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A pulse-sequence resolved study on evolution of streamer dynamics and discharge mode transition under repetitive frequency nanosecond pulses in high-pressure nitrogen

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Nanosecond repetitively pulsed discharge (NRPD) is attracting extensive attention recently due to its unique chemistry and physics properties, which are important for various applications including the plasma fruit sterilization. Streamer dynamics and discharge mode transition were fundamental properties of NRPD. Previous studies mainly investigated the NRPD by using two consecutive pulses and in relative low pressure. However, the streamer dynamics in the long-time continuous operation and high pressure would be dramatically different. In this paper, a pulse-sequence resolved study was carried on streamer dynamics and discharge mode transition under repetitive frequency nanosecond pulses (RFNP) in high-pressure nitrogen.

Two high voltage RFNP generator were designed including the long-pulse-width generator based on the magnetic switch and the short-pulse-width generator based on the avalanche transistor Marx circuit. The gap voltage, light intensity and discharge ICCD image were collected. The pulse-sequence resolution study (every pulse waveform collected in a complete sequence) was achieved by the sequence acquisition mode.

Spatial movement of streamer initiation position and different morphological characteristics under positive RFNP were found, which were determined by the space charge behavior. The steamer channel was found to be narrower under latter voltage pulse than that of the first corona discharge. Under negative RFNPs, the streamer propagation speed decreased with the PRF. The discharge mode would quickly change from the corona discharge to the spark discharge for the 5 mm rod-plane gap under 10 ns pulses. Meanwhile, the spark discharge would transform into the corona discharge in the quasi-stable stage, which was confirmed by the voltage and emission light intensity waveforms.

Streamer dynamics and discharge mode transition were studied based on the pulse-sequence resolved analysis. Several unique characteristics were found in the high-pressure nitrogen, revealing that the positive ions may play the dominating role in the discharge developing process as well as the metastable species.

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