Development of 2.45 GHz Microwave Torch System*

배 영순, 최 은미, 정 원석, 이 용환, 남궁 원, 조 무현
(포항공과대학교)

엄 환섭
(아주대학교)

Abstract

- We developed a 2.45 GHz microwave torch system for the decomposition of toxic gases. The microwave torch system is composed of a magnetron tube, an isolator, a directional coupler, a 3-stub tuner, a H-plane tapered region, and a torch region where a quartz tube located. The cross-section of the tapered region is 72 x 17 mm. The magnetron generates the 2.45 GHz microwave with the maximum DC power of 900 W. The plasma can be initiated by an igniter powered with 6 W in the tapered region and shorted waveguide or by touching the nozzle. The plasma gas flow is confined inside a quartz tube which penetrates through the center of the wide waveguide walls. This paper presents the detail design of the torch system using the HFSS program and the torch performance.
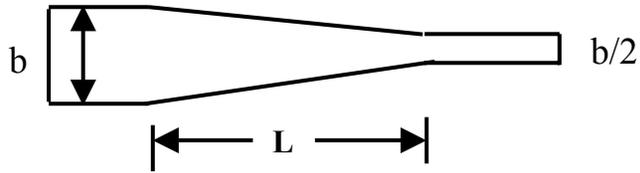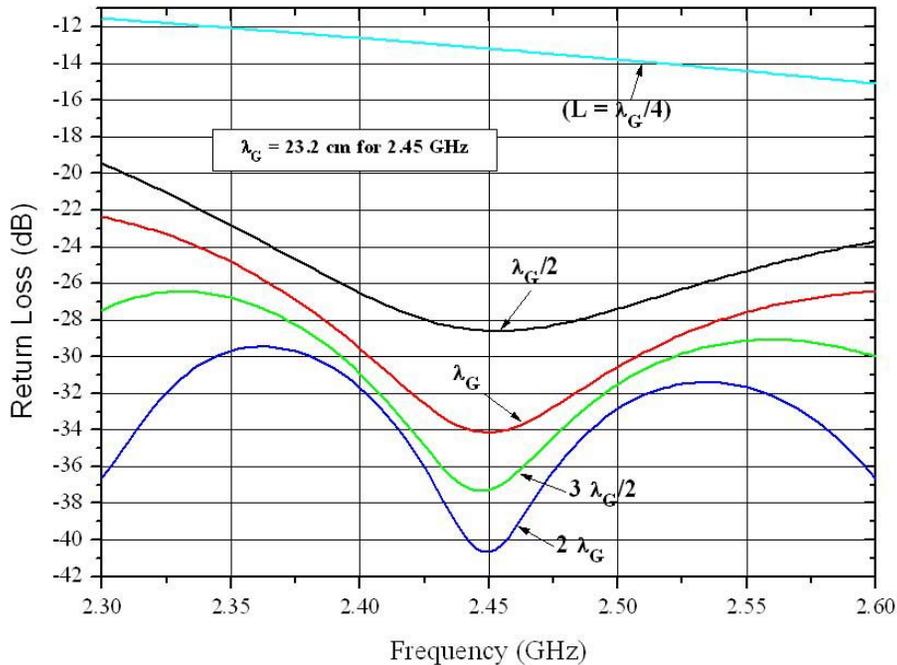
Schematic of the torch system

