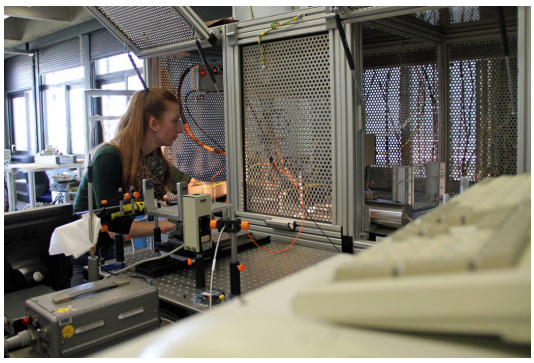
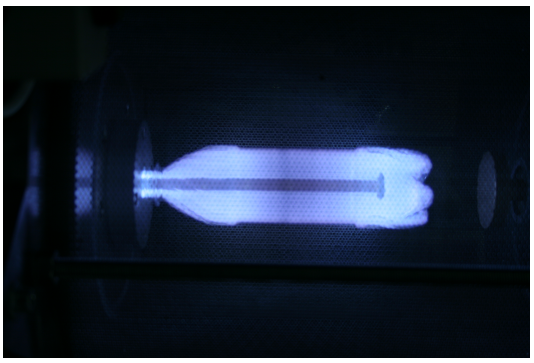
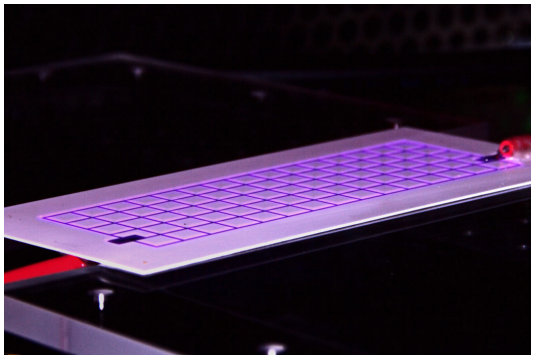
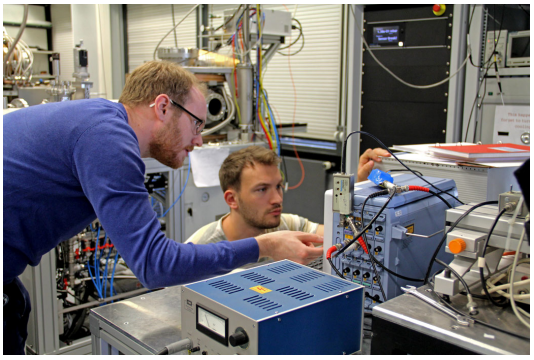
SFB-TR 87

SFB 1316

NEWSLETTER

EDITION 5

Foreword

Approvement of the third funding phase of the SFB-TR 87

The path to new materials on the basis of classic materials such as for electromobility (e.g. lightweight construction), energy technology (e.g. solar cells), but also medical technology (e.g. packaging, sterilization) leads over plasma technology. Researchers in plasma technology, plasma physics, materials science, and interfacial chemistry work together in the SFB-TR 87 *Pulsed high power plasmas for the synthesis of nanostructured functional layers*.

On Thursday, 17th May 2018, the German Research Foundation approved the third funding phase of the SFB-TR 87. The past eight years of funding were shaped by a large scienitific progress in the field of film synthesis, modelling, mechanical material science, plasma processes, plasma science, and plasma technology. Due to the great success within the consortium, the final funding phase was approved.

However, in the preparation of the strategy for application of the third funding phase, a lot of work had to be done, e.g. strategical meetings, gaining new PIs, and express the central research tasks for the third funding phase. Last year, the pre-proposal had to be handed over to the German Research Foundation and afterwards the proposal, limited to 400 pages, needed to be written. Here, the challenge was to keep the page limit, because every project has its story and the neccessarity to explain the importance of its reaserach. Hundreds of tables, corrections within parapgrahps of the proposal were also challenges that had to be overcome on the way. Finally, in December 2017 we deposit the proposal made of 400 pages for the third funding phase of the SFB-TR 87.

The collaborations of the different projects have envolved over the last eight years to a stable research cooperation between different research groups in Bochum, Aachen, and Paderborn. Students, PhD students, PIs has been supporting the great collaboration from the first day by their great effort over the whole time. People within the projects changed in the last years, but the intensive collaboration continues since the first day of funding. Furthermore, new projects join the research collaboration for the third funding phase to bring the SFB-TR 87 to a successfull ending with interesting scientific results.

