# Tuning characteristics of metal-cylinder-based microwave plasma source operated with argon, nitrogen and methane at atmospheric pressure

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## MOTIVATION

Development of microwave plasma source operated at high gas flow rates

## APPLICATIONS

Gas processing:
hazardous gas treatment [1]
***production of hydrogen via hydrocarbons decomposition*** [2, 3]

## TUNING CHARACTERISTICS

The tuning characteristics are defined as the dependence of the reflect coefficient $P_R / P_I$ as a function of the normalized distance $l / \lambda_g$

$P_I$, $P_R$ - incident and reflected power, measured directly by directional coupler
$l$ - distance between the plasma axis and the movable short
$\lambda_g$ - the wavelength in the WR 430 waveguide: 147.7 mm

## MICROWAVE PLASMA SOURCE (MPS)

### TECHNOLOGY

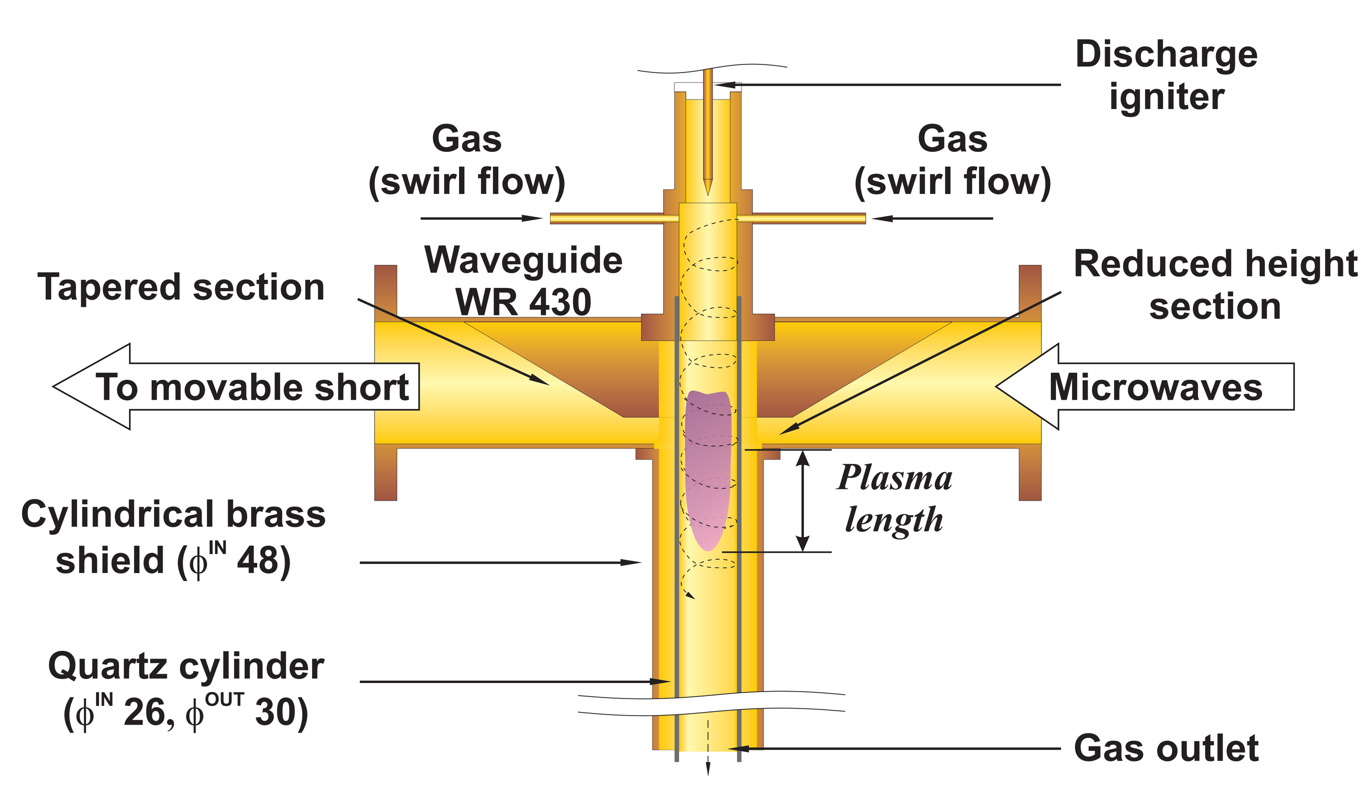
Nozzleless
Waveguide-supplied
Metal-cylinder-based
With inner dielectric tube

