Tuning characteristics of coaxial 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 flow rates

Applications

Production of hydrogen via hydrocarbons decomposition, hazardous gas treatment

Tuning Characteristics

The tuning characteristics are defined as the dependence of the reflect coefficient $R_p$ as a function of the normalized distance $l / \lambda_p$.

$P_i, P_r$ - incident and reflected power, measured directly by directional coupler

$\lambda_p$ - the wavelength in the WR 430 waveguide: 147.7 mm

Microwave Plasma Source (MPS)

Gas flows:
- Swirl: 50 l/min (nitrogen)
- Axial: 50-200 l/min (argon, nitrogen, methane)

Microwave (2.45 GHz) powers:
- 600-5600 W

The sketch of coaxial MPS

Experimental Setup

- Gas inlet (axial)
- Directional coupler with sensors
- MW power head with water insulator
- Gas outlet
- Gas inlet (swirl)

The experimental setup

Results

Normalized tuning characteristics of the coaxial MPS operated in argon (a), nitrogen (b) and methane (c) at atmospheric pressure and the fraction of the incident power reflected at the MPS input as a function of incident power for different axial gases at fixed position of movable plunger ($l / \lambda_p = 0.41$ (d), $\lambda_p = 147.7$ mm)

Microwave plasmas at different microwave absorbed powers $P_i (P_i = P_r - P_d)$ and axial flow rates

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 2%, 1% and 5% 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 successfully used for production of hydrogen via methane decomposition.

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