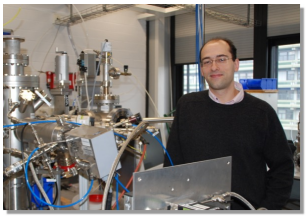
During the preparation of the evaluation by the German Research Foundation, a lot of work and effort had been put into the proposal and the evaluation days itself. Finally, the evaluation days were supported by motivated and interested reviewers.

Hence, our work was rewarded by the approvement of the third funding phase. I'm looking forward to the third phase with all the challenges it will put forth.

Prof. Dr.-Ing. Peter Awakowicz, Spokesperson of the SFB-TR 87

Farewell

Dr. Carles Corbella leaves the SFB-TR 87



After seven years of intensive research in project *C7 - Surface processes in the interaction of high-performance plasmas with HPPMS target surfaces and plastics* of the SFB-TR 87, Dr. Carles Corbella decided to continue his professional career at the George Washington University in the United States.

His research focus was on the treatement of metallic samples to investigate electron emission and cross-sections by oxygen bombardement. Further, he worked on PP coated samples to find the impact of Ar ions. Especially, the photon impact was excluded to separate this effect from the treamtent of the PP samples.

We wish him all the best for his further professional career!

Non-equilibrium excitation of CO_2 in an atmospheric pressure helium plasma jet

First results are submitted to the *Journal of Physics D: Applied Physics* on the non-equilibrium excitation and dissociation of CO_2 in an atmospheric pressure helium RF plasma jet. The objective of the project A3 in the SFB 1316 and the BMBF project Carbon2Chem is the separation of plasma and surface chemistry studied for the example of CO_2 plasma excitation admixed to the noble gas within the plasma jet. This method offers the possibility to control the gas temperature of the feed gas as well as the molecule excitation by low energy electrons or by Penning collisions with the excited noble gas atoms or dimers.

The plasma jet is driven with varying absorbed plasma power and admixture levels of CO_2. The excitation of CO_2 is monitored by in-situ set-up of Fourier-Transform Infrared Spectroscopy. Concetrations of CO_2 and the produced CO are analysed. Furthermore, the vibrational and rotational temperatures of the possible degrees of freedom of the measured molecules are determined.

The gas feed of the atmospheric pressure plasma jet was helium, because of the large mass difference and, therefore, poor momentum transfer to CO_2. This results in the smallest collisional quenching of all noble gases. The plane parallel plasma jet is driven with RF. This kind of plasma source is already very well investigated in respect to their plasma physics and chemistry for different gas mixtures of noble gases and molecules.

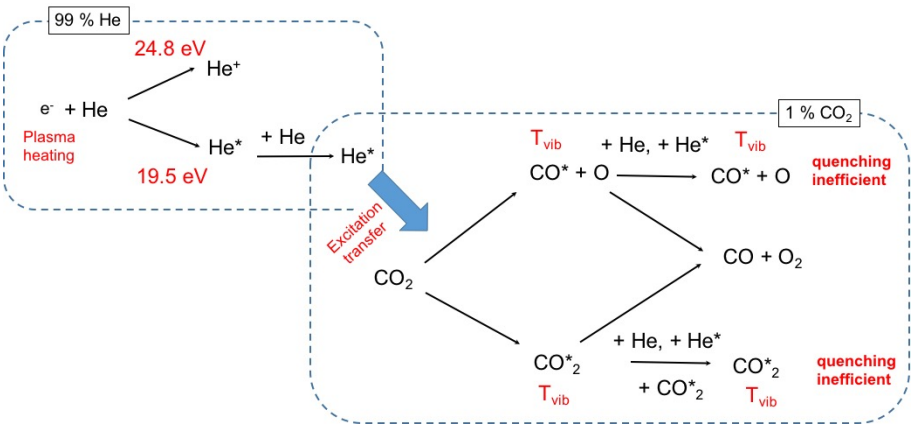


Figure 1: Reaction pathways for the contribution to the vibrational temperature of CO and CO_2 at an admixture of 1% CO_2.

The main result of this work is the clear non-equilibrium excitation of CO_2 and CO. In detail, the rotational temperature of CO is below 400 K and, in contrast to this, the vibrational temperature reached values up to 1600 K, and the temperature of the excitation of the asymmetric vibration of CO_2 is about 700 K. The impact of variable plasma power and admixture of CO_2 to the He gas flow is rather weak. It is assumed that the vibrational and rotational excitation of CO mainly originates from the dissociation reaction either by direct electron impact of CO_2 or by Penning dissociation between CO_2 and excited helium metastables. From this electronic energy transfer to CO_2, highly vibrational excited CO molecules are produced by dissociation.

