Study of the influence of a substrate on the axis of the plasma discharge by optical emission spectroscopy (OES)

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INTRODUCTION

Currently, plasma torches find applications in a wide variety of fields such as production of thin layers, surface cleaning or even sterilization [1,2,3]. The use of plasma has a significant advantage from an environmental point of view compared to processes using liquid phases which generate effluents to be reprocessed. The device used for this study is composed of a plasma torch operating at atmospheric pressure called an "Axial Injection Torch" (or TIA for "Torche à Injection Axiale"). The plasma emitted by the TIA is characterized with an optical emission spectroscopy (OES) device.

OBJECTIVES

Evaluate the influence of several parameters:

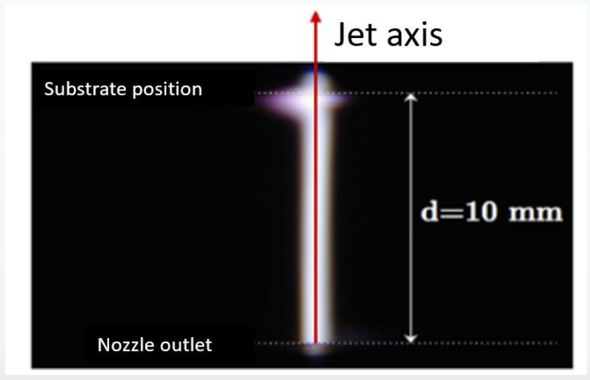
- the nozzle – substrate distance on the characteristic temperatures of the plasma
- the nature of the substrate
- the impact of process parameters

on the characteristic temperatures of the plasma jet

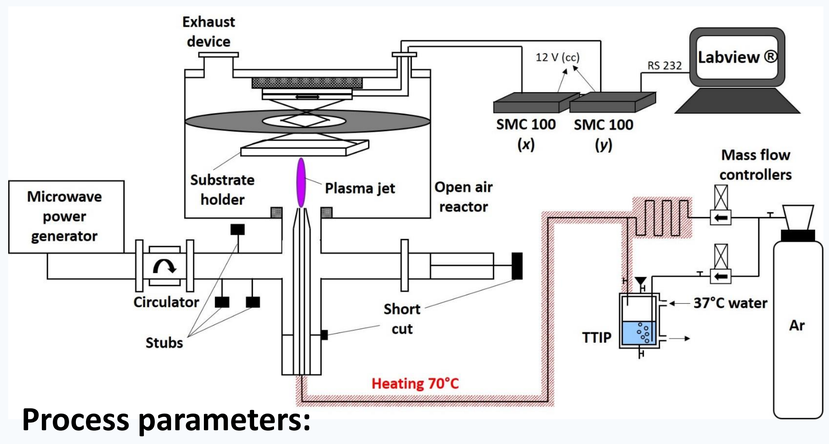
CONTEXT

In order to be more representative of the treatment conditions, a substrate is positioned in the axis of the discharge at different distances from the nozzle depending on the intended application (thin film deposition or surface disinfection).

The addition of this substrate causes a crushing of the plasma and seems to have an influence on its characteristic temperatures.



THE AXIAL INJECTION TORCH[3]



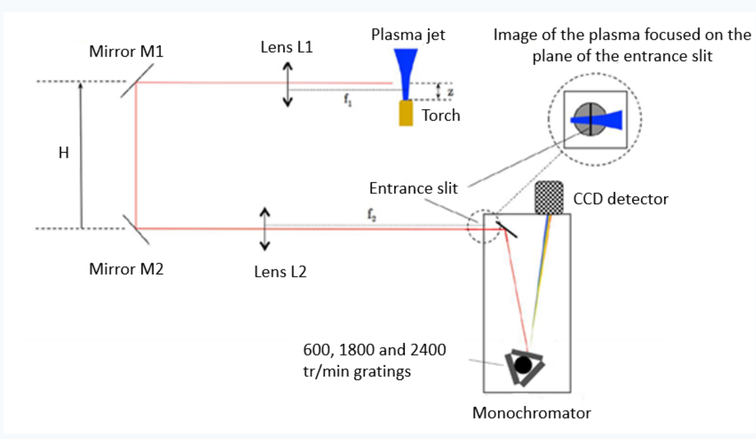
Process parameters:

- Substrate-nozzle distance
- Microwave power
- Argon flow rate

Substrate holder movement:

- LabView program
- Moving speed: 1 to 5 mm/s

OPTICAL EMISSION SPECTROSCOPY



Study of TIA plasma along its axis:

- Gas temperature (T_{gas})→ N_2^+ molecular band

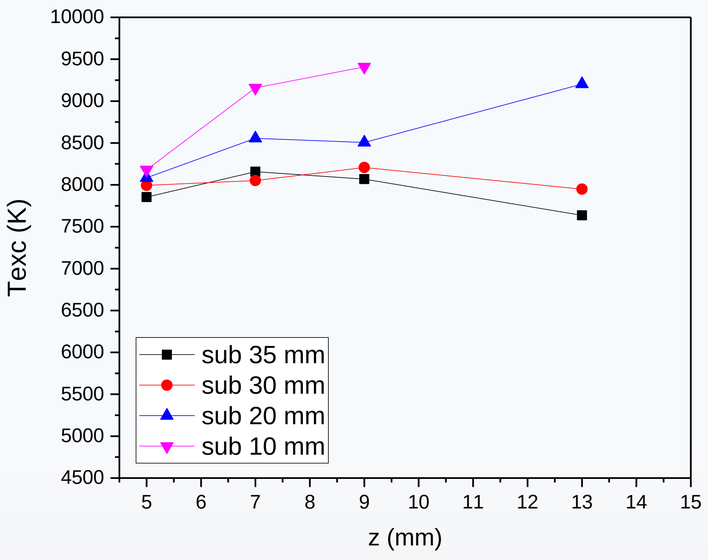
Conditions of acquisition: grating 2400tr/min, slit width 100µm

- Excitation temperature (T_{exc}) → Boltzmann plot method with argon lines

Conditions of acquisition: grating 1800tr/min, slit width 40µm

RESULTS AND DISCUSSION

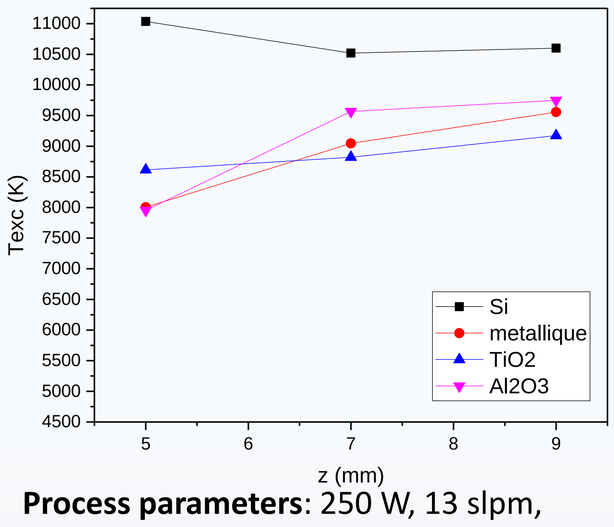
NOZZLE – SUBSTRATE DISTANCE



Process parameters: 350 W, 13 slpm

- T_{exc}: 7500 – 9500 K
- T_{exc} increases when the nozzle – substrate distance decreases
- The substrate does not seem to have any influence beyond 30 mm, in fact the temperature and the trends for 30 and 35 mm are similar.
- A confinement is created therefore the excitation temperature increases in the vicinity of the substrate.

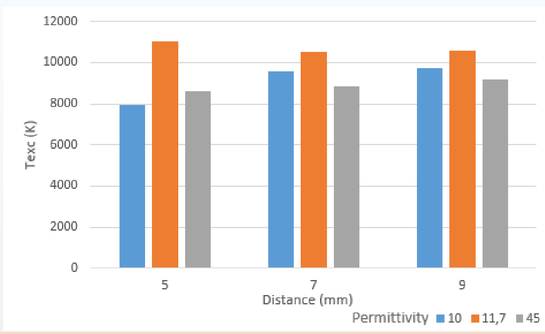
NATURE OF SUBSTRATE



Process parameters: 250 W, 13 slpm, nozzle-substrate distance 10 mm

	Permittivity
Si	11.7
Al_2O_3	9.5-11
TiO_2	45

- T_{exc}: 8000 – 11000 K
- T_{exc} increases along the plasma jet (except for Si) and varies depending on the substrate
- The influence could be linked to the permittivity of the substrate but the correlation is not evident



CONCLUSION AND PERSPECTIVES

- The excitation temperature varies according to the process parameters, the position of the substrate in the axis of the discharge and the nature of the substrate.
- The influence of the nature of the substrate is interesting however it's not understood for the moment, the hypothesis of the permittivity of the substrates does not seem conclusive.
- The temperature of the gas will be calculated with the Specair software using a mathematical adjustement of the molecular band of N_2^+ in order to evaluate the influence of the different parameters.

REFERENCES

[1] A. Bogaerts, E. Neyts, R. Gijbels, J. van der Mullen, Spectrochimica Acta Part B 57 (2002)

[2] Y. Huang, Basic Photomedicine, Photobiological Sciences Online (2009)

[3] A. Perraudeau, C. Dublanche-Tixier, P. Tristant, C. Chazelas, S. Vedraine, et al, EDP sciences, 2019, 10, pp.5.