

論文 / 著書情報  
Article / Book Information

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| 題目(和文)            | 多孔質固体酸化酸素極における電気化学的挙動に関する研究 -活性サイト分布と酸素イオン輸送-   |
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| 著者(和文)            | ChanthanumatapornMerika   |
| Author(English)   | Merika Chanthanumataporn  |
| 出典(和文)            | 学位:博士(工学),<br>学位授与機関:東京工業大学,<br>報告番号:甲第11305号,<br>授与年月日:2019年9月20日,<br>学位の種別:課程博士,<br>審査員:花村 克悟,平井 秀一郎,伏信 一慶,森 伸介,笹部 崇  |
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| 種別(和文)            | 論文要旨  |
| Type(English)     | Summary   |

(博士課程)  
Doctoral Program

## 論文要旨

THESIS SUMMARY

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|--|--------------------------|----------|---|--------------------------|---------------|
| 系・コース：<br>Department of, Graduate major in | 機械<br>エネルギー              | 系<br>コース | 申請学位 (専攻分野)：<br>Academic Degree Requested | 博士<br>Doctor of          | (Engineering) |
| 学生氏名：<br>Student's Name                    | Merika Chanthanumataporn |          | 指導教員 (主)：<br>Academic Supervisor(main)    | Prof. Katsunori Hanamura |               |
|  |                          |          | 指導教員 (副)：<br>Academic Supervisor(sub)     |                          |               |

要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words )

Solid oxide cells (SOCs) are attractive electrochemical energy conversion devices that can potentially provide sustainable future energy economy, which would be heavily reliant on intermittent renewable energy, by operating reversibly in solid oxide electrolysis cell (SOEC) and solid oxide fuel cell (SOFC) modes. Electrical energy and chemical energy of fuel can be reversibly converted in the SOEC and SOFC manners through series of electrochemical reactions occurred at electrodes of SOC. The performance of the electrode is thus of fundamental importance to improve overall performance of SOC. In this thesis, we examine a way to instantly enhance catalytic properties of electrodes and investigate the electrochemical behaviour of porous SOC cathodes, where significant reduction reactions occur at the double- and/or triple -phase boundary inside their complex microstructures, through methods of electrical reduction and oxygen-18 labelling. Advance in technique as well as precise understanding of electrochemical behaviour of the electrodes are one of the key issues required to develop and design electrode structures that are capable of delivering high performance and stability while ensuring cost- and time-efficient manufacture. The key findings of this thesis are summarized as follows:

**Chapter 2** (*Electrical reduction for in situ preparing perovskite electrodes with exsolved nanoparticles*) examines the appeal of potential reduction for preparation of high performance SOC electrodes decorated with *in-situ* exsolved nanoparticles under carbon dioxide electrolysis condition. The impedance spectra of single cells measured before and after electrochemical poling at varying voltages showed that the onset of exsolution process occurred at 2 V of potential reduction. Characterizations of resulting exsolved nanoparticles and electrochemical performances of the cells based on the prepared electrodes are also analysed and presented. The desirable electrochemical performance in both electrolysis and fuel cell of the cells with the reduced electrode suggested that the electrical reduction could be potentially useful for accelerating exsolution of active nanoparticles and instantly producing high performance SOFC anodes and SOEC cathodes.

**Chapter 3** (*Visualization of oxygen incorporation in porous mixed-conducting cathode I: Effects of applied current density*) describes important characteristics of oxygen incorporation for the cathodic reduction reaction at a porous mixed-conducting LSC cathode through

visualization using a technique of oxygen isotope ( $^{18}\text{O}$ ) labelling combining with rapid cooling. Correlations between oxygen incorporation in the LSC cathode and applied current density, including associated transfer phenomena of oxygen incorporated into the GDC interlayer and the YSZ electrolyte are presented and discussed. The obtained  $^{18}\text{O}$  distribution images and concentration profiles under applied current densities clearly reflect extension of active reaction zone over surface area of LSC, as well as distribution of oxygen chemical potential in the porous LSC cathode, which strongly depends on an applied current density. The present results provide the first experimental evidence of oxygen chemical potential distribution in the porous mixed-conducting cathode under realistic operating conditions.

**Chapter 4** (*Visualization of oxygen incorporation in porous mixed-conducting cathode II: Effects of operating temperature*) explores and describes different characteristics of the oxygen incorporation reaction and the electrochemical reaction site distribution in the porous cathode at low operating temperature of 500 °C. The uneven distribution of incorporated  $^{18}\text{O}$  concentration indicates the inhomogeneous distribution of the electrode reaction and the existence of localized high resistance area for oxygen incorporation and transport inside the electrode at this temperature (500 °C). The considerably high concentration of incorporated  $^{18}\text{O}$  observed inside the GDC interlayer indicates a significant role of GDC for the electrode reaction at low operating temperature. The present method of performing isotope exchange and electrochemical experiment at low operating temperature (close to an electricity generation limit of a cell) was found to be useful for identifying a local high resistance area in a porous microstructure of electrodes.