

Proceedings of the 22nd International Conference on Gas Discharges and Their Applications



Novi Sad — Serbia
September, 2-7, 2018

Volume 1



Serbian Academy of
Sciences and Arts



Proceedings of the 22nd International Conference on Gas Discharges and Their Applications



Novi Sad — Serbia
September, 2-7, 2018

Volume 2



Serbian Academy of
Sciences and Arts



PROCEEDINGS OF
THE XXIIND INTERNATIONAL
CONFERENCE ON GAS DISCHARGES
AND THEIR APPLICATIONS

- VOLUME 2 -

2nd - 7th September 2018

Novi Sad, SERBIA

Serbian Academy of Sciences and Arts
&
Institute of Physics, University of Belgrade

Editors: Prof. Zoran Lj. Petrović

Dr. Nevena Puač

Dr. Saša Dujko

Dr. Nikola Škoro

EXECUTIVE MANAGEMENT COMMITTEE

Dr. J.E. Jones, Chair
Prof. G.R. Jones
Prof. J.W. Spencer
Prof. K Hidaka
Dr. A.B. Murphy
Prof. D. Hong
Dr. P. Robin-Jouan

INTERNATIONAL SCIENTIFIC COMMITTEE

Dr. J.-M. Bauchire, France	Dr. J.-P. Borra, France
Prof. Yann Cressault, France	Prof. M. Farzaneh, Canada
Prof. C.M. Franck, Switzerland	Prof. A. Haddad, UK
Prof. K. Hidaka, Japan	Prof. D. Hong, France
Prof. G.R. Jones, UK	Dr. J.E. Jones, UK
Dr. A.B. Murphy, Australia	Prof. Z. Lj. Petrović, Serbia
Prof. G.J. Pietsch, Germany	Prof. V. Rakov, USA
Prof. Ph. Robin-Jouan, France	Prof. A. Robledo-Martinez, Mexico
Prof. Kohki Satoh, Japan	Dr. M. Seeger, Switzerland
Prof. J.W. Spencer, UK	Dr. S. Stangherlin, Switzerland
Dr. T. Teich, Switzerland	Dr. Igor Timoshkin, UK
Prof. J. -Y. Trepanier, Canada	Prof. K.-D. Weltmann, Germany
Prof. Y. Wu, China	Dr. J. D. Yan, UK
Dr. J. L. Walsh, UK	

LOCAL ORGANIZING COMMITTEE

Prof. Zoran Lj. Petrović, Chair	Dr. Nevena Puač, Co-Chair
Dr. Saša Dujko, Co-Chair	Dr. Nikola Škoro, Secretary
Dr. Danko Bošnjaković	Prof. Bratislav Obradović
Dr. Dragana Marić	Dr. Gordana Malović
Kosta Spasić	Jelena Sivoš
Marija Puač	Dejan Maletić
Nenad Selaković	Jasmina Atić
Ilija Simonović	Vladan Simić

Panacomp Wonderland Travel

FOREWORD

The International Conference on Gas Discharges and Their Applications is organized in the city of Novi Sad. It is the second largest city in Serbia and has a long tradition of excellent science and culture. It is designated to be the European Capital of Culture in the year 2021, the first from a candidate country.

This conference is intended for scientists and engineers who deal with gas discharges and related phenomena. The special emphasis is on ideas, construction and implementation of devices for a wide range of possible applications. This field has seen a major growth in the past thirty years, mainly due to its involvement in some of the most productive and modern technologies. The conference is organized by the Serbian Academy of Sciences and Arts and the Institute of Physics of the University of Belgrade.

This book contains 169 papers that have been reviewed by referees selected by the Local Organizing Committee. In addition, this conference will include thematic workshops where certain authors have been invited to present progress reports of their research. All those papers will be presented orally in two parallel sessions according to the tradition of the conference. Last, but certainly not least, the book contains papers associated with 10 invited plenary lectures that will be presented in joint sessions. The present version of the proceedings is published beforehand and is thus only a preliminary version subject to changes in the last minute due to possible absences of some authors. The final and therefore the official version of the proceedings will be presented on the web site of the conference <http://gd2018.ipb.ac.rs/> and will be available to the attendees on a memory card.

The Local Organizing Committee wishes to thank the Executive Management Committee and the International Scientific Committee for their support and advice. The conference received some financial support from the Ministry of Education, Science and Technological Development of the Republic of Serbia and from the Serbian Academy of Sciences and Arts as well as from the funds of the Centre for Non-equilibrium Processes of the Institute of Physics, University of Belgrade. All members of this centre have participated to some degree in the organization of the conference.

