A new DBD microplasma burner for measuring the effect of nanosecond discharge on burning velocity of CH4-Air flame at atmospheric pressure

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A new DBD microplasma burner for measuring the effect of nanosecond discharge on burning velocity of CH_4/Air flame at atmospheric pressure

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Motivation

Non-thermal and low temperature plasmas in air or gas mixtures at atmospheric pressure are very efficient sources of active species (radicals, excited species, charged particles, photons emission, etc.).

The main objective of this project is to investigate the effectiveness of using non-thermal plasma to enhance the combustion characteristics through the following :

- Radical and species production
- Thermal enhancement
- Increasing burning velocity
- Reducing emissions

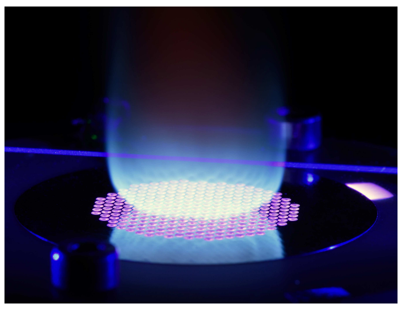
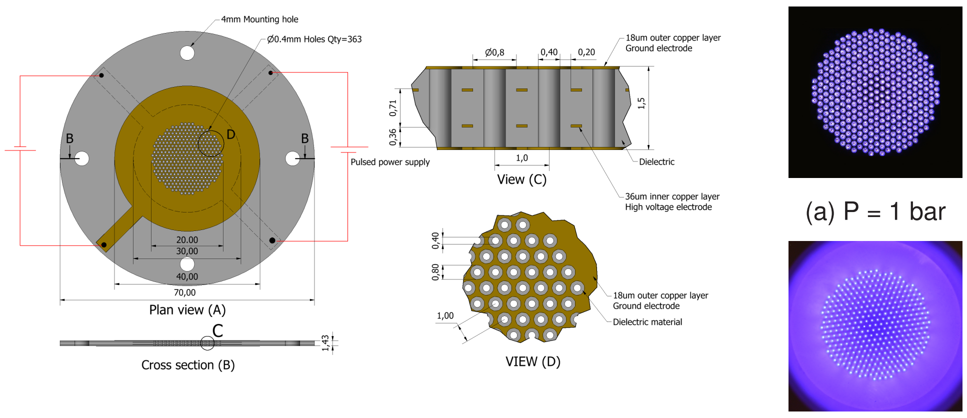


Figure 1: DBD microplasma burner

DBD Microplasma Flow Reactor

In this work, we introduce a new geometry to generate a two layers of a stable non-thermal plasma discharge in a DBD micro-holes structure for gas flow applications at atmospheric pressure.



(a) P = 1 bar

(b) P = 0.1 bar

Figure 2: DBD microplasma reactor geometry

Experimental Setup

The schematic representation of the experimental setup is shown in figure 3.

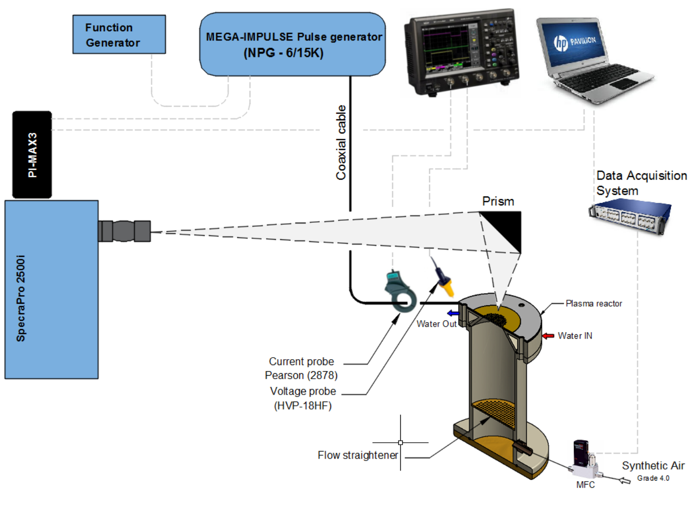


Figure 3: Experimental setup

Experimental Results

Electrical pulse characteristics

- A peak voltage and current of $4kV$ and $40A$ have been measured and a pulse energy of $1mJ$ has been calculated for plasma discharge at atmospheric pressure.
- Two power waves separated by $40ns$ are recorded, and they agree with the spectroscopic measurements.

