

Spectroscopic study of atmospheric pressure microwave plasma at high nitrogen flow rate

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Introduction

SUBJECT :

Spectroscopic study of rotational and vibrational temperatures in high flow rate atmospheric pressure N_2 microwave plasma

MOTIVATION :

Development of microwave plasma technology at atmospheric pressure and high gas flow rates

The gas temperature can often be inferred from the rotational temperature of the heavy species of the gas [1-3]

APPLICATIONS :

Gas processing:

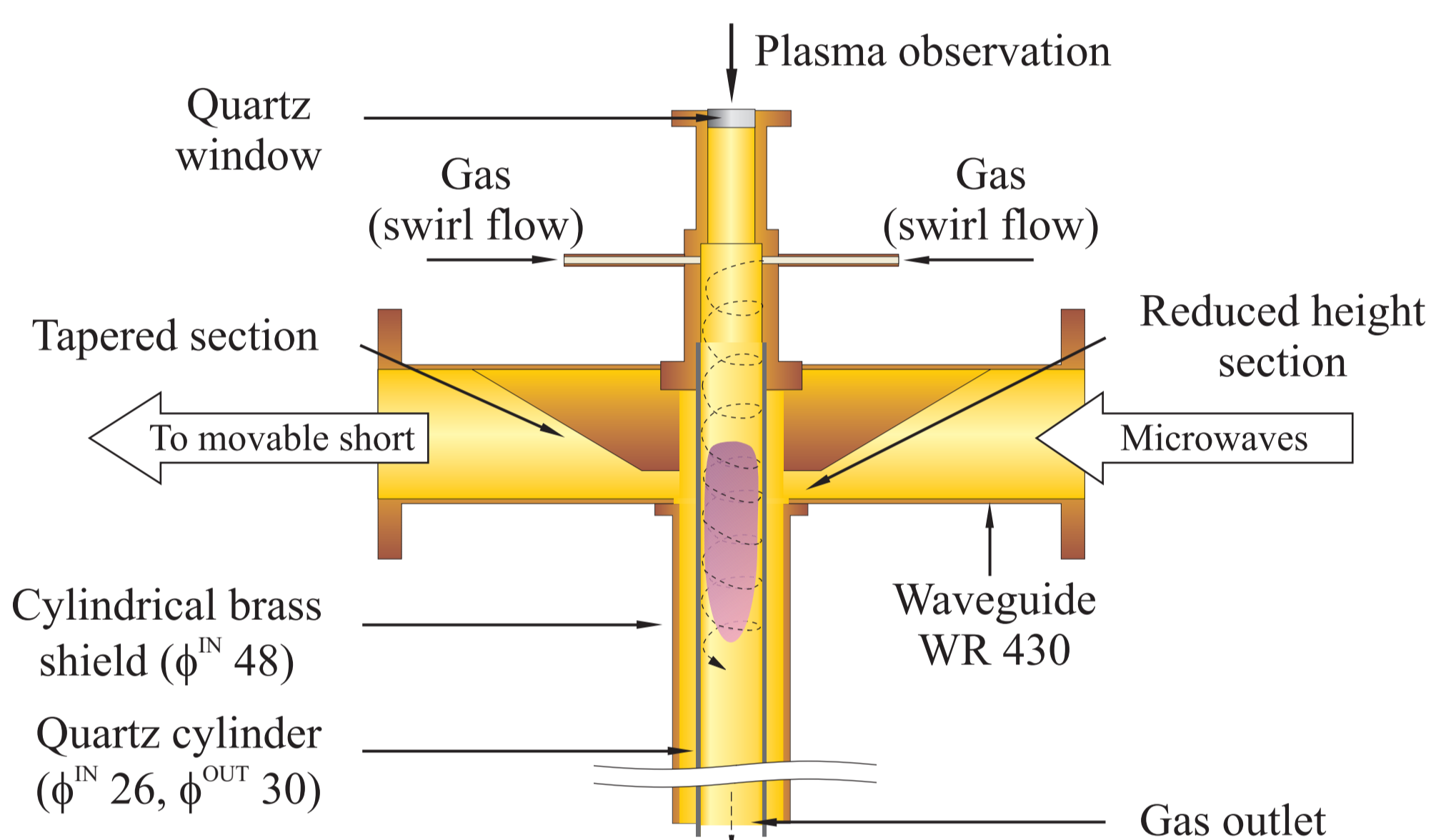
production of hydrogen via hydrocarbons decomposition [4, 5]
hazardous gas treatment [6]

