowski from project A6 from the CRC 1316 with the title *Initial ignition behavior of a micro cavity plasma array (MCPA)*. Moreover, an invited talk was given by Dr. Volker Schulz-von der Gathen from the CRC with the title *Micro cavity plasma array devices: From first ignition to continuous operation*.

Marina Prenzel, public relations

About novel research activities

Precision and accuracy of atom probe tomography for TiAlN thin films

The characterization technique atom probe tomography (APT) offers spatially-resolved chemical composition analysis at the nanometer scale. Hence, this technique is extremely useful for SFB-TR 87 in order to identify local chemical composition variations and correlate them with e.g. thermal stability and phase formation [1-5].

In a recent publication from project **A3** "On the chemical composition of TiAlN thin films - comparison of ion beam analysis and laser-assisted atom probe tomography with varying laser pulse energy" (M. Hans and J.M. Schneider, Thin Solid Films, `https://doi.org/10.1016/j.tsf.2019.04.026`) we have compared the absolute chemical composition of TiAlN thin films determined by ion beam analysis and laser-assisted APT. The laser pulse energy during APT was increased subsequently from 10 to 20, 30, 40, 50, 100 and 200 pJ within a single measurement, covering the range that is typically employed for the analysis of transition metal nitrides. The laser pulse energy-dependent Ti, Al and N concentrations were compared to ion beam analysis data, combining Rutherford backscattering spectrometry (RBS) and elastic recoil detection analysis (ERDA) with the total measurement uncertainty of 2.5% relative deviation. It can be learned that the absolute N concentration from APT is underestimated by at least 5.5 at.% (up to 8.2 at.%) and the absolute Al concentration from APT is overestimated by at least 4.5 at.% (up to 6.2 at.%), while absolute Ti concentration values are for both techniques in good agreement with maximum deviations < 2 at.%.

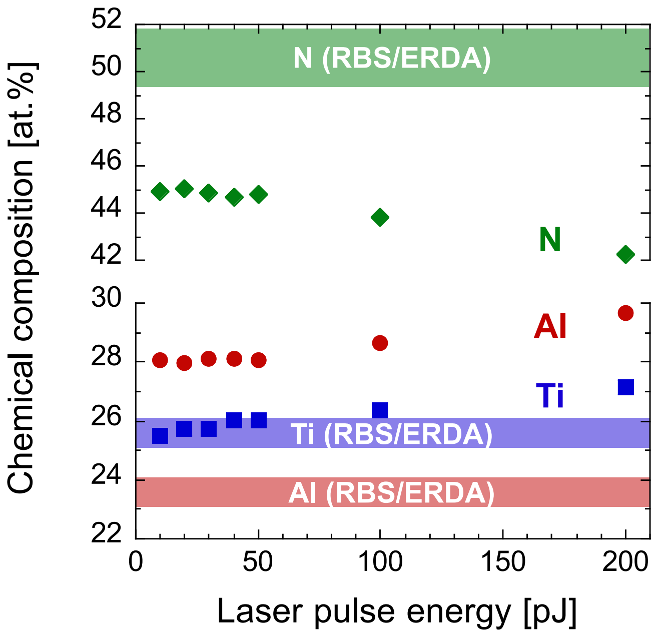


Figure 3: *Chemical composition, obtained by APT, as a function of laser pulse energy. Ti, Al and N are represented by filled squares, circles and diamonds, respectively. The colored regions indicate chemical compositions quantified by RBS/ERDA: 25.5±0.6 at.% Ti (blue), 23.5±0.6 at.% Al (red) and 50.5±1.3 at.% N (green).*

Hence, the here presented comparative analysis clearly shows that absolute Al and N concentration values obtained by ion beam analysis deviate significantly to the APT data for the laser pulse energy range from 10 to 200 pJ. Possible causes for the compositional discrepancy between RBS/ERDA and APT, such as molecular ions, multiple detection events and preferential evaporation/retention of species with different evaporation fields, are discussed. The presented data emphasize that laser-assisted APT is a precise tool to quantify the chemical composition of TiAlN thin films, that lacks accuracy.

[1] M. Hans, M. to Baben, Y.-T. Chen, K.G. Pradeep, D.M. Holzapfel, D. Primetzhofer, D. Kurapov, J. Ramm, M. Arndt, H. Rudigier, J.M. Schneider, Substrate rotation-induced chemical modulation in Ti-Al-O-N coatings synthesized by cathodic arc in an industrial deposition plant, Surf. Coat. Technol. 305 (2016) 249-253.