### MICROWAVES

Frequency: 2.45 GHz
Powers: 600 - 6000 W

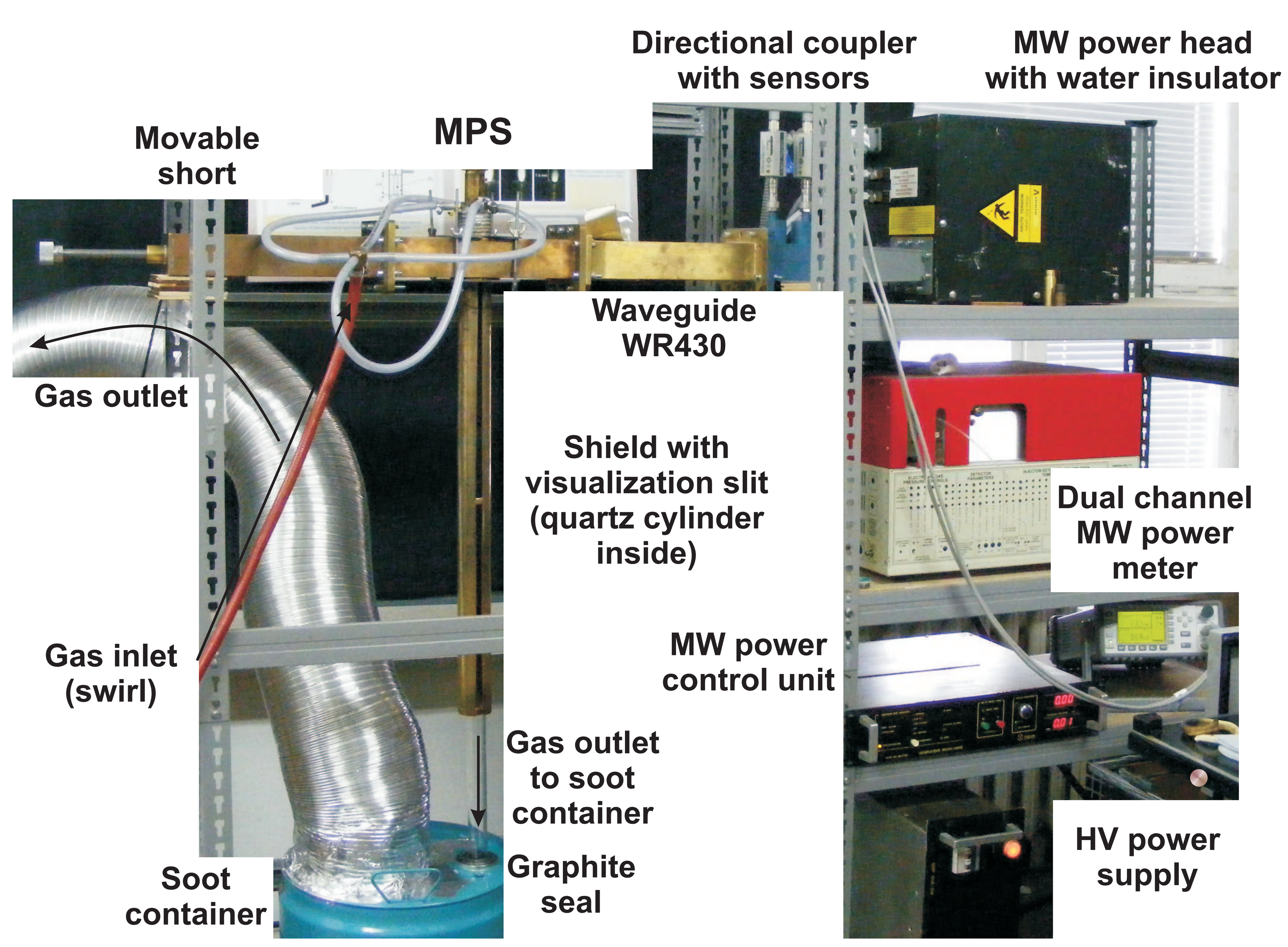
### GAS

Ar, $N_2$, $CH_4$
Swirl flow
Flow rate: 50 - 200 l/min




The sketch of metal-cylinder-based MPS

## EXPERIMENTAL SETUP




The experimental setup