Magnetron tube • Circulator • Directional Coupler • 3-stub Tuner • Directional Coupler • H-plane tapered region • nozzle • To power meter • To matched dummy Load
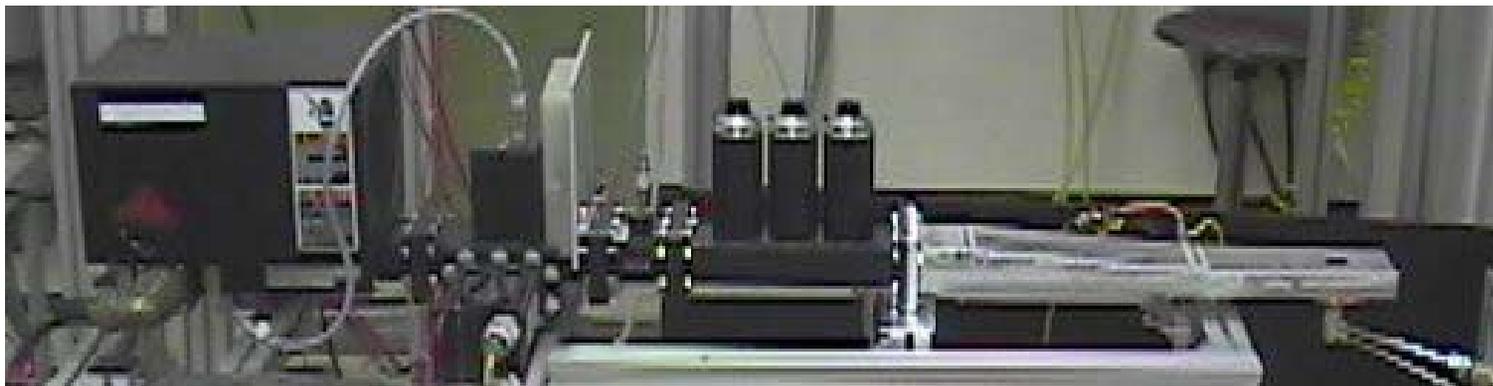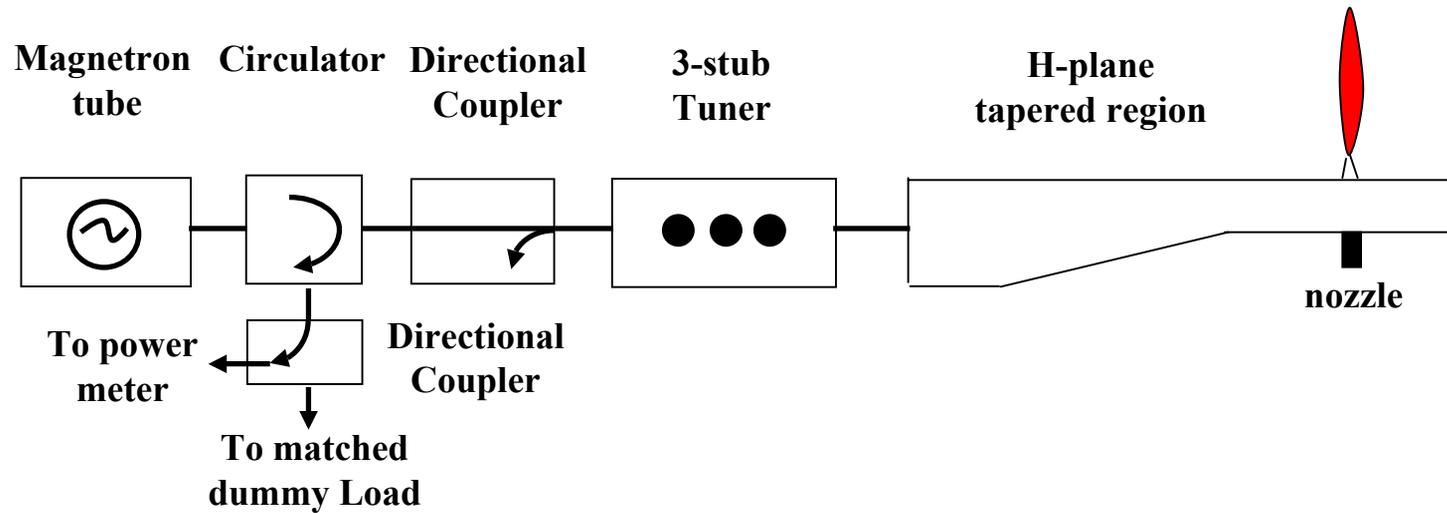
H-planes taper design

