A Thesis for the Degree of Ph.D. in Engineering

Application of Boron Doped Diamond Electrodes to Electrochemical Gas Sensors

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Thesis Abstract

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Thesis Title

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Thesis Summary

In the last decades, electrochemical sensors have presented a promising way forward for gas sensor application, since they offer real time measurement, simplicity with a low limit of detection (LOD) and good selectivity. Therefore, research on high sensitivity, selectivity and highly durable materials for electrochemical gas sensors has become a hot issue. Boron doped diamond (BDD) electrodes have been applied as electrochemical sensors for various targets, such as free chlorine, oxalic acid and proteins, or as immunosensor, since they have attractive electrochemical properties such as wide potential window, low background current, chemical stability and mechanical durability compared to conventional electrodes. Although several works of BDD applied to gas sensors have been reported so far, they do not include detailed studies on the electrochemical behavior and the oxidation mechanisms. In this thesis, the use of BDD as the working electrode material for gas sensors without any mediator or modification is proposed, which is simple, low cost, highly durable and environmentally friendly.

Chapter 1 describes the background and purpose of this research.

Chapter 2 describes an oxidation reaction of dissolved hydrogen sulfide (H_2S) in aqueous solution using BDD electrodes. In order to study the oxidation behavior, the effects of pH and the scan rate were investigated. No sulfur fouling was detected on the BDD surface by X-ray photoelectron spectroscopy. A linear calibration curve was observed for the detection of H_2S. Moreover, a comparison of the analytical performance with sensors using glassy carbon and platinum electrodes is shown.

Chapter 3 describes the electrochemical oxidation reaction of nitrogen dioxide (NO_2) in aqueous solution using BDD electrodes. The pH and scan rate dependences were investigated to study the oxidation mechanism. In addition, the analytical performance was compared with that using glassy carbon, platinum and stainless steel as the working electrode.

Chapter 4 describes the electrochemical reduction behavior of oxygen (O_2) in blood using BDD electrodes. The scan rate dependence was investigated to study the reduction reaction mechanism. A linear calibration curve was observed, and the analytical performance was better than in the case of using glassy carbon or platinum electrodes as the working electrode. In addition, an application to bovine blood was performed. The O_2 concentration in the blood measured with the BDD electrodes was compared to that measured using the OxyLite Pro^{TM} fiber-optic oxygen sensor device.

Chapter 5 summarizes the results of this thesis and presents conclusions with future perspectives.