[2] M. to Baben, M. Hans, D. Primetzhofer, S. Evertz, H. Ruess, J.M. Schneider, Unprecedented thermal stability of inherently metastable titanium aluminum nitride by point defect engineering, Mater. Res. Lett. 5 (2017) 158-169.

[3] G. Greczynski, S. Mráz, M. Hans, D. Primetzhofer, J. Lu, L. Hultman, J.M. Schneider, Unprecedented Al supersaturation in single-phase rock salt structure VAlN films by Al^+ subplantation, J. Appl. Phys. 121 (2017) 171907.

[4] G. Greczynski, S. Mráz, H. Ruess, M. Hans, J. Lu, L. Hultman, J.M. Schneider, Extended metastable Al solubility in cubic VAlN by metal-ion bombardment during pulsed magnetron sputtering: film stress vs. subplantation, J. Appl. Phys. 122 (2017) 025304.

[5] M. Hans, D. Music, Y.-T. Chen, L. Patterer, A.O. Eriksson, D. Kurapov, J. Ramm, M. Arndt, H. Rudigier, J.M. Schneider, Crystallite size-dependent metastable phase formation of TiAlN coatings, Sci. Rep. 7 (2017) 16096.

Marcus Hans, project A3 of the SFB-TR 87

Conference organization

Successful Frontiers conference in Bad Honnef

Between May 12th and May 16th, 2019 the 13th Frontiers Low-Temperature in Plasma Diagnostics and the 1st Frontiers in Low-Temperature Plasma Simulations was held in the Physikzentrum in Bad Honnef.

The conference takes place every two years at another location in Europe. The recent Frontiers conference was organized by the Research Department Plasmas with Complex Interactions under the local chair of Prof. Czarnetzki from the CRC 1316. Here, a meeting for the simulation community was set up for the first time. Therefore, beside separated talks for each discipline, also joined sessions were offered, so that scientists could exchange their later research results. During the informal discussions and poster sessions, fruitful discussions took place.

In sum, 103 participants from both disciplines joined the meeting. Furthermore, scientists from both collaborative research centers joined the scientific meeting. In detail, six poster presentations and four oral presentations were given by members of both CRCs.

Especially for Julian Held, PhD student in project A5 of the SFB-TR 87, the meeting was a great success. He won the prize "Young Scientist award for the best oral presentation" with his contribution *Velocity distribution function of atoms and ions in HiPIMS by Doppler broadening of optical emission lines*. Congratulations to him!

Marina Prenzel, public relations

About novel research activities

Estimation of the plasma parameters during the ignition of a discharge in water

Recently, the first results of project **B7** of the CRC 1316 were published in *Plasma Sources Science and Technology*. This project adresses in-liquid pulsed plasmas generated by a high voltage power supply. In the past decade, these in-liquid plasmas became more important for different fields such as decontamination of liquids, electrolysis and plasma medicine. The objective of this project is to gain a deep understanding of these unique plasmas so that they can be used for controlled surface modification of e.g. catalytic surfaces in electrochemical cells.

The plasma is generated at a thin electrode immersed in distilled water. The ignition of the plasma is taking place on the picosecond time scale, which makes it hard to monitor the different processes leading to ignition. Therefore, a plasma ignition model was introduced to explain those fast phenomena. Additionally, time-resolved optical emission spectroscopy (OES) was performed to illustrate the change of emission spectra over time. In the afterglow of the plasma, the electron density was determined out of the H_α emission line with maximum values of 10^{25} m^{-3}. For earlier times than ~100 ns, only estimations of the electron density were possible due to the uncertainty of the analysis method. The plasma propagation and the generated gas bubble after ignition were monitored with Shadowgraphy imaging. The results were compared with a cavitation model, describing the bubble growth and collapse and the corresponding pressure and temperature evolution.