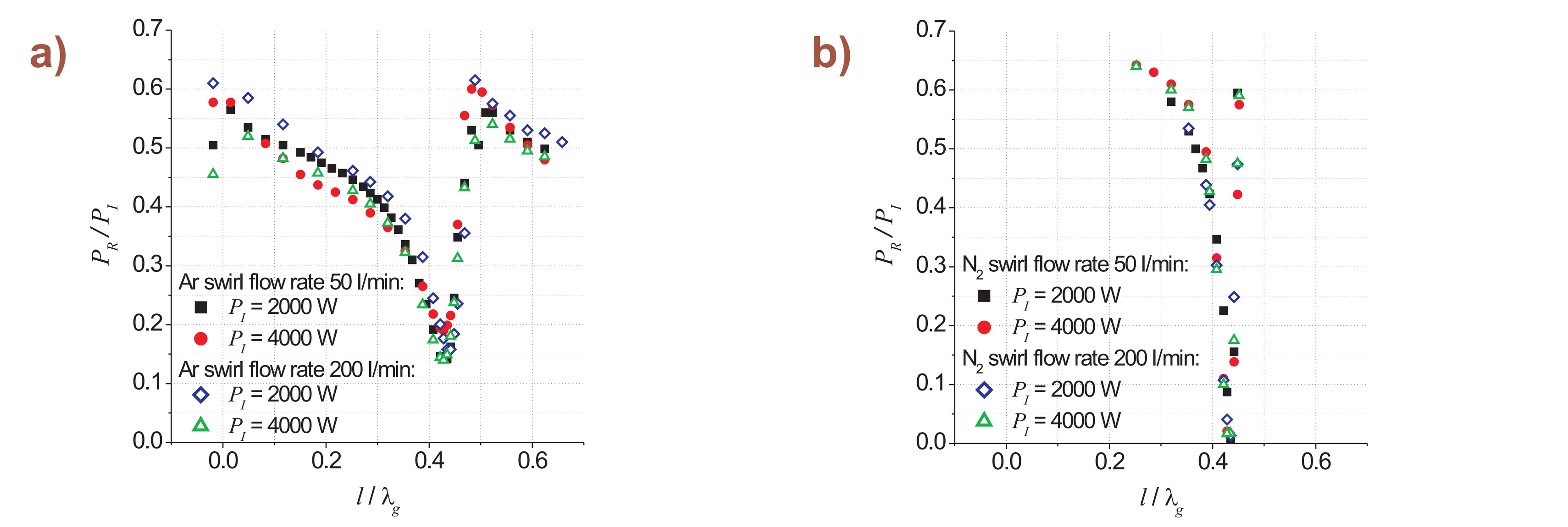
REFERENCES:

[1] Jasiński M., Dors M., Mizeraczyk J., Destruction of freon HFC 134a using a nozzleless microwave plasma source, *Plasma Chem. Plasma Process.*, 29 (2009), No .5, 363-372