Microwave Plasma Source (MPS)

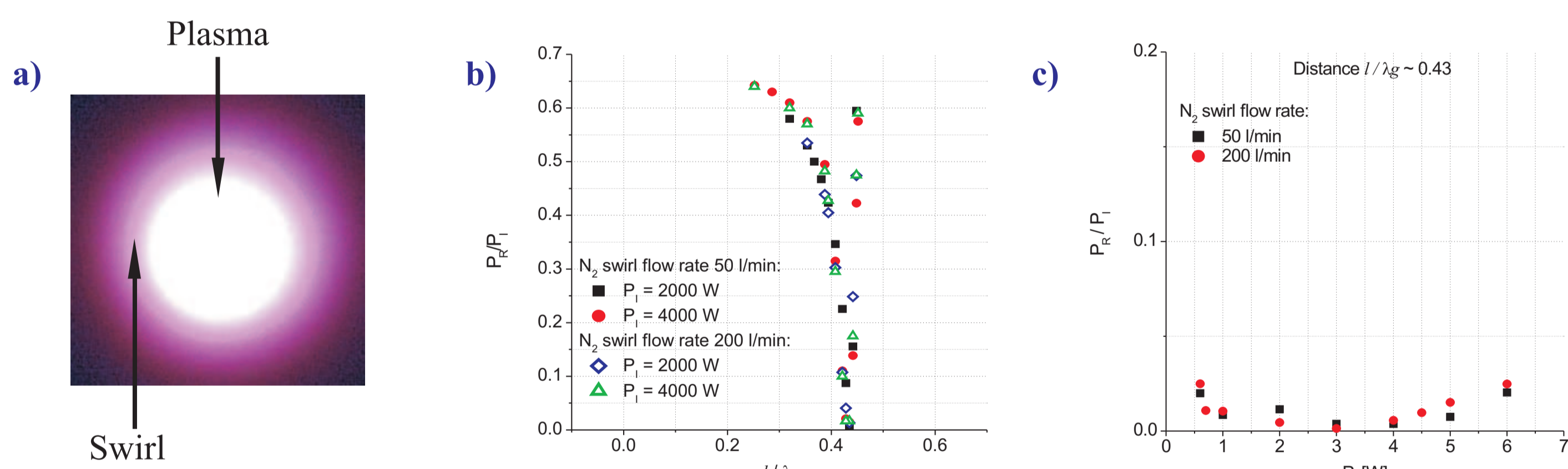
MICROWAVES
Frequency: 2.45 GHz
Powers: 1000 - 4000 W