Finally, our special thanks go to the participants of this conference who have travelled from different continents, from far and wide and have invested their efforts in maintaining this conference and its tradition. We have tried to honour that tradition for the benefit of future organizers and future generations of scientists working in the field of gas discharges.

On Behalf of the Local Organizing Committee, the Editors

Prof Zoran Lj. Petrović (Co-chariman)

Dr Nevena Puač (Co-chariman)

Dr Saša Dujko (Co-chariman)

Dr Nikola Škoro (Secretary)

TOPICS

Volume 1

- A. Arcs
- B. Corona, Barrier and Surface Discharges
- C. Glows and Breakdown

Volume 2

- D. High Pressure Plasmas and Applications
- E. Low Pressure Plasmas and Applications
- F. Environmental and Medical Applications
- G. Pulsed-Power Applications
- H. Light Sources
- J. Lightning
- K. Test Techniques and Diagnostics
- L. Fundamental Processes and Cross-Sections
- M. Emerging and Topical Applications of Gas Discharges
- N. Measurement Techniques

Table of Contents – VOLUME 1

INVITED LECTURES

IL1	Numerical and experimental study of arc fault in aeronautical conditions J.M. Bauchire, M. Lisnyak, H. Rabat, M. Chnani, A. Bigand, C. Espinosa	1
IL2	Nonequilibrium kinetics in CO ₂ plasmas T. Silva, M. Grofulović, L. Terraz, P. Ogloblina, C. D. Pintassilgo and V. Guerra	5
IL3	Low temperature plasma surface interactions for their future basic researches and applications M. Hori, M. Ito and K. Ishikawa	9
IL4	Controlling plasma surface interactions when challenged by statistics and equilibrium J. Kruszelnicki, S. Huang, C. Huard, C. Qu, A. M. Lietz, S. Mohades, G. Parsey and M. J. Kushner	13
IL5	Basic data calculation and fundamental experiment for SF ₆ -alternative gases X. Li, X. Guo, B. Zhang and, J. Xiong	17
IL6	The verification of a computational model of arc motion using an arc imaging system J.W. McBride	27
IL7	Simulation of subnanosecond discharges in high-pressure gases N. Yu. Babaeva and G. V. Naidis	31
IL8	Laser spectroscopy on plasma liquid systems S. Reuter, B. Goldberg, A. Dogariu, Y. Zhang and R. Miles	35
IL9	Electric breakdown in high voltage gas circuit breakers M. Seeger	39
IL10	Low temperature plasmas: fundamental and biological applications M. Yousfi	43

ORAL CONTRIBUTIONS

A. Arcs

A1	The Effect of Lorentz Force on Nozzle-Arc Characteristics over a range of Currents Sumedh Pawar and Atul Sharma	47
A2	Calculation Model Development of PTFE Nozzle Ablated Mass and Pressure Changes in High-Voltage Circuit Breaker Motohiro Sato, K. Horinouchi, S. Hiza, Y. Nakamura, Y. Yoshitomo, Y. Shimizu and Y. Yokomizu	51
A3	Investigations on the Switching Capability of Medium Voltage Load Break Switches in an Alternative Quenching Gas Marvin Bendig, Nicolas Götte, Thomas Krampert, Armin Schnettler, Achim Kalter and Martin Schaak	55