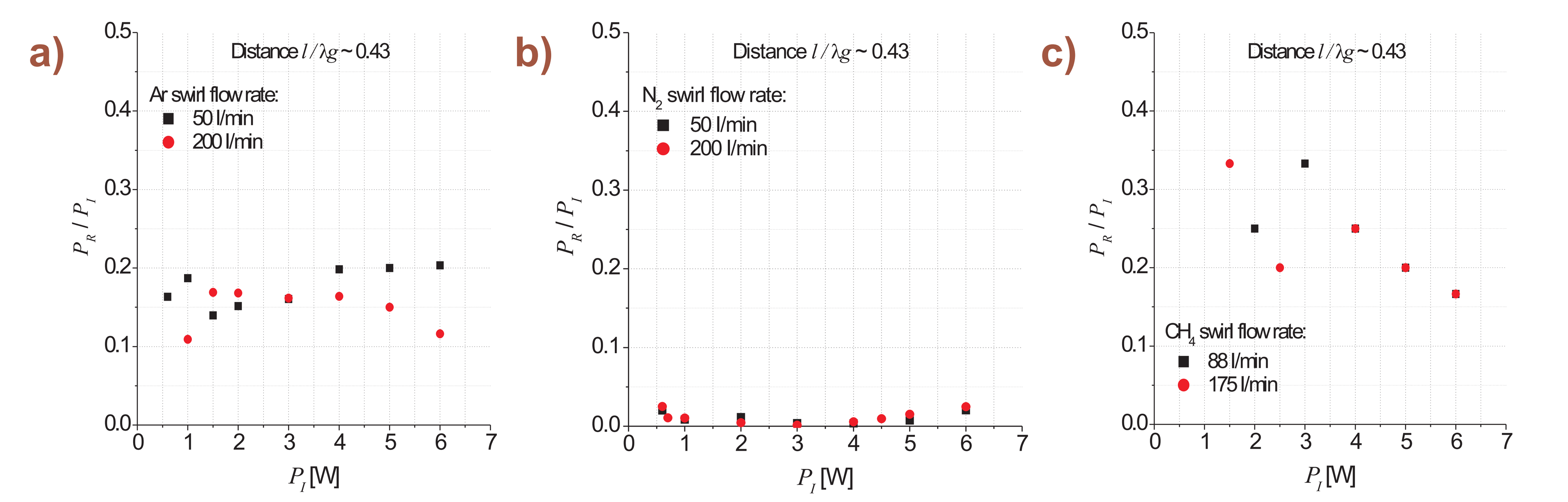
[2] Jasiński M., Dors M., Mizeraczyk J., Production of hydrogen via methane conversion using microwave plasma source with CO2 or CH4 swirl, *Przegląd Elektrotechniczny,* 85 (2009), nr 5, 121-123

[3] Jasiński M., Dors M., Mizeraczyk J., Applications of atmospheric pressure microwave plasma source for production of hydrogen via methane reforming, *Eur. Phys. J. D*, 54 (2009), No. 2, 179-183

