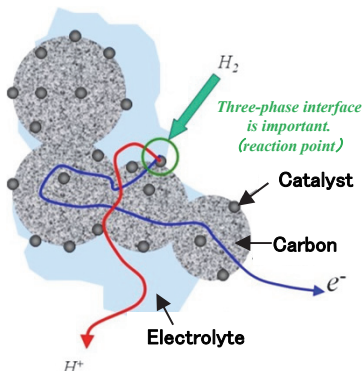


# Three-dimensional analysis of coating conditions of ionomer in catalyst layer before and after cycle test

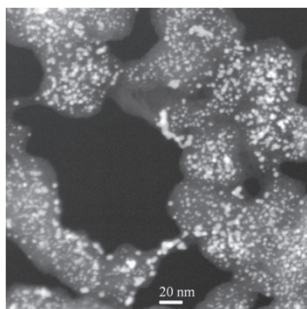
Image contrast of ionomer is enhanced using Ru electron staining to analyze the morphologies of catalyst, carbon, and ionomer. We can evaluate the difference in coating condition of ionomer between before and after cycle test by Ru electron staining and TEM tomography.

## Analysis of distribution of ionomer in catalyst layer using Ru electron staining

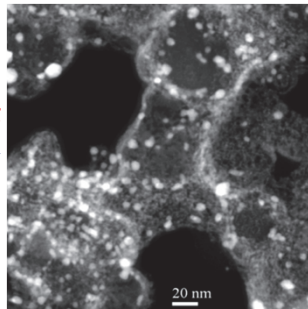
Schematic of catalyst layer



HAADF-STEM image



Ru staining



3D-reconstructed image

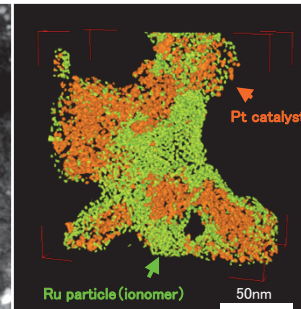
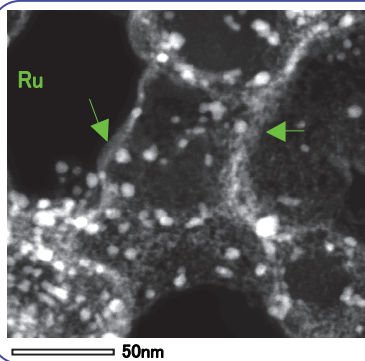


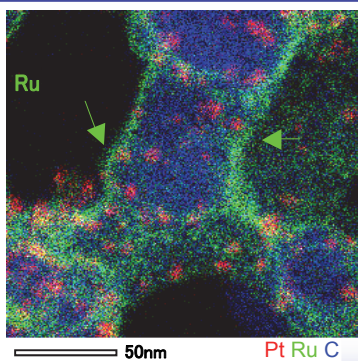
Image contrast is enhanced by Ru electron staining, since Ru penetrates only into ionomer (electrolyte). Ru particles on carbon support are visualized. This technique is applicable to TEM tomography.

## Morphologies of Ionomer on carbon before and after cycle test analyzed by EDX/TEM tomography

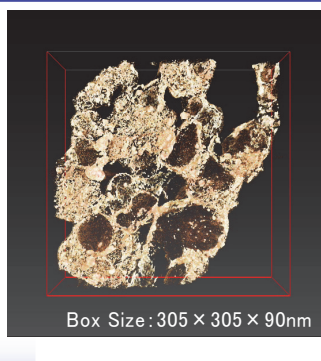
Before cycle test



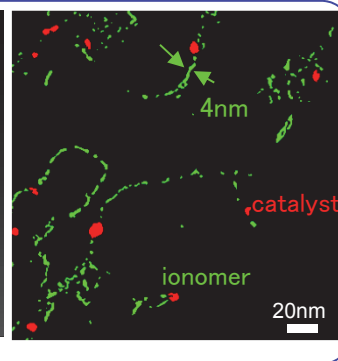
2D-EDX map



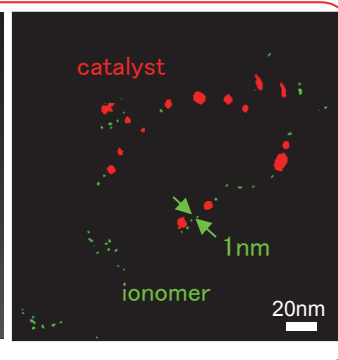
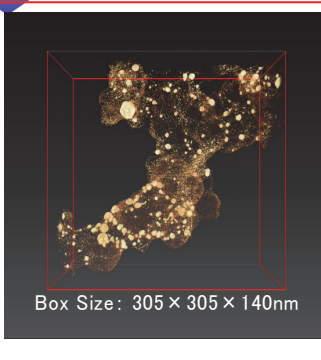
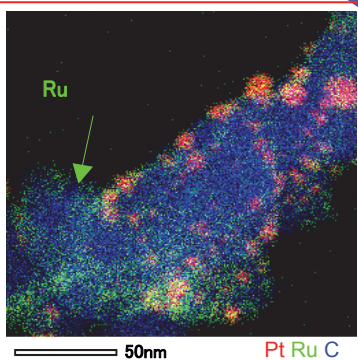
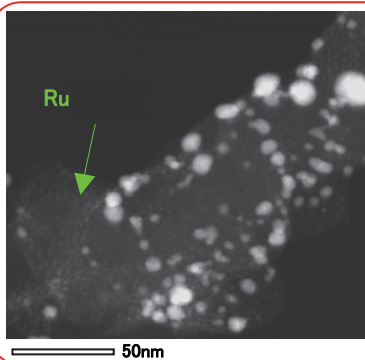
3D-reconstructed image



Sliced image



After cycle test



The ionomer around the carbon support is drastically reduced after cycle test. Thickness of the ionomer can be precisely evaluated based on sliced image.

※The results was partly supported by New Energy and Industrial Technology Development Organization (NEDO), Japan.