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(I) Investigation of the Pre-ionization Mechanisms in Atmospheric Pressure Townsend Discharges Obtained in Various Gases

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Dielectric barrier discharges are an easy way to generate cold atmospheric pressure plasmas. For millimeter-range gas gap, a streamer breakdown generally occurs resulting in filamentary discharges. They are made of several short-lived plasma channels randomly distributed along the gas gap, which can be a serious drawback for example in the frame of surface coating processes when a homogeneous and dense layer is required [1].

Nevertheless, the possibility to obtain homogeneous discharges in similar conditions has been evidenced for a long time [2]. To do so, it is necessary to promote a Townsend breakdown by slowing down the ionization process; it can be done by supplying seed electrons before the discharge ignition. These so called pre-ionization mechanisms generally result from the previous discharges and are thus called memory effect. The latter strongly depends on the operating conditions such as the background gas or the dielectric materials properties and can occur both in the gas bulk or at the surface.

Discharges generated in different mixtures of N2 and O2 provide a good representation of the mechanisms diversity. In pure nitrogen, it is now well accepted that N2(A) metastable molecules play a significant role. As they diffuse towards the dielectric surface, they can be responsible for the release of trapped electrons from the surface. When a very little amount of O2 (up to 500 ppm) is added, the number of seed electrons dramatically increases suggesting that a new mechanism arises. A possible explanation involve associative ionization reactions between N(2P) metastable atoms generated by N2(A) and O(3P) atoms [3,4]. For larger concentration of oxygen, the strong quenching of N2(A) dramatically reduces its lifetime. In these conditions, it is very likely that surface processes such as spontaneous electron desorption are responsible for the pre-ionization of the gas.

During this presentation, a non-exhaustive overview of the different pre-ionization mechanisms will be provided. This understanding will then be used to address the main keys allowing to obtain operate homogeneous discharges in various gases such as Nitrogen, Nitrogen + oxidizing gazes, Air, CO2 ⋯

References
[1] https://doi.org/10.1002/ppap.201200029
[2] https://doi.org/10.1051/epjap/2009064
[3] https://doi.org/10.1088/1361-6463/ab7518
[4] https://doi.org/10.1088/1361-6463/aad472

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