a = 72.1 mm, b = 33.8 mm

$\lambda_G = \lambda_0 / \sqrt{[1-(\lambda_0/2a)^2]}$

b   b/2

L

H-planes linear taper
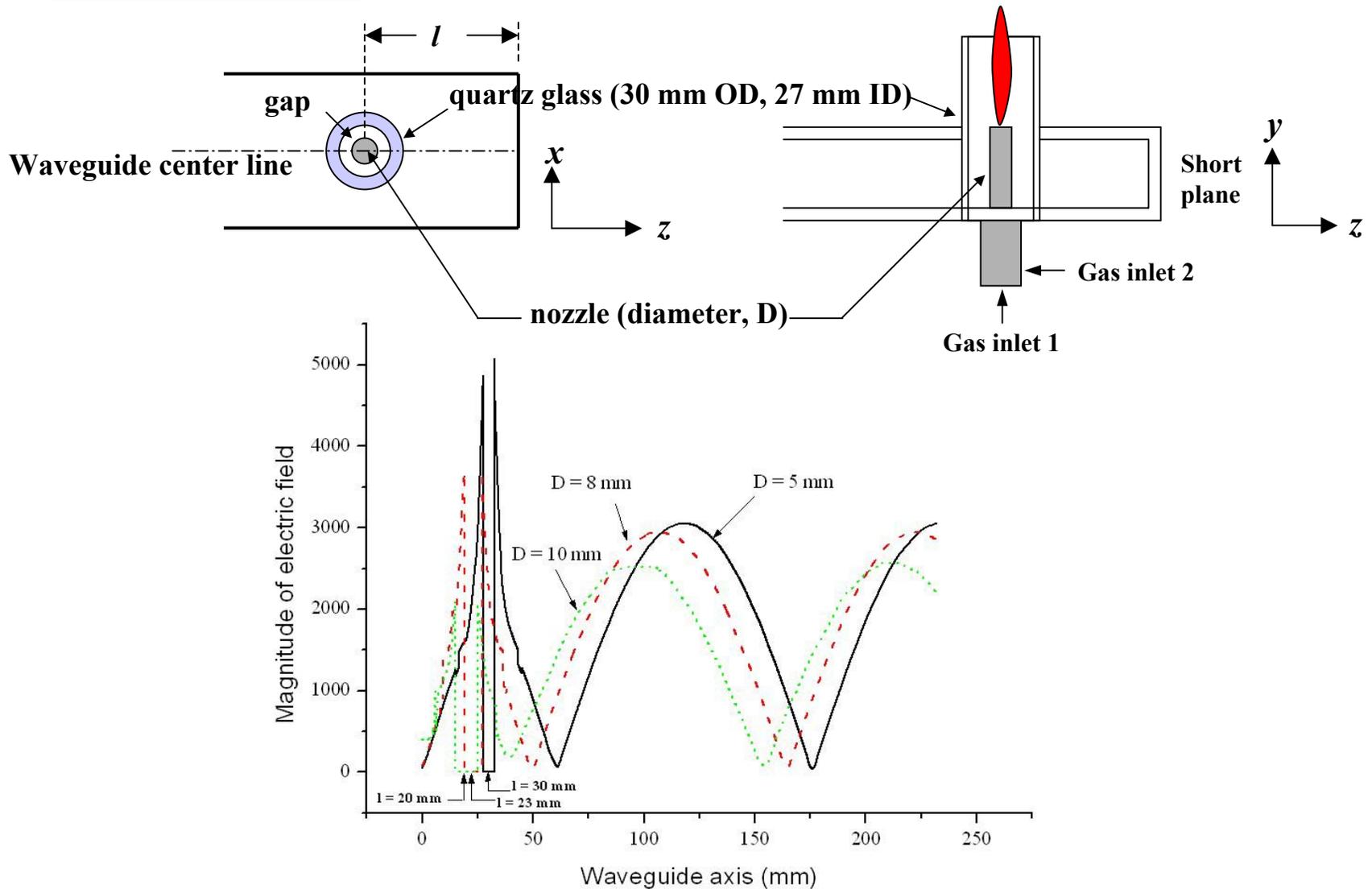
$(L = \lambda_G/4)$

$\lambda_G = 23.2$ cm for 2.45 GHz

$\lambda_G/2$

λ_G

$3\,\lambda_G/2$

$2\,\lambda_G$

Return Loss (dB)

Frequency (GHz)

Only one H-plane taper

Taper length = 23.2 cm (λ_G)

Return loss (dB)

Frequency (GHz)
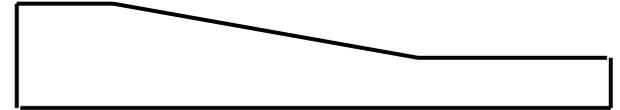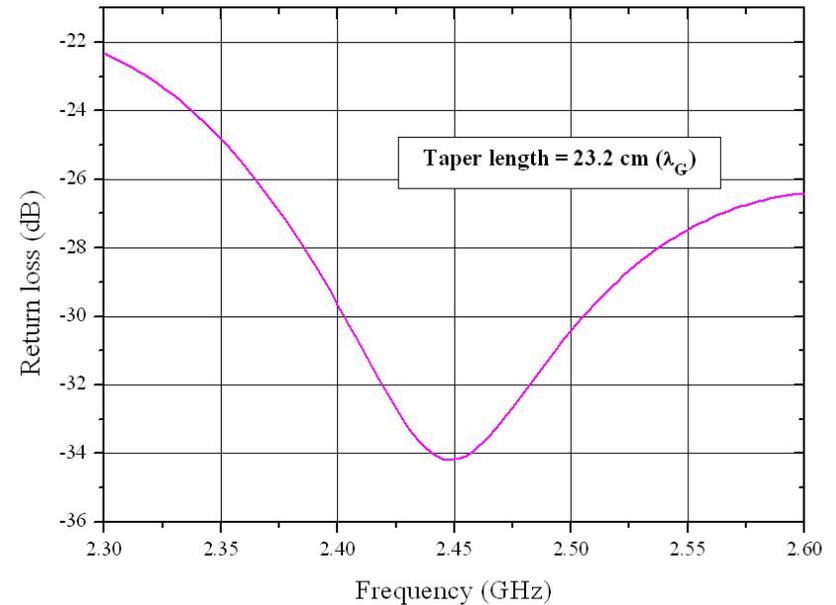
Position of the nozzle and the quartz glass

L is determined to have a peak electric field at the center of the nozzle end.

