

# Non-thermal plasma-assisted fuel conversion for green chemistry

Tomohiro Nozaki and Seigo Kameshima

Department of Mechanical Sciences and Engineering, Tokyo Institute of Technology  
2-12-1 O-okamaya, Meguro, Tokyo Japan 1528550

This paper describes dry methane reforming (*DMR*) using Ni catalysts and DBD hybrid reactor, aiming for efficient conversion of greenhouse gas into syngas. Both  $\text{CH}_4$  and  $\text{CO}_2$  are vibrationally excited through low-energy electron collision, which is the efficient energy transfer pathways between molecules and electrons. Subsequently, vibrationally excited molecules are absorbed onto the catalyst surface with much smaller threshold energy than that of ground state molecules. Therefore, material and energy conversion efficiency is expected to increase in the hybrid operations, enabling energy efficient and low-temperature greenhouse gas conversion. Low temperature gas conversion is critically important because high temperature thermal energy, which is produced through combustion of initial feed, is eliminated: Overall exergy loss through the reforming process is greatly minimized.

DBD is produced in 20 mm inner diameter quartz tube packed with  $\text{Ni-Al}_2\text{O}_3$  catalyst pellets (3 mm sphere) over 20 mm length. 3 mm metallic rod was inserted into the center of quartz tube as a high voltage electrode. DBD is readily extinguished once solid carbon, or electrically conductive film, is formed on the pellet surface. Therefore, total pressure was reduced to 10 kPa so that DBD is generated independently of coking. Moreover,  $\text{CH}_4$  was supplied intermittently (5 min. interval), while  $\text{CO}_2$  was continuously supplied: Solid carbon was removed during  $\text{CH}_4$  flow is off. The catalyst bed was heated by external electric heater and the bed temperature was monitored by an infrared camera. Output gas ( $\text{CO}$ ,  $\text{H}_2$ ,  $\text{CH}_4$ ,  $\text{CO}_2$ ) was analyzed online by quadruple mass spectrometer, providing semi-quantitative information of reforming reaction. Time dependent change in gas components is provided in Fig. 1. Between A and C, steady state was established by the thermal reaction. DBD is turned on at point C, *DMR* is enhanced, then  $\text{H}_2$  and  $\text{CO}$  partial pressure increased: The bed temperature also increased slightly. Between D and E,  $\text{CH}_4$  was turned off while DBD was kept running. This period is de-coking phase. Because endothermic enthalpy is small for this reaction, the bed temperature increased markedly.  $\text{CH}_4$  is introduced at point E again: The bed temperature decreased dramatically due to *DMR* and stabilized in 5 min. For better understanding reaction mechanism in hybrid operation, detailed analysis of reforming reaction and the electronic kinetics will be discussed at the symposium.

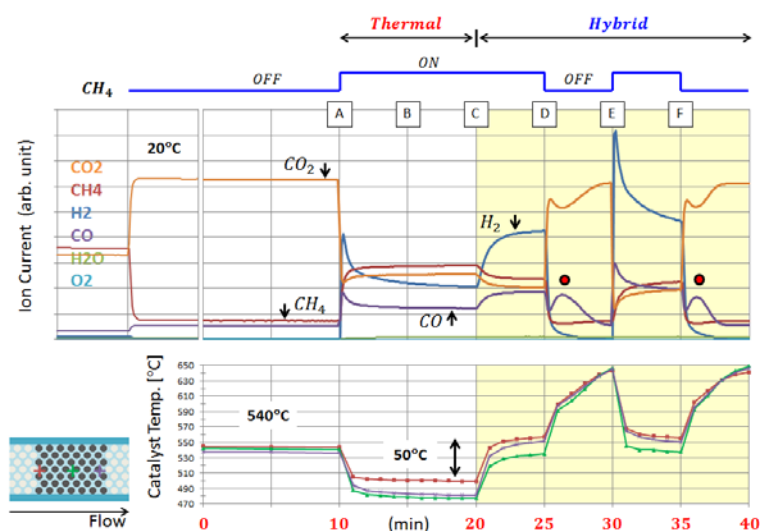


Figure 1, Time dependent change in gas components and bed temperature: GHSV: 20600h<sup>-1</sup>, 70W, SEI: 0.5J/cm<sup>3</sup>.