Electrocatalytic Oxygen Reduction with Metal Nanoparticles Deposited on BDD Electrode

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Boron doped diamond (BDD) is an attractive electrode material due to its wide electrochemical potential windows in aqueous solution and nonaqueous media and extreme electrochemical stability compared with other carbon electrodes, e.g., glassy carbon (GC), pyrolytic graphite (PG), and highly oriented pyrolytic graphite (HOPG), which have been widely used as common electrode materials for last decades. [1-2] In particular, polycrystalline diamond is ideally suited as an electrocatalyst support for fuel cell, although diamond itself is relatively inert. [3]

Electrocatalysis of the oxygen reduction reaction is practically interest because of its importance for electrochemical energy conversion and industrial electrolysis. Au nanoparticles coated electrode has been found to be of the highly catalytic performance for the oxygen reduction and the catalytic activity was found to depend on particles size, nature of the support as well as the method of preparation. [4-5]

In present study, the electrochemical characterizations of Au nanoparticles deposited on BDD electrodes were carried out, mainly on electrocatalytic activities for oxygen reduction.

Au nanoparticles were electrodeposited on BDD electrode from acidic bath of 0.5 M H_2SO_4 solution containing 1.0 mM Na[$AuCl_4$] by applying a potential step from 1.1 to 0.0 V *vs.* Ag/AgCl. The duration time of the potential step was varied from 5 to 900 s to obtain Au deposited BDD electrode. SEM analysis of the Au nanoparticles deposited on BDD was carried out using a JSM-T220 scanning electron microscopy.

Figure 1 shows the SEM image of BDD and Au nanoparticles deposited BDD electrodes. SEM revealed that small Au nanoparticles dispersed on BDD. As shown in Figure 1(b)-(d) the gold deposited randomly as small spherical particles with average diameter of ca. 30 nm. The result shows that the active sites for gold nucleation are inhomogeneously distributed on the surface of BDD electrodes. The size of Au nanoparticles deposited on BDD electrode depends on the duration time of potential step.

The electrochemical behavior for oxygen reduction was examined in 0.1 M KOH solution saturated with Ar gas and O_2 as shown in Figure 2. In the alkaline solution, oxygen reduction on Au deposited BDD electrode was found at -0.6 V (*vs.* SCE), where on bare BDD electrode, broad peak for oxygen reduction peak was observed at -1.1 V (*vs.* SCE). The catalytic potential shifted positively about 0.5 V and the current increased. Au nanoparticles deposited on BDD electrode shows higher electrocatalytic activity for oxygen reduction. The Au nanoparticles deposited BDD electrode showed different mechanism and high catalytic efficiency for the oxygen reduction with those of the polycrystalline Au electrode.

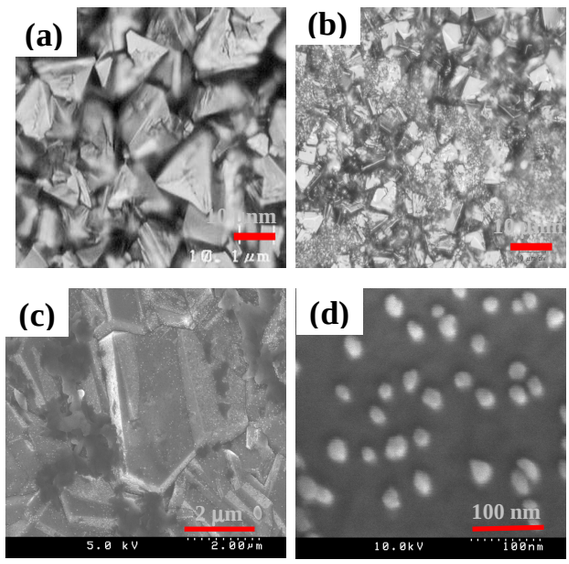

Figure 1. SEM images of (a) BDD and Au nanoparticles deposited BDD electrodes (b, c, and d) prepared from 0.5 M H_2SO_4 solution containing 1 mM Na[$AuCl_4$] via 300s of potential steps from 1.1V to 0.0V *vs.* Ag/AgCl.

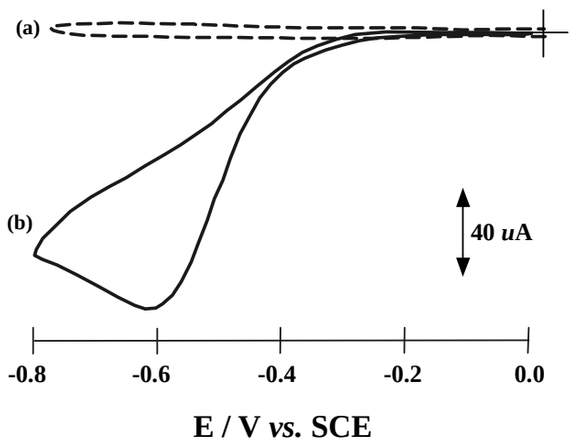

Figure 2. CVs obtained for Au nanoparticles deposited on BDD electrode in 0.1 M KOH solution (a) saturated with argon gas and (b) saturated with O_2. Scan rate: 100 mV/s.

The growth of Au was deposited on the boron doped diamond electrode in 0.5 M H_2SO_4 solution containing 1.0 mM Na[$AuCl_4$] by applying a potential step from 1.1 to 0.0 V *vs.* Ag/AgCl. The Au nanoparticles deposited BDD shows the high electrocatalysis for the oxygen reduction in 0.1 M KOH solution.

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