Development of Catalytic Reactors and Solid Oxide Fuel Cells Systems for Utilization of Ammonia

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Hydrogen carrier & energy conversion technology

➢Ammonia as a promising hydrogen carrier:

High H_2 density, Carbon-free, Low production cost, High boiling point, Ease in liquefaction and transportation, etc.

	H_2 density (kg-H_2 / m^3-liq.)	Boiling point (ºC)	ΔH_r (kJ/mol-H_2)
Liquid H_2	70.8	–252.6	–
NH_3	120.3	–33.3	30.6 $2NH_3 \rightarrow N_2 + 3H_2$
C_7H_{14} (Methylcyclohexane)	47.1	101.1	80.0 $C_7H_{14} \rightarrow C_7H_8 + 3H_2$

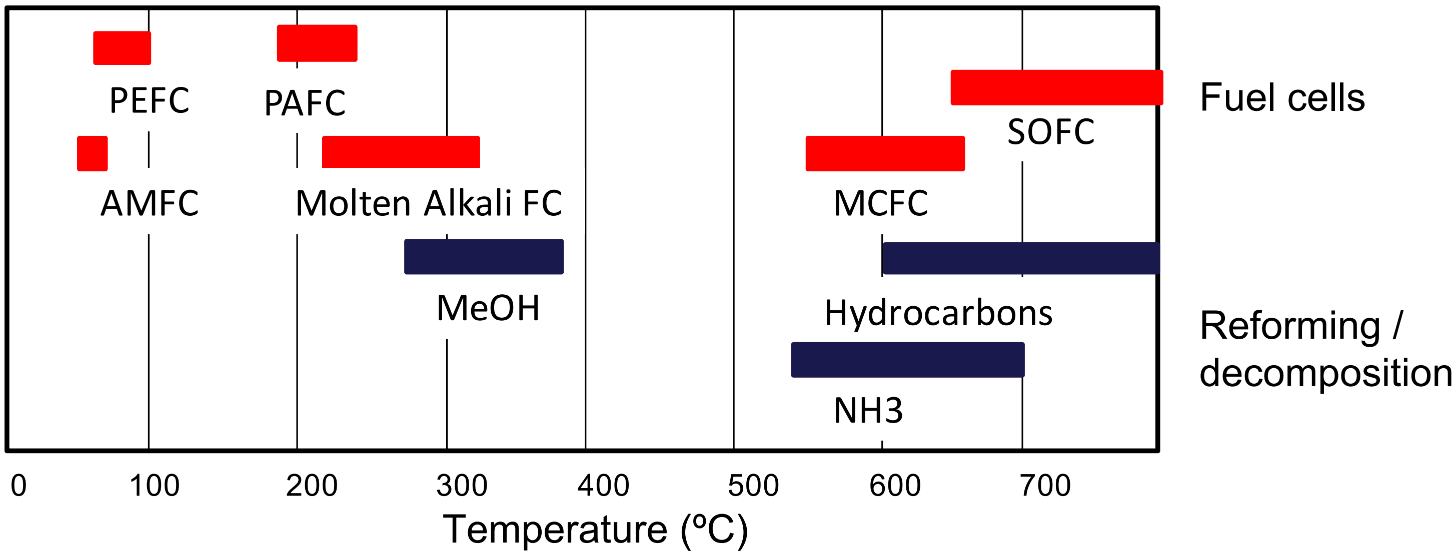
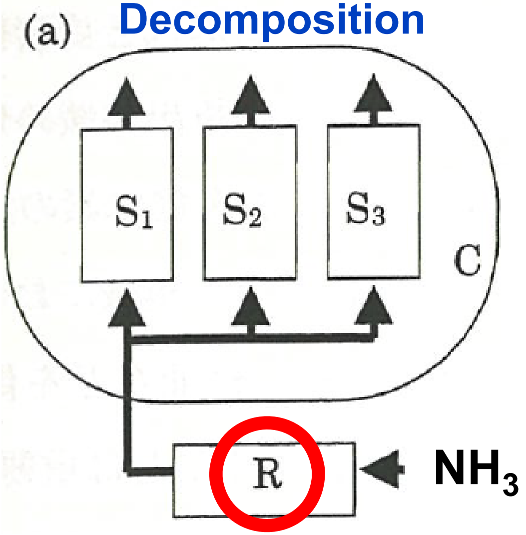


Fig. Operating temperature ranges of fuel cells and catalytic reformers

Operation type of ammonia fueled SOFC

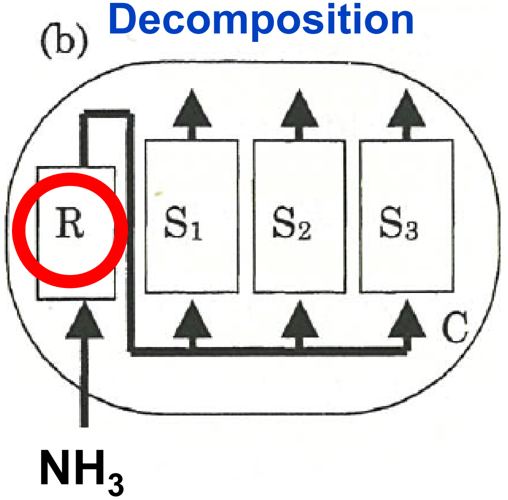
R: NH_3 decomposition reactor, C:Fuel cell chamber, S:SOFC stack

