ATMOSPHERIC PRESSURE MICROWAVE PLASMA DEVICE FOR HYDROGEN PRODUCTION

Mariusz Jasiński[1], Dariusz Czylkowski[1], Bartosz Hrycak[1], Mirosław Dors[1], Jerzy Mizeraczyk[1,2]

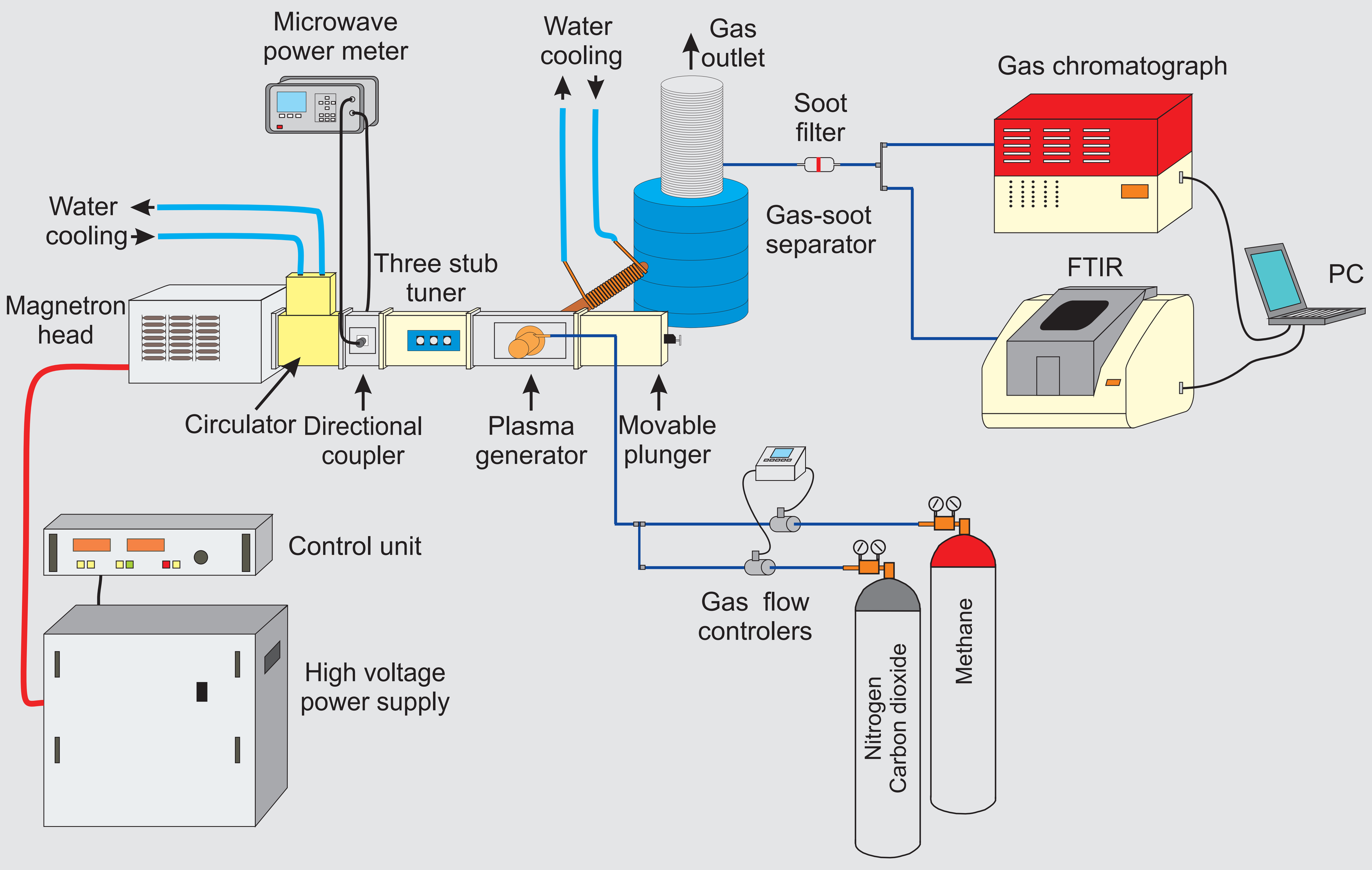
Centre for Plasma and Laser Engineering, The Szewalski Institute of Fluid Flow Machinery, PAS, Gdańsk, Poland (1)

