LAAN-A-ND-E016

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Application News

No.N123

Industrial X-ray Inspection System

X-Ray CT Observation of Fuel Cell MEA

Introduction

Fuel cells are devices that convert the energy obtained from an electrochemical reaction of hydrogen fuel directly into electrical energy. Because they are highly efficient and emit only water, fuel cells have attracted great interest due to their potential for contributing significantly to providing a solution for both energy and environmental concerns. The use of fuel cells is currently expected to increasing spread in automotive, housing, and mobile device fields, in particular.
However, further improvements in performance, durability, and cost are required before there is widespread adoption. Achieving such improvements will require that those in fuel cell R&D and quality control fields evaluate multiple aspects of fuel cells, including measuring their physical properties, analyzing the structure, observing their morphology, and performing various strength tests.
Therefore, this Application News bulletin provides an example of using an X-ray CT system for fuel cell observation.

Observation of Fuel Cell MEA

At the heart of polymer electrolyte fuel cells is the membrane electrode assembly (MEA), which consists of electrolyte membrane, catalyst, and gas diffusion layers. Electrolyte membranes must be conductive to protons, but not conductive to electrons or gases, and generate electricity in a stable manner. Thus, it is important to control the moisture generated during electrical power generation.
Catalyst layers consist of platinum or other precious metal catalyst held on the surface of a carbon black substrate and an electrolyte. To reduce costs, efforts are being made to reduce the amount of platinum or other precious metal used. To improve conversion efficiency, the surface area of the substrate is being increased. To reduce the environmental impact, measures to prevent carbon monoxide poisoning are being implemented.
Gas diffusion layers (GDL) are conductive substrates made of carbon paper or other porous material that are treated with polytetrafluoroethylene (PTFE) or other material for water repellency. Each MEA is then sandwiched between separators with grooves used to supply reaction gases and so on. This MEA sandwich is called a single cell. Actual fuel cells contain multiple single cells connected in series in a stack configuration.
Actual results (Fig. 3) from observation of the MEA (Fig. 2) using an inspeXio SMX-100CT microfocus X-ray CT system (Fig. 1) are shown as MPR images in Fig. 3. (To enable the image to be enlarged, a small section was cut from the MEA specimen, as shown on the right side of Fig. 2.)

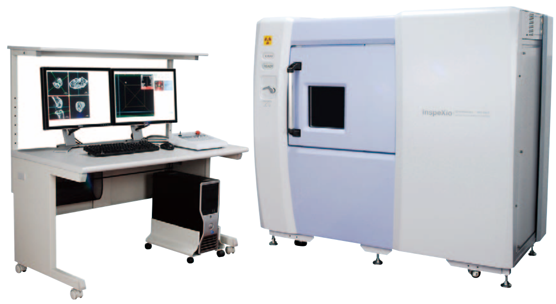

Fig. 1 inspeXio SMX-100CT Microfocus X-Ray CT System

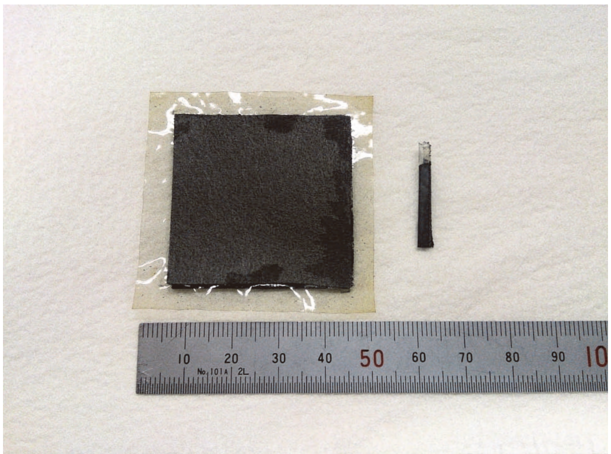

Fig. 2 Photograph of MEA Exterior

MPR images load multiple CT images in a virtual space to display four images on one screen, including a CT image in frame (1), mutually orthogonal longitudinal section images in (2) and (3), and a user-selected cross section image that is orthogonal to the longitudinal section images in (4).
In these MPR images, the cross section of the MEA is shown in frame (1). The higher density the material, the whiter it appears in CT images. In the upper left image, the electrolyte membrane is the faintly colored object in the center of the image, whereas the material that appears white is the catalyst layer. The gas diffusion layer is also visible on the outer side of the catalyst layer.

