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Apokamp discharge: the transient luminous event in physical laboratory

In 2016 the group of experimentalists led by Eduard Sosnin (Institute of High Current Electronics, Tomsk, Russia) has been discovered a new phenomenon in low-temperature plasma physics: an extended plasma jet developing perpendicular to the bending point of the pulsed arc discharge channel between two electrodes [1]. This phenomenon occurs if the discharge ignites between two electrodes: first one must be under the high pulse-periodic potential, and the other have to be floating potential, i.e. connected via a capacitor to "ground" . The discharge has been entitled an "apokamp"(from Greek $\alpha\pi o$ - "off" and $\kappa\alpha\mu\pi\eta$ - "bend"). As it was found that apokamp represents a single needle or a conical jet of 6–7 cm length being attached to the bending point of the current channel. This new unusual type of discharge phenomenon is observed at high (atmospheric) and medium pressures in gas mixtures usually containing a small portion of electronegative admixture, e.g. oxygen or chlorine. It was shown experimentally that apokamp does not exists in highly purificated non-electronegative gases (argon, krypton, nitrogen). It should be also noted that depending on voltage pulse parameters, the apokamp can turn into more than one plasma jets also directed almost perpendicularly to the current channel [2]. In [3], it was shown that the apokamp in low-pressure air represents an exact tiny analogue of large-scale stratospheric transient luminous events, e.g. "blue jets"or "sprites"depending on the operating pressure.

Here we give first theoretical backgrounds for the apokamp phenomenon in terms of deterministic DC-discharge theory. We use the "two-moment model"[4] of a multicomponent discharge plasma to describe a self-sustained periodic discharge in pure oxygen both in the inter-electrode gap and in the surrounding space above the electrodes. To simplify the consideration of a physical situation the 2D-model is used instead of 3D, so the discharge between two plane electrodes with similar to experimental physical conditions has been considered. In simulations, the high-voltage potential is connected to the pulse voltage source through the 10 kohm ballast load. The floating potential electrode is connected to the ground through the 10 pF capacitance. We also consider a simplified plasma-chemical reactions and species sets for oxygen [5]. Our reduced formulation includes only electrons, neutral molecules O and O2, positive O2+ and negative O2- single charged ions. The reactions number are restricted to four most important: electron impact ionization, impact dissociation, electron attachment and ion-ion recombination. We also used non-uniform initial conditions for quasi-neutral plasma density and temperature distribution in the inter-electrode space to perform the simulations in the pre-conditioned medium.

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Authors: KOZHEVNIKOV, Vasily (Institute of High Current Electronics); Prof. KOZYREV, Andrey (Institute of High Current Electronics); Dr SITNIKOV, Alexey (Institute of High Current Electronics); Mr KOKOVIN, Aleksandr (alex@to.hcei.tsc.ru)

Presenter: KOZHEVNIKOV, Vasily (Institute of High Current Electronics)

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