A4	A Method to Determine the Rate of the Dielectric Recovery in a Medium Voltage Load Break Switch with a Free Burning Switching Arc Marvin Bendig, Nicolas Götte, Thomas Krampert, Armin Schnettler, Achim Kalter, and Martin Schaak	59
A5	Comparison of calculated transport properties with measurements in a wide pressure range Tobias Runge, Steffen Franke, Sergey Gortschakow, Ralf Methling and Michael Kurrat	63
A6	Determination of the Voltage Recovery Process for VSC HVDC Systems after transient Single-Pole to Ground Faults Maximilian Stumpe, Armin Schnettler and Ankur Garg	67
A7	Simulation studies of high-intensity arcs for switching applications Chayma Mohsni, Margarita Baeva, Sergey Gortschakow, Steffen Franke, Kamel Charrada and Zouhour Araoud	71
A8	Study of simple substituted test method for evaluating protective ability of face shield against hazards of electric arcs Shizue Furukawa, Tomo Tadokoro and Michiharu Ichikawa	75
A9	Enhanced Low Voltage DC Switching Using a Permanent a Magnet John Shea	79
A10	Optical Emission Spectroscopy of Ablation-Dominated Arcs during High-Current Phase and around Current Zero Klaus-Dieter Weltmann, Ralf Methling, Nicolas Götte, Sebastian Wetzeler and Dirk Uhrlandt	83
A11	Evaporation-determined model for cathodic heating in GMA welding Oleg Mokrov, Marek Simon, Alexander Schiebahn and Uwe Reisgen	87
A12	Arc Voltage Measurements of Ultrahigh-Pressure Nitrogen Arc in Cylindrical Tubes Fahim Abid, Kaveh Niayesh, Nina Støa-Aanensen, Erik Jonsson and Magne Runde	91
A13	CFD simulation of a 3D featured electrical arc configuration in a 2D axisymmetrical simulation domain Arkadz Petchanka and Frank Reichert	95
A14	Experimental and simulative study on the influence of the electrical field distribution on the dielectric switching behavior of natural gases Nicolas Götte, Marvin Bendig, Thomas Krampert, Paul Gregor Nikolic and Armin Schnettler	99
A15	Last development results for 170kV circuit-breaker project using g3 gas Philippe Robin-Jouan, Jung Hae Eun, Oh Kwang Keun, Kim Young-Geun, Karim Bousoltane, Maxime Perret, Jean-Yves Trépanier and Sina Arabi	103
A16	Investigation on the adjunction of O2 in g3 and its impact on dielectric and breaking in high voltage circuit breaker Karim Bousoltane, Yannick Kieffel, Louis Maksoud, Philippe Robin-Jouan, Daniel Vigouroux, Philippe Teulet and Damien Vancell	107
A17	Improvement of Fault Current Interrupting Arcing Horns for 77-kV Overhead Transmission Lines Toshiya Ohtaka, Mikimasa Iwata, Hayato Awazu, Eiichi Nishikawa, Tatsuya Nakanishi and Minoru Uehara	111
A18	Characteristics of Contact Erosion at Arc Initiation in Low Voltage Switches Katsuki Hotta, Shinya Watanabe and Takashi Inaguchi	115

A19	Numerical Study on CO ₂ Gas Circuit Breaker Using Semi-empirical Model for Radiative Energy Transfer Tomoyuki Yoshino, Amane Majima, Toshiyuki Uchii, Tadashi Mori and Takayasu Fujino	119
A20	Relation between Dynamic Behaviors of Arc Jet and Input Power in a Non-Transferred DC Plasma Torch Kei Maeshima, Hikaru Matsumoto, Hiroki Saito and Takayasu Fujino	123
A21	Radiative Transfer Calculation of CO ₂ Thermal Plasma Using a Hybrid Plank-Rosseland Mean Absorption Coefficient Shunsuke Kozu, Takayasu Fujino, Tomoyuki Yoshino and Tadashi Mori	127
A22	Configuring the Test Current of Internal Arc Tests to replace SF ₆ with Air in SF ₆ -Insulated Power Equipment Masashi Kotari, Tomo Tadokoro, Shin-Ichi Tanaka and Mikimasa Iwata	131
A23	Comparison of the Arc Characteristics and Arc Quenching Capabilities Between CO ₂ and SF ₆ in High-voltage Gas Circuit Breakers Ze Guo, Xingwen Li and Li Chen	135
A24	Dielectric properties of C ₅ F ₁₀ O and its mixtures with CO ₂ at the elevated temperature Xiaoxue Guo, Jiayu Xiong and Xingwen Li	139
A25	Comparative Study on High-Current Arc Extinction Process under Air, CO ₂ and SF ₆ Gas Blasting Using Two-Dimensional Electron Density Visualisation System Yuki Inada, Hiroyuki Nagai, Kumada Akiko, Hisatoshi Ikeda, Hidaka Kunihiko, Tomoyuki Nakano, Yu Tabata, Yasunori Tanaka and Mitsuaki Maeyama	143
A26	Radiation of a nozzle-stabilized, high-current arc in air: measurements and calculations Marley Becerra, Janne Nilsson and Steffen Franke	147
A27	Unified Transfer Matrix Evaluation of the Emission Current Density from Non-refractory Cathodes of Electric Arcs Margarita Baeva	151
A28	CFD Simulation of Multi-Component Flows in High Voltage Circuit Breaker Chambers Sina Arabi, Jean-Yves Trepanier, Ricardo Camarero, Phillippe Robin-Jouan, Patrick Guiavarch and Tianbo Zhou	155
A29	Measurement and simulation on pressure field in arc chamber of low voltage circuit breaker in different structures Yujie Wang, Lijun Wang, Dan Wang and Shenli Jia	159
A30	Analysis of the mechanical effect of high current impulse discharge arc Jiaming Xiong, Lee Li, Hongyu Dai, Haibo Wu and Bin Yu	163
A31	Chemically Non-equilibrium State in SF ₆ Arc Plasmas due to Time Variation and Spatial Gradient in Temperature Yasunori Tanaka and Takanori Iijima	167
A32	Pressure dependence of optimized mean absorption coefficients Petr Kloc, Vladimir Aubrecht and Milada Bartlova	171
A33	Effects of Enclosure Wall Material Ablation on Arc's Voltage-Current-Characteristics Mario Muermann, Henrik Nordborg, Michael Schueller and Alexander Chusov	175

A34	Research on Characteristics of Series Arc Fault under Mechanical Vibration Condition Lizhi Liu, Fengyi Guo, Yanli Liu, Peilong Wang and Shaolei Wang	179
A35	Two-dimensional Temperature Distribution of Air Arc Migrating to Iron Arc Runner Taiga Nagata, Shigeyasu Matsuoka, Akiko Kumada, Kunihiko Hidaka, Shinya Watanabe and Kentaro Kokura	183
A36	Residual Current in Separation Process of Brush and Commutator Segment of Direct Current Motor Immersed in Ethanol Takashi Fukutsuka, Yasunobu Yokomizu, Kazuya Oshima and Hiromitsu Asai	187
A37	Effect of optimized / non-optimized spectral intervals used for Mean Absorption Coefficients on the radiative transfer of clean air Narjisse Kabbaj, Yann Cressault and Philippe Teulet	191
A38	Low-voltage arc plasma simulation in 3D with contact opening process Jiawei Duan, Hao Sun, Mingzhe Rong, Yi Wu and Keyao Huang	195
A39	Motion Characteristics of H ₂ -N ₂ Mixed Gas Arc under High Pressure with Magnetic Field Bowen Jia, Jianwen Wu and Yuan Jiang	199
A40	Analysis of arc parameters for Low voltage DC arc quenching process by using modified Mayr model Kazuho Hasegawa, Akihiro Tsusaka, Toshiro Matsumura, Kazuto Yukita, Yasuyuki Goto, Atsushi Miyamoto, Hiroyuki Ito and Yasunobu Yokomizu	203
A41	Systematic investigation on radiation modeling errors Roman Fuchs and Henrik Nordborg	207
A42	Comparison of different models to calculate the composition of a multi-temperatures plasma of SF ₆ Xavier Baumann, Yann Cressault, Philippe Teulet and Gabriel Vanhulle	211
A43	Numerical simulation of the radial temperature distribution dynamics in an air arc plasma at atmospheric pressure Alexei Merkushev, Jaroslav Triaskin and Artem Vasilev	215
A44	Simulation of impulse arc discharge Alexander Chusov, E. Rodikova, M. Murmann and R. Fuchs	219
A45	Research on the transient characteristic of VF ₆ based on the improved Vlastos reigniting model of SF ₆ gas discharge Zhining Yang, Xixiu Wu, Chaoqun Li and Wenlong Pang	223
A46	Investigation of C ₂ Swan Bands in Optical Emission and Absorption Spectroscopy of Ablation-Dominated Arcs Ralf Methling, Nicolas Götte, Sebastian Wetzeler, Dirk Uhrlandt and Klaus-Dieter Weltmann	227
A47	Influence of the power supply on the electrical arc behaviour Aurore Risacher, Loïc Hermette, Gaétan Chanaud and Nicolas Chadourne	231
A48	Rotary arc in load switch and its simulation using a three dimensional arc model Jing Qiang, Joseph Yan, Duanlei Yuan, J Humphries and J.W Spencer	235
A49	Effect of Applying Magnetic Field on Dynamic Behavior of Arc Jet Produced by A Non-transferred Direct-Current Plasma Torch Takayasu Fujino, Hikaru Matsumoto, Kei Maeshima and Hiroki Saito	239

A50	A coupled model of an LTE arc column and the cathode in high-pressure arc discharges Diego Santos, Marina Lisnyak, Mario D. Cunha, Nelson A. Almeida and Mikhail S. Benilov	Ad 1
------------	--	-----------------

B. Corona, Barrier and Surface Discharges

B1	Electro-hydrodynamics simulation of ozone production in a multi pins to plane corona discharge reactor Jean Philippe Sarrette, Olivier Ducasse and Olivier Eichwald	243
B2	Study of charges deposited on dielectric by a surface DBD using 2D polarimetry technique coupled to discharge imaging measurement Hervé Rabat, Fadi Zoubian and Dunpin Hong	247
B3	Development of a plasma source to enhance atmospheric pressure spatial atomic layer deposition for silicon heterojunction solar cells application Fadi Zoubian, Hervé Rabat, Olivier Aubry, Nicolas Dumuis, Sebastien Dozias and Dunpin Hong	251
B4	Impact of N ₂ O admixture in N ₂ on the characteristics of pulsed-driven DBDs at atmospheric pressure Hans Höft, Manfred Kettlitz, Markus M. Becker and Ronny Brandenburg	255
B5	Discharge Characteristics of Micrometer-scale Gap on Dielectrics upon Pulse Voltage Application Hideki Ueno, Naoki Tani, Atsushi Nishio and Sho Okada	259
B6	Heat transfer analysis of capillary-DBD source Kiriakos Sklias, Dimitrios Athanasopoulos, Policarpos Papadopoulos, Panagiotis Svarnas, Kristaq Gazeli and Panayiotis Vafeas	263
B8	Plasma Jet Simulation in Helium-Air Mixtures Farah Fawaz, Olivier Eichwald, Malika Benhenni and Mohammed Yousfi	271
B9	3D Streamer Simulation in a Point to Plane Configuration Olivier Ducasse, Joseph Plewa and Olivier Eichwald	275
B10	The influence of high-speed airflow on characteristics of nanosecond sliding surface discharge Irina Mursenkova, Alexander Kuznetsov, Anton Sazonov and I. Znamenskaya	279
B11	Surface Flashover Characteristics of Insulator in SF ₆ /CF ₄ Gas Mixture with DC Voltage Xiaolong Li, Xin Lin, Miao Wen, Zhixuan Zhai and Mingzhi Yang	283
B12	Filamentation of nanosecond surface barrier discharge at high pressures: physics and applications Sergey Shcherbanev, Nikolay Popov and Svetlana Starikovskaia	287
B13	Influence of Metallic Particles on the Insulating Properties of Basin-Type Insulator Miao Wen, Xin Lin, Xiaolong Li, Fan Ge, Wenjie Wang and Yaxiang Wang	291

C. Glows and Breakdown

C1	ICCD-imaging of a plasma glow during the prebreakdown stage of nanosecond discharges in different gases at both polarities of voltage Victor Tarasenko, Dmitry Beloplotov, Mikhail Lomaev and Dmitry Sorokin	295
C2	Flashover of metallic-particle polluted insulators in compressed SF ₆ under different voltage waveforms Valeria Teppati, Martin Seeger, Torsten Votteler and Angelos Garyfallos	299
C3	Experimental Characterization and Modeling of the Dielectric Breakdown Strength for Technical Surfaces in F-gas Free High-Voltage Switchgear Svetlana Gossmann, Bernhard Lutz, Andreas Geisler and Paul Gregor Nikolic	303
C4	Objectives and setup to study electrical breakdown in CO ₂ as an alternative to SF ₆ Siddharth Kumar and Tom Huiskamp	307
C5	Breakdown phenomenon across mm-scale gap with thin cavity Hiroyuki Iwabuchi, Yuya Nakaso and Tsutomu Oyama	311
C6	On the Luminosity of a Field-Theoretic Model of Ball Lightning James Jones	315
C7	A particle simulation of subnanosecond breakdown in nitrogen filled gap Dan Wang and Lijun Wang	319
C8	Numerical modelling of pre-breakdown discharges in a wide range of conditions Nuno G. C. Ferreira, Diego Santos, Pedro G. C. Almeida, George V. Naidis and Mikhail S. Benilov	323
C9	Discharges in alcohol vapours at low pressures Jelena Sivoš, Nikola Škoro, Dragana Marić, Gordana Malović and Zoran Lj. Petrović	327
C10	Pulsed electrical discharge in water: from propagation modes to physical mechanisms Cathy Rond, Jean-Michel Desse, Nicolas Fagnon, Xavier Aubert, Mine Er, Arlette Vega and Xavier Duten	331
C11	Modeling of radio-frequency breakdown by a Monte Carlo technique Marija Puač and Zoran Lj. Petrović	335
C12	Detection of breakdown in radiofrequency fields Jana Petrović, Antonije Djordjević, Marija Savić, Dragana Marić and Zoran Lj. Petrović	339
C13	SLF Interrupting Performance Evaluation of CO ₂ Gas Circuit Breaker Seung-Jae Lee, Hyun-Kyo Jung and Hong-Kyu Kim	343