技術情報 Technical Information

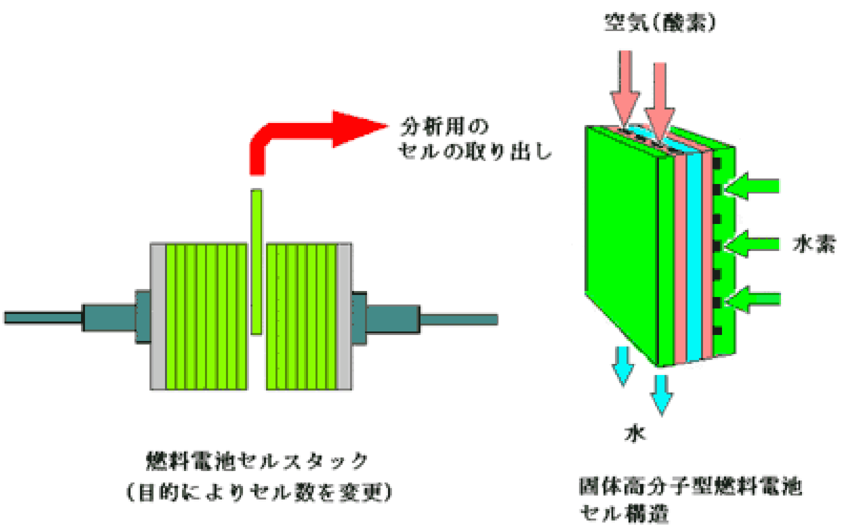
Analysis of Solid Polymer Electrodes in a Fuel Cell by XPS
For Enhanced Durability of Clean Energy Fuel Cells

1. General

Fuel cells are increasingly attracting attention as a next generation energy source as we step up our effort in protecting environment and reducing the dependence on fossil fuels. Practical applications of fuel cells are being studied, as reflected in new automobiles that run on fuel cells, hydrogen gas stations available on an experimental basis, and power sources of mobile equipment such as PC, PDA, and cellular phone.

Fuel cells vary in design depending on the type and application. The figure below shows a solid polymer fuel cell. The cell stack contains 100 layers of cells to achieve the specified voltage and current. A cell is composed of a separator, electrode (cathode), electrolyte, electrode (anode), and separator arranged in layer. Reactants such as hydrogen gas and air are injected. The hydrogen gas will react with the anode, and the resulting electrons and protons will travel to the cathode where they react with oxygen, generating water. This continuous flow of the gas, ions, electrons, and water makes the fuel cell a high performance source of power.

The characteristics of a fuel cell are determined by the materials used for the electrodes. Maintaining the performance of the electrodes is one of the most critical issues being studied using different analytical instruments. X-ray photoelectron spectroscopy (XPS) was used to analyze an electrode sample to test its effectiveness.



Typical solid polymer fuel cell

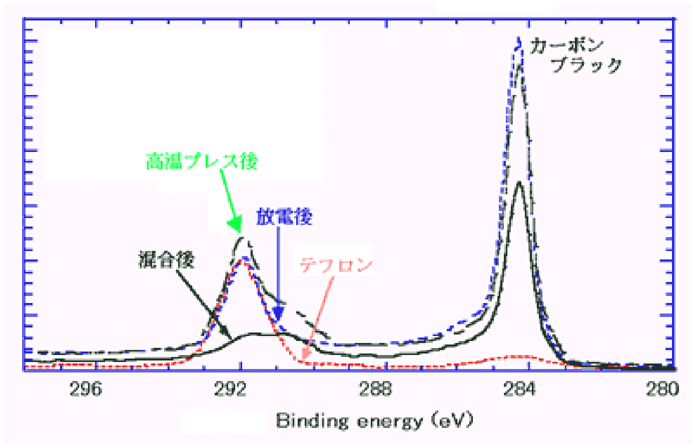
2. Analysis in XPS

Durability of fuel cells is one of the issues being studied in developing a commercial product. Of special importance is preventing the electrodes from deteriorating. Electrodes (cathode and anode) are normally made of carbon black or fluoropolymers, while Pt and Au are used as a catalyst. The electrode analyzed was a membrane electrode assembly (MEA), and its fluoropolymer film had no CF_3 bond at the end, had a number of CF bonds at the side chain, and, unlike Teflon, had CF_2 and CHF bonds in its C1s and F1s spectra. The surface of the electrode before and after use (discharge) was analyzed in XPS to identify the cause of deterioration.

