Evaluation of an Oxygen Reduction Reaction Material Synthesized by Microwave Surface-Wave Plasma Chemical Vapor Deposition

Susumu Ichimura\textsuperscript{1,2}, Toru Iijima\textsuperscript{2}, Tomoharu Tokunaga\textsuperscript{3}, Yasuhiko Hayashi\textsuperscript{2}, Masayoshi Umeno\textsuperscript{1}

\textsuperscript{1}Institute for General Research of Science, Chubu University, Kasugai, Aichi 487-8501, Japan
\textsuperscript{2}Department of Electrical and Electronic Engineering, Okayama University, Okayama-shi, Okayama 700-8530, Japan
\textsuperscript{3}Department of Quantum Engineering, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, Aichi 464-8603, Japan

Several studies have attempted to obtain oxygen reduction reaction materials by partially substituting metal for nanocarbon [1-3]. These studies have generally employed methods in which chemically synthesized metal nanomaterials were supported on the nanocarbon. In contrast, we report here the successfully preparation of an oxygen reduction reaction material by amorphous carbon (a-C) growth using microwave surface-wave plasma chemical vapor deposition and metal thin film evaporation deposition.

a-C was grown to a thickness of 50 nm on Cu foil (30 μm) at room temperature by microwave surface-wave plasma chemical vapor deposition, and a 2–nm-thick layer of Au was deposited on the a-C by vacuum evaporation deposition. The stacked layers on the copper foil were processed by H\textsubscript{2} plasma treatment at 800 °C using microwave surface-wave plasma, providing the oxygen reduction reaction material. The copper foil attached to the catalyst material was dissolved by wet etching, and the resulting material was photographed on a transmission electron microscopy (TEM) grid (Fig. 1). The material was analyzed by Raman scattering spectroscopy (inVia, Renishaw) and planar TEM (JEM-2100F, JEOL).

Figure 2 shows the Raman scattering results. A 2D band indicating the presence of graphene was observed. Figure 3 shows the TEM images. As seen from Fig. 3(a), the Au particle size was around 5 nm. Figure 3(b) shows that there were around 7 graphene layers.

References

FIG. 1. Photograph of the TEM grid

FIG. 2. Raman spectrum indicating the presence of graphene

FIG. 3. Planar TEM images