The non-equilibrium is due to the nature of excitation of molecules by collisions with electrons with energies larger than 7 eV at the oscillating sheath edges and Penning collisions with excited helium atoms. The low rotational gas temperature is explained by the helium plasma gas which acts as a buffer. This non-equilibrium character offers more investigations within the field of plasma catalysis, through which the reaction rate of a desired catalytic reaction is supported. Moreover, it is important to ensure the enhancement of the reaction rate through the impact of excited molecules and not due to an unintentional heating of the catalyst surface by the plasma itself.

In the future, the experiments will be extended to other gas mixtures and the impact of catalytically active surfaces will be explored.

Theresa Urbanietz, project A3 in the SFB 1316

German Physical Society - Spring Meeting in Erlangen

On Monday, 4th March 2018, the 82nd Annual Conference of the DPG and DPG Spring Meeting was held at the Friedrich-Alexander-Universität Erlangen-Nürnberg in Erlangen. Scientists from all over Germany met to discuss their newest results on atomic, molecular, plasma physics, and quantum optics.

Three groups from Bochum also joined the traditional meeting with three poster presentations and ten oral contributions from the experimental physics II group of Prof. Achim von Keudell (SFB 1316, SFB-TR 87) as well as the group experimental physics V of Prof. Uwe Czarnetzki (SFB 1316) and the theoretical electrical engineering of Prof. Ralf Peter Brinkmann (SFB 1316, SFB-TR 87).

Beside the scientific program, social events like an EinsteinSlam or an award ceremony with musical interludes completed the conference program.

Katharina Grosse, project B7 of the SFB 1316

International Conference on Metallurigcal Coatings of Thin Films

One of the largest conferences in the research field of the SFB TR-87 is the International Conference on Metallurgical Coatings & Thin Films (ICMCTF) which was held in San Diego from the 23rd until the 27th April this year. The conference was a week of highly interesting talks including three plenary and five special interest talks complemented by a poster session on Thursday afternoon. In addition, very fruitful discussions took place outside the session rooms under the nice californian sun.

Of course, very many members of the SFB TR-87 participated, starting with the special interest talk held by Prof. Jochen M. Schneider and followed by three invited talks, three sessions chaired by SFB members and a lot of further talks as well as posters presented by researchers from our team. The conference reflects the research progress in our field and, further, is a nice opportunity to get in contact with other researchers, exchange ideas and initiate cooperations.

Sascha Monjé, project C7 of the SFB-TR 87

Prof. Dr. Achim von Keudell joins Ted^{x} event

Prof. Achim von Keudell, had the honour to join the Ted^{x} event on 19th May 2018 in Bochum with a 15 minutes talk on the impact of plasma technology on the daily life with a small focus on HiPIMS. The overarching topic of the event was "Changing Perspectives". Only 200 tickets for the audience were avaible.

TED^{x} is a wolrdwide offspring of the TED conference series. The range of topics of the TED^{x} event was extremly broad covering societal and scientific challenges of the future. The video of the presentation will be avaible soon in the web.

About Novel Research Activities

Results on scattering of magnetized electrons at the boundary of low temperature plasmas

Subproject C5 focused on the electron dynamics in magnetized technological plasmas, especially high power pulsed magnetron sputtering (HPPMS). In this plasma regime ($p \approx 0.5$ Pa) kinetic simulations are required.

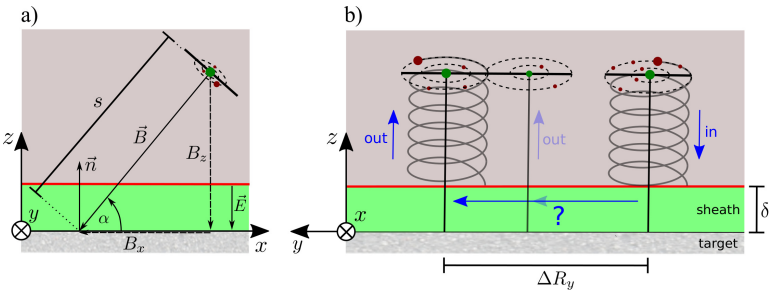


Figure 2: Simulation setup: (a) Definition of the magnetic field. (b) Schematic of the interaction of magnetized electrons with the boundary sheath.

The SFB member Dennis Krüger recently published the article "Scattering of magnetized electrons at the boundary of low temperature plasmas" in the journal Plasma Sources Science and Technology **27**, 2018.