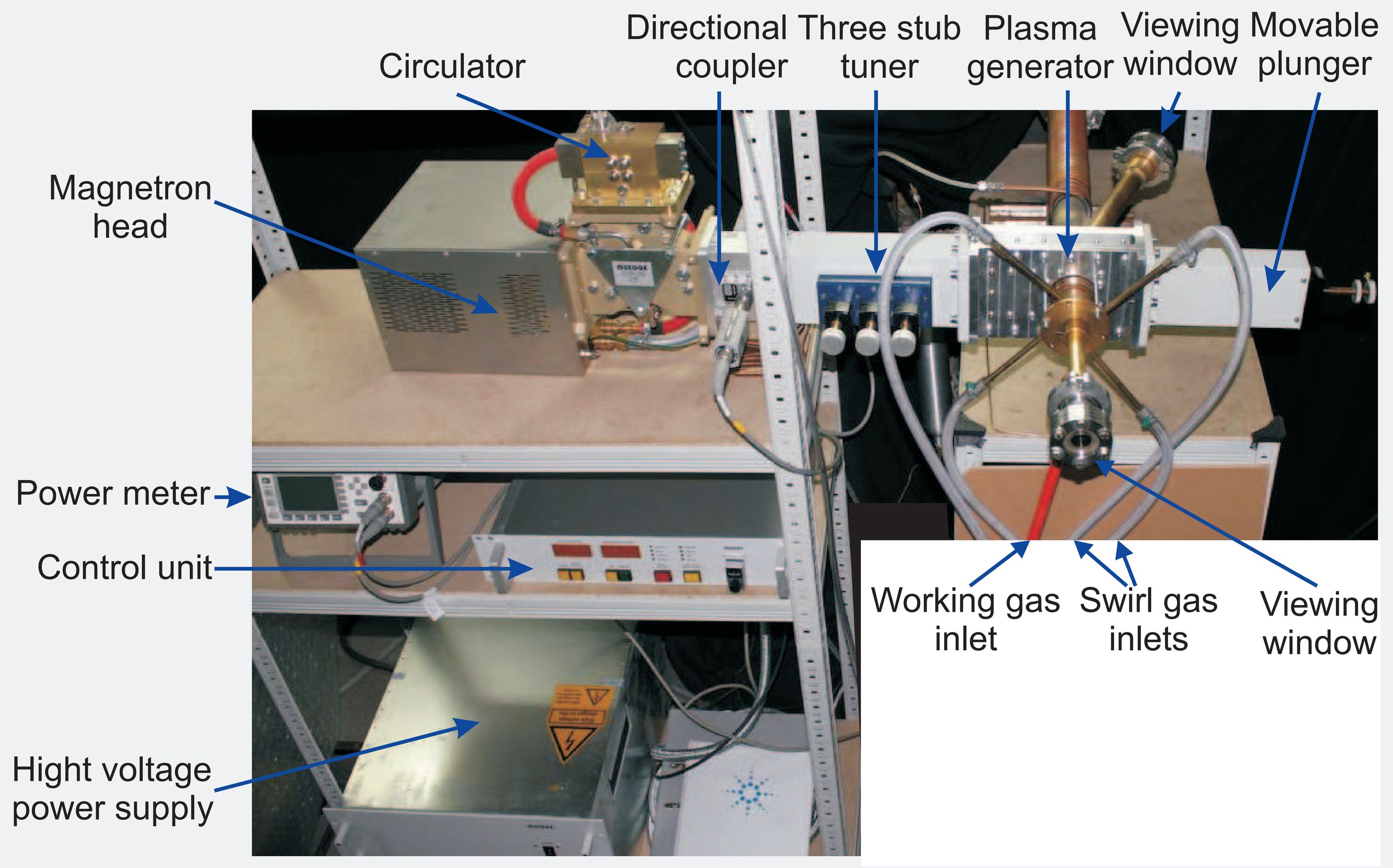
Faculty of Marine Electrical Engineering, Gdynia Maritime University, Gdynia, Poland (2)

