Symposium Pulsed Power für Medizin und Biotechnologie (SYPP)

gemeinsam veranstaltet
vom Fachverband Kurzzeit- und Angewandte Laserphysik (K),
vom Fachverband Plasmaphysik (P) und
vom Deutschen Chapter NPSS von IEEE

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Übersicht der Hauptvorträge und Fachsitzungen

(HS 3)

Hauptvorträge

SYPP 1.2	Do	11:15–11:45	HS 3	**30 years of Pulsed Power in medical Excimer laser** — •Claus Strowitzki
SYPP 1.3	Do	11:45–12:15	HS 3	**Frontiers of Electroporation, from Mechanisms to Applications: Unraveling new key molecular level aspects using computational chemistry** — •Mounir Tarek
SYPP 1.4	Do	12:15–12:45	HS 3	**Calcium electroporation - a novel, low-cost anti-cancer treatment** — •Stine Krog Frandsen, Julie Gehl
SYPP 2.1	Do	14:00–14:30	HS 3	**Pulsed Electric Fields for the Manipulation of Cancer Cells** — Anna Steuer, Fukun Shi, Christina M. Wolff, •Juergen F. Kolb
SYPP 2.2	Do	14:30–15:00	HS 3	**Pulsed electric field use in food industry - process and equipment design** — Robin Ostermeier, Julian Witt, •Stefan Töpfl
SYPP 2.3	Do	15:00–15:30	HS 3	**Pulse Generators for a Scale-Up of an Electroporation Device for Mash** — •Martin Sack, Martin Kern, Hermann Armbruster, Johannes Fleig, Dennis Herzog, Martin Hochberg, Georg Mueller
SYPP 2.4	Do	15:30–16:00	HS 3	**Spark discharges as tool for the extraction of microalgal compounds** — •Katja Zocher, Raphael Rataj, Anna Steuer, Juergen F Kolb

Fachsitzungen

SYPP 1.1–1.4	Do	11:00–12:45	HS 3	**Pulsed Power für Medizin und Biotechnologie I**
SYPP 2.1–2.4	Do	14:00–16:00	HS 3	**Pulsed Power für Medizin und Biotechnologie II**

SYPP 1: Pulsed Power für Medizin und Biotechnologie I

Zeit: Donnerstag 11:00–12:45 Raum: HS 3

SYPP 1.1 Do 11:00 HS 3

Pulsed Power Yesterday, Today and Tomorrow — •Andreas Görtler[1] and Juergen Kolb[2] — [1]Gymnasium Wertingen, Pestalozzistraße 12, 86637 Wertingen — [2]Leibniz Institute for Plasma Science and Technology, Felix-Hausdorff-Str. 2, 17489 Greifswald

Pulsed Power is primarily an enabling technology. Continuous development of devices and respective know-how has always motivated and initiated novel approaches and concepts, often in fields that were not readily anticipated. This is seen in particular for applications in medicine and biotechnology but also other areas. Examples are excimer lasers and plasmas in general that are generated by pulsed discharges and are for example used for decontamination of air and water but also for the synthesis of nanomaterials. Pulsed electric field treatments have instigated new medical therapies especially for tumor therapies but have also been successfully introduced in the processing of food crops, e.g. potatoes and wine. Other emerging applications are found for the generation of biofuels or the extraction of valuable compounds from algae. This special session is giving an overview on possibilities and recent advances for applications that rely on Pulsed Power technologies.