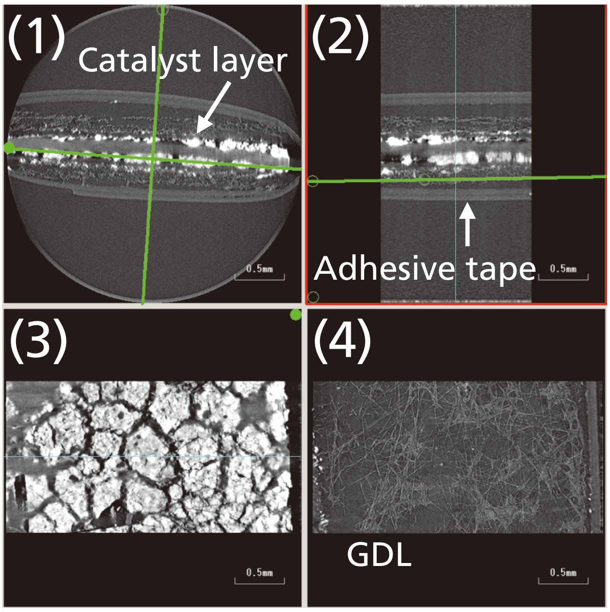

Fig. 3 MPR Images of MEA

The lower right image in Fig. 3 shows the gas diffusion layer, where the fiber-like objects are carbon fibers. The carbon fibers are held together by the binder material. By enlarging the X-ray CT image, the image can be used to confirm the status of bonding between the carbon fiber and binder.
The material visible along the outer edge is the adhesive tape, used to maintain the MEA shape. The cross section corresponding to the vertical line in the image on the upper left is the cross section image shown on the upper right. The cross section corresponding to the green line in the image on the upper right is the cross section image shown on the lower right, which shows the GDL. A 3D image of the same cross sections is shown in Fig. 4.

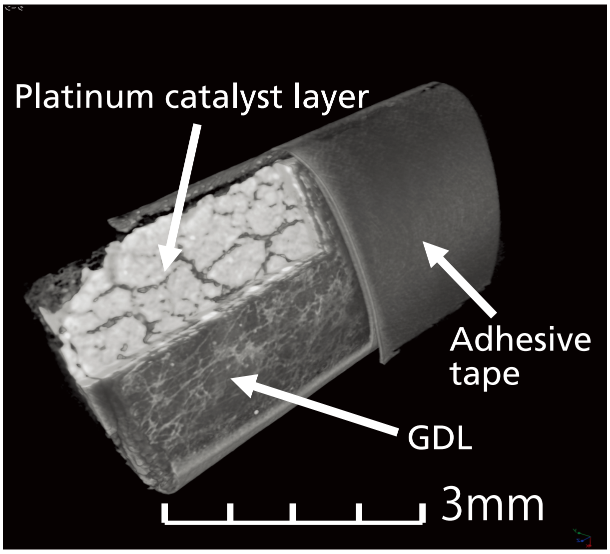

Fig. 4 3D Image of MEA

In Fig. 4, the GDL is visible on the outer side of the platinum catalyst layer. The GDL consists of carbon paper or carbon cloth about 100 to 300 µm thick, which offers excellent gas permeability and conductivity. In addition to diffusing the fuel and oxidizer across the catalyst layer, the gas diffusion layer also serves to discharge water, which is a reaction product, and to control the moisture content inside the catalyst layer. Therefore, the surface state of the GDL layer is also controlled, such as by treating the substrate for water-repellency or using various machining processes.
Fig. 5 shows only the catalyst layer contained in the sample. Using analysis software, the volume of the catalyst was calculated to be 1.6362 mm^3.

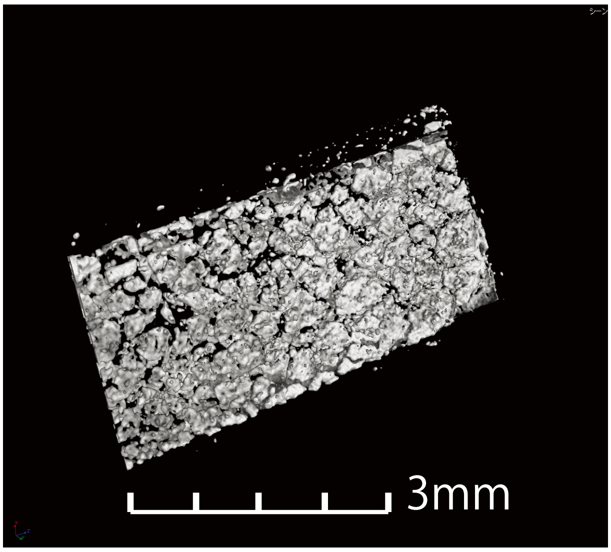

Fig. 5 3D Image of Catalyst Layer

Conclusion

As indicated above, the inspeXio SMX-100CT can be used not only to observe the internal shapes and status inside MEAs, it can also be used with analysis software to measure the amount and location of catalyst in the catalyst layer.

First Edition: Feb. 2014

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