Introduction

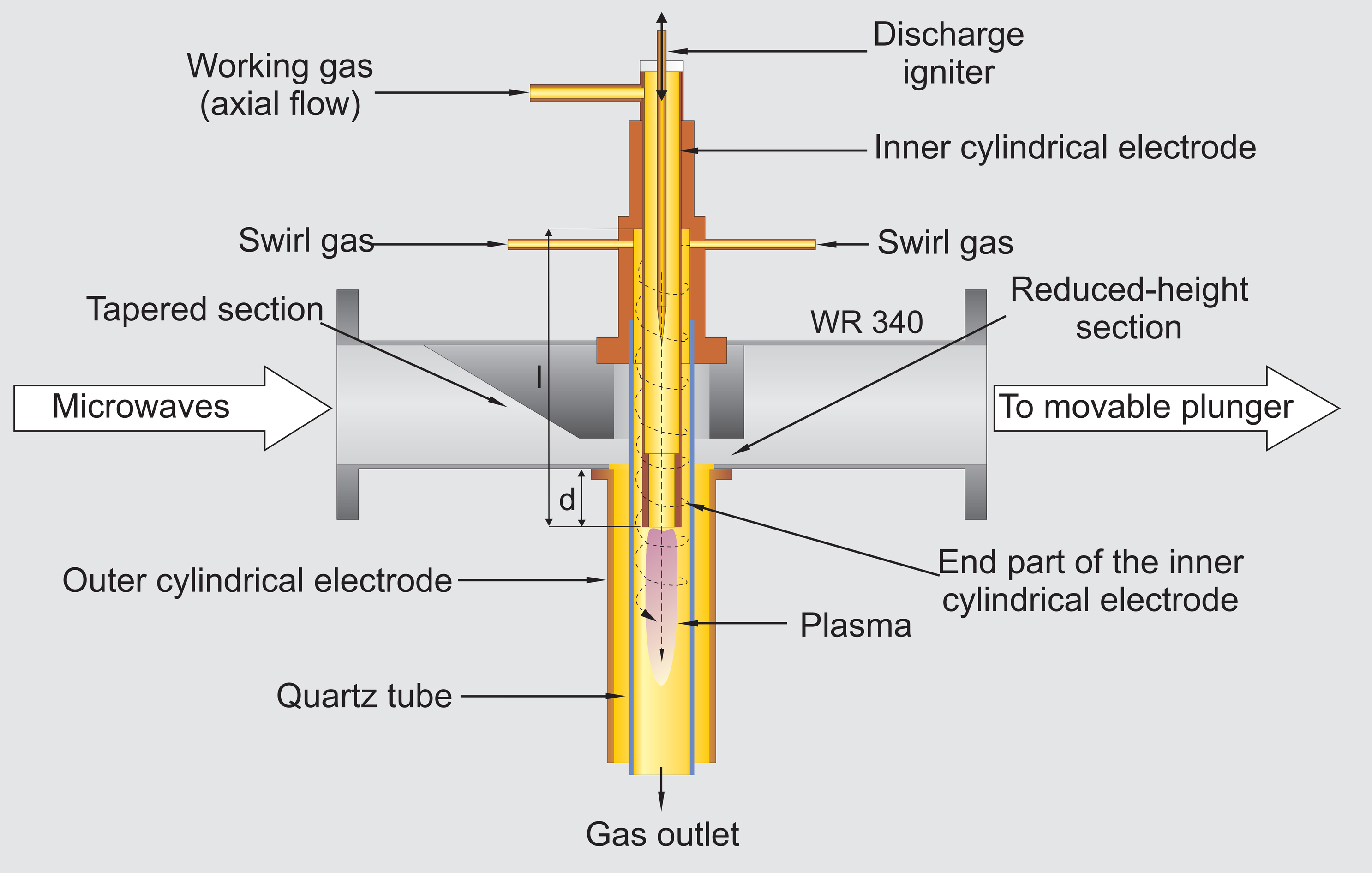
We present a method for production of hydrogen via methane conversion using an atmospheric pressure microwave plasma source (MPS). The MPS was a nozzleless waveguide-supplied coaxial-line-based microwave plasma source operated at high gas flow rates. It allows us operate with microwave (2.45 GHz) power up to 6 kW at relatively high gas flow rates (from 50 to 150 l/min). The preliminary results showed that the hydrogen production rate and the energy efficiency in the presented methane conversion method were up to about 53 g[H_2]/h and 21 g[H_2]/kWh, respectively. These parameters prove that the atmospheric pressure MPS presented in this paper is promising for hydrogen production.