The article concentrates on the interaction of magnetized electrons with the thin (due to the high plasma density) boundary sheath at the cathode. For a model description of the electron dynamics, an appropriate boundary condition for the plasma/sheath interface is required. A comparison regarding the peculiar feature of the drift ΔR_y of the guiding center between a Bohm sheath (assuming a finite Debye Length λ_D) and a hard wall model ($\lambda_D \to 0$) is conducted. This displacement depends on the magnitude of the magnetic field, the kinetic energy of the incoming electron and the angle α between the sheath and the magnetic field.

Finally, it is found that the assumption of a hard wall model (also called specular reflection) can be used as a valid boundary condition for more realistic kinetic models.

These results support the work of the experimental projects such as A5 in the SFB-TR 87, which's research focus is on the understanding of spokes and, therefore, the understanding of processes directly in front of the cathode.

Katharina Nösges, public relations SFB-TR 87

Upcoming Dates 2018

June 17th - 22th
7th International Conference on Plasma Medicine (ICPM)
Philadelphia, USA

June 24th - 28th
IEEE International Conference on Plasma Science (ICOPS)
Denver, Colorado, USA

June 25th - 28th
9th International Conference on Fundamentals and Industrial Applications of HIPIMS
Sheffield, UK

July 1st - 6th
45th Conference on Plasma Physics (EPS)
Prague, Czech Republic

July 11th - 13th
Project Meeting SFB 1316
Kerkrade, The Netherlands

September 2nd - 7th
16th International International Symposium on High Pressure Low Temperature Plasma Chemistry (HAKONE)
Beijing, China

September 17th - 21th
16th International Conference on Plasma Surface Engineering (PSE)
Congress Center Garmisch-Partenkirchen, Germany

September 24th - 25th
Project Meeting SFB-TR 87

October 6th - 13th
22nd Plasma School and Master Classes
Physikzentrum Bad Honnef, Germany

November 5th - 9th
71st Gaseous Electronics Conference (GEC)
Portland, Oregon, USA

November 12th
Plasma Day
Bochum, Germany

November 29th - 30th
Workshop on the Exploration of Low-Temperature Plasma Physics (WELTPP-21)
Kerkrade, The Netherlands

Approved Transfer Project

IKV and AEPT work together with the KHS Corpoplast GmbH on a barrier solution for refillable PET-bottles

The SFB-TR 87 has been enriched with yet another new and exciting project, which research results are expected to have a fundamental impact on the plastics packaging industry. The DFG recently gave way to this collaborative project of the "Institute for Electrical Engineering and Plasma Technology (AEPT)" of the RUB Bochum, the "Institute of Plastics Processing (IKV)" of the RWTH Aachen and the KHS Corpoplast GmbH, in which a new media resistant coating system will be developed in the course of the following three years.

In order to distribute sensitive and high-quality beverages, such as beer, wine, juice or carbonated beverages in plastic bottles, it is often necessary to enhance the barrier properties of the packaging material. Plasma technology is today well established for the barrier coating of non-returnable PET bottles. With the help of these barrier coatings, commonly silicon oxide (SiO_x), barrier improvement factors (BIF) by a factor of 7 for CO_2 and a factor of 40 for O_2 can be achieved. This makes it possible, for example, to increase the shelf life of cold aseptically filled fruit juice from three months in an uncoated PET bottle to twelve months for the coated PET bottle. For refillable PET bottles on the other hand, a comparable development cannot be described. SiOx coatings cannot withstand the cleaning process with caustic soda (NaOH) in the reusing process and are completely or partially removed. Furthermore does the NaOH solution chemically attack the PET, leading to a significantly roughened surface even after a single washing process and thereby to a reduced barrier performance of consequently applied barrier coatings (see Figure 3).

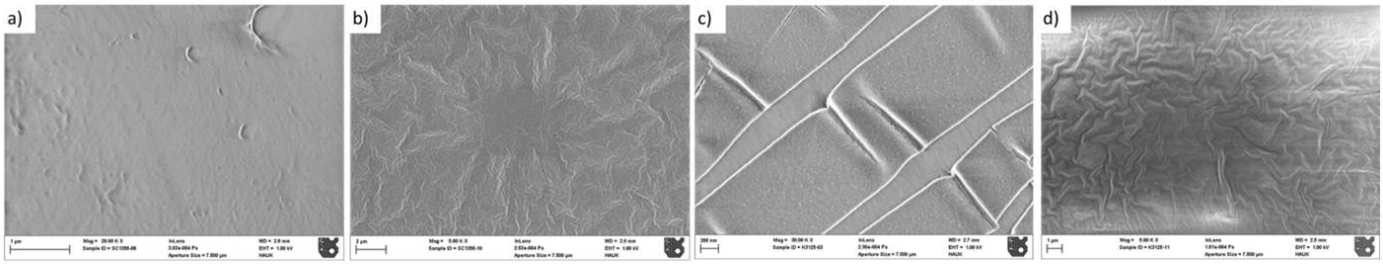


Figure 3: FESEM images of an a) untreated PET surface, b) a NaOH-washed surface, c) a coated PET surface (mechanically strained in order to make coating visible), and d) a coated and then washed surface.