The OES measurements showed shortly after ignition a broadband continuum which is generated by recombination radiation and bremsstrahlung of the species generated by the plasma. This observation is in good agreement with the hypothesis from literature, that nanosecond plasmas with short rising times of a few ns and high applied powers are created directly *inside* the liquid and not in a previously formed gas bubble. It is assumed that the water ruptures under the influence of the high electric field which exerts a negative pressure difference at the electrode tip. The first electron avalanches which lead to plasma formation occur in so-called nanopores which then develop to streamer channels. For these processes to appear, high pressures and therefore high temperatures have to be present during the ignition process. Pressure spikes of 10-100 GPa during ignition lead to an initiation of fast sound waves propagating through the liquid.

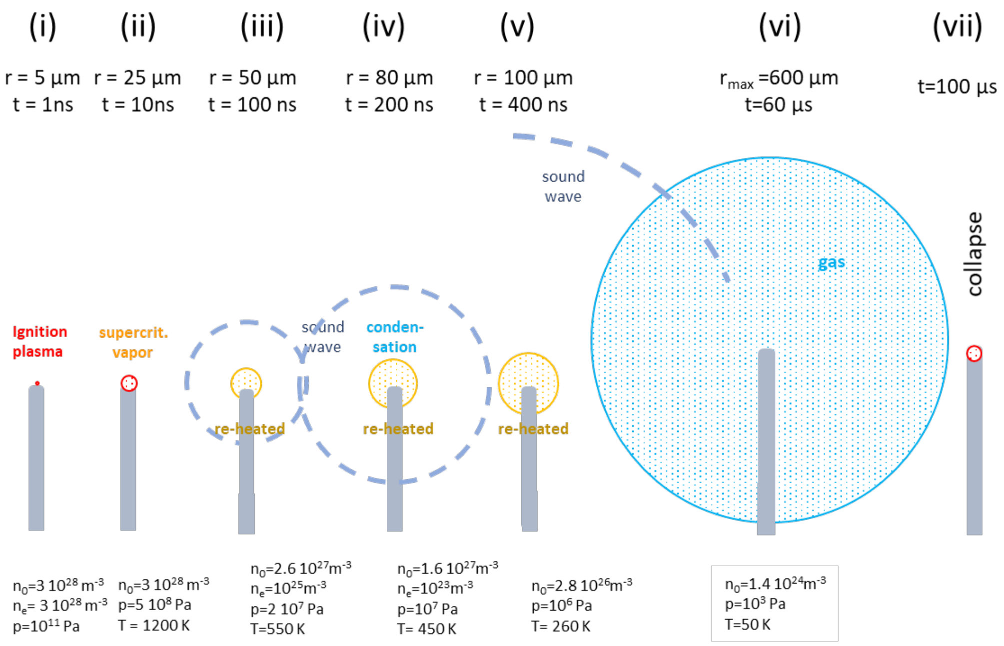


Figure 4: *Schematic of bubble properties during the expansion at different points in time (i)-(vii).*

In the afterglow, the initial high pressure from the plasma ignition causes cavitation and the hot gas drives the expansion of the bubble. Until then, the energy transport dominated the mass transfer. During the adiabatic expansion of the bubble, condensation of the water vapour causes a pressure drop and also the temperature drops significantly. Consequently, the surface tension reverses the movement and the bubble collapses.

In the framework of this study it was possible to combine theory and experiments to describe the different processes and plasma parameters at different points in time. Future work in this project will investigate the continuum radiation to derive gas temperatures for the ignition process, the production of various species as H_2O_2 and OH via absorption spectroscopy and the modification of catalytic surfaces through in-liquid discharges.

Katharina Grosse, project B7 of the CRC 1316

New members

New PhD students within the SFB-TR 87

Lara Kleines studied mechanical engineering at the RWTH Aachen. She already dealt with topics of plasma and surface technology as part of her master's thesis, where she developed coatings for a medical application.

Since June 2018, she has been working on project B1, in which investigations on the scalability of plasma processes from project area B are continued, especially by testing the influence of microwave energy sources on the homogeneity of plasma and layer properties. Furthermore, the transferability to new materials, complex substrate geometries and new applications will be investigated. As one aspect, coatings with defined separation properties are to be developed which can be used as membranes for gas separation.

In addition, the adjustability and controllability of the system properties will be analyzed in B1 by using amongst others inline monitoring of layer stress and process temperature to extend the spectrum of controllable parameters for the targeted adjustment of coating properties.

Sabrina Schwiderek studied chemistry at the University of Paderborn. She already worked in context of her Bachelor thesis in the SFB-TR 87, project B3. The focus was the investigation of pores in plasma deposited silicon dioxide. Since November 2018, she is working on project A2.