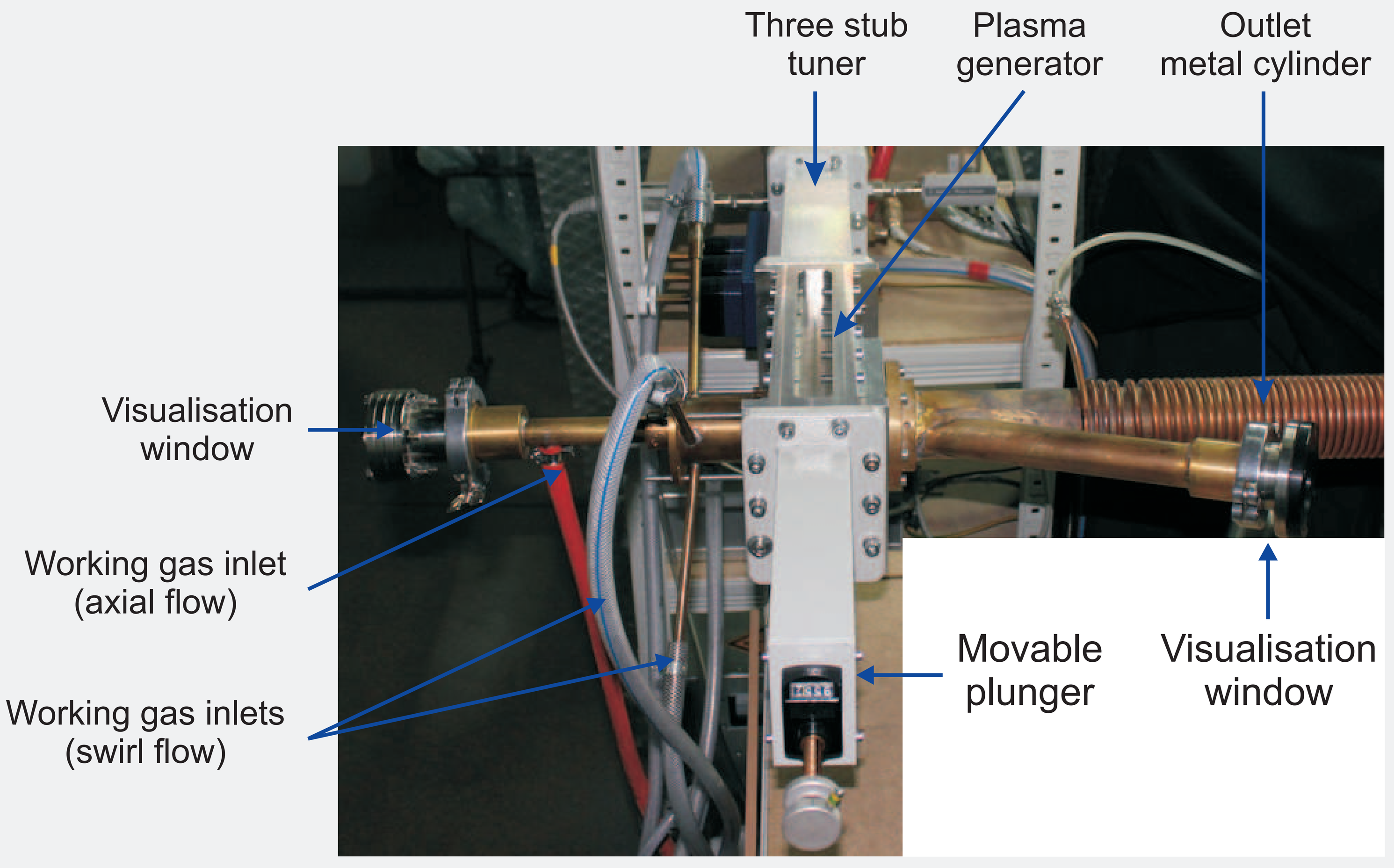
Experimental setup



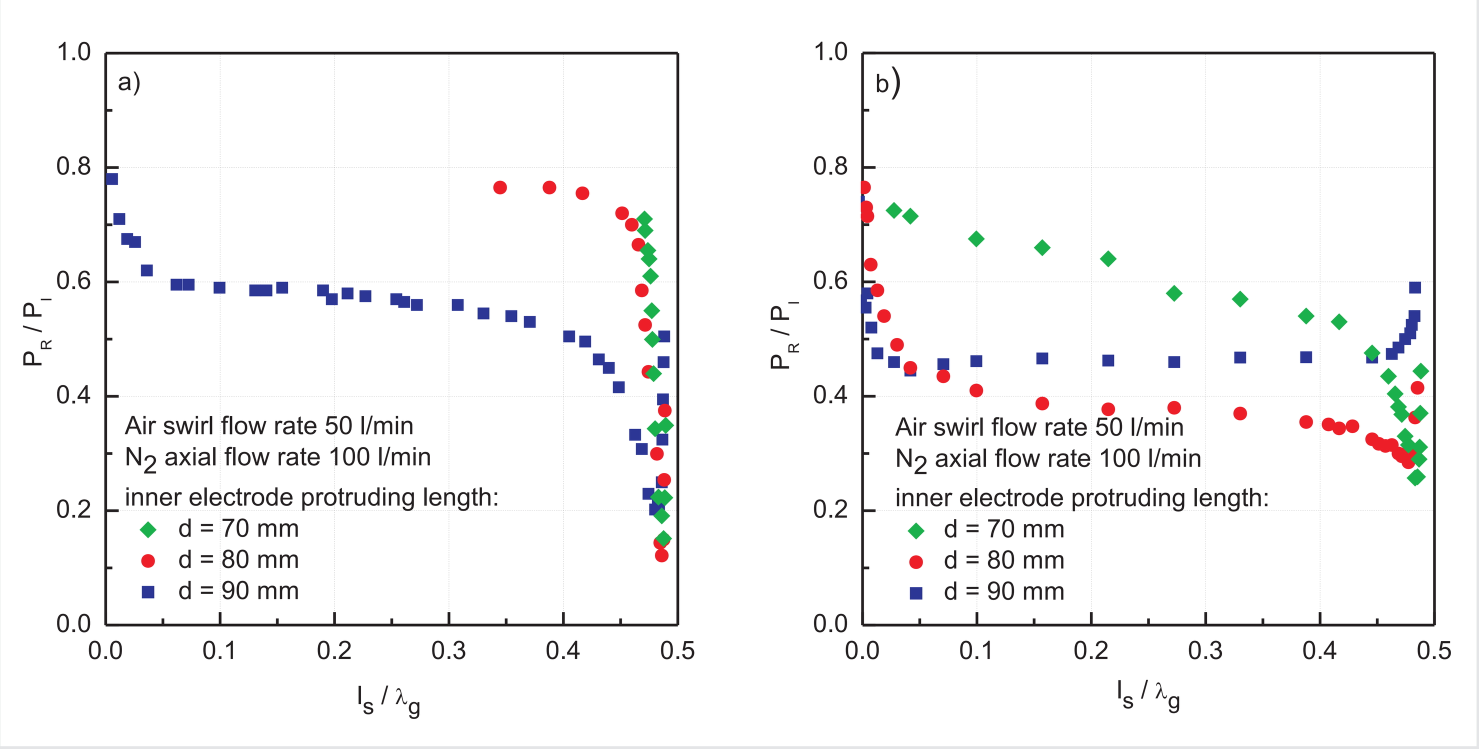


Nozzleless waveguide-suplied coaxial-line-based MPS

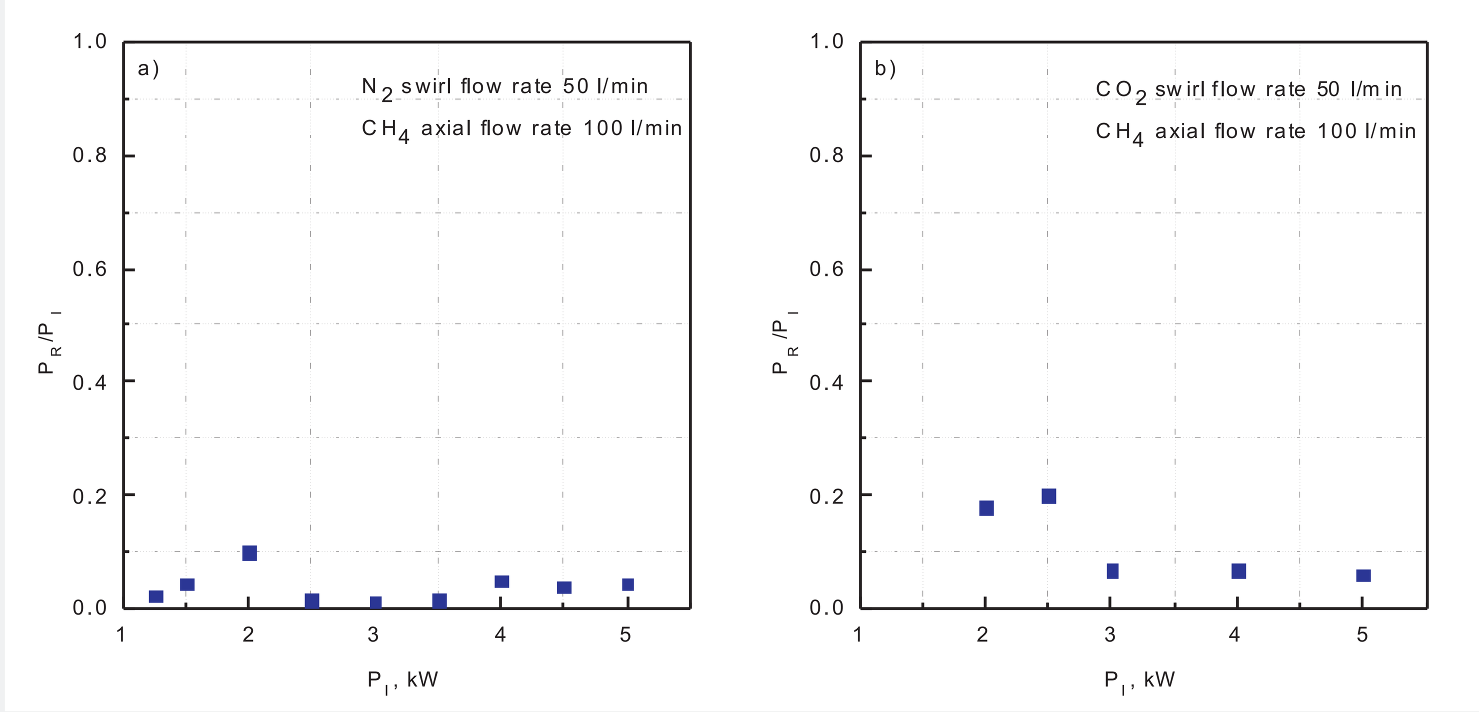