Compared to disposable PET bottles and refillable glass bottles, refillable PET bottles perform significantly better in life cycle assessments. Collecting and washing refillable PET bottles requires less energy than the production and disposal of new PET bottles or the recycling process of disposable PET bottles. The transition from using disposable PET bottles and returnable glass bottles for sensitive beverages to refillable PET-bottles would lead to a significant reduction in climate-changing CO_2 emissions in the packaging industry.

With the knowledge gained in the SFB-TR 87 over the last years, suitable coating systems for this application will be developed in this transfer project in order to open the advantages of plasma technology to the field of refillable PET-bottles. The goal is to develop multilayer systems which, in addition to the already proven high barrier effect against O_2, also have good resistance to caustic soda. Alternatively, the coating system could be resistant enough to only almost be removed during the washing process, making a new coating possible by protecting the PET surface. These approaches can be pursued through the continuation and further development of the multilayer concept and the results for plasma pre-treatment from project area B of the SFB-TR 87. The architecture of the coating systems to be developed must be designed in such a way that it can be implemented with a marketable plasma system. The project benefits from the fact that a large part of the SFB-TR 87's research work was carried out using PET films. The plasma and process diagnostics methods developed and used in SFB-TR 87 provide an excellent basis for these challenges.

With the KHS Corpoplast the SFB-TR 87 has gained a strong partner. The company is focused on stretch blow molding, barrier technologies and the development of new types of plastic bottles and brings much experience in the field of plasma technologies for PET bottles to this project.

The results of this transfer project, in particular new findings on media resistance and further processing related stress on substrates and layers, will flow directly back into the SFB-TR 87, which will start into the third project phase. Furthermore, the experience gained in process transfer from laboratory reactors to marketable coating systems can provide decisive indications for the later applicability of the results of the SFB-TR 87.

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Tributes

ISPLAMA Prize for Prof. Uwe Czarnetzki

The 10th International Symposium Plasma (ISPlasma) took place between March 4th and March 8th 2018 at Meijo University, Nagoya, Japan. A newly introduced prize was given *for outstanding achievements in the field of Plasma Science and its Applications as well as great contribution towards the continued success of ISPlasma/IC-PLANTS*. This year, the prize was presented for the first time with Prof. Uwe Czarnetzki being the recepient.

The presented picture shows Prof. Uwe Czarnetzki at the ceremony of the award ceremony.

EMMC16 presentation prize for Shahed Rezaei

At the EMMC16 (16th European Mechanics of Materials Conference) in Nantes, Shahed Rezaei from the Insitute of Applied Mechanics at RWTH Aachen working in project A6 in the SFB-TR 87, won the price for the best student presentation (EuroMech Awards) with the presentation title: *Developing an interface model to investigate the damage and fracture in hard nano-coating layers*.

Young researcher training

International school on low temperature plasma physics

After 21 years of successful performance of the international school on low temperature plasma physics, we will carry on with this tradition also in 2018. Between October 6th and 11th the International School on Low Temperature Plasma Physics: Basics and Applications will take place in the Physikzentrum Bad Honnef. Further, the Master Class with an intensive focus on Electronegative plasmas will take place from October 11th until October 13th, 2018.

Career within the SFB-TR 87

Interview with Dr. Jan Trieschmann

Dr.-Ing. Jan Trieschmann, PI in the project C8, has been an SFB-TR 87 member almost from the start. We jumped on the opportunity and asked him some questions about the SFB, his career and his life after his Ph.D.

Jan, you have kind of „grown up" scientifically within the SFB-TR 87. Could you describe the development the research centre has made from its start in 2010?

When I first got in contact with the SFB as a student assistant in 2010, the SFB was in an initial period of formation. Collaborators from the different disciplines of physics, materials science, mechanical and electrical engineering shared the same vision of overcoming the prevalent empirical approach to plasma-based coatings system design and of developing a knowledge-based alternative. Not only the language and terminology was different among disciplines, but also the individual dedication toward more fundamental or applied science. As I see it now, over the past 8 years the superior development was that we were able to establish a common language while – in fact – preserving the individual focus.