TECHNOLOGY
Waveguide-based
Nozzleless
Cylindrical

GAS FLOW
 N_2
Swirl flow
Flow rate: 50 - 200 l/min

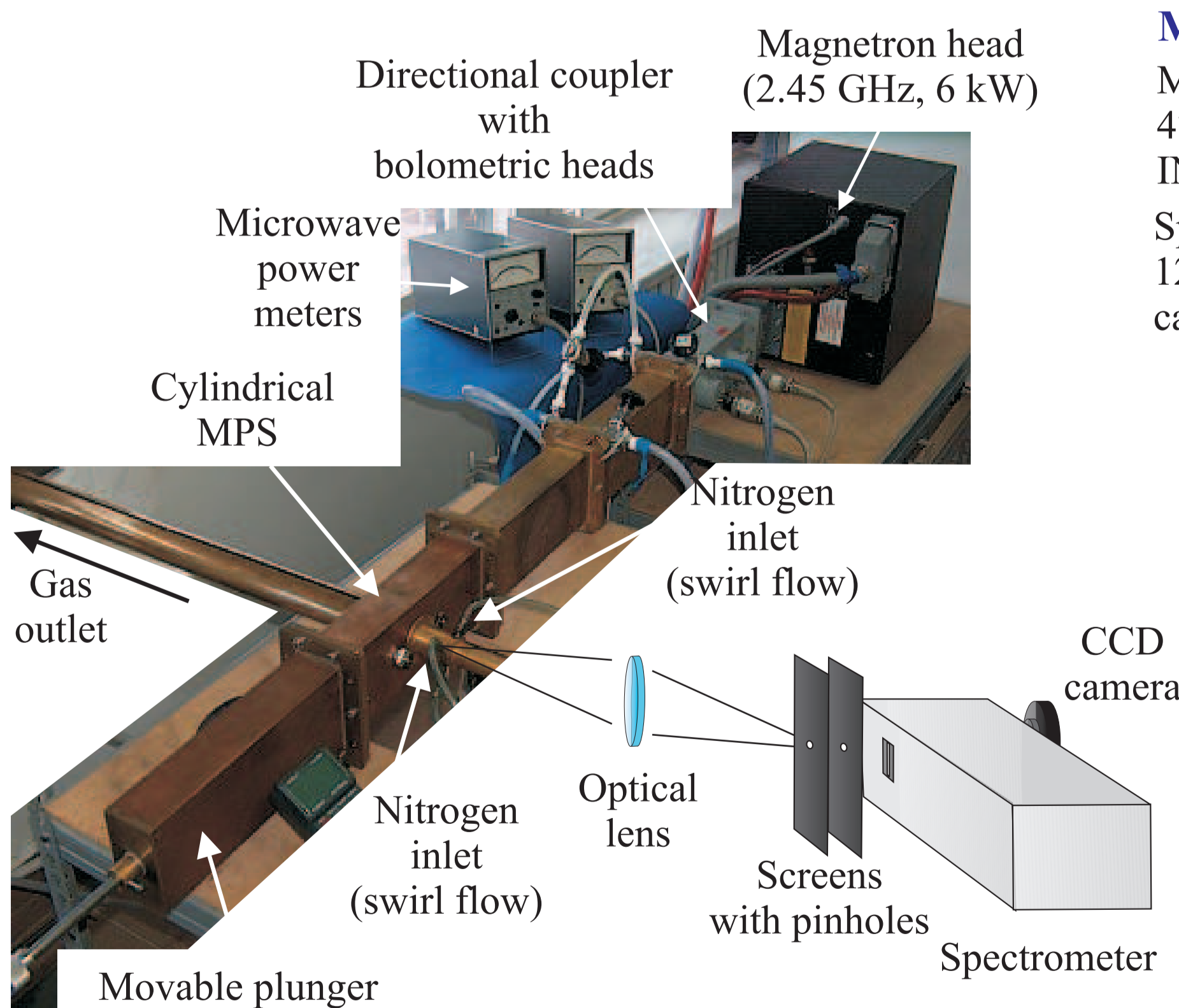


The sketch of cylindrical MPS



a) Bottom view of N_2 plasma ($P_{abs} = 2$ kW and N_2 flow rate - 50 l/min), b) normalized tuning characteristics of the cylindrical MPS operated in N_2 , l/λ_g - distance between the plasma axis and movable plunger, λ_g - waveguide wavelength (147.7 mm), c) the fraction of the incident power reflected at the MPS input for different conditions at fixed position of movable plunger ($l/\lambda_g \sim 0.43$)