The project is about the connection of the models of interfacial interaction and interface damage, developed during the first and second project phases, to create a model for the layer-structure-dependent deposit formation by HPPMS.

The focus lies on characterization of the interaction between the hard coatings and the polymer phase and resulting effects on both. By means of this knowledge subsequently, application-relevant phenomena, for example polymer degradation and adhesive wear, will be investigated.

Promotion for future researchers

Teenagers enjoy plasma physics

During the Easter holidays the so called*Schülerprojektwoche* for 14 and 15 year old pupils took place at the Ruhr-University Bochum. The *Schülerprojektwoche* is an established part of public relations for pupils and is, belong others, organized and supported by both CRCs.

For one week 60 girls and boys did experiments in four different workshops, namely "astronomy", "plasma physics", "energy efficient house building" and "physics in medicine".

In the plasma project, which was supervised by PhD and Master students of both CRCs, the pupils deposited thin gold layers on glass substrate using a plasma coater. Additionally, they characterized different samples regarding thickness, optical transmission and conductivity in dependence of the plasma deposition time.

Besides the workshops, the girls and boys experienced university life. They attended a lecture, visited "real" physics laboratories and watched a show at the planetarium in Bochum. At the end of the four days, they created posters and presented their results of the workshops to the other pupils during a poster session.

The *Schülerprojektwoche* was successfully finished with a quiz duel about the learned physics between the four workshop groups. Here, the plasma physics group won and was awarded with a cup.

Rahel Buschhaus, project C7 of the SFB-TR 87

Workshop activities

SFB-TR 87/CRC 1316 Joint Workshop 'Plasma Modeling and Simulation'

On March 25th, 2019 the annual workshop of the SFB-TR 87 and CRC 1316 was organized in Bochum. Besides fundamentals of plasma modeling and simulation (e.g. fluid and kinetic descriptions), also data-driven concepts like artificial neural networks were part of the program.

In this joint SFB-TR 87 and CRC 1316 workshop, scientist of both consortia were invited to get into contact with the respective other research field. As entitled, the workshop addressed both fundamental and applied aspects of plasma modeling and simulation. High power low pressure plasma processes of concern within SFB-TR 87 as well as low temperature atmospheric pressure plasma discharges relevant within CRC 1316 were considered. By initiating a common discussion, this workshop aimed to bridge the gap between both research topics and to establish a vital cooperation.

Jan Trieschmann, Marcus Hans & Thomas Mussenbrock

Plasma and its interaction with electrical networks

Project **C4** published recenlty the article "A generic method for equipping arbitrary rf discharge simulation frameworks with external lumped element circuits" (F. Schmidt, J. Trieschmann, T. Gergs and T. Mussenbrock, Journal of Applied Physics **125**, 173106 (2019)).

This article concerns external electric networks and their necessity in plasma processing. Therefore, to correctly represent the physics, these networks need to be included in simulations. Since the coupling of plasma and circuit is not trivial and involves solving coupled differential equations following Kirchhoff's laws, the circuit is often neglected. This work provides a generic method based on harmonic balance, which allows any plasma simulation to be coupled to complex electric network by using the simple input of a netlist.

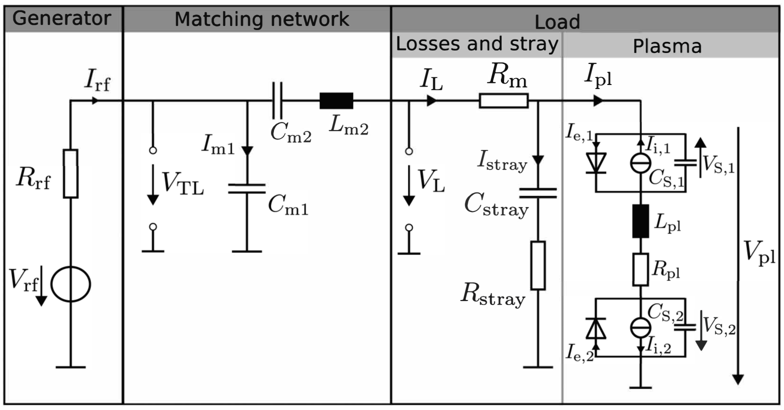


Figure 5: *Generator, matching network, and stray elements attached to an equivalent circuit of the plasma.*

Harmonic balance is a method for calculating the interactions of linear and nonlinear circuits. It ensures that the voltage at the interconnection of the regimes satisfies Kirchhoff's laws for both the excitation frequencies and the nonlinear created harmonics. The method, once implemented, can be applied to any plasma simulation one desires to use.