In your opinion, what characterizes the SFB-TR 87 and what is the most remarkable treat?

The intrinsic character of the SFB-TR 87 is determined by its synergistic interdisciplinary research approach overarching the involved disciplines. The SFB has been extremely successful in conducting research, but the most remarkable treat for me personally are the unique possibilities it offers to the many ambitious young researchers.

What are the benefits and disadvantages of such a big interdisciplinary and transregional research project as the SFB-TR 87?

In my perception, it is sometimes difficult to work jointly in teams with dissimilar internal structure. In addition, it may be difficult to motivate participants due to an apparent lack of immediate revenue. A certain level of conflict, however, also induces a more intense and productive interaction. The challenge is to get everyone to invest first and benefit later.

What are your wishes for the third period?

. . . that our vision becomes reality.

You obtained your Ph.D. at the Institute of Theoretical Electrical Engineering at the Ruhr University Bochum and now you are working as a postdoctoral research fellow at the Brandenburg University of Technology Cottbus-Senftenberg, Electrodynamics and Physical Electronics Group. Could you tell us what you are working on now in your „After Ph.D. Life" and what changed for you from the scientific point of view? And why have you decided to stay within the SFB-TR 87?

My situation in Cottbus is not vastly different compared to Bochum. I enjoy a lot of freedom in deciding what to work on and how to approach it. I'm partly continuing the work I have been doing during my Ph.D., now with a more supervising perspective. Working with and guiding younger researchers like Tobias Gergs, who is working on the topic of subproject C8, is an interesting experience. In addition, I'm trying to get involved in a few other topics, for instance concerning the interaction of electromagnetic waves with plasmas and matter.

Do you have any advice for current Ph.D. candidates working in the SFB-TR 87?

Take advantage from the benefits the SFB offers especially to Ph.D. students and get in touch with one another. For me, the collaborative work within the SFB has always amplified the output tremendously ... and it's fun!

Thank you and all the best!

Nadine Al Shami, public relations SFB-TR 87

New Research Members

The start of the first funding phase of the SFB 1316 yields in the growth of the consortium of a large group of PIs, PostDocs as well as PhD students. In the following editions of the newsletter, we are going to present all new PIs from the SFB 1316 in a small article.

Prof. Timo Jacob - Project leader SFB 1316

Project B4 *Theoretical studies on the interaction of excited species with catalyst surfaces* is led by **Prof. Timo Jacob**. He is the director of the institute of electrochemistry at the university Ulm (since 2011) and a director of the Helmholtz-Institut-Ulm (HIU). At his institute, electrochemical reactions on the surfaces of monocrystals, which are in contact with mostly aqueous electrolytes, are investigated. They study the basics of electrochemical systems and boundary layers combining theory and experiments. Frequently their research has direct reference to applications in the fields of energy storage, energy conversion, electromobility or metal deposition.

Project B4 will concentrate on the theoretical modelling of reactive catalytic surfaces in vicinity of plasmas. First they want to develop methods to model the characteristics of a plasma. Then they want to use these methods to investigate the structural, physical and catalytic properties of different surfaces in terms of CO_2 reduction and various oxidation reactions.

New Administrative Assistance SFB 1316

Since May of this year, the administrative work of the SFB 1316 is supported by the start of employement of **Alicia Gonzalez**. She is management assistant for office communication and manages the third party funding at the chair for experimental physics II at RUB, especially the SFB 1316.

Alicia Gonzalez is the contact person for all questions within the SFB 1316 concerning financial or activity responses.

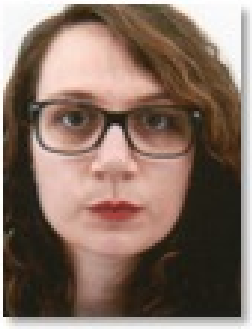
Please write to sfb1316@rub.de or alicia.gonzalezfontela@rub.de for clarification of administrative questions. You can reach her under the telephone number 0234 - 32 23056.

Successfull start of the first funding phase

Kick-Off Meeting SFB 1316

On February 5th and 6th the Kick-Off Meeting of the newly approved collaborative research centre, SFB 1316, took place at Beckmanns Hof in Bochum. Nearly 40 scientists from the collaboration presented their research goals and started to discuss about scientific goals and collaborations between the different projects.