Structure of nozzle and gas feeding
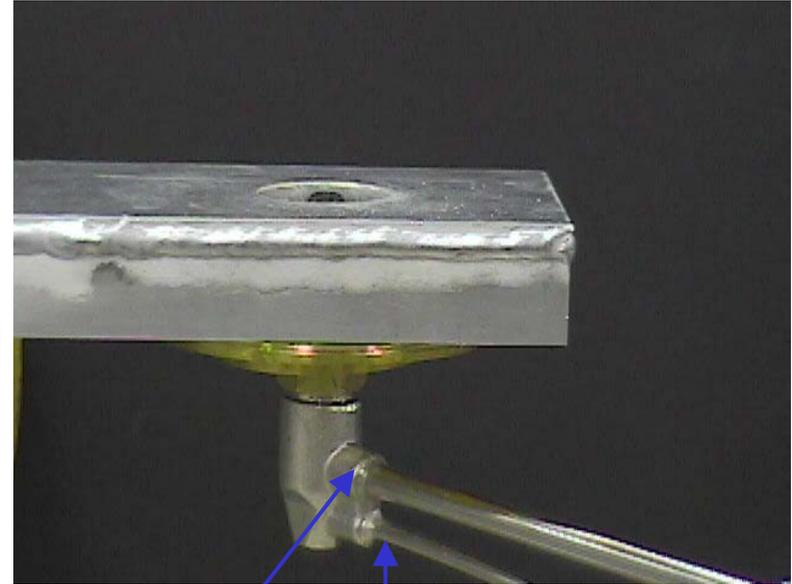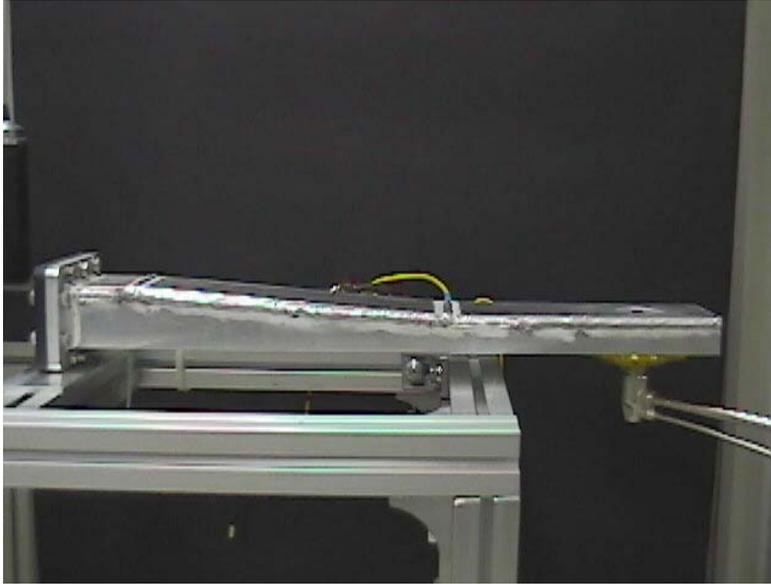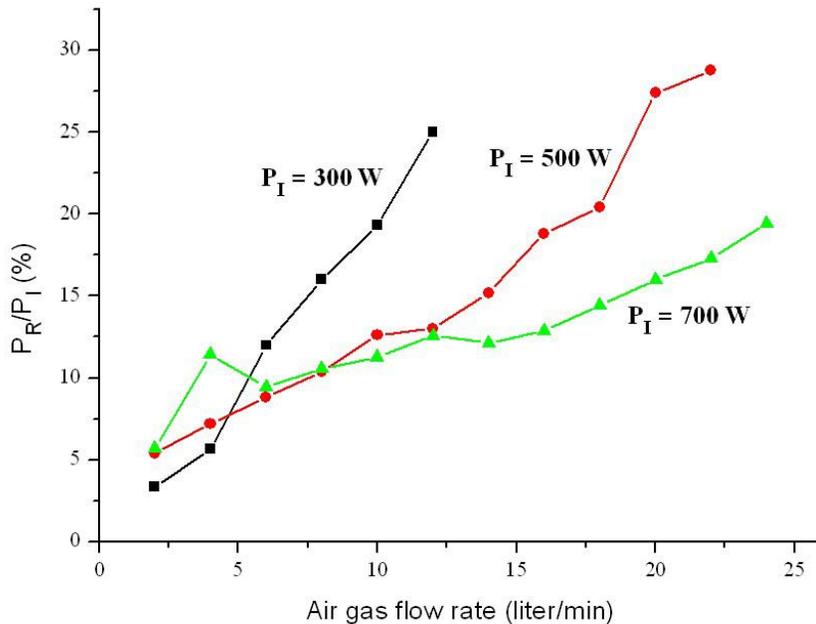

Converging nozzle inlet   Center nozzle inlet

Center nozzle
(1 mm dia.)