Hauptvortrag SYPP 1.2 Do 11:15 HS 3

30 years of Pulsed Power in medical Excimer laser — •Claus Strowitzki — MLase AG

This paper gives an overview of the development of pulsed power in medical excimer lasers. Pulsed power in medical excimer lasers is quite challenging. The load is a discharge; this means the impedance changes from open to virtually a short circuit in some ns. Hence a matching of the pulsed power module to the load is not possible. In the last 30 years 3 development big steps were made. First circuits work with a Thyratron. These circuits were quite simple, but suffer from low lifetime. About 50 % of the energy is reflected by the discharge. The reflected Energy produces oscillation in the circuit. The next step was the replacement of the Thyratron by a Thyristor. Due to the lower voltage and switching capability, the voltage has to be raised by a pulse transformer and the pulse has to be compressed by magnetic pulse compression (usually 3 stages). IGBT modules became more powerful and enable faster switching than Thyristors. Hence, the pulse compression network became smaller (only 2 compression stages) and due to a blocking diode together with an energy recovery circuit, reflected energy could be restored. These modules avoid oscillating and enable excellent live time. The live time of the laser is also extended because total charge through the discharge is reduced. This is the current state of the art. Current development is a new circuit topology based on a full bridge primary switch configuration. These circuits have smaller part count and uses standard phase legs IGBT modules. They are especially suited for high repetition rate operation (above one kHz).

Hauptvortrag SYPP 1.3 Do 11:45 HS 3

Frontiers of Electroporation, from Mechanisms to Applications: Unraveling new key molecular level aspects using computational chemistry — •Mounir Tarek — Centre National de La Recherche Scientifique (CNRS), Université de Lorraine, Nancy, France

The application of short and intense electric pulses enables to transiently alter the properties of cell membranes, making them permeable to a wide range of chemical species. This phenomenon is routinely used in a range of medical applications as well in biotechnology and industrial processing. Few years ago, pioneering MD simulations have been conducted in order to model the effect of electric fields on membranes, providing perhaps the first molecular model of the electroporation process of lipid bilayers. Our knowledge however about all occurring processes is still sketchy. In this contribution we show how we harness the capabilities of computational resources and the predictive power of advanced atomistic and quantum level molecular dynamics techniques to decipher key steps in several physical and biophysical and chemical processes occurring at the cell membranes when these are subject to electric pulses used in Electroporation Based Technologies and Treatments.

Hauptvortrag SYPP 1.4 Do 12:15 HS 3

Calcium electroporation - a novel, low-cost anti-cancer treatment — •Stine Krog Frandsen[1] and Julie Gehl[1,2] — [1]Department of Clinical Oncology and Palliative Care, Zealand University Hospital, Roskilde, Denmark — [2]Department of Clinical Medicine, University of Copenhagen, Denmark

Calcium electroporation is a potential novel anti-cancer treatment where supraphysiological calcium concentrations are introduced into cells by electroporation, a method where short, high voltage pulses induce a transient permeabilisation of the plasma membrane allowing passage of ions and molecules into the cytosol. Calcium electroporation efficiently induce cell death in vitro and tumor necrosis in vivo (1). The first clinical trial showed that calcium electroporation is efficient on cutaneous metastases (2). The mechanism is associated with ATP depletion, and normal cells are less affected than malignant cells in vitro and in vivo (1). This difference in sensitivity might be due to differences in the expression of calcium transporters and differences in the cytoskeleton organization. Interestingly, it has recently been shown that calcium electroporation induces a systemic response in vivo (3) and in the clinical trial (4). Calcium electroporation is an efficient and simple, novel anti-cancer treatment that can easily be implement in the clinic. Recent studies indicate that this local treatment also induces a systemic immune response.

1. Frandsen, et al. Cancer Res. 2017. 2. Falk, et al. Acta Oncol. 2017. 3. Falk, et al. Oncoimmunology. 2017. 4. Falk, et al. Acta Oncol. 2017.

SYPP 2: Pulsed Power für Medizin und Biotechnologie II

Zeit: Donnerstag 14:00–16:00 Raum: HS 3

Hauptvortrag SYPP 2.1 Do 14:00 HS 3

Pulsed Electric Fields for the Manipulation of Cancer Cells — Anna Steuer, Fukun Shi, Christina M. Wolff, and •Juergen F. Kolb — Leibniz Institute for Plasma Science and Technology, Greifswald

Pulsed electric fields with durations of nanoseconds and strengths on the order of tens of kilovolts per centimetre have been developed as an alternative method to induce cell death in cancer cells by apoptosis. Following many successful experiments with animals, currently also clinical studies are devised. Basic research on the underlying mechanisms has mostly focused on the study of individual cells in suspension. However, for cells that are organized in a tissue, connections and communication between cells are crucial. Accordingly, we investigated besides intracellular effects also extracellular effects and in particular the response on tight junctions and cell-cell communication and how both affect the development of cells in a tissue, such as their potential to metastasize. Distinct effects could be found that are primarily caused by a transient disassembly of respective membrane proteins that are only compensated by repair mechanisms over the course of one hour. Conversely, these changes have an immediate effect on intracellular biomolecular pathways, elastic properties of cells and on the permeability of tissues. Some of these effects can be enhanced by combining the treatment with pulsed electric fields and exposures to non-thermal plasmas. Overall this allows for new possibilities for tumour treatment and potentially also tissue regeneration.

