Diagnostics of nanosecond atmospheric pressure and liquid plasmas

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1. Introduction

Atmospheric pressure plasmas have received a renewed interest in last decades for a variety of applications ranging from environmental remediation, material processing and synthesis to envisioned medical applications such as wound healing.

While most low pressure plasmas are diffuse, atmospheric pressure plasmas are often filamentary in nature. This is due to the increased ionization rate leading to instabilities (constriction) for glow discharges and causes that the Meek criterion for streamer formation in an avalanche is easily fulfilled. The existence of these filaments is correlated with strong gradients in plasma properties both in space and time that can significantly affect the plasma chemistry. As these filaments are often randomly appearing in space and time, stabilization of the filament is necessary to study the chemistry in and around a filament.

In this contribution, diagnostics of a stabilized nanosecond pulsed plasma filament in a pin-pin geometry and a filament in a nanosecond pulsed atmospheric pressure plasma jet will be presented. In addition, nanosecond pulsed discharge in bubbles and directly in liquid water will also be briefly discussed.

2. Results

2.1. Electron kinetics

The electron kinetics in nanosecond pulse discharge for a streamer discharge [3] and spark-like discharges [4] will be analyzed. In particular the excessive hydrogen broadening in liquids and spark discharges in atmospheric pressure discharges found by different researchers will be discussed.

2.2. OH and H kinetics

In the last few years, our group has extensively studied H_2O related chemistry and in particular OH and H kinetics in atmospheric pressure nanosecond pulsed discharges (figure 1). An overview of the chemical kinetics of H_2O related chemistry and the different chemistry observed in different background gases such as Ar, He, N_2 and O_2 will be addressed.

2.3. Optical emission spectroscopy

Due to the often limited accessibility of active (laser) diagnostics and the complicated plasma geometries, emission spectroscopy is often used as a diagnostic tool to investigate plasmas in liquids. The typical strong emission of OH(A–X) and of the hydrogen Balmer lines in liquid plasmas provide a means for obtaining gas temperatures and electron densities. The interpretation of plasma emission can be complex. We will discuss some challenges and opportunities for obtaining a better understanding of these discharges based on studies in atmospheric pressure discharges which allowed a comparison of laser diagnostics with optical emission spectroscopy. Examples of diagnostics of discharges in bubbles [6] and direct liquid discharges will be shown and limitations and challenges will be discussed.

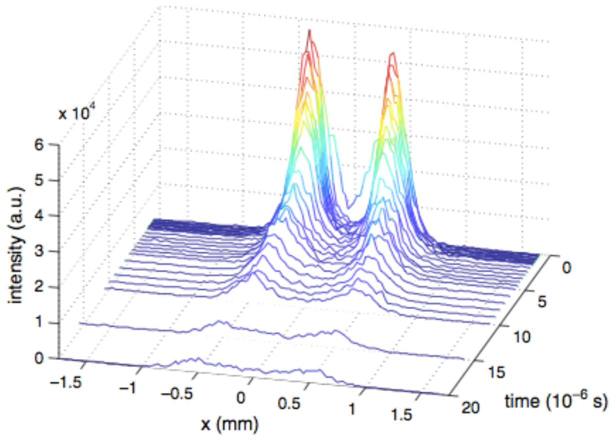

Fig. 1: Time resolved radial profile of the OH fluorescence signal for a nanosecond pulsed discharge in He-H_2O [5].

References

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