Tuning characteristics of the MPS

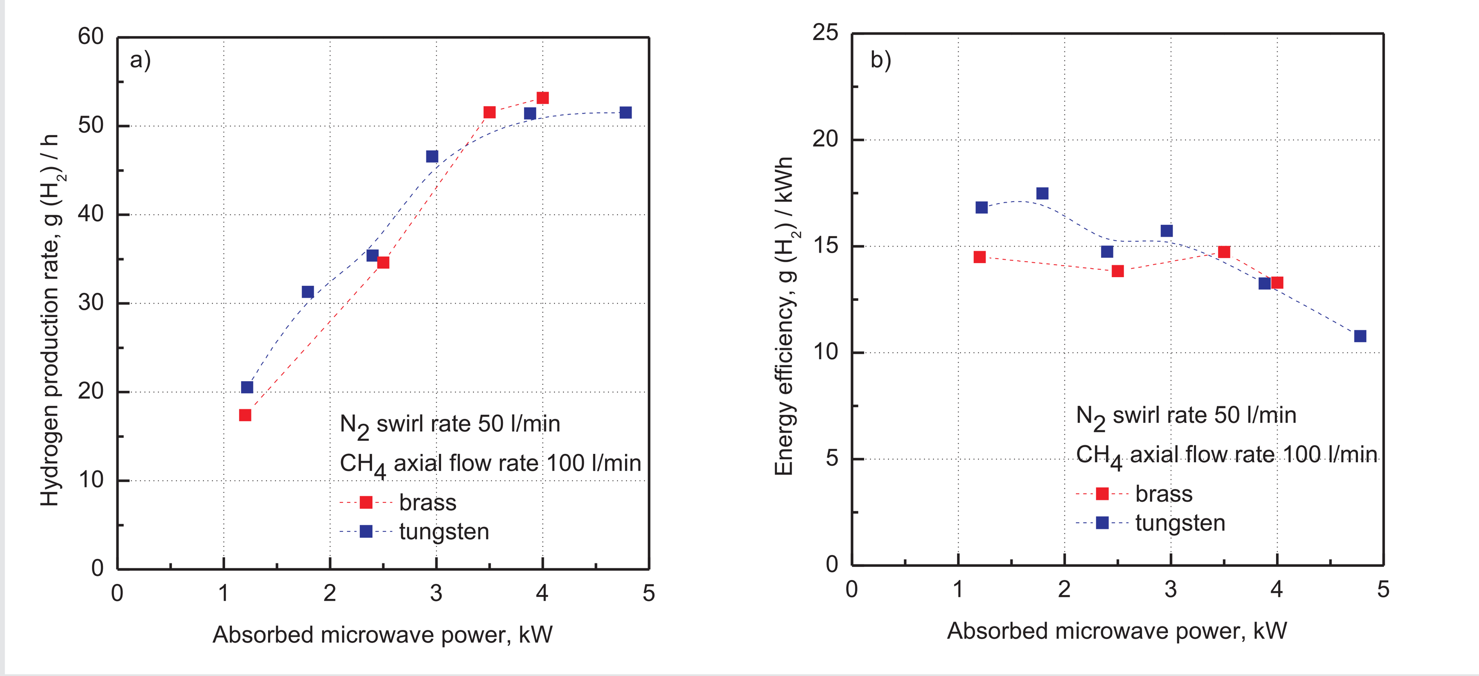


Tuning characteristics of the MPS operated in N_2 axial flow (rate 100 l/min) and air swirl flow (rate 50 l/min) measured for different inner cylindrical electrode protruding length d. The coaxial line length l=42 mm (a) and l=52 mm (b). Incident microwave power P_I=2000 W.