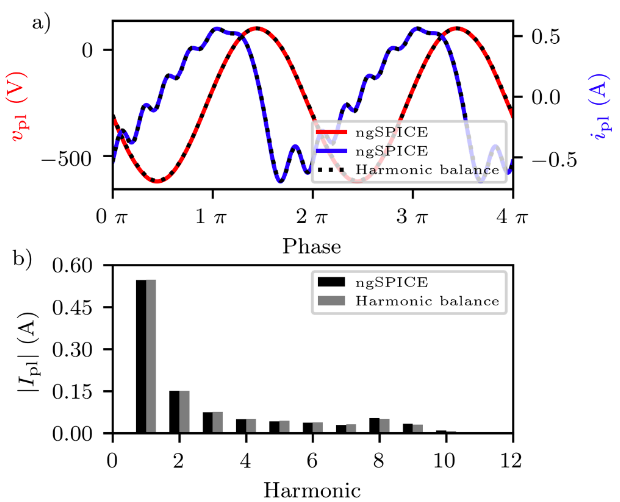


Figure 6: *Voltage and current using the global plasma model. (a) Transient solution (b) Absolute values of the different current harmonics.*

In this work, two different plasma models are used: a) A nonlinear global equivalent circuit model and b) a self-consistent 1D Particle-In-Cell (PIC) simulation. The network shown in Figure 5 includes Model a) and is simulated with both ngSPICE – a circuit simulation software – and the harmonic balance algorithm. The electric circuit is treated as the linear part and the whole plasma model is treated as the nonlinear part. Figure 6 shows the results of the harmonic balance method together with the ones produced by ngSPICE, which is used as a reference. In the next step a symmetric setup using PIC simultaneously with a resistor and capacitor in series is simulated.

In Figure 7 the results of the harmonic balance algorithm are plotted. As a reference method serves a scheme introduced by Verboncoeur, which includes the electric circuit by manually setting up the differential equations and including them in the PIC code.

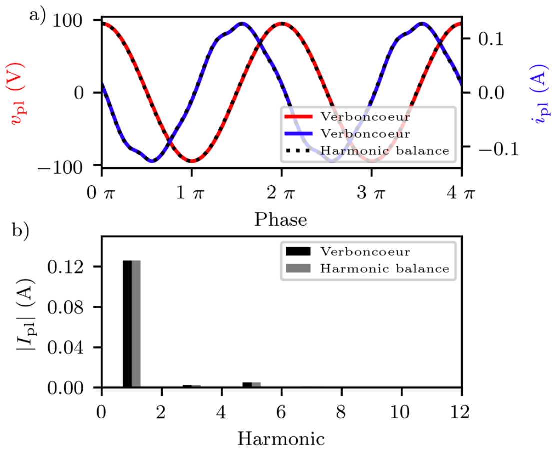


Figure 7: *Plasma-voltage and current using PIC and an external RC-element. (a) Transient solution (b) Absolute values of the different current harmonics.*

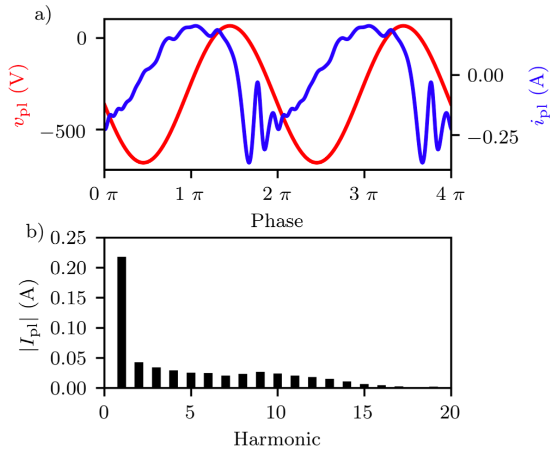


Figure 8: *Current and voltage resulting from a PIC simulation with an attached generator, matching network, and stray elements. (a) Transient solution (b) Absolute values of the different current harmonics.*

Both simulations show the same results and demonstrate therefore the validity of the harmonic balance approach. Lastly, an asymmetric setup in PIC is attached to as generator, matching network, and reactor losses. For this case there exists no reference and therefore serves to demonstrate the flexibility of the method. The results are plotted in Figure 8. The results are shown for a matched case. This is achieved by varying the capacitances C_{m1} and C_{m2} until matched is obtained.

