Spectroscopic study of CO_2 plasma in microwave source designed for hydrogen production via hydrocarbons decomposition

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INTRODUCTION

SUBJECT :

Spectroscopic study of rotational and vibrational temperatures of selected heavy species in high flow rate atmospheric pressure microwave CO_2 plasma

MOTIVATION :

Development of microwave plasma technology at atmospheric pressure and high gas flow rates
Determination of the plasma gas temperature from the rotational temperature of the heavy species [1-3]

APPLICATIONS :

Gas processing:
production of hydrogen via hydrocarbons decomposition [4]
hazardous gas treatment [5]

MICROWAVE PLASMA SOURCE

TECHNOLOGY

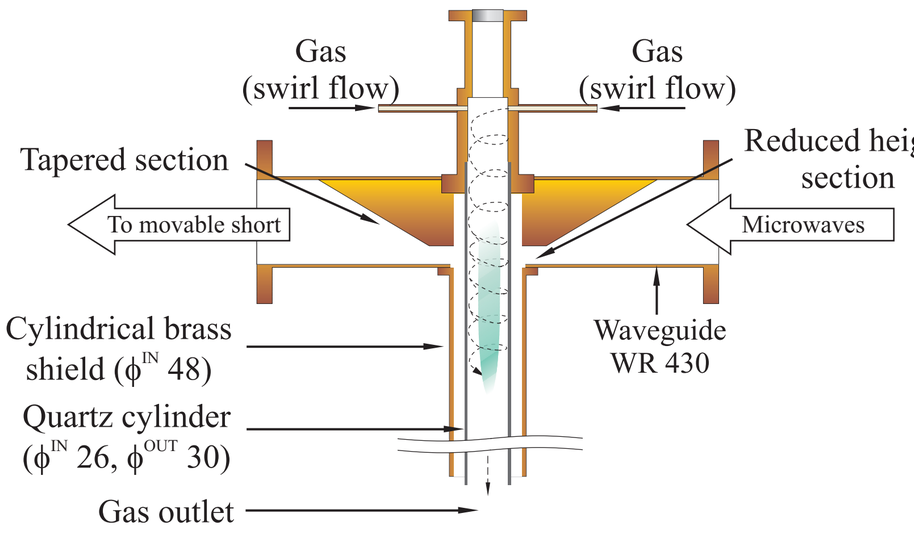
Waveguide-suplied
Nozzleless
Cylindrical type

MICROWAVES

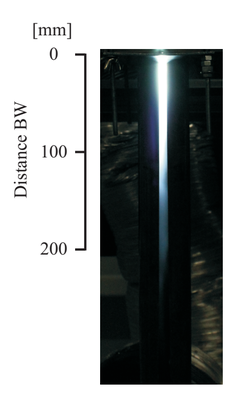
Frequency: 2.45 GHz
Powers: 1000 - 5500 W

