Experimental study of ns pulsed microdischarge arrays reactor in nitrogen

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Advanced material deposition such as BN, GaN, … require the use of an efficient plasma source to produce N. To do so, we made use of a Micro Hollow Cathode Discharge (MHCD) technology [1] which generates an electron density in auto-pulsed mode up to 10^{16} cm^{-3} [2]. This value depends directly on the intensity of the current. To increase this intensity, a pulsed power supply was used. In order to deposit over a cm size substrate the source must be extended. Thus, we use an MHCD matrix. Experimental study through fast imaging and spectroscopy emission techniques of array of 7-MHCDs in nitrogen (N_2) has been realized.

1. General

The device is composed of an anode-dielectric-cathode sandwich drilled with a ps laser. An array of 7-MHCDs, with 400 µm in diameter for each MHCD is disposed at the junction between two chambers at different pressures. In chamber 1, the pressure is 50 mbar and the electrode is polarized negatively to favor the high production of nitrogen dissociation. In chamber 2, the electrode is connected to ground and the pressure is 3 mbar in order to limit the nitrogen recombination as illustrated in Fig. 1. Three windows for optical diagnostics are shown (W1, 2, 3). The ICCD is positioned perpendicularly to the MHCDs array, whereas the spectrometer is in front of the plasma jet.

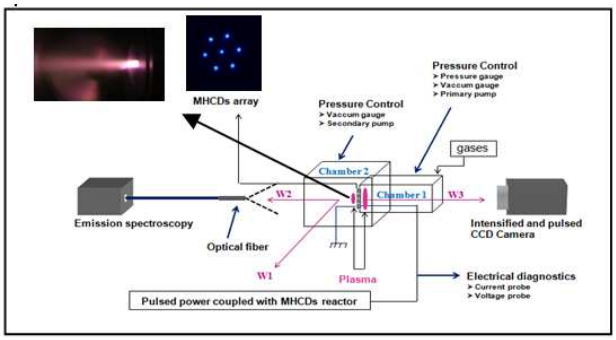

Fig.1. Experimental setup with pictures of the N_2 microplasma jet generated in the low pressure side.

2. Results

Discharge voltage, discharge current and energy per pulse and the corresponding frames of the discharge are shown in Fig. 2. Three main behaviors of N_2 microplasma are identified.

Step 1: the plasma is located on the sandwich throughout the negative pulse of current (0.5 mA) and voltage (800 V).

Step 2: at 1 µs the cathodic inversion occurs. The radiative zone moves at a speed of ~ 80 $km.s^{-1}$, which is typical of the velocity of a streamer.

Step 3: at the voltage decay, the overlapping jets are observed until disappearance, with a velocity of 100 $m.s^{-1}$, which corresponds to the gas velocity.

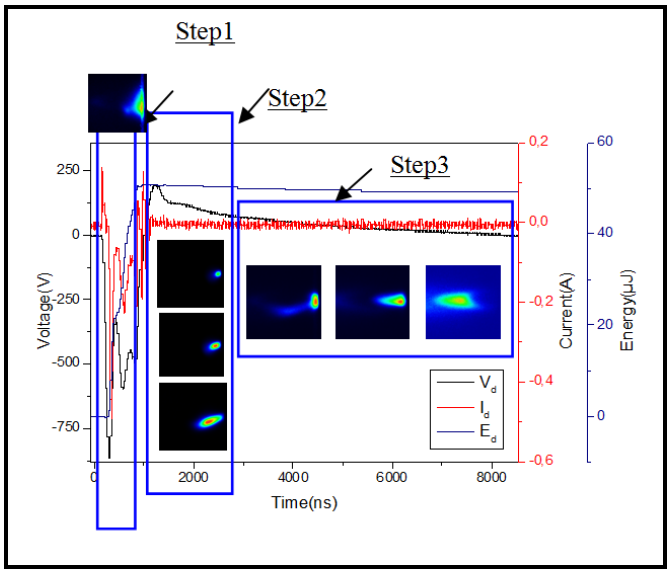

Fig.2. Main steps of the N_2 plasma propagation in the low pressure side of the reactor, including electrical signals

Using a fitting procedure of the second positive system of N_2 at 337 nm [3], we estimate the rotational temperature to be 850 ± 20 K, and the vibrational temperature equal to 3210 ± 200 K under the same conditions.

3. References

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[3] K. Gazeli *et al.*, J. Appl. Phys. (2015) **117**, 093302