Frederik Schmidt, project C4 of the SFB-TR 87

Award

Prof. Uwe Czarnetzki accepted as Japan Society of Applied Physics Fellow International

Prof. Uwe Czarnetzki from project A1/A2 of the CRC 1316 is selected as International Fellow of the Japan Society of Applied Physics. The awarding ceremony for his tribute will be on September 18th, 2019 during the Japan Society of Applied Physics autumn meeting. During the ceremony, the honoured fellows are invited to give a scientific contribution. International fellows of the Japan Society of Applied Physics are honored to scientists who support the progress of Japan Society of Applied Physics and in recognition of their achievements. Congratulations for this achievement!

Marina Prenzel, public relations

About novel research activities

Rational catalystand electrolytedesign for CO_2 electroreduction towards multicarbonproducts

Excessive CO_2 emissions from the utilization of traditional fossil energy sources cause severe environmental issues, hindering a sustainable development of our industrial society. The CO_2 electroreduction reaction represents a viable alternative to help close the anthropogenic carbon cycle and convert intermittent electricity from renewable energy sources (i.e. solar, wind) to chemical energy in the form of fuels and feedstocks. Selective conversion of CO_2 to more reduced chemicals, especially multicarbon oxygenates and hydrocarbons with higher energy density is highly desirable for industrial applications. However, the generation of such products is severely limited by the competition from the formation of single-carbon chemicals as well as hydrogen evolution reaction.

How to facilitate the C-C coupling over other reaction pathways in CO_2 electroreduction reaction remains a great challenge in fundamental catalysis research. In this article, we discuss strategies to achieve high selectivity for multicarbon products through rational design of the catalyst and electrolyte. Current state-of-the-art catalysts, including Cu and Cu-bimetallic catalysts as well as alternative materials are considered. Of them, plasma technique has shown unique advantages in the development of highly active and selective Cu-based catalysts. The electrolyte effect on the catalyst structure before and during the reaction as well as on the activity and selectivity are discussed. The importance of taking into consideration the dynamic evolution of the catalyst structure and composition are highlighted, focusing on findings extracted from in situ and operando characterizations. Additional theoretical insight into the reaction mechanisms underlying the improved selectivity of specific catalyst geometries/compositions in synergy with a well-chosen electrolyte are also provided. At the end, we bring current challenges in the research of the CO_2 electroreduction reaction into the community's attention. A selective and stable production of a specific multicarbon product of interest (e.g. ethylene) under industrial conditions should be the goal. In situ and operando characterization techniques compatible with realistic reaction conditions should be developed and conducted to understand reaction mechanisms, which would in turn help the efficient design of catalyst and electrolyte.

[1] D. Gao, R. M. Arán-Ais, H. S. Jeon, B. Roldán Cuenya, Nature Catalysis 2, 198-210 (2019)

Dunfeng Gao, project B1 of the CRC 1316

Upcoming Dates 2019

June 19th - 20th
10th International Conference on Sputter Technology (HIPIMS-Conference 2019)
Braunschweig, Germany

July 8th - 12th
46th European Physical Society Conference on Plasma Physics (EPS)
Milan, Italy

July 14th - 19th
International Conference on Phenomena in Ionized Gases (ICPIG)
Sapporo, Japan

July 8th - 10th
CRC 1316 Project Meeting
Rolduc, The Netherlands

July 15th - 17th
SFB-TR 87 Workshop
Schermbeck, Germany

September 23th - 27th
PLATHINIUM (Plasma Thin film International Union Meeting)
Antibes, France

October 5th - 12th
23rd International School on Low-Temperature Plasma Physics (School & Master Class)
Bad Honnef, Germany

October 28th - November 1st
72nd Annual Gaseous Electronics Conference (GEC)
College Station, Texas, United States

November 18th - 19th
CRC 1316 Project Meeting
Bochum, Germany

Impressions of the first half year 2019

Impressum

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