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Hydrogen production from steam using plasma membrane reactor with a flow channel

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1. Introduction

Hydrogen production methods that do not emit CO_2 can be a breakthrough that significantly reduces CO_2 emissions. Recently, a water electrolysis method by photovoltaic power generation is common as a CO_2-free hydrogen production technology. However, water electrolysis has high power consumption and low conversion efficiency, so there is a demand for innovative high efficiency CO_2-free hydrogen production method [(1)]. We have developed hydrogen production technology that can obtain high purity hydrogen from ammonia by plasma treatment [(2)]. Plasma with high electron temperature is generated with low power consumption by dielectric barrier discharge (DBD). It was thought that hydrogen could be generated from gaseous water (steam) using plasma generated by DBD.

A plate type plasma reactor with flow channel was used to perform hydrogen production from humidified Ar gas. In this paper, the steam decomposition characteristics of the plate type plasma reactor were investigated, and the possibility of hydrogen production from steam was examined.

2. Experimental equipment and conditions

Fig. 1 shows the experimental setup for steam decomposition by DBD. The experimental equipment consisted of an Ar cylinder, a humidifier, a plate type plasma reactor, and a hydrogen gas analysis system. The sample gas was adjusted by introducing Ar gas into the temperature-controlled humidifier. Vapor with sample gas was decomposed to H_2 by plate-type plasma reactor. The H_2 concentration of the sample gas processed by the plasma reactor was measured by gas chromatography after dehumidification.

Fig. 2 shows structural drawing of plate-type plasma reactor. This reactor has serpentine flow channel. (Flow channel: width 1 mm, depth 4.5 mm, length of 1010 mm)

3. Result and discussion

Fig. 3 shows the effect of applied voltage on hydrogen conversion from steam in argon gas at different humidification temperatures. It has been confirmed that hydrogen is generated from the vapor in Ar gas by plasma treatment. The hydrogen conversion rate increased as the applied voltage increase. It is considered that the vapor decomposition is promoted by the increase of the energy density in the plasma reactor with

the increase of the applied voltage.

On the other hand, the hydrogen conversion rate decreased as the humidification temperature increased. As the amount of saturated steam increases with the increase of the humidification temperature, the volume of vapor supply per unit time increases. It is considered that the hydrogen conversion rate is lowered because the vapor supply volume is increased under the same applied voltage condition. The maximum hydrogen conversion rate was 0.9 %. (The applied voltage was 18 kV and the humidification temperature was 40 °C)

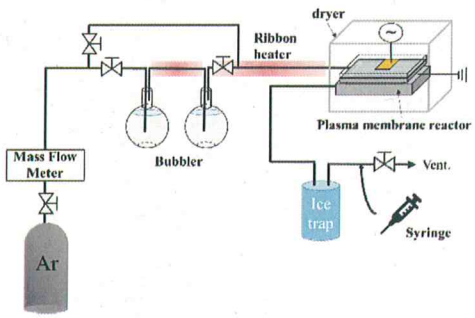

Fig. 1 experimental setup for H_2 production from water vapor.

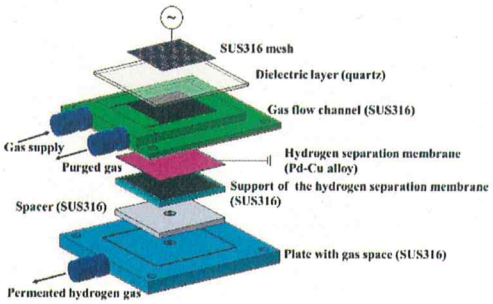

Fig. 2 Structural drawing of plate-type plasma reactor.

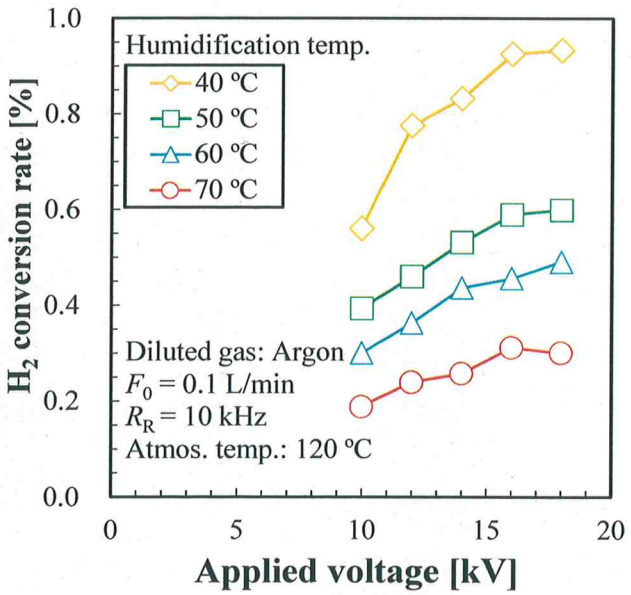

Fig. 3 The effect of applied voltage on H_2 conversion from vapor in Ar gas at different humidification temperatures.

4. References

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