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Inception Voltage for Corona-like Discharges Generated with 100-ns High Voltage Pulses in Water Depending on Pulse Shape and Water Conductivity

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The development of corona-like discharges that are instigated in water by the application of high voltage pulses is not only important for switching applications but also for discharges that are exploited for water treatment [1]. A parameter that is affecting discharge developments and foremost inception voltages is the pulse shape (rise time, amplitude, pulse duration) but in particular water parameters, such as conductivity and dissolved gas content [2]. Presumably, the influence of pulse shapes is especially crucial for the application of high voltage pulses of only a few nanoseconds.

For the investigation of discharges that are generated with short high voltage pulses of 100 ns, rise and fall times were adjusted between 20 and 45 ns for otherwise equivalent pulse durations. The pulses were applied to a point-to-plane electrode geometry, which was submerged in water with different conductivities from 1 µS/cm to 700 µS/cm. Voltages, currents and emitted light intensities were recorded together with spatial-resolved images of the individual discharge development. For each parameter-set, a statistical analysis was conducted with respect to inception voltages, time lags and channel lengths.

For water conductivities up to 300 µS/cm, the inception voltages decreased with increasing conductivity. This correlates with a decrease of the Helmhotz-layer thickness, which results in a higher electric field near the needle tip. Interestingly, for higher conductivities, inception voltages are increasing again. This can be explained by the change from dielectric to resistive behavior of water. Concurrently, discharge propagation characteristics and reaction chemistries are changing, as illustrated by the channel lengths, light emission and time lags.

[1] Banaschik, R., et al., Electrochimica Acta 245 (2017): 539-548.
[2] Kolb, J.F., et al., Journal of Physics D: Applied Physics 41.23 (2008): 234007

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