GAS FLOW

CO_2
Swirl flow
Flow rate: 50 - 150 l/min

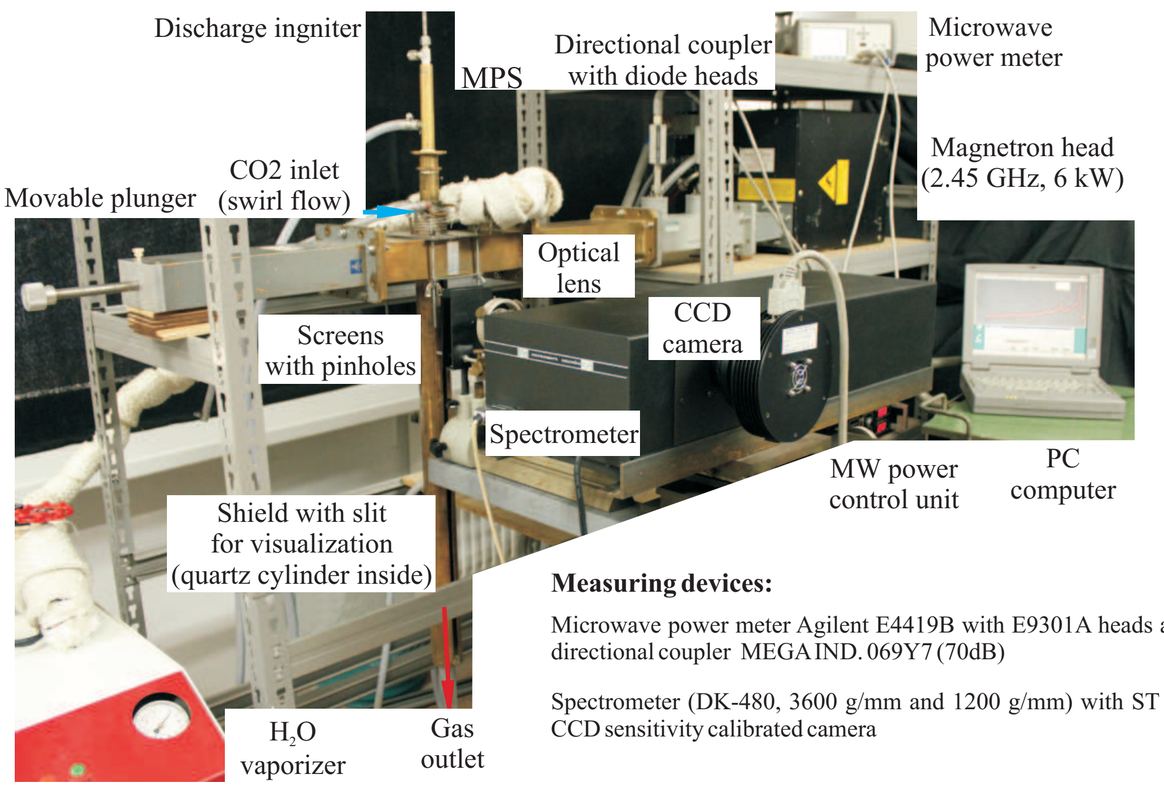


The sketch of MPS



Microwave plasma

EXPERIMENTAL SETUP



Measuring devices:

Microwave power meter Agilent E4419B with E9301A heads and directional coupler MEGA IND. 069Y7 (70dB)

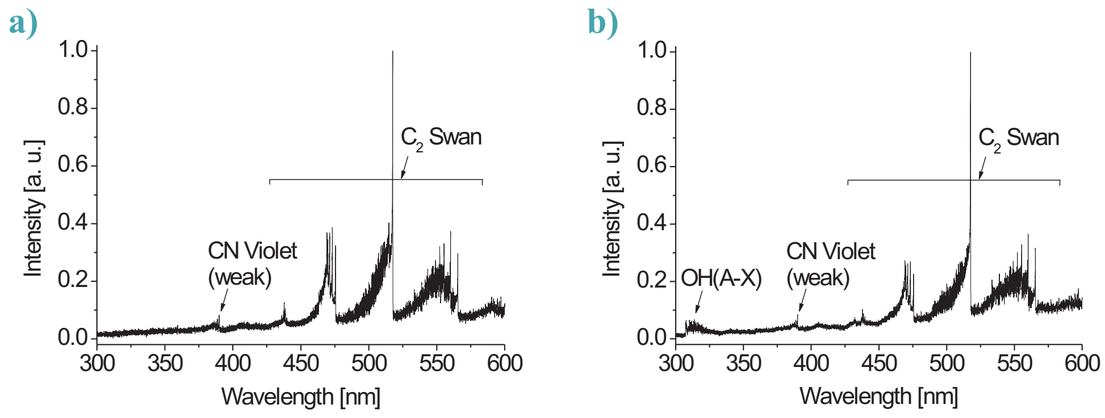
Spectrometer (DK-480, 3600 g/mm and 1200 g/mm) with ST - 6 CCD sensitivity calibrated camera

The experimental setup for spectroscopic study of CO_2 microwave atmospheric pressure plasma at high flow rates

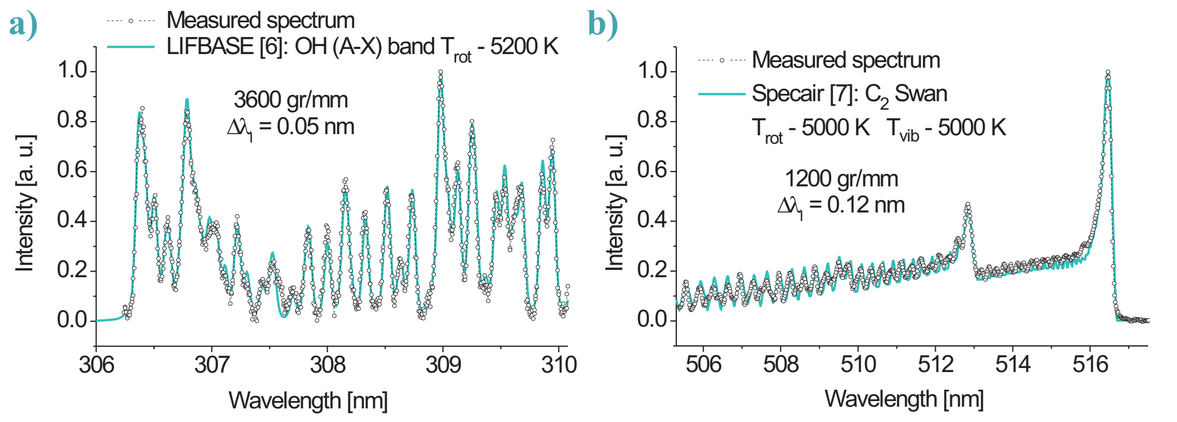
REFERENCES:

[1] E. Pawelec, M. Simek, H. Nassar, et al.: Acta Physica Polonica A **89** (1996), 503
[2] Ch. Izarra: J. Phys. D: Appl. Phys. **33** (2000), 1697
[3] J. Raud, M. Laan, I. Jogi: J. Phys. D: Appl. Phys. **44** (2011), 345201
[4] M. Jasinski, M. Dors, J. Mizeraczyk: J. Power Sources **181** (2008), 41
[5] M. Jasinski, M. Dors, J. Mizeraczyk: Plasma Chem. Plasma Process. **29** (2009), 363
[6] http://www.sri.com/psd/lifbase/
[7] http://www.specair-radiation.net

