

Nanosecond pulsed discharges in N₂ and N₂/H₂O mixtures

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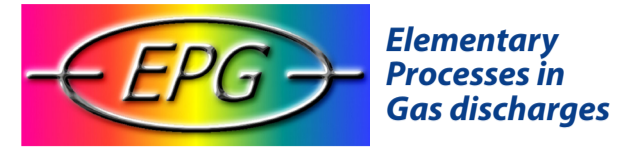
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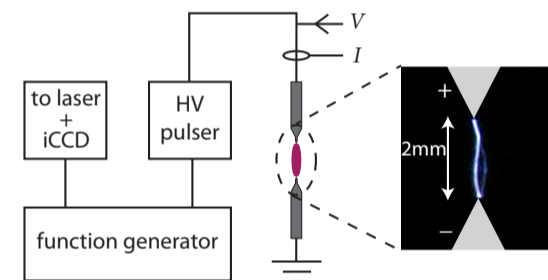
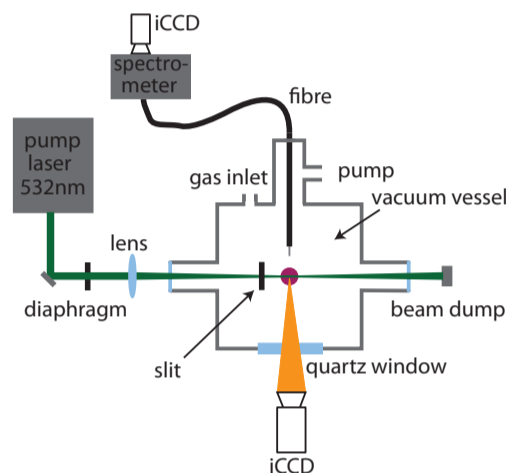
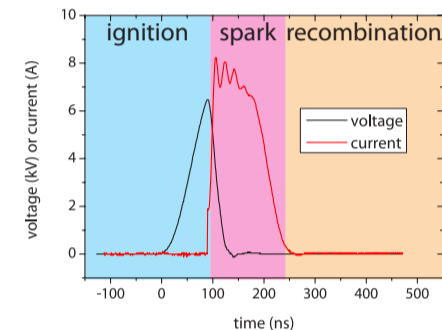


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Introduction

Nanosecond repetitively pulsed (NRP) discharges are of increasing interest in a broad range of biomedical, industrial and environmental applications because these discharges are a rich source of radicals at a low temperature. In this contribution NRP discharges are investigated in N₂ and N₂/H₂O mixtures with time-resolved optical emission spectroscopy and Rayleigh scattering.

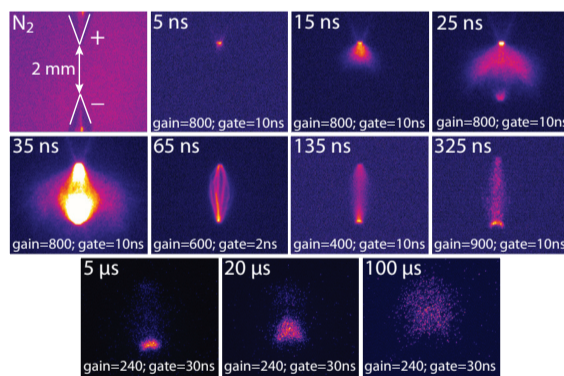
Experimental setup



Voltage: 9 kV
 Frequency: 1 kHz
 Width: 170 ns
 Pressure: 1 bar
 Gap distance: 2 mm
 Gas: N₂ or N₂+0.9% H₂O

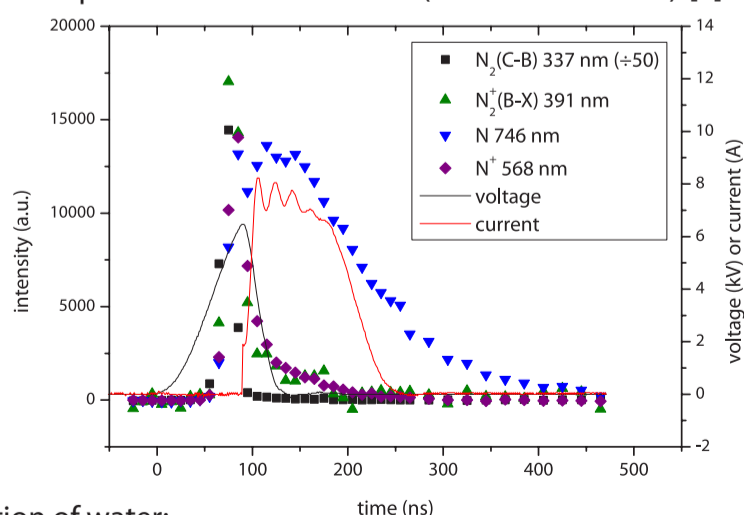
Imaging

- Discharge starts at anode
- Emission 'travels' upward at long timescales (>5 μs)
 - » Gradient in ion density
- No significant difference between N₂ and N₂/H₂O