New Research Members SFB 1316



Dr. Laura Chauvet started working within the SFB 1316 as well. Before joining the Ruhr-Universität Bochum in May 2018, she worked at the Diagnostics des Plasmas Hors Equilibre laboratory (DPHE) at the University of Albi in France. She did her PhD thesis there and stayed for one more year of research. Her research focus was on the experimental characterization of an atmospheric pressure plasma jet source. Furthermore, she worked on the coupling of this source with a time of flight mass spectrometer for applications in analytical chemistry. For the SFB 1316 she will be in charge of the mass spectrometry part at atmospheric pressure.

Dr. Ihor Korolov joins project A4 of the SFB 1316 *Process control in micro atmospheric pressure RF plasma jets by voltage waveform tailoring and customised boundary surfaces*. Since Janary 2018, he is a PostDoc at the Institute for Electrical Engineering and Plasma Technology (AEPT) at Ruhr-Universität Bochum. Previously, he worked as a research fellow at the Wigner Research Center for Physics at the Hungarian academy of Sciences. His work was concentrated on experimental studies of different plasma process and on computational modeling of low-temperature radiofrequency discharges.

New PhD students within the SFB 1316

The new PhD students in the SFB 1316 in Bochum are **Jan Kuhfeld** working in the project A2 on the coherent anti-Stokes Raman scattering at experimental physics V. Recently, **Christoph Stewig** started his PhD thesis in project A3 on the excitation transfer between molecules in the group experimental physics II. In the field of electrical engineering, **Ryan Smith** now works on the influence of voltage characteristics on surface dielectric barrier discharges in project A5. Two PhD canditates join the consortium in project A7, **Lars Schücke** from the electrical engineering and **Niklas Peters** from the chemical institute. Morevover, in the physics faculty, **Patrick Preissing** supports the research field in project B2 by surface treatment of combined atmospheric pressure plasmas and laser irradiation. Finally, in the faculty of biology, **Abdulkadir Yayci** studies plasma-driven biocatalysis in project B8.

At the University Ulm, **Florian Nägele** and **Christoph Jung** work on theoretical studies of excited species with catalyst surfaces in project B4.

New Research Member SFB-TR 87

Marco Carlet studied mechanical engineering at RWTH Aachen University. Since March 2018, he has been working on subproject A1, which develops a connection between the application requirements in plastics processing and the coating properties of nanostructured PVD coatings. An important result of the subproject within the second phase is the development of a multilayer system made of Cr-Al-O-N. In this system, the individual layers fullfill opposing requirements placed on the components and tools in plastic extrusion. In the third phase, the transfer of process development and the coating concept from Cr-Al-O-N to Ti-Al-O-N and V-Al-O-N is to succeed. Within the interaction model, the transfer and verification of the analysis methods used so far from polycarbonate to other plastics will be investigated. In addition, another focus is the increase of the bond between the applied coatings and the substrates.

Plasma-enhanced atomic layer deposition for low temperature thin films

As the SFB-TR 87 was perpetuated for a second phase in 2014 (and recently successfully funded for the third phase - congratulations to everybody in the SFB-TR 87), a new entity of plasma-assisted thin film fabrication technique was introduced to the overall framework and, in particular, to the B4 subproject: Plasma-enhanced atomic layer deposition (PEALD). As a discontinuous deposition technique, this method is capable of producing highly conformal and homogeneous thin films in a layer-by-layer manner at temperatures as low as room temperature. Together with plasma-enhanced chemical vapor deposition, this technique was employed to deposit inorganic gas barrier layers on polymer foils, focusing on several aspects potentially influencing the structure-property relationship of gas barrier layers.

One approach employing PEALD dealt with the investigation of using different precursors (molecular compounds) for the deposition of alumina (Al_2O_3) thin films and the in-situ analysis of film growth using quartz-crystal microbalance. Furthermore, Al_2O_3 and SiO_2 thin films as well as dyads thereof were investigated in terms of residual film stress and their gas barrier layer performance, allowing to correlate mechanical properties with gas barrier layers performance. The results of this detailed study, involving the subprojects B1 (adhesion), B3 (atomic force microscope, spin-coating), B4, and C2 (stress measurements), have been published recently[1].