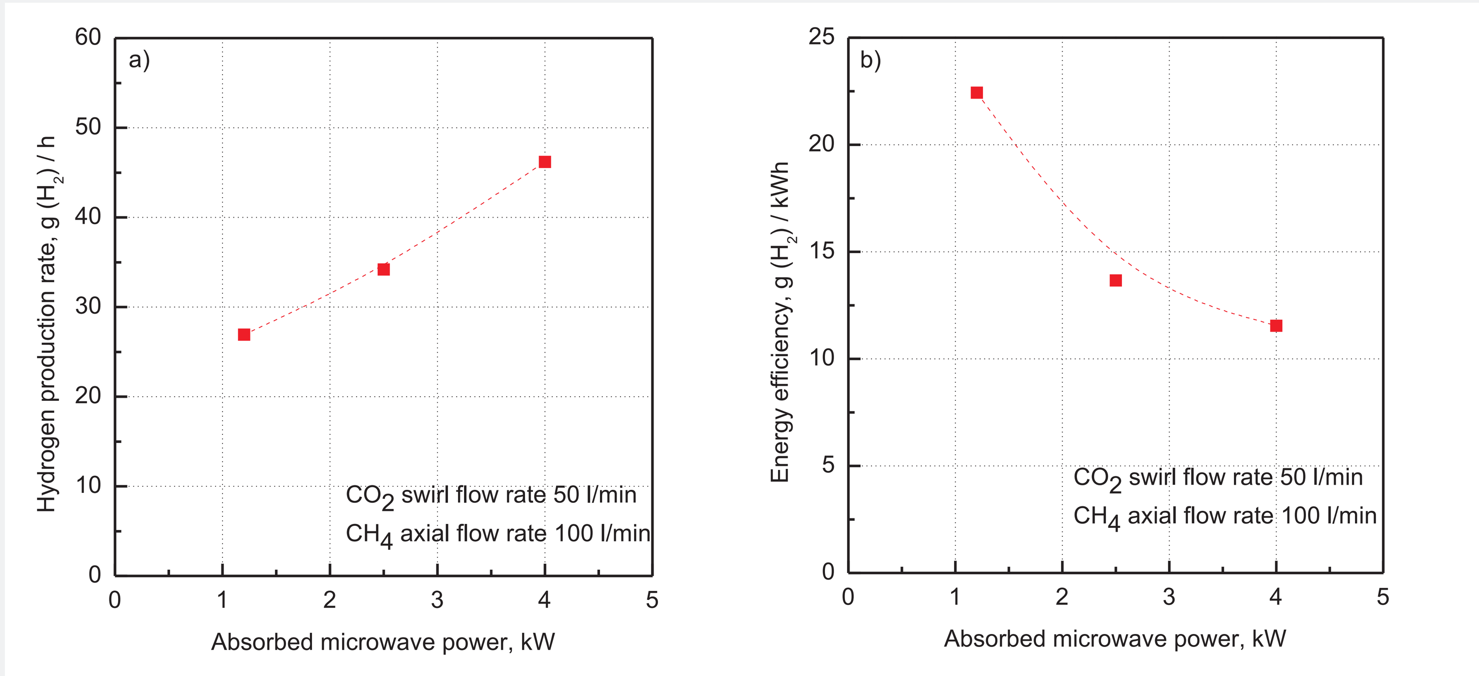


Dependence of the reflection coefficient on the incident microwave power of the MPS with nitrogen swirl flow (a) and carbon dioxide swirl flow (b) after tuning by using three stub tuner.

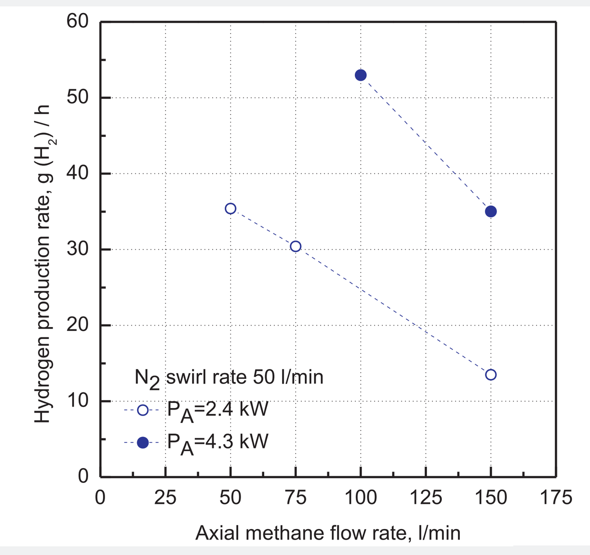
Hydrogen production

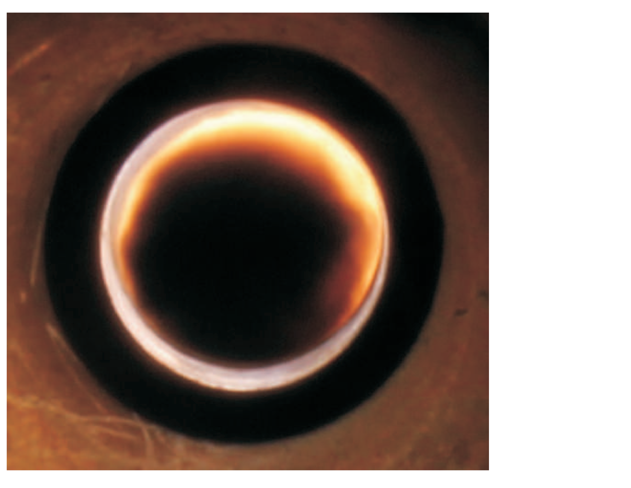


Hydrogen production rate (a) and energy efficiency of hydrogen production (b) as a function of absorbed microwave power. The MPS with nitrogen swirl flow and inner cylindrical electrode end part made of brass and tungsten.



Hydrogen production rate (a) and energy efficiency of hydrogen production (b) as a function of absorbed microwave power. The MPS with carbon dioxide swirl flow and inner cylindrical electrode end part made of brass.





The hydrogen production rate as a function of axial methane flow rate for two values of absorbed microwave power. The MPS with nitrogen swirl flow and inner cylindrical electrode end part made of tungsten. Photo of the plasma flame taken via viewing window close to gas input. N_2 swirl flow rate 50 l/min, CH_4 axial flow rate 100 l/min. The absorbed microwave power P_A=3500 W.

Summary

The nozzleless waveguide-supplied coaxial-line-based microwave plasma source has been presented as a device for hydrogen production. It can be operated with microwave power of a few kW with axial gas flow rates of hundreds l/min. The plasma generation was stabilized by forming an additional gas (N_2, CO_2) swirl flow. The conversion of methane was investigated versus absorbed microwave power up to about 5 kW and axial methane flow rate up to 150 l/min. The hydrogen mass yield rate and energy hydrogen mass yield were about 53 g[H_2]/h and 21 g[H_2]/kWh, respectively. The results show that methane conversion increases when increasing microwave power and decreases when increasing methane flow rate. We conclude that presented MPS is a promising device for hydrogen production.

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