On the role of the design and discharge conditions on the Surfaguide tuning characteristics

D. Czylkowski[1], M. Jasiński[1], J. 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)

The aim

The aim of our experimental investigations is to determine the role of the Surfaguide-type plasma generator design and discharge conditions on its tuning characteristics.

Tuning characteristics

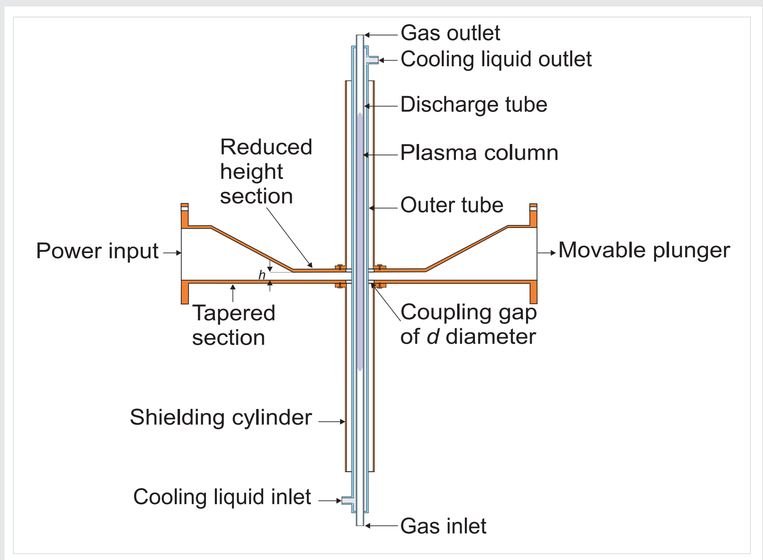
The tuning characteristics is defined as the dependence of the fraction of the power reflected at the microwave plasma generator input P_R/P_I, on the normalized position of the waveguide movable plunger l_s/λ_g, where λ_g is the wavelength in the waveguide.

Experimental procedure

Factors taken into account in the study:

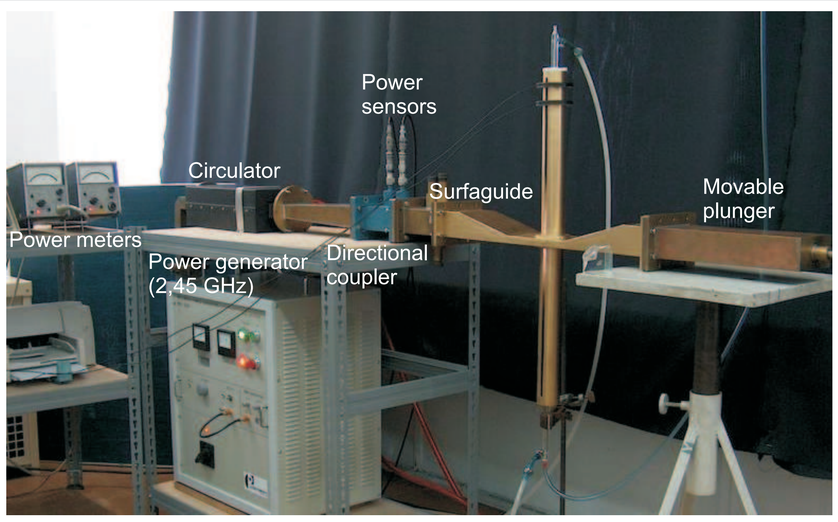
- height of the reduced height section: h=8 mm, h=10 mm, h=12 mm
- coupling gap diameter: d=9 mm, d=14 mm, d=20 mm
- presence of the shielding cylinder with the inner diameter of 46 mm
- cooling of the discharge tube (cooling coat of diameter 12 mm)
- input microwave power: P_I=200 W, P_I=400 W, P_I=500 W
- argon flow rate Q from 0,5 l/min up to 6 l/min