Converging
nozzle

Front nozzle

Bottom nozzle
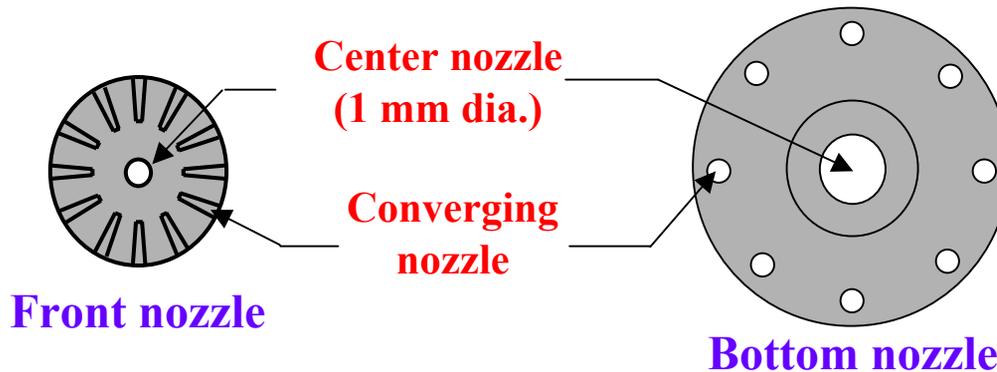
The electric field lines in the region of the nozzle.
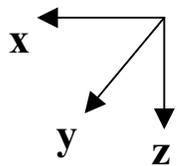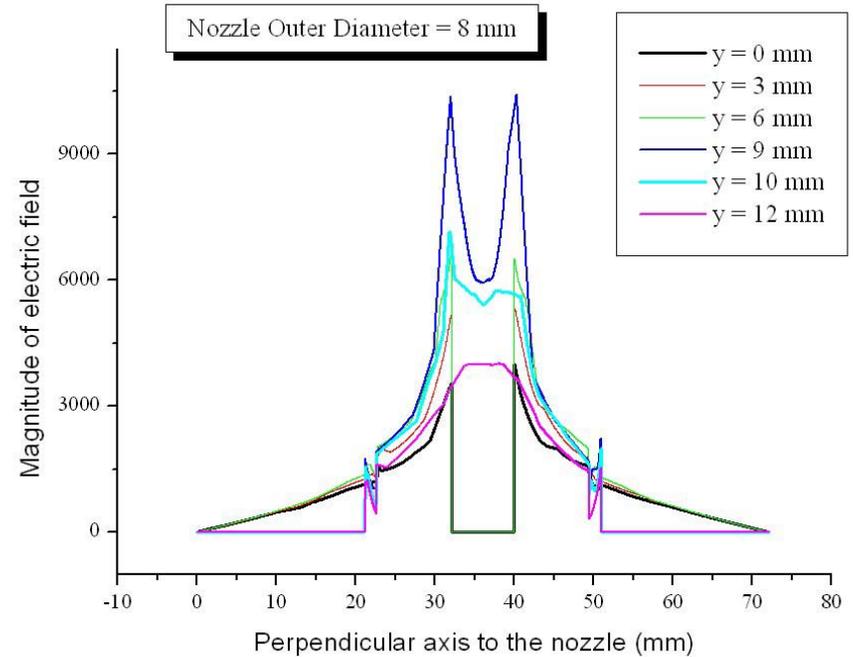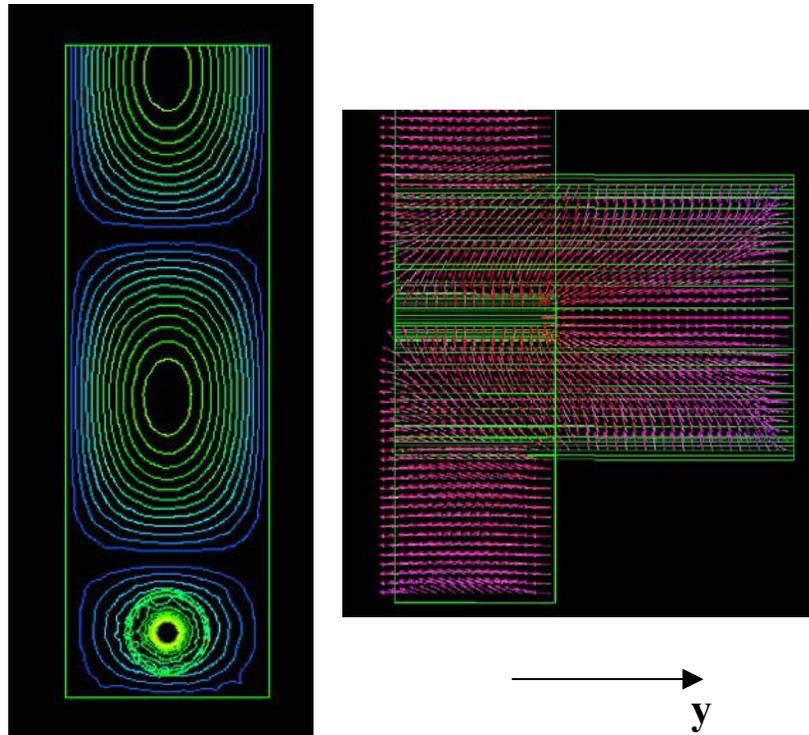
Power reflections vs. gas flow rates

