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Optical Spectroscopic Measurement during Hydrogen and Hydrocarbon Combustion in Atmospheric Microwave Plasma

大気圧マイクロ波プラズマによる水素および炭化水素燃焼時の分光計測

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Recovery of tritium in nuclear fusion plasma is a key issue for safety. So far, the oxidation procedure using atmospheric pressure plasma is expected to the recovery method. In this study, we investigated optical emission spectroscopic measurement along the plasma axis during hydrogen and hydrocarbon combustion in an atmospheric plasma discharge. It is found that the Ar and OH intensity in hydrogen and methane combustion exponentially decrease along the plasma. In addition, OH density distribution in hydrogen and methane combustion is expected to be similar.

1. Introduction

Tritium recovery in a nuclear fusion reactor building is an important technology in terms of safety. As for the conventional technology, a combustion using precious metal catalysts and an absorption by a molecular sieve bed method have high recovery rate and are adapted to recover[1,2]. However it is difficult to process a large volume because of large pressure drop caused by packed bed of particles. In addition, warm up time of the catalyst bed is needed.

To solve these problems, a combustion method by an atmospheric pressure plasma, which are widely applied as chemical processing, has been proposed[3-6]. So far, we have shown the possibility of the hydrogen oxidation by the atmospheric pressure microwave plasma condition, and hydrogen combustion efficiency rises with increasing input microwave power and has reached up to 84%. In addition, an optical emission peak of OH radical was observed during hydrogen combustion[5,6]. However, the optical emission measurements observe integrated emission of whole plasma in the study, and optical emission along the plasma torch has not investigated.

In this research, we report experimental results of optical emission spectroscopic measurement along the plasma axis during hydrogen and hydrocarbon combustion in an atmospheric plasma discharge.

2. Experimental Setup

Figure 1 shows a schematic of the experimental apparatus for hydrogen and hydrocarbon combustion using a microwave discharge at atmospheric pressure. The plasma was generated by 2.45GHz microwave source under atmospheric pressure condition. Argon, oxygen, hydrogen and hydrocarbon (methane) were used as sample combustion gases. A mixture gas of these species was fed into the plasma source through a buffer tank. Each gas flow rate was controlled by mass flow controllers.

Visible light emissions from the plasma were observed by a spectrometer through a biconvex lens and an optical fiber. Plasma would be generated at the tip of plasma source's antenna. So the optical

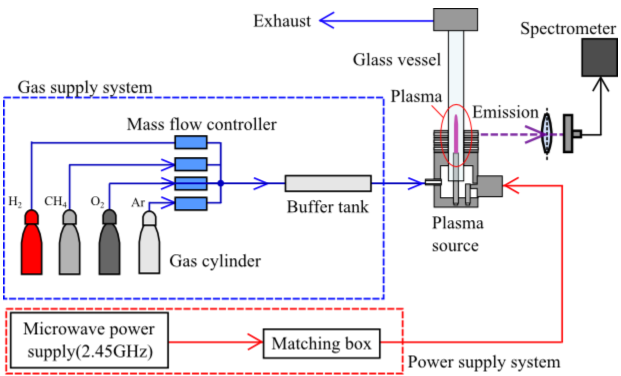

Fig.1 Experimental setup for hydrogen and hydrocarbon combustion in atmospheric microwave plasma.

view port was set in the position of 2mm, 6mm and 10mm from the tip of the antenna. The size of view port is 2mm in diameter.

In this experiment, the total flow rate was set 1.0L/min, and three different concentrations were set as shown Table 1. Microwave power for the discharge was fixed to 100W as the output power of the power supply.

Table I. Experimental gas concentrations.

#	Ar [%]	O_2 [%]	H_2 [%]	CH_4 [%]
1	100.0	0	0	0
2	78.8	20.0	2.0	0
3	78.8	20.0	0	2.0

3. Results and Discussion

ArI (811.5nm) which is the highest lines was monitored as indicator of plasma density during hydrogen and methane combustion. Also OH (A-X, 309.3nm) was focused as indicator of OH density.

Figure 2 shows the ArI (811.5nm) intensity with the position from tip of the antenna. In case of #2 and #3, the Ar intensity were smaller compared to the case of #1. These results indicate decrease of electron density. A possible reason of this result that oxygen, hydrogen, methane molecules take energy from electron by vibrational and rotational excitation. In addition, strong reduction of the intensity along the plasma is observed in the case of #2 and #3. This result suggest us that hydrogen and hydrocarbon combustion regions are much smaller than pure Ar plasma field

Figure 3 shows the OH(309.3nm) intensity with the position from tip of the antenna. Strong reduction of the OH intensity along the plasma is observed in the similar to Ar intensity. The result suggests that OH density is independent of electron density. Also Figure 3 shows OH intensities of hydrogen and methane combustion are quite similar. This result suggests these experimental conditions have similar OH density distributions.

4. Summary

Optical emission measurement along the plasma in hydrogen and hydrocarbon combustion during atmospheric microwave discharge was investigated. The Ar and OH intensity in hydrogen and methane combustion exponentially decrease along the plasma. The results suggest that hydrogen and methane combustion regions were much smaller than pure Ar plasma regions. It is also suggested that OH density is independent of electron density. OH density distribution in hydrogen and methane combustion is expected to be similar in this experimental condition.

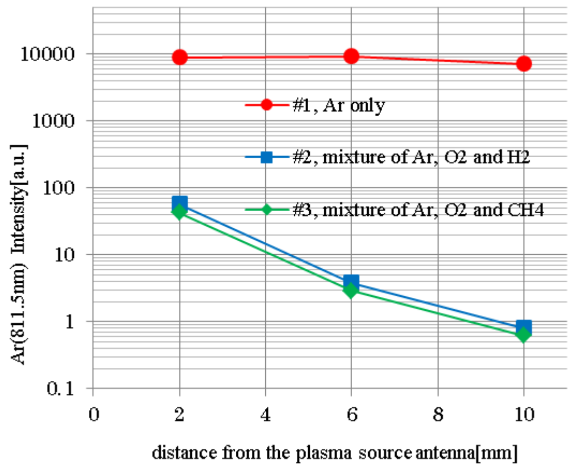

Fig.2 ArI (815nm) intensity emitted from plasma during hydrogen or hydrocarbon combustion.

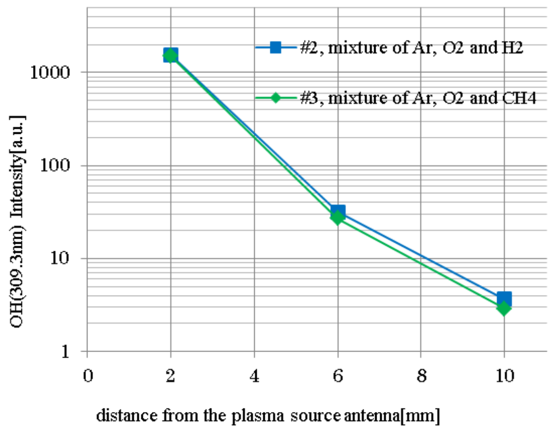

Fig.3 OH (A-X, 309.3nm) intensity emitted from plasma during hydrogen or hydrocarbon combustion.

Acknowledgments

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