Characteristics of diffused streamer to spark filament transition observed on the water-air interface

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Electrical discharges in contact with or in liquids have been studied for decades due to their numerous potential applications [1]. Hoffer et al. [2] recently proposed a unique surface coplanar DBD-like electrode system allowing the generation of multiple filamentary discharges expanding along the water surface, leading to effective nitrogen fixation in water. In this work, the detailed characteristics of the discharge are obtained by combining electrical characteristics with time-resolved emission spectroscopy and ultrafast imaging for two different values of initial water conductivity (tap and DI). Ultrafast imaging reveals an initial bi-directional ionization avalanche, followed by discrete discharge channels (filaments), implying the transition of the streamer to the spark phase. This transition is further studied using time-resolved emission spectroscopy. The initial spectra (streamer phase) are composed of molecular bands ($N2/N2^+$) followed by a remarkable increase in intensity and broadening of atomic lines of H^I, O^I, and N^I (spark phase) indicating degree of dissociation and ionization in the discharge channels. The emission spectra are utilized to estimate plasma parameters such as gas temperature (T_{gas}), electric field (E/N), electron density (n_e), and temperature (T_e). The streamer phase is characterized by low gas temperature 300/350 K and E/N 700-850Td whereas the spark phase is characterized by 400/1100 K, $n_e \sim 10^{17}$-10^{18} cm^{-3} and $T_e \sim$ 2-4 eV.

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References

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