Air gas

Argon gas
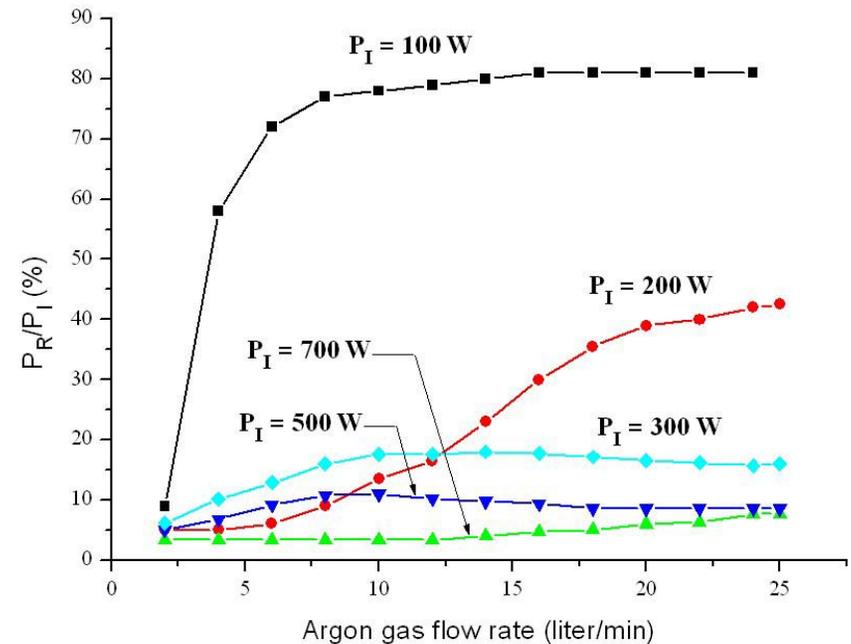
We made a torcch at the 2.0 lpm gas flow rate and the torch is tuned using the 3-stub tuner. And then, the reflection power is measured with increasing the gas flow rate without tuning operation.
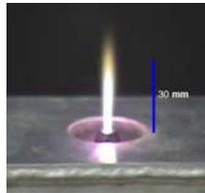
Torches (Air gas)

2 lpm **10 lpm** **15 lpm** **20 lpm** **25 lpm**
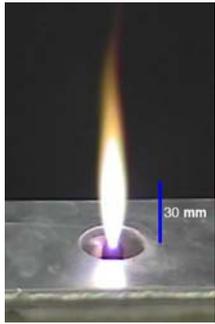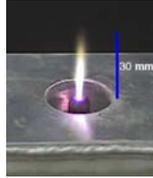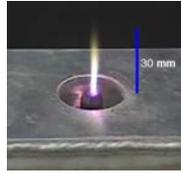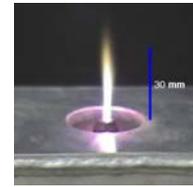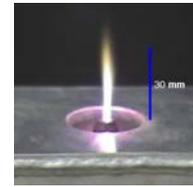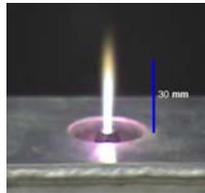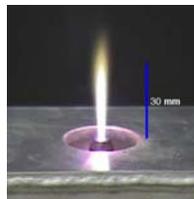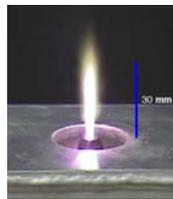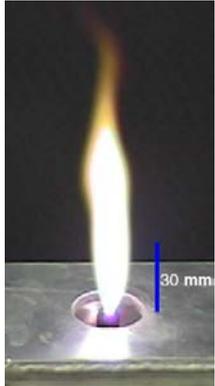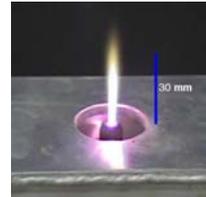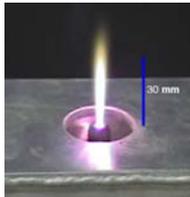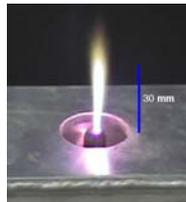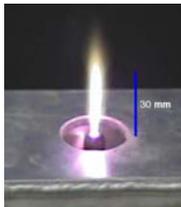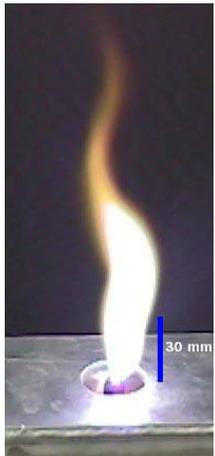
$P_I = 300$ W

$P_I = 500$ W

$P_I = 700$ W

Torches (Argon gas)