Surfaguide-type plasma generator



The overall view of the Surfaguide

Experimental setup

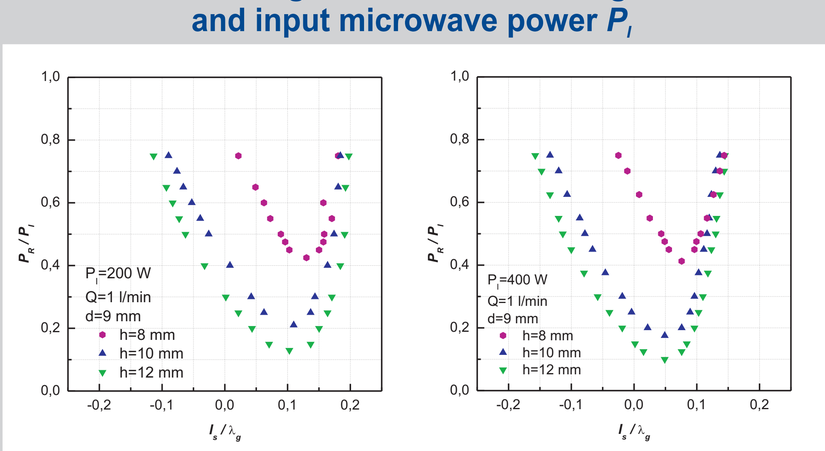


The photo of the experimental setup

Conclusions

Crucial role of the height of the reduced height section, coupling gap diameter and shielding cylinder was showed. Accurate choice of them can significantly improve the efficiency of microwave power transfer to the plasma and the stability of operation. Presented results should be useful from practical point of view in designing microwave plasma sources based on surface waves propagation.

The role of the height of the reduced height section h and input microwave power P_I

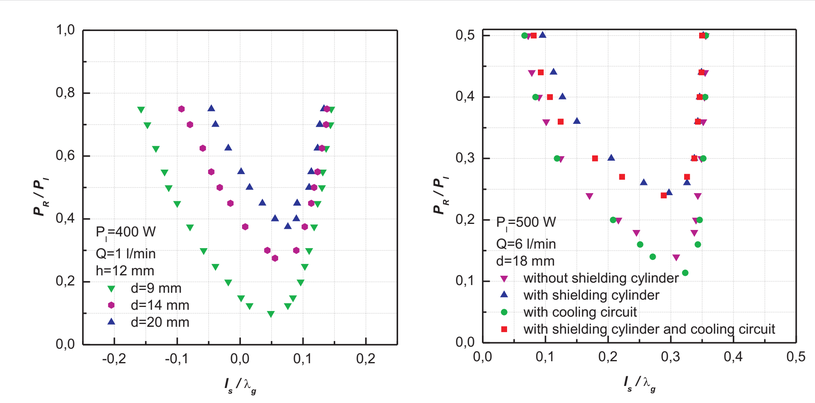


The minimum of the measured tuning characteristics moves toward the center of the l_s/λ_g scale with increase of h and simultaneously, the width of the tuning characteristics increase. The minimum of the reflected power coefficient P_R/P_I is the lowest in the case of Surfaguide with the highest value of h (h=12 mm).

	P_I=200 W		P_I=400 W	
	min(P_R/P_I)	min(l_s/λ_g)	min(P_R/P_I)	min(l_s/λ_g)
h=8 mm	0.43	0,13	0.42	0,08
h=10 mm	0.21	0,11	0.18	0,05
h=12 mm	0.13	0,10	0.10	0,05

The difference due to the input microwave power P_I regard rather the position of the minimum of the reflected power coefficient P_R/P_I on the l_s/λ_g scale then the minimal value of P_R/P_I.

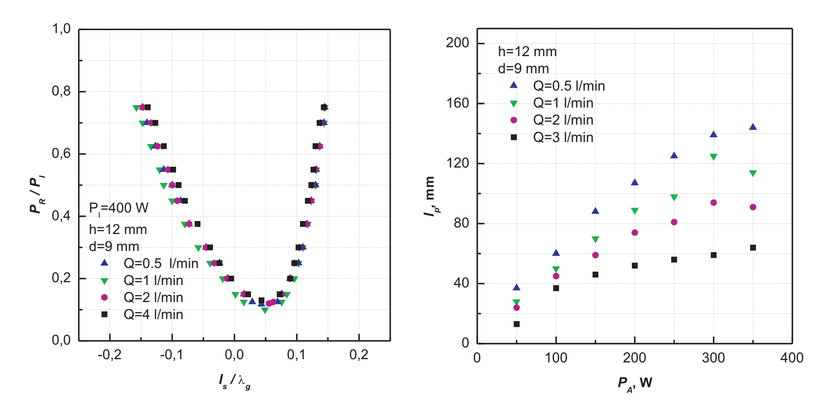
Influence of the coupling gap diameter d, presence of the shielding cylinder and cooling circuit



With decreasing the gap diameter, the minimum of the reflection coefficient P_R/P_I moves to the left and the minimum decreases with decreasing the gap diameter.

The metal cylinder significantly affects the tuning characteristics. When comparing the tuning characteristics measured for discharge tube with and without cooling (and without shielding grid) it can be seen that this first one are slightly lower situated in the P_R/P_I scale.

Dependence on the gas flow rate Q



Although the gas flow rate Q in the applied range from 0,5 l/min to 4 l/min only slightly influences the measured tuning characteristics, significant changes in plasma column lengths were observed.