External Decomposition



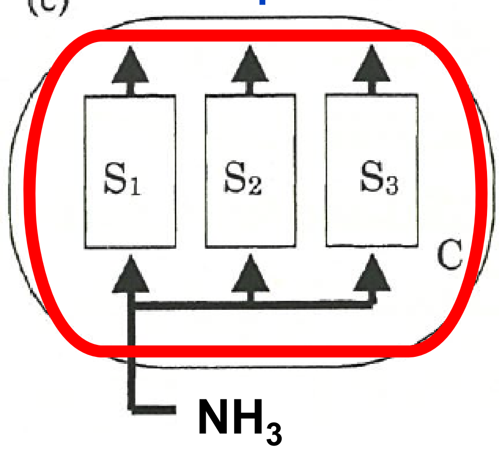
- NH_3 decomp. reactor installed on the flow line
- Optimized operation of each reactor
- Large energy loss
- Large system size
- Stationary application

Indirect Internal Decomposition



- Reactor installed in the FC chamber
- System design with effective heat management
- Either stationary or mobile application

Direct Internal Decomposition

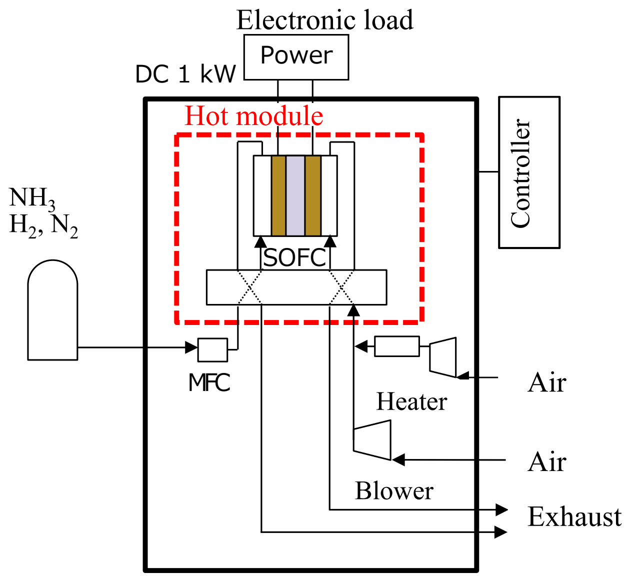


- NH_3 decomp. reactor unnecessary
- NH_3decomp. And anode reaction proceed on the electrode
- Simplified system
- Multifunctional electrode
- Heat management
- Either stationary or mobile application

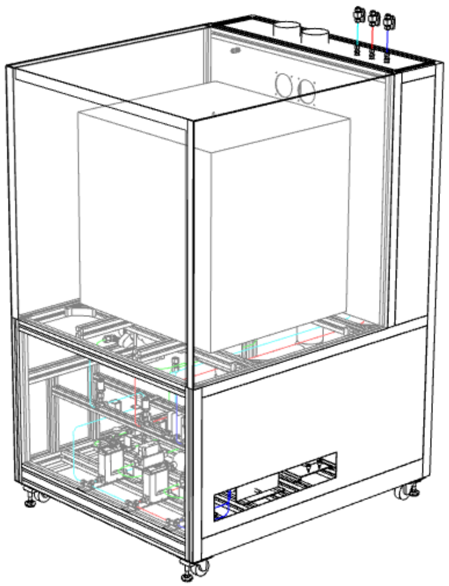
Development of 1kW generation package

System specification & flow diagram

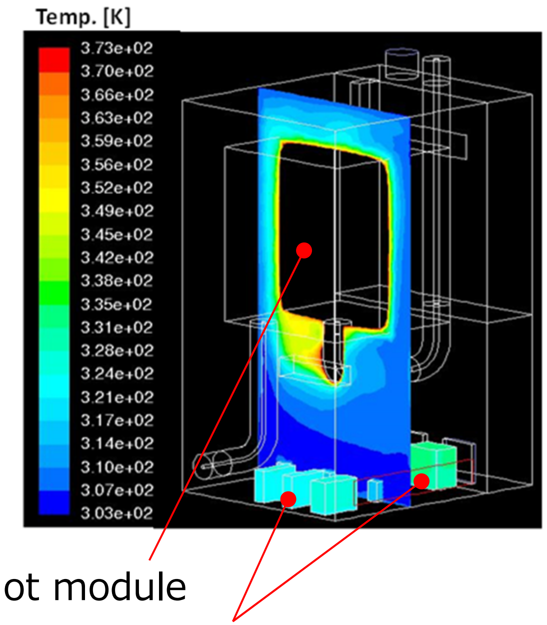
Term	Specification
Fuel / Supply	Steady condition Direct Supply of ammonia (100%) without cracker
Heat output	None (electricity only)
Output	DC (without inverter)
Operation	Automatic control
Start-up	Heating with cathode gas with air preheater



Design of system



System package CAD model



Hot module

BOP : MFC, Blower

Summary

Ammonia-fueled SOFC stack with 1 kW power output has been successfully operated and high DC efficiency over 50% LHV.

Stability of the stack has been improved by introducing ammonia pre-cracking catalyst and surface treatment of metal separators.

Automated 1 kW-class SOFC package has been successfully operated.

Auto-thermal ammonia cracker has been developed for start-up of the SOFC systems.

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