2 lpm   **10 lpm**   **15 lpm**   **20 lpm**   **25 lpm**
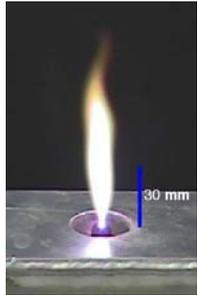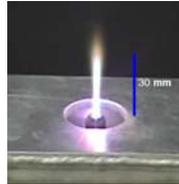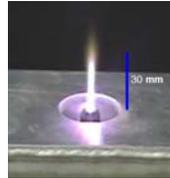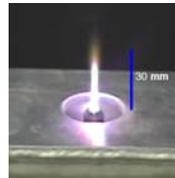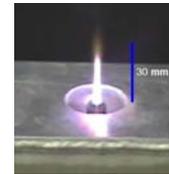
$P_I = 300$ W
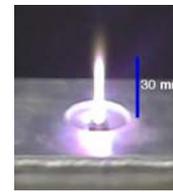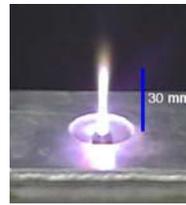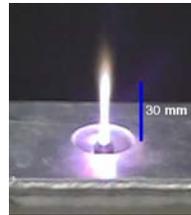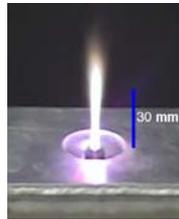
$P_I = 500$ W
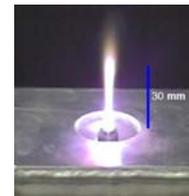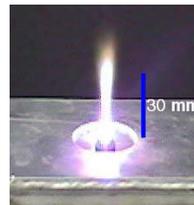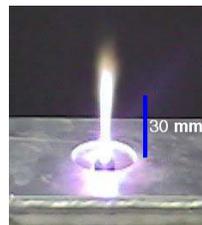
$P_I = 700$ W

Torch spectrums (RF power = 300 W)

Torch spectrum (RF power = 700 W)

