OH density measurement by LIF and time-resolved broad band absorption spectroscopy in atmospheric pressure DBD with He(Ar)-H_2O and small O_2 additions

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A fruitful combination of Laser Induced Fluorescence and Time-Resolved Broad-Band Absorption Spectroscopy has been realized for the absolute measurement of OH density and its kinetics in a pulsed dielectric barrier discharge. New findings on the addition of small O_2 concentrations to a He-H_2O mixture are presented.

The hydroxyl radical is thought to play an important role in the plasma chemistry of many atmospheric pressure (ATP) discharge applications like, for example, the removal of VOCs (Volatile Organic Compounds), the ignition and stabilization of flames, or in affecting cells apoptosis or proliferation in Plasma Medicine issues. Direct knowledge of its absolute density and kinetics is then of importance for the understanding of applicative processes and for the validation of discharge kinetics models. Being ATP discharges highly transient and spatially inhomogeneous, a sensitive, time/space resolved technique is necessary.

We have approached this issue by a combination of Laser Induced Fluorescence (LIF) and Time-Resolved Broad Band Absorption Spectroscopy (TR-BBAS). The latter is a novel implementation of BBAS that makes use of a pulsed UV LED source and achieves a time resolution of 100 μs with a minimum detectable density of about $5 \times 10^{12} cm^{-3}$ [1]. This time resolution is of great importance for ruling out the discharge emission from the absorption measurement. A scheme of the diagnostics assembly is shown in figure 1. TR-BBAS provides calibration of LIF and on-line measurement of the OH rotational temperature. LIF provides superior time-resolution and sensitivity, and information on the gas composition through the analysis of the collision quenching and vibrational relaxation characteristics

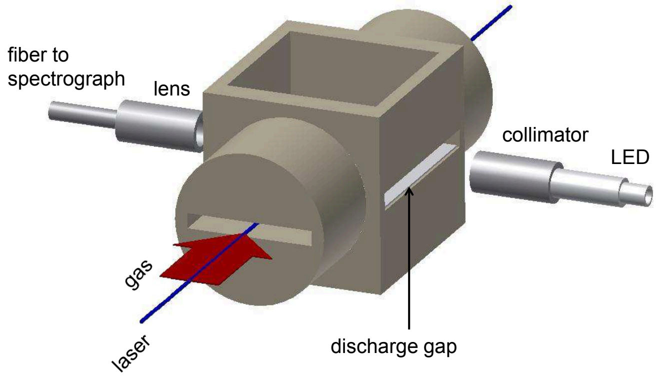

Fig. 1: Drawing of the discharge vessel and of the LED plus optic fiber collection optics assembly.

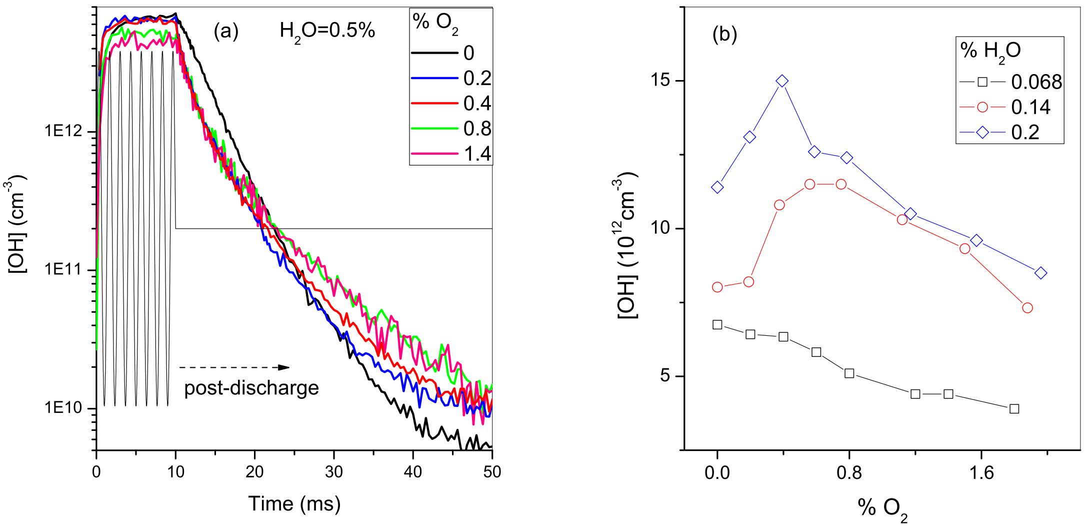

Fig. 2: OH density measurements in He-H_2O-O_2 mixtures: (a)-time evolution at various O_2 percentages and 0.5 % H_2O content - a schematic picture of the pulsed discharge voltage is also shown; (b) density at the end of the discharge for various O_2 and H_2O percentages.

of the fluorescence. In this contribution we present a detailed discussion of the techniques, the OH density measurements already published in [2, 3], made in a pulsed DBD in He/Ar buffer gas with addition of water vapour and nitrogen, calibrated by the TR-BBAS. Moreover we present new findings on the addition of small oxygen quantities to an He-H_2O mixture. Sample results are shown in figure 2. Oxygen addition increases the OH loss rate, as shown by the OH decay in the post-discharge in figure 2a, while the density presents a non-monotonic behaviour (figure 2b). At low O_2 percentage, below 1% and depending on the water concentration, a clear enhancement of OH formation rate is then observed, that overcomes the loss rate increase. Further oxygen increase then reduces the OH density.

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References

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