2-1. Macro analysis of electrode surface

When an electrode is analyzed in XPS, an area of a few mm in diameter is usually selected, and the information acquired from this area is processed and examined. The figure shows the C1s spectrum acquired from an area of 3 mm in diameter on the electrode surface. The spectrum shows CF_2 peaks at 292 eV and CHF-CF_2 peaks at 290 eV. Since the electrode is made of a conductor and insulator, it is important to identify the distribution of these components before and after the fuel cell is used (discharged).

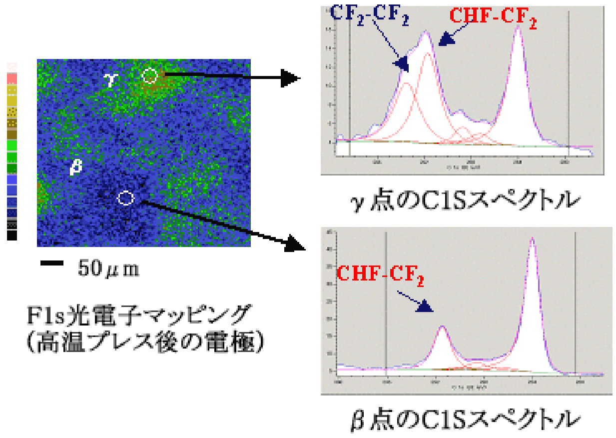
Optical micrograph of a fuel cell electrode



C1s spectrum after surface treatment

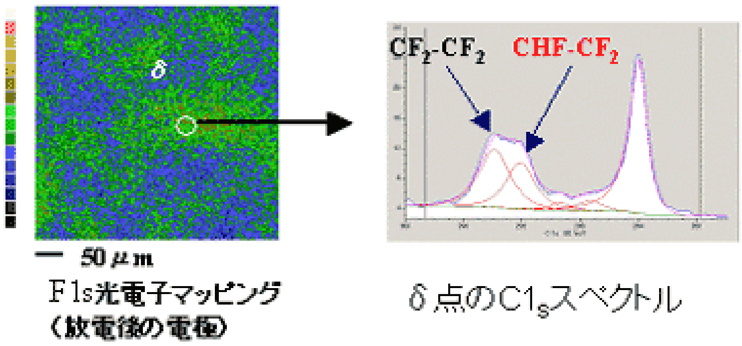
2-2. Micro analysis of electrode after high temperature press

The figure below shows the F1s photoelectron map and C1s spectra of the sample. The spectra show CHF-CF_2 and CF_2-CF_2 peaks at point γ and a CHF-CF_2 peak of Teflon polymer at point β. The map shows that the Teflon polymer (insulator) was localized on the electrode surface after a high temperature press was applied.



2-3. Micro analysis of discharged electrode

The figure below shows the F1s photoelectron map and C1s spectrum at point δ. The spectrum shows CHF-CF_2 and CF2-CF_2 peaks similar to those at point γ after high temperature press. Of these two components, the quantity of the CF_2-CF_2 bond was higher than that of the CHF-CF_2 bond. Furthermore, the component of the Teflon polymer was reduced significantly in quantity and was distributed widely on the surface compared to point γ after high temperature press. This demonstrates that the insulator that the gas had traveled through changed a great deal after the cell was discharged.



3. Summary

The electrode of a fuel cell was analyzed in XPS before and after use (discharge). Data obtained from macro and micro areas showed how the fluoropolymer decomposed, demonstrating that XPS is effective in identifying the cause of fuel cell deterioration.