

Achieving diffuse propagation of cathode-directed surface ionization waves at atmospheric pressure, over liquid water

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Diffuse propagation of a surface ionization wave over water is achieved at atmospheric pressure, in positive polarity, using high-voltage nanosecond pulses with ultra-fast rise times (20 kV/ns). The discharges are generated in a pin-to-surface configuration and can cover several cm² across a wide range of water conductivities (5-900 $\mu\text{S}/\text{cm}$). Under moderate voltage rise rate (4 kV/ns) the discharge follows the usual 3 development stages ending with the formation of multiple streamers emerging simultaneously from an initial planar wave front (ionization instability) [1]. At higher voltage rise rates (20 kV/ns), the planar wave does not destabilize, and the discharge continues to propagate as a uniform, circular ring until the voltage drops. Conductivity variations (5–900 $\mu\text{S}/\text{cm}$) do not prevent the diffuse propagation, however they influence propagation length, speed, and energy deposition. These findings suggest that high-voltage nanosecond pulses with steep rise times enable controlled, uniform SIW propagation at atmospheric pressure, over diverse dielectrics and in electronegative gases, using simple electrode setups. The authors know only one other work that achieved uniform propagation of cathode-directed nanosecond discharge at atmospheric pressure, by using a very specific bilayer material Si-SiO₂ [2]. In the present work, greater versatility of surface conditions is achieved.

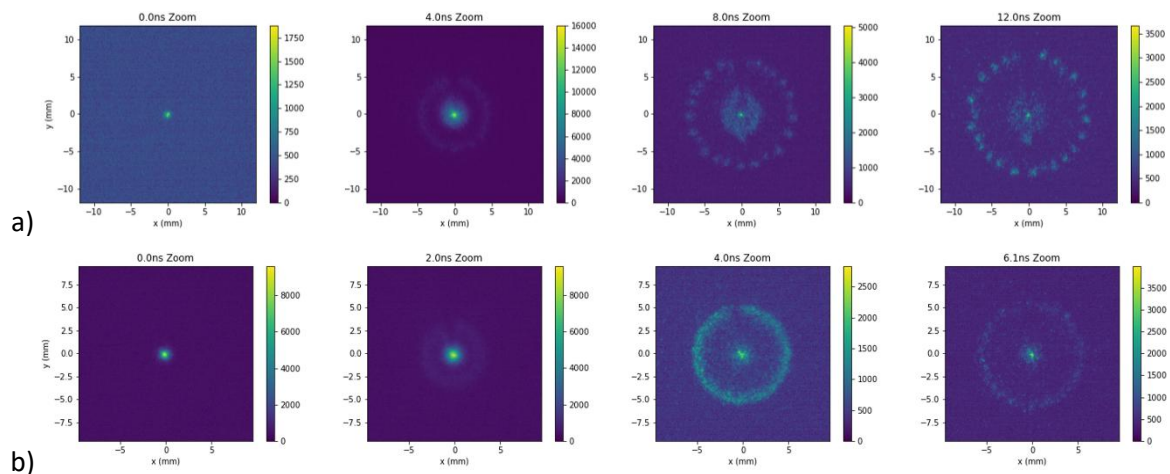


Figure 1 : Optical emission of the surface discharge generated in ambient air over water 5 $\mu\text{S}/\text{cm}$ (a) 20 kV - 1 ns rise time - 4 ns duration, (b) 20 kV - 5 ns rise time - 15 ns duration. Gate width 500 ps. Time 0 corresponds to the time when light emission starts to be detected at the pin.

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Références

- [1] Herrmann et al. Plasma Sources Sci. Technol. 34 (2025) 015004
- [2] Darny T. et al Plasma Sources Sci. Technol. 29 (2020) 065012

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