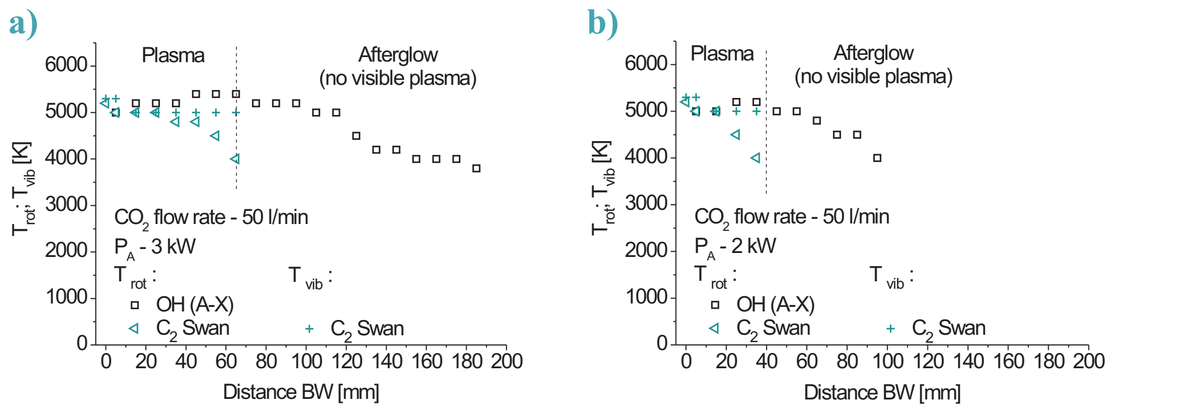
RESULTS



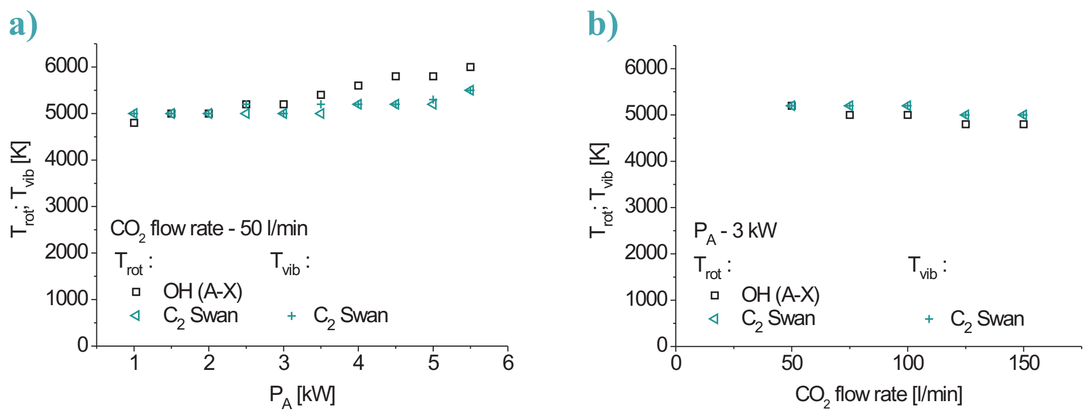
Measured emission spectrum of CO_2 plasm without (a) and with (b) a small addition of water vapour (P_A – 3 kW, CO_2 flow rate - 50 l/min, 15 mm below the waveguide)



Comparison of the measured and simulated emission spectra of OH (A-X) band (a) and C_2 Swan system (b) (P_A – 3 kW, CO_2 flow rate - 50 l/min, 15 mm below the waveguide)



Measured rotational temperature of OH radicals and rotational and vibrational temperatures of C_2 molecules as a function of distance below the waveguide (Distance BW) (P_A - 3 kW (a), P_A - 2 kW (b), CO_2 flow rate - 50 l/min)



Measured rotational temperature of OH radicals and rotational and vibrational temperatures C_2 molecules as a function of microwave absorbed power (a) at CO_2 flow rate - 50 l/min and as a function CO_2 flow rate (b) at P_A - 3kW (15 mm below the waveguide)

SUMMARY

- All temperatures depended on location in the plasma, absorbed microwave power and CO_2 flow rate.
- The rotational and vibrational temperatures of heavier C_2 molecules were from 4000 to 5500 K and from 5000 to 5500 K, respectively.
- The rotational temperature of OH radicals renged from 4000 to 6000 K.
- The rotational temperature of OH radicals seem to be good estimation of the plasma gas temperature in CO_2 microwave plasma.
- Stable operation with various gases as well as wide range of parameters make presented MPS an attractive tool for different gas processing at atmospheric pressure and high flow rates.
- The MPS was successfully used for hydrogen production via hydrocarbons conversion [4] and for Freon destruction [5] owing to high plasma gas temperature.

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