Experimental setup

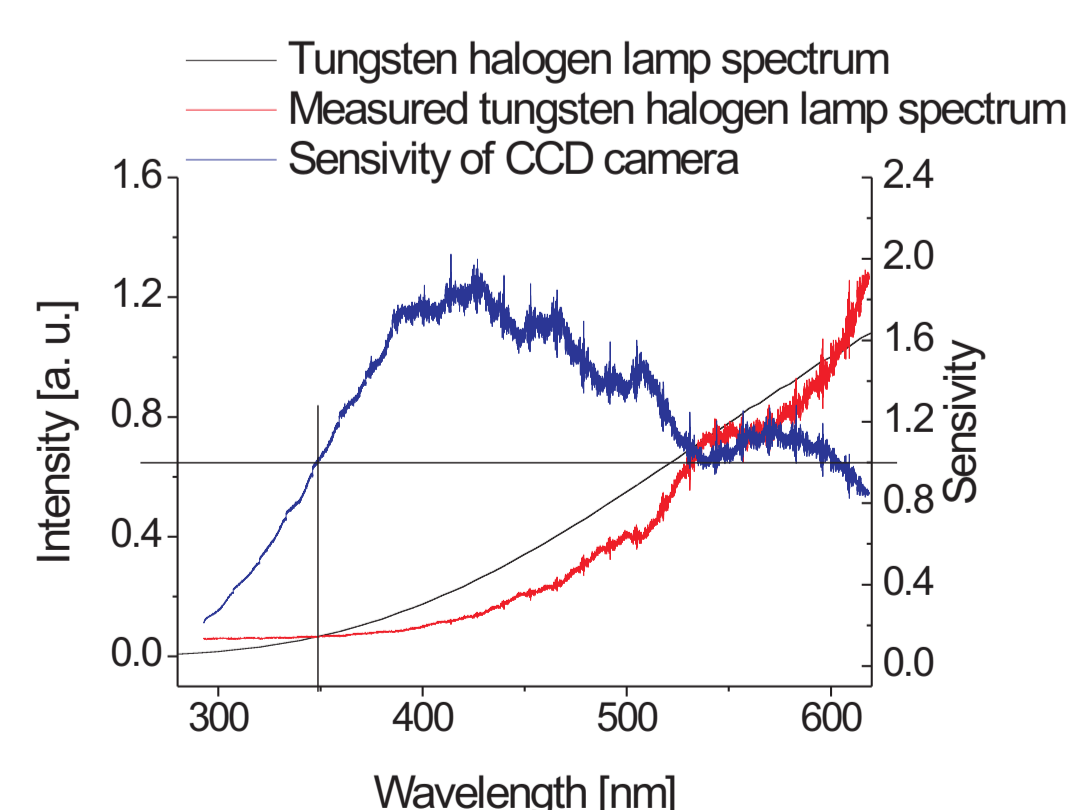


The experimental setup for spectroscopic study of N_2 microwave atmospheric pressure plasma at high flow rates

Measuring devices:

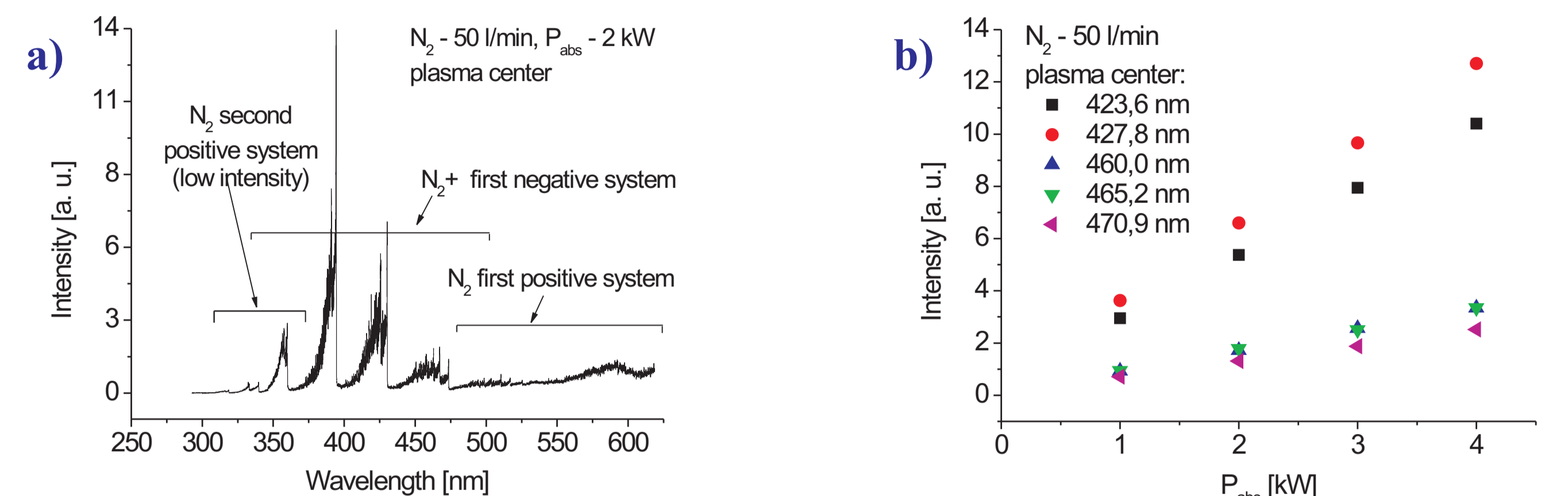
Microwave power meters HP 432A with HP 478A heads and directional coupler MEGA IND. 069Y7 (70dB)