Conclusion

- We have developed a microwave-sustained atmospheric-pressure plasma torch system based waveguide. This system is simpl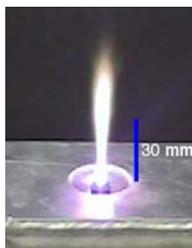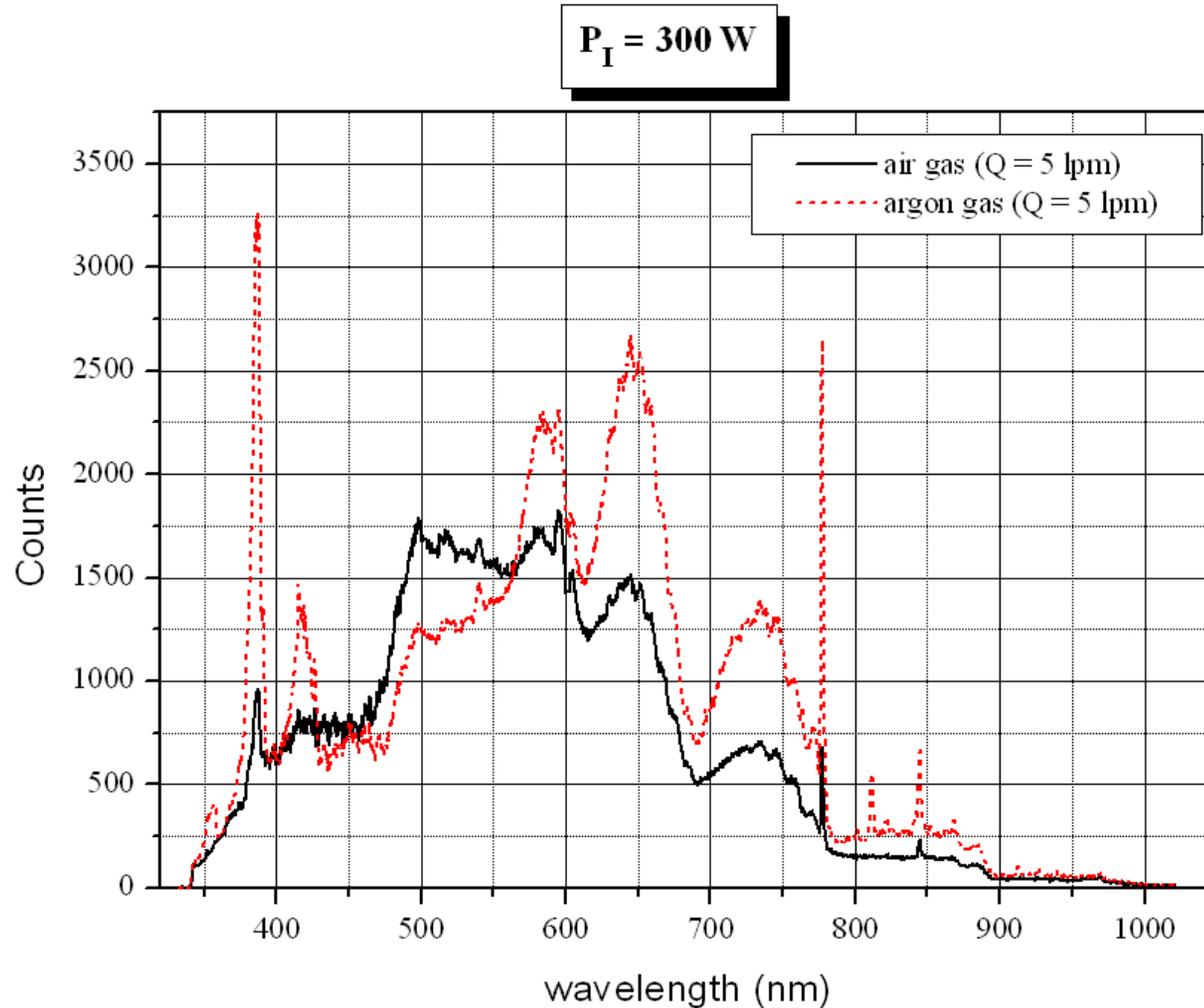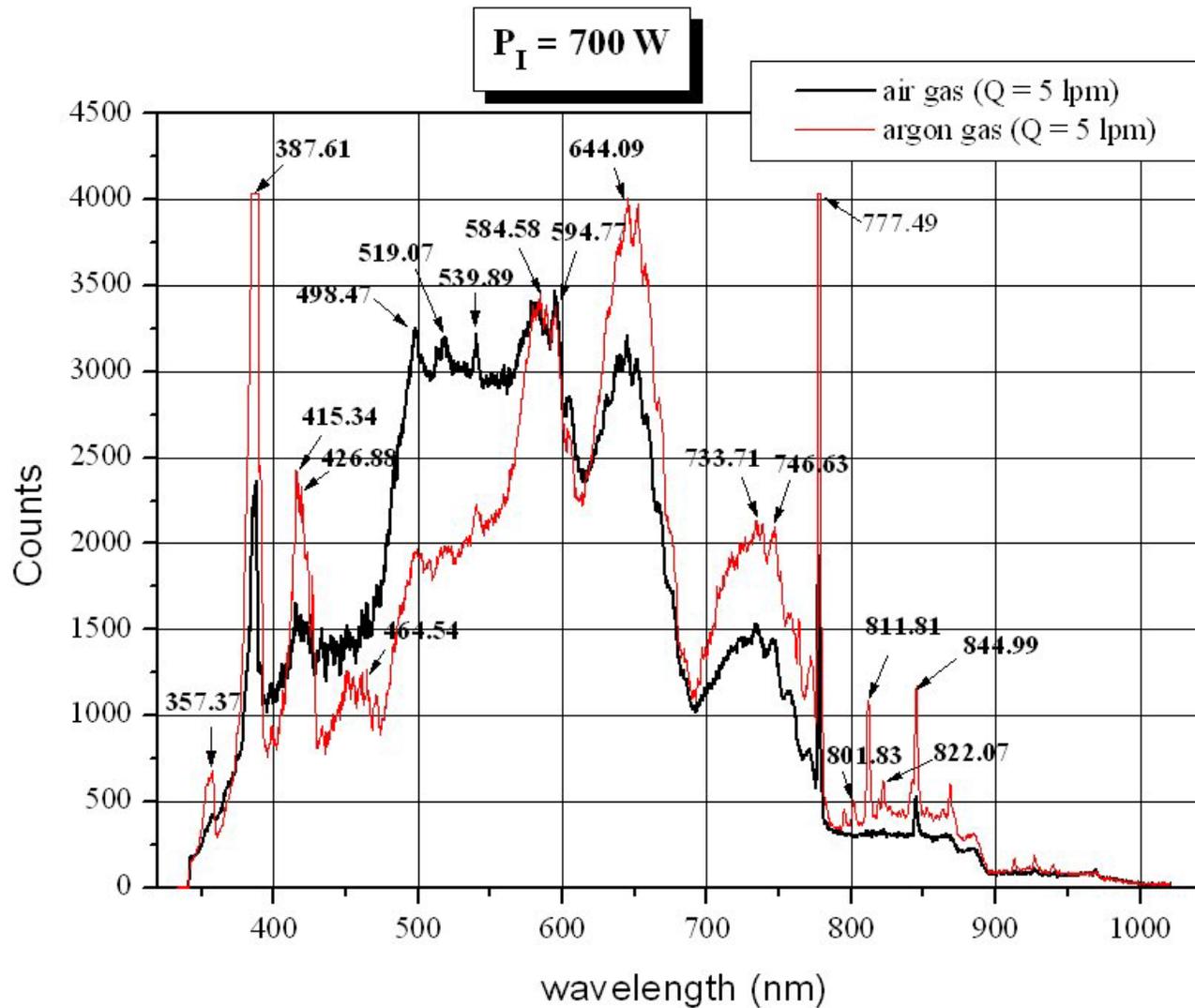e and has low sensitivity to the gas flow. The plasma initiation is very easy by touching the nozzle with a metal. The argon plasma torch can be obtained with 100 W RF power and the 2.0 lpm flow rate.

- The position of the nozzle is 50 mm from the short and on the waveguide centerline. The position from the short can be adjusted with a movable short. The nozzle tip diameter is 8.0 mm and the hole diameter is 30 mm. If we don't use a 3-stub tuner, the impedance can be matched using the movable short but the position of the nozzle must be optimized using the HFSS program. We used the cutting tip used in the Oxy-fuel torch cutter for the nozzle of this torch system.