

In situ Observation of Deposited Carbon on Anode for Solid Oxide Fuel Cells

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INTRODUCTION

Solid oxide fuel cells are operated at high temperature, so that it can utilize hydrocarbons as a fuel through internal reforming. In this case, carbon deposition may occur in some condition depending on the temperature, the combination of electrode and electrolyte, and the ratio of steam and carbon. Carbon deposition has been recognized to be serious problem, because it causes deterioration of the cell performance. It is very important to obtain information of carbon deposition for the development of SOFC anodes. However, there is little information about carbon deposition under the practical operating condition, so far. To elucidate the deposition and oxidation mechanism of adhered carbon directly, we performed the electrochemical measurements combined with Raman microspectroscopy at high temperature.

EXPERIMENTAL

The electrochemical cells were disk-shaped samples of ϕ 5 mm \times t 0.5 mm, whose configurations were Pt pasete/8YSZ/Pt paste and Ni mesh/8YSZ/Pt paste.

Figure 1 shows the quartz chamber for simultaneous measurement of electrochemical properties and Raman microspectroscopy at high temperature. The chamber was divided into two compartments by pyrex® glass sealing: one side is filled with fuel and the other is air. Electrochemical measurement and Raman microspectroscopy were conducted through potentiostat/galvanostat (Toho, PS-14) and commercial Raman microspectroscopic system (Jovin-Yvon, T64000), respectively. The excitation line was Ar ion laser of 488 nm (NEC, GLG3200). Surface observation with optical microscope and a measurement of Raman spectra were carried out on the top of the sample through the window in humid methane or butane atmospheres.

RESULTS AND DISCUSSION

After several-ten-minute exposure to hydrocarbon, the deposited carbon was observed by Raman microspectroscopy (Fig. 2). Concerning to Pt/8YSZ in dry butane, two broad peaks appeared which were identified to disordered carbon (1355 cm^{-1}) and graphite (1590 cm^{-1}), respectively¹⁾. This indicates that the deposited carbon was amorphous carbon. While, in the case of Ni/8YSZ in humid methane, there was one sharp peak at 1560 cm^{-1} . *i.e.* crystalline graphite was deposited on Ni. The result means that the forms of deposited carbon depend on gas species and anode materials.

In order to elucidate whether the deposited carbon could be burnt out electrochemically, the Ni/YSZ cell was under anodic polarization of $+170\text{ mV}$ ($11\mu\text{A}/\text{cm}^2$) after the deposition. The deposited carbon was not burned apparently by permeated oxygen (Fig. 3).

1) S. M. Mominuzzaman et al., Carbon **38**, 127 (2000)

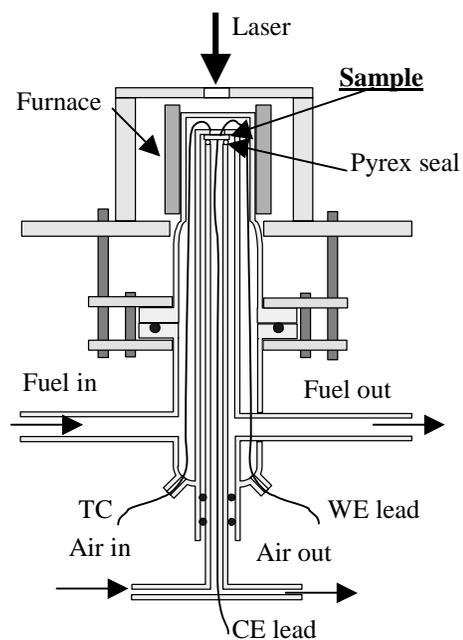


Fig. 1 Schematics of experimental setup.

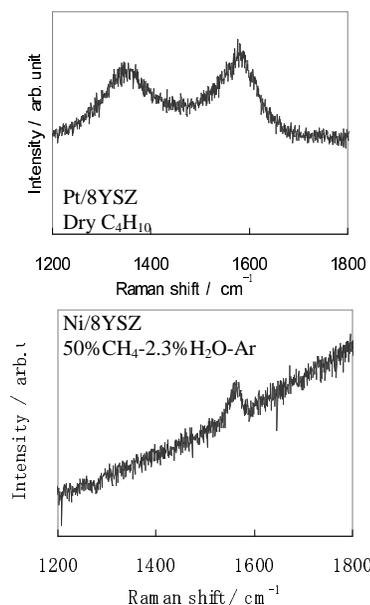


Fig. 2 In situ Raman spectra of deposited carbon at $800\text{ }^{\circ}\text{C}$

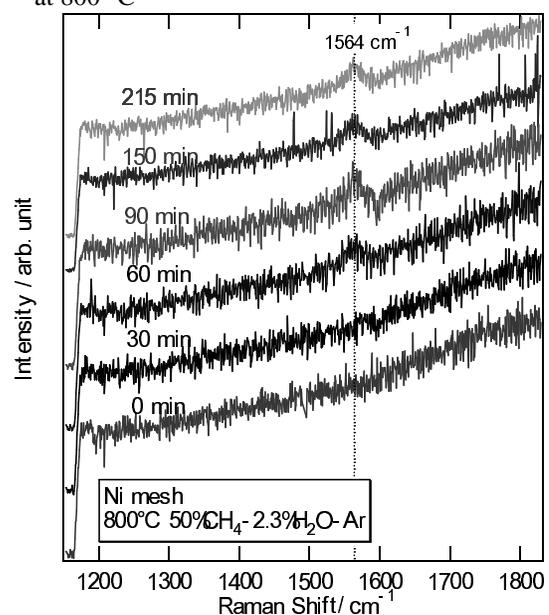


Fig. 3 Raman spectra of deposited carbon before and after polarization. The cell was anodically polarized [$+170\text{ mV}$, $11\mu\text{A}/\text{cm}^2$] from 60min after gas introduction.