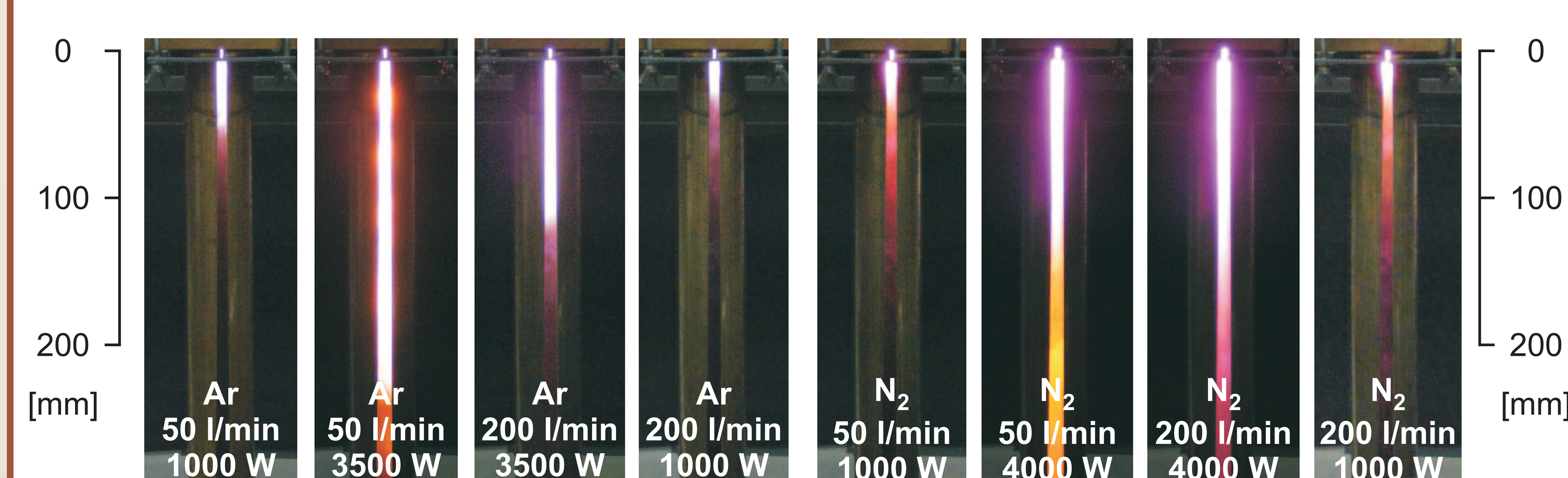
## RESULTS



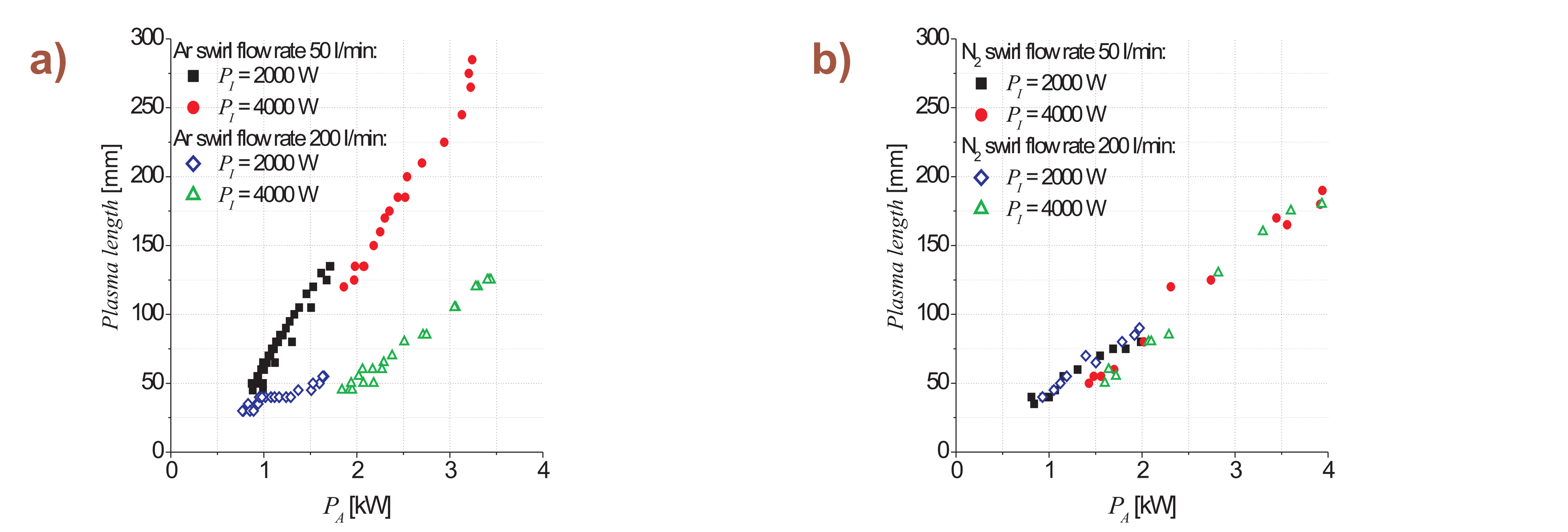

Normalized tuning characteristics of the metal-cylinder-based MPS operated in argon (a) and nitrogen (b) at atmospheric pressure




The fraction of the incident power reflected at the MPS input as a function of incident power for argon (a), nitrogen (b) and methane (c) as a working gas at fixed position of movable plunger $l / \lambda_g \sim 0.43$




Microwave plasmas at different microwave absorbed powers $P_A$ ($P_A = P_I - P_R$) and axial gas flow rates




The lengths of argon (a) and nitrogen (b) plasmas (measured from the waveguide) as a function of microwave absorbed power $P_A$ ($P_A = P_I - P_R$) for different flow rates and incident microwave powers

## SUMMARY

- Investigations of the tuning characteristics showed that at optimal positions of movable plunger, the use of argon, nitrogen and methane as the working gas caused, that 15%, 0% and 17 % of the incident power was reflected, respectively. The tuning characteristics could be improved by further optimization.
- Stable operation at wide range of parameters, as well as good impedance matching allows the concluding that MPS can be very attractive tool for different gas processing at high flow rates.
- The MPS was used for Freon HFC-134a destruction (34.5 kg $[C_2H_2F_4]$ $h^{-1}$; 23.5 kg $[C_2H_2F_4]$ $kWh^{-1}$) [1] and for production of hydrogen via methane decomposition (866 g $[H_2]$ $h^{-1}$; 381 g $[H_2]$ $kWh^{-1}$) [2, 3]. The energetic parameters were very attractive.

**This research was supported by The National Centre for Research and Development (NCBiR) under the programme NR14-0091-10/2010**