§4. Investigation of Hydrogen Isotope Combustion Processes in Atmospheric Pressure Plasma

Ezumi, N. (Nagano National College of Tech.),
Sawada, K. (Shinshu Univ.),
Tanaka, Y. (Kanazawa Univ.),
Tanaka, M., Nishimura, K.

Recovery of tritium in a nuclear fusion reactor building is an important issue. Current tritium removal systems remove tritium from a gas by cracking the tritium containing components on a heated precious metal catalyst. The tritium combines with oxygen in the air stream to form tritiated water. Then, the tritiated water contained in the air stream is removed by a molecular sieve bed. Although this system offers adequate efficiency, problems such as a high-pressure drop, the use of a large amount of precious metals, and inefficient heating occur when the processing throughput is quite large. To resolve these problems, we have proposed hydrogen isotope combustion in atmospheric pressure plasma[1,2]. In the plasma, hydrogen and oxygen radicals are easily generated by high-energy electron and ion impacts in the plasma. These radicals are considered to play an important role in hydrogen oxidation in gas phase reactions. Therefore, it is expected that highly effective oxidation without precious metals can be developed using atmospheric pressure plasma. So far, hydrogen conversion efficiency rises with increasing input power and has reached over 80% at 100W for input microwave power.

We experimentally investigated hydrogen combustion by atmospheric pressure plasma generated by a 2.45 GHz microwave discharge as shown in Fig. 1. Small amounts of hydrogen and oxygen were mixed in the operational argon gas during discharge. A quadrupole mass spectrometer (QMS) was used primarily to measure time evolution of hydrogen, oxygen, and argon gases. To clarify the details of combustion, visible light emissions from the plasma were also observed by a spectrometer through a biconvex lens and an optical fiber. Gas temperature in the plasma flame was evaluated by the spectrum profile of OH emission.

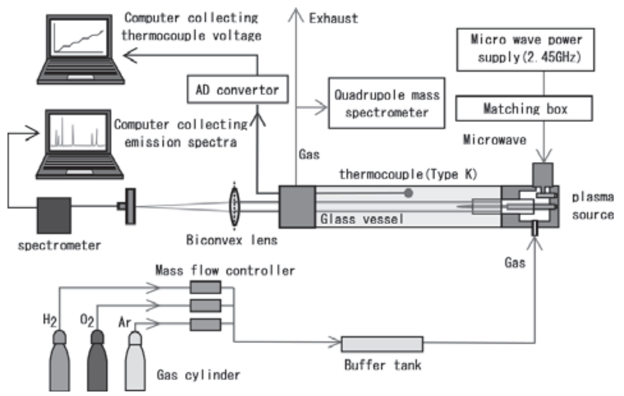

Fig. 1. Schematic of the experimental setup for hydrogen combustion in atmospheric pressure plasma.

Figure 2 shows that energy density dependence of the hydrogen combustion efficiency for several input power and gas flow rate. This result clearly shows that the combustion efficiency depends on energy density in spite of different input power and gas flow rate. Hence, the energy density would be considered as one of key parameters for combustion processes in the atmospheric pressure plasma.

Typical radial profiles of electron density (n_e), OH radical density (n_{OH}) and gas temperature (T_g) during hydrogen combustion are shown in Fig. 3. Although OH density profile shows a hollow profile, the T_g profile in the plasma is almost flat. These results suggest that importance of OH transport. Furthermore, the broad profile of high gas temperature indicates the area of the combustion reaction reaches to the outside of plasma flame.

In order to confirm the validity of this method for tritium recovery, we are preparing hydrocarbon combustion experiment using the atmospheric pressure plasma.

1) Akahane, K., Ezumi, N. et al.: Fusion Sci. Technol. **60** (2011) 1343.
2) Ezumi, N., Akahane, K. *et al*., Plasma and Fusion Research, **7**, (2012) 2401075.

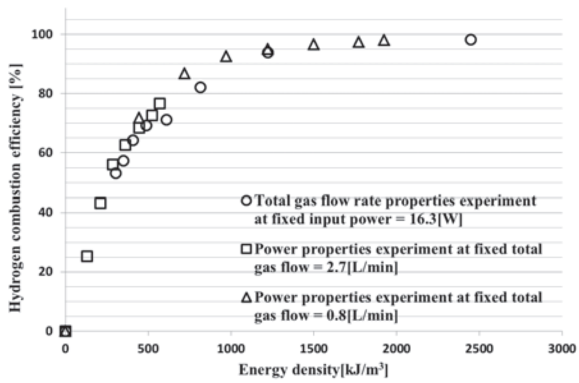

Fig. 2. Energy density dependence of hydrogen combustion efficiency. The energy density is evaluated as the ratio of input microwave power and total gas flow rate.

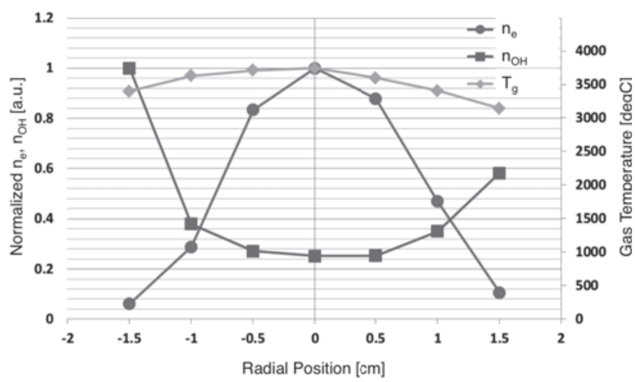

Fig. 3. Radial profiles of n_e, n_{OH} and T_g during hydrogen combustion.