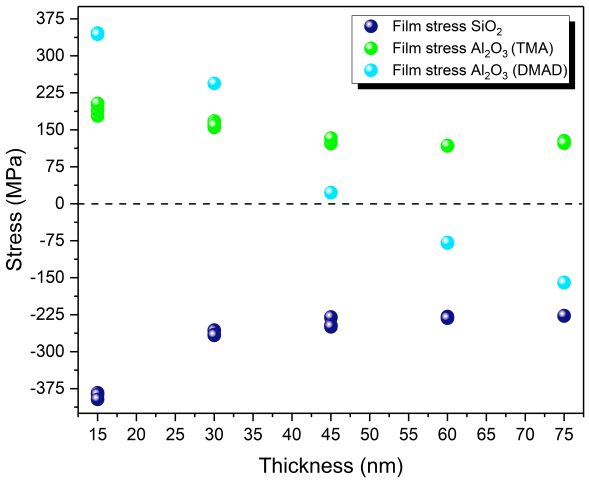


Figure 4: Residual film stress of SiO_2 and Al_2O_3 thin films, deposited by PEALD. For Al_2O_3, either TMA or DMAD was used as precursor.

In close collaboration with B3, quartz-crystal microbalance crystals were functionalized with a thin spin-coated PP layer on top, making it possible to investigate the PEALD Al_2O_3 thin film growth on polymers and to monitor the various growth mechanisms occurring during the initial PEALD cycles, involving etching and growth. One major outcome of this study on PEALD processes was that the recently reported Al-precursor [3-(Dimethylamino)propyl]aluminum(III) (DMAD),[2] which exhibits lower reactivity than the predominantly used trimethylaluminum (TMA), facilitates the constitution of a more abrupt interface between of Al_2O_3 and the PP surface, while TMA yields a gas barrier layer exhibiting a more diffusive interface in combination with lower growth rates. To deposit similar thin films using TMA, a pre-treatment of the PP substrate was found to be of utmost importance. Even more interesting, it was possible to measure the residual film stress by employing Si-sensor chips (see Figure 4). From this collaboration together with C2, the DMAD deposited Al_2O_3 thin films were found to have a compressive or tensile residual stress, depending on their thickness.

The central results of this research project cover findings with respect to the influence of precursor chemistry on material properties and the relationship between different functional properties. In the context of materials science, the reported data gives rise to several opportunities, such as the development of mixed or hybrid materials with tailored properties to design advanced applications in packaging. For example, encapsulation of sensitive goods like electronics and pharmaceuticals can benefit from such advances.

[1] M. Gebhard, L. Mai, L. Banko, F. Mitschker, C. Hoppe, M. Jaritz, D. Kirchheim, C. Zekorn, T. de los Arcos, D. Grochla, R. Dahlmann, G. Grundmeier, P. Awakowicz, A. Ludwig, and A.Devi, *ACS Appl. Mater. & Interf.*, **10**, 2018

[2] L. Mai, M. Gebhard, T. de los Arcos, I. Giner, F. Mitschker, M. Winter, H. Parala, P. Awakowicz, G. Grundmeier, and A. Devi, *Chem. Eur. J.* 2017, **23**, 10768

Dr. Maximilian Gebhard, project B4 of the SFB-TR 87

Dr. Sven Dirkmann - Theoretical Electrical Engineering

Recently the SFB-TR 87 member Sven Dirkmann finished his PhD with summa cum laude. His PhD thesis has the title *Modelling and Simulation of memristive devices*. Based on the results from the theoretical and experimental work, an analog switching memristive device has been developed. This device can be used in neuronal networks.

Beside his research, Sven Dirkmann was responsible for the MGK of the SFB-TR 87. He was the contact person for questions around the MGK project.

Dr. Maximilian Gebhard - Inorganic Materials Chemistry

Dr. Max Gebhard started his PhD in October 2013 in the group of Prof. Devi at the faculty of chemistry at RUB. He was member of project B4 in the SFB-TR 87. Moreover, he was collaborating closely with Felix Mitschker, who is part of the SFB-TR 87 project B4 in the SFB-TR 87 at the Institute for Electrical Engineering and Plasma Technology. The outcome of the research resulted in already ten published papers.

Max Gebhard's thesis has the title *Plasma-Enhanced Atomic Layer Deposition of binary metal oxides as gas barrier layers on polymers*, which he defended in December 2017.

Dr. Wolfgang Breilmann - Reactive Plasmas

Wolfgang Breilmann started his scientific career as a Bachelor student in the SFB-TR 87 in 2011 and was a member of the SFB for more than three years as PhD student and defended his thesis on July 17th 2017. His PhD thesis has the title *The connection between spokes and the energy distribution function of ions in high power impulse magnetron sputtering*.

He now works as a Post-Doc within this research field to strengthen his expertise in mass spectrometry and the understanding of spokes. At the moment, an intensive research focus is on the combination of mass spectrometry data and emission spectra together with Julian Held from project A5.

Impressum

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