Optical emission spectroscopy

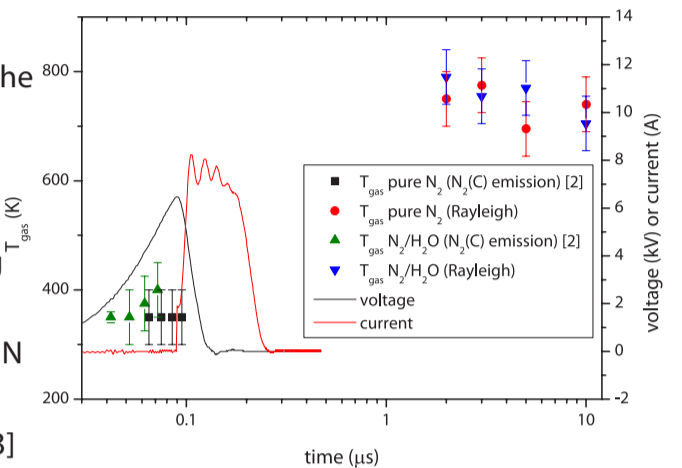
- Molecular emission only during ignition phase
- Decay time of N is (92±3) ns > 51 ns (NIST) in recombination phase
 - » Source present: N⁺ + 2e → N + e (k = 1.1 · 10⁻³³ m⁶s⁻¹) [1]



- Addition of water:
 - » N₂(C-B) emission weaker due to quenching by H₂O
 - » NH(A-X) and H_α emission visible

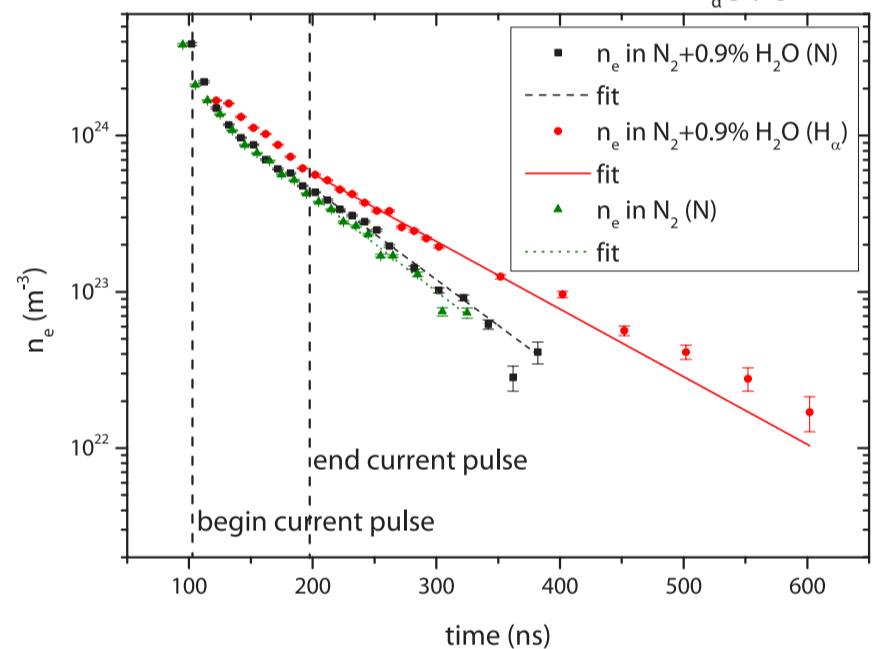
Gas temperature

- High temperature in the recombination phase
 - » Elastic collisions too slow
 - » Due to quenching of excited N₂, recombination of N and electron-ion recombinations [3]



Electron density

- Determined from the width of the N 746 nm line and H_α [4,5]



- Are these densities realistic? Other contributions to FWHM:
 - » External electrical field: <1%
 - » Additional Van der Waals: <1%
 - » Self-absorption: <5%
 } **yes**
- E-field can be determined from the current and electron density
 - » n_e=10²⁴ m⁻³ → V_{electrodes}=70 V } **current density measurements**
 - » n_e=10²² m⁻³ → V_{electrodes}=125 V } **not reliable to obtain n_e**
- Decay different than expected from electron-ion recombination and a slow rate (≈ 10⁷ s⁻¹)
 - » Source present: Penning and associative ionization and vibrational pumping

Conclusion

The temperature in the recombination phase is 750 K. The electron density reaches values up to 10²⁴ m⁻³ and decreases slowly during the recombination phase. Both illustrate the energy stored in metastable species.

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