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

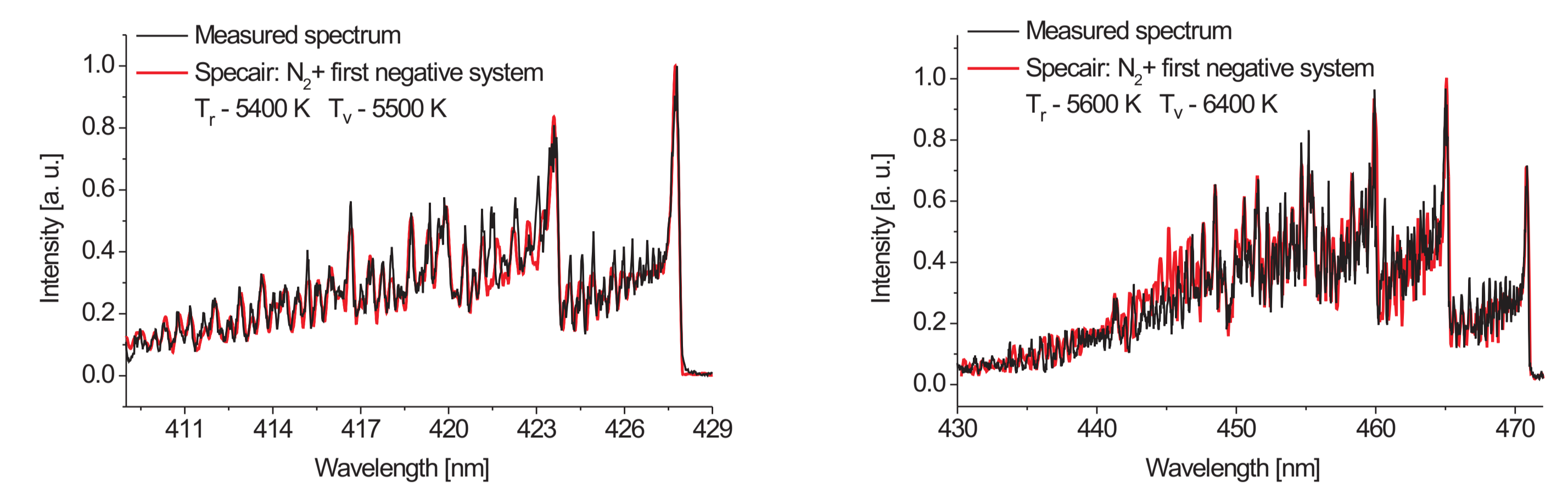


CCD camera sensitivity calibration

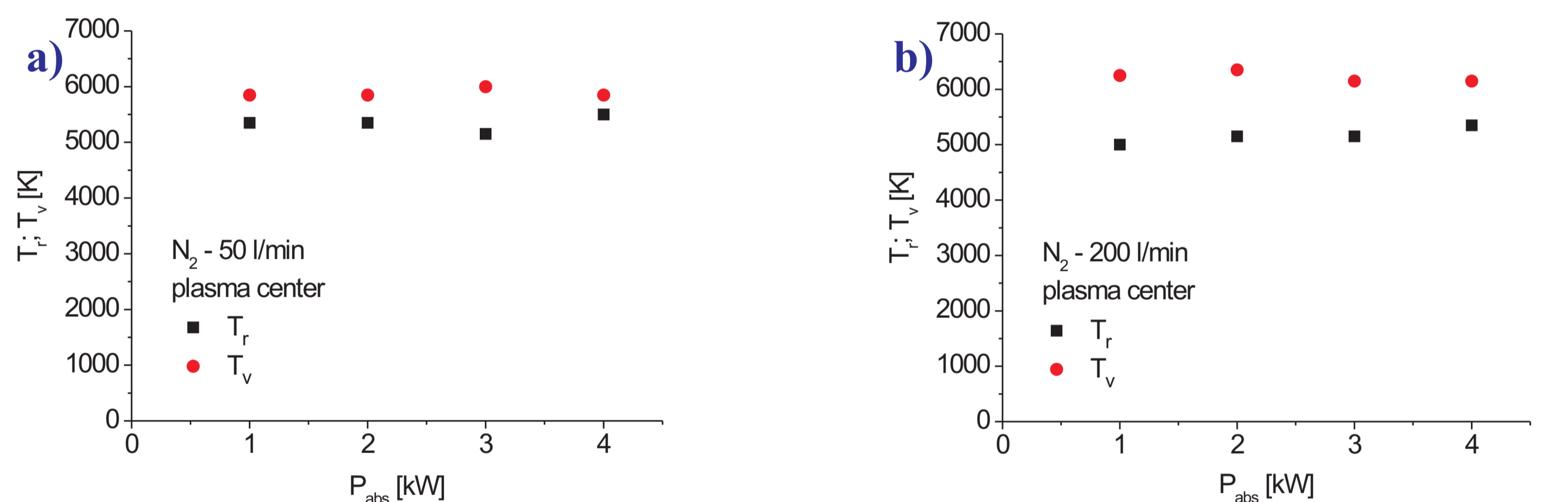
Results



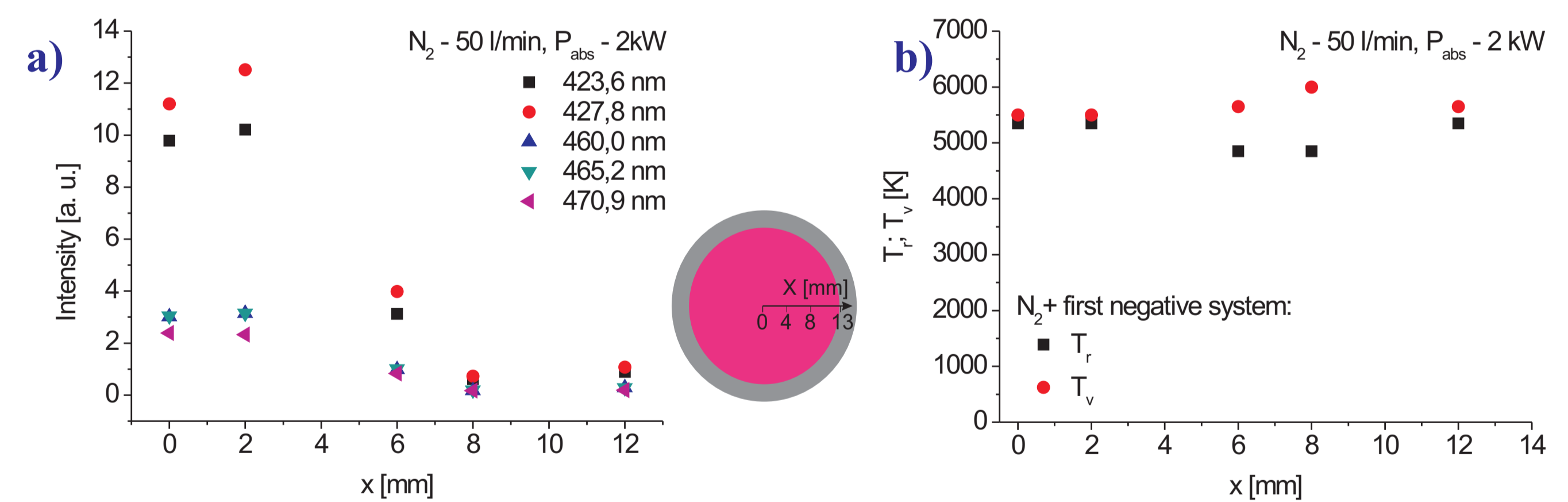
a) Measured emission spectrum of N_2 plasma ($P_{abs} = 2$ kW and N_2 flow rate - 50 l/min), b) intensities of the selected lines of N_2+ first negative system as a function of microwave absorbed power (N_2 flow rate 50 l/min)



Comparison of the measured and simulated in Specair program [7] emission spectra of N_2+ first negative system in N_2 plasma ($P_{abs} = 2$ kW, N_2 flow rate - 50 l/min)



Rotational T_r and vibrational T_v temperatures as a function of microwave absorbed power for N_2 flow rates 50 l/min (a) and 200 l/min (b)



Intensities of the selected lines of N_2+ first negative system (a) and rotational T_r and vibrational T_v temperatures (b) in N_2 plasma as a function of position in quartz tube cross-section

Summary

- The study concerns the rotational and vibrational temperatures of N_2+ first negative system emitted by microwave N_2 plasma at atmospheric pressure and high flow rates
- Obtained rotational and vibrational temperatures ranged from 4500 to 6000 K and from 5000 to 7000 K, respectively, depending on location in N_2 plasma, N_2 flow rate, and also depending on selected N_2+ first negative system band
- Stable operation and the high gas temperature makes MPS attractive tool for different gas processing at atmospheric pressure and high flow rates

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