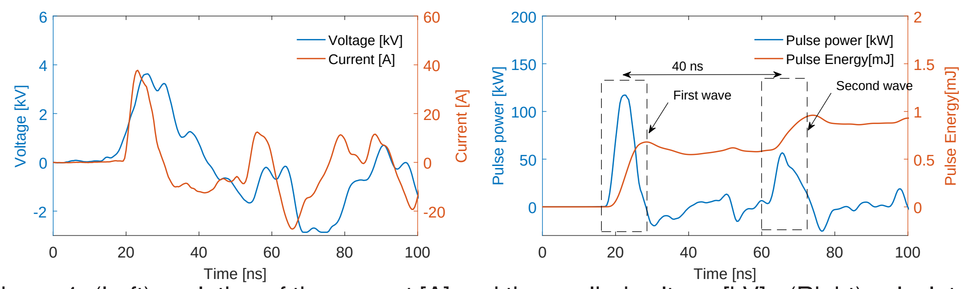


Figure 4: (Left) evolution of the current [A] and the applied voltage [kV] - (Right) calculated instantaneous power [kW] and the pulse energy [mJ] in air at atmospheric pressure

Discharge temperatures

- Plasma discharge in microplasma reactor has a vibrational and rotational temperatures of 3460 K and 550 K respectively at atmospheric pressure.
- Temperature measurements done by comparing the broadening of the emission lines of the second positive system for $N_2(C-B)$ with the Specair code.
- High level of non-equilibrium discharge has been reported.

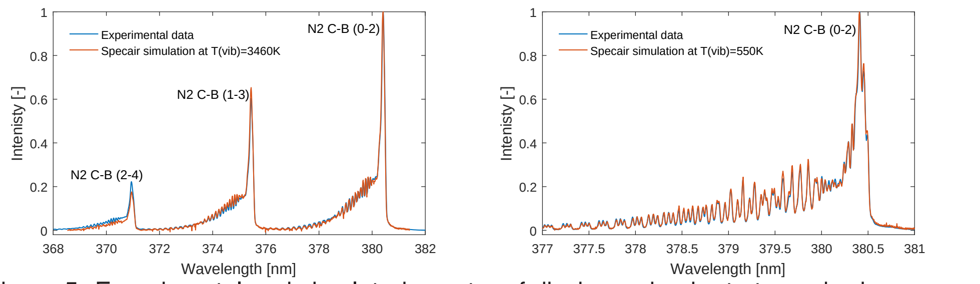


Figure 5: Experimental and simulated spectra of discharge in air at atmospheric pressure (left) using 1800 groove/mm grating (right) using 3600 groove/mm grating

Effect of plasma on burning velocity

- Burning velocity measurements have been done by measuring the angle of a conical flame.
- The graph shows an increasing of the burning velocity as a result of plasma effect.
- In atmospheric pressure, most of the enhancement is due to thermal effect of the discharge.

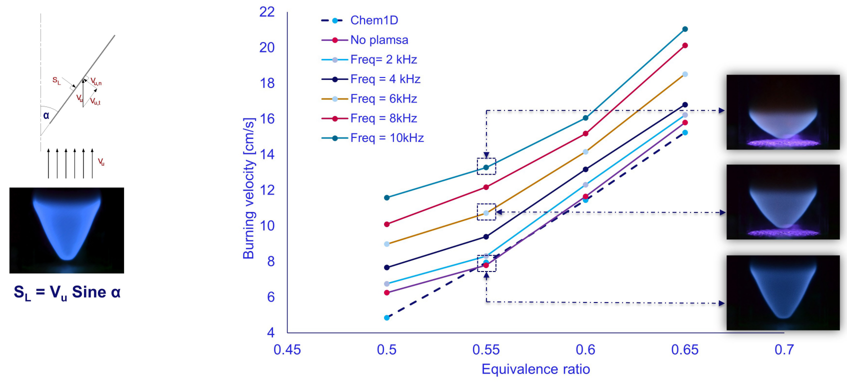


Figure 6: Effect of plasma discharge on burning velocity of CH4/Air flame at atmospheric pressure

Future Work

- Using Raman spectroscopic technique to investigate the plasma discharge effect on flame chemistry.
- Studying the effect of pressure on the plasma emission and flame chemistry.
- Studying the effect of plasma discharge on NOx and CO emissions at different working pressures.

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