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Excitation Waves in Micro-structured Atmospheric Pressure Plasma Arrays

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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. While their small confining structures allow localised treatment and reduced working gas consumption, the absence of vacuum equipment additionally reduces processing costs compared to their low pressure counterparts.

The variety of possible applications becomes obvious regarding so-called micro-structured atmospheric pressure plasma arrays [1]. Such plasma devices can be used as efficient UV light sources whereas they exceed commercial plasma display panels (PDP) in the VIS by a factor of 2 [2]. Moreover, the photosensitivity of these microplasma arrays excels that of conventional Si-based detectors b an order of magnitude [2]. Microplasma arrays can be produced in various sizes and in form of flexible or transparent devices. Thus, they are well suited for numerous applications such as wound sterilisation or optoelectronics as well.

However, the fundamental knowledge of such plasmas, particularly with regard to ignition and sustaining mechanisms, is only rudimentary.

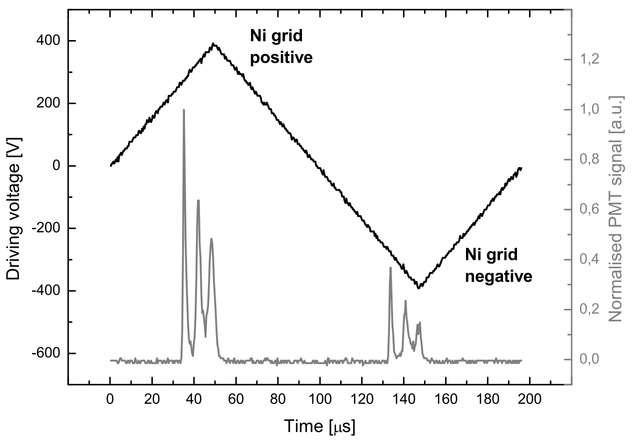

Fig. 1: PMT intensity signal (black) and driving voltage (gray) [4] over one ac cycle for p = 1000 mbar, f = 5 kHz, $Vp-p$ = 780 V, Ne/Ar mixture at a ratio of 4:1.

The arrays investigated here have typical dimensions of 5x5 mm and consist of 50x50 cavities, where each cavity measures 50x50 μm^2. 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_{p-p}.

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 far-field 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 (see Fig. 1) [3, 4]. However, each emission peak of the self-pulsing is composed of a successive ignition of individual discharge cavities forming a wave-like excitation feature. This ionisation wave indicates cross-talk between individual discharge cavities. Basic energy transport processes, species involved and excitation dynamics leading to this phenomenon are investigated.

References

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