Hauptvortrag SYPP 2.2 Do 14:30 HS 3

Pulsed electric field use in food industry - process and equipment design — Robin Ostermeier, Julian Witt, and •Stefan Töpfl — Elea GmbH, Prof.-von-Klitzing-Str. 9, D-49610 Quakenbrück, Germany

Application of Pulsed Electric Fields (PEF) results in permeabilization of plant, animal and microbial cells. This allows acceleration of mass transport processes such as drying or extraction as well as improving cutting properties. For liquid media a low heat microbial decontamination can be achieved. The talk will present selected application examples of PEF in industrial use and their commercial, technical and legislative framework.

Hauptvortrag SYPP 2.3 Do 15:00 HS 3

Pulse Generators for a Scale-Up of an Electroporation Device for Mash — •Martin Sack[1], Martin Kern[2], Hermann Armbruster[3], Johannes Fleig[1], Dennis Herzog[1], Martin Hochberg[1], and Georg Mueller[1] — [1]Karlsruhe Institute of Technology, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany — [2]KEA-TEC GmbH, Kaigartenallee 8, 68753 Waghäusel, Germany — [3]Armbruster Kelterei-Technologie GmbH, Zu den Weiherwiesen 1-3, 74363 Güglingen, Germany

For a scale-up of an electroporation device for mash an existing design for a Marx generator equipped with spark gap switches has been improved to allow for a higher pulse repetition rate and a synchronized operation of two Marx generators charged by a single high-voltage power supply. As the pulse repetition rate of spark gap switches is limited due to the time required to remove charged particles and debris from the inter-electrode area, each spark gap has been equipped with a nozzle to guide the gas towards the gap and, hence, increase the gas flow between the electrodes. A pulse repetition rate of 38 Hz has been achieved. Synchronized operation of Marx generators feeding one electroporation chamber enables to overcome limitations in power due to the circuit inductance. A trigger circuit to trigger the generators by overvolting the first spark gap has been set up and tested successfully. In the talk selected design details and results will be presented.

Hauptvortrag SYPP 2.4 Do 15:30 HS 3

Spark discharges as tool for the extraction of microalgal compounds — •Katja Zocher, Raphael Rataj, Anna Steuer, and Juergen F Kolb — Leibniz Institute for Plasma Science and Technology, Felix-Hausdorff-Straße 2, 17489 Greifswald, Germany

Microalgae have gained in importance for green biotechnology during the last years. Besides their potential as feedstock for alternative renewable energy resources, they also contain valuable metabolites for pharmaceutical and nutritional applications, such as lipids, proteins, polysaccharides, and pigments.Although only frugal cultivation conditions are necessary, microalgae are distinguished by a robust cell wall, which allows a remarkable mechanical and chemical robustness. This characteristic often results in poor extraction yields. Conventional extraction techniques have shown to be therefore frequently energy and time consuming, which causes disproportional economic costs. Accordingly, major improvements of extraction technologies are necessary for successful commercialisation. In previous works [1][2], we could show that spark discharges, instigated directly in the microalgae suspension by 100-ns high voltage pulses, offer a gentle and yet effective approach. In comparison to a selected reference method, proteomic analysis revealed commonalities and differences in the protein distribution pattern, although the number of extracted proteins was the same and, in particular, valuable heat sensitive compounds could be extracted. Schlieren diagnostics and atomic forced microscopy was applied to elucidate the responsible spark characteristic for successful cell wall rupture. [1-2] Zocher, K. et al., 2016 and 2018 (under review)