Excitation Waves in Micro-structured Atmospheric Pressure Plasma Arrays

H. Boettner[1], A. Wollny[2], J. Winter[1], V. Schulz-von der Gathen[1], R. P. Brinkmann[2], T. Mussenbrock[2]
[1]Institute for Experimental Physics II: Applied Plasma Physics,
[2]Institute for Theoretical Electrical Engineering
Ruhr-Universität Bochum, 44780 Bochum, Germany
henrik.boettner@rub.de

Atmospheric pressure microplasmas are a growing field in recent research activities. This is due to their promising properties, making them attractive for technological and biomedical applications. The variety of possible applications becomes obvious regarding so-called micro-structured atmospheric pressure plasma arrays [1].
Microplasma arrays can be produced in various sizes and in form of flexible or transparent devices.
The arrays investigated here have typical dimensions of 5x5 mm and consist of 50x50 cavities, where each cavity measures 50x50 µm. The spacing between two neighboured cavities measures 50 µm as well. One cavity is composed of an inverted pyramidal Si electrode where a Ni grid serves as counter electrode. The electrodes are covered with SiO_2-Si_3N_4 polymers and separated by a polyimide layer. The discharges are operated in helium, argon or neon, and in mixtures of those at different mixing ratios. Excitation frequencies are in the order of several kHz and voltages in the range of a few 100 V_{pp}.

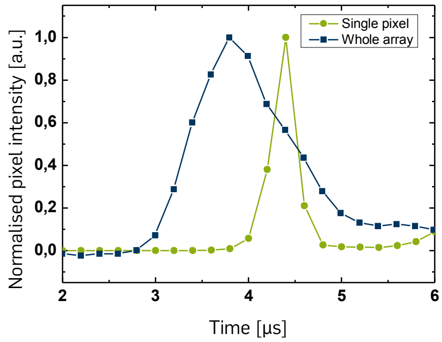

Fig. 1: Comparison of emission from one pyramidal structure to the integral array

We report on simultaneously phase, space and wavelength resolved optical emission spectroscopic measurements on such micro-structured atmospheric pressure plasma arrays. An intensified CCD camera with attached long distance microscope allows to resolve small sections of the array without interfering with the discharge.
Measurements using triangular driving voltages show that the ignition behaviour of such plasma arrays is similar to that of a Townsend discharge whereas self-pulsing similar to that of dielectric barrier discharges (DBD) is observed [2]. However, each emission peak of the self-pulsing is composed of a successive ignition of individual discharge cavities forming a wave-like excitation feature (Fig. 1). This ionisation wave indicates cross-talk between individual discharge cavities. Simulation results (Fig. 2, [3]) of the cross-talk between single discharge cavities are presented and compared to the experiments. Basic energy transport processes, species involved and excitation dynamics leading to this phenomenon are investigated in this combined effort.

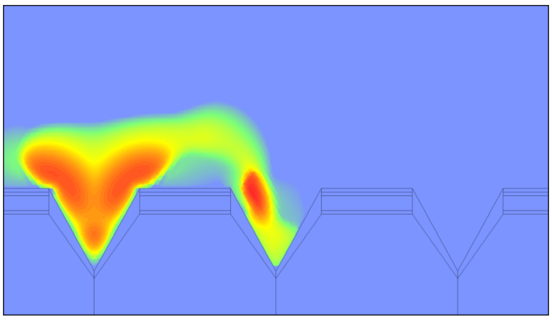

Fig. 2: Simulation of the ionization wave, ignition of centred cavity.

The authors would like to thank J. G. Eden and S.-J. Park from the University of Illinois, Urbana-Champaign for providing us with discharge arrays and stimulating discussions as well as M. J. Kushner for providing *nonPDPSIM* and fruitful discussions. This work is funded by the DFG in the frame of research projects A1 and B1 within the frame of the Research Group FOR 1123 'Physics of Microplasmas' at the research department 'Plasmas with Complex Interactions'.

[1] J. G. Eden at al. 2003 J. Phys. D: Appl. Phys. **36** 2869-2877
[2] H. Boettner et al. 2010 J. Phys. D: Appl. Phys. **43** 124010
[3] M. J. Kushner 2003 J. Appl. Phys. **92** 3, 846-59