Development of Plate Type Plasma Reactor With a Flow Channel

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Ammonia is a promising raw material for hydrogen production because it may solve several problems related to hydrogen transportation and storage. A cylindrical plasma membrane reactor has been developed to produce pure hydrogen from ammonia. However, the gas flow is not uniform; therefore, the plasma state is unstable, resulting in a low ammonia decomposition rate in the cylindrical plasma reactor. To address this issue, a plasma membrane reactor with a flow channel was considered, assuming that this configuration would simulate a fuel cell separator to create a uniform gas flow. A 1-mm-wide and 1-mm-deep flow channel was fabricated on the surface of a 5-cm square quartz plate.

To test the configuration, 0.5% ammonia gas was supplied to the flow channel plasma reactor at a 0.4-L/min flow rate. Stable plasma was observed; the ammonia decomposition rate reached 45.4%, which represents a higher conversion efficiency than that measured in a cylindrical plasma membrane reactor with the same gas residence time. Because the plate plasma reactor can be laminated, it can be easily scaled up for large-scale hydrogen production.

The effects of the applied voltage, gas flow rates, and ammonia concentration on the ammonia decomposition rate were investigated. The results showed that an increase in the applied voltage leads to a higher ammonia decomposition rate because the high plasma density causes greater dissociation of molecular ammonia by electron impacts. Further, increases in the ammonia gas flow rate or the ammonia concentration reduces the ammonia decomposition rate.

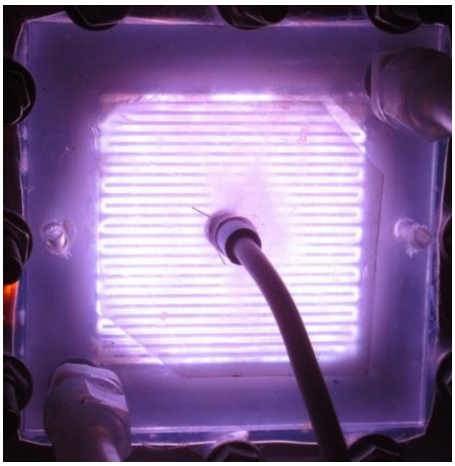

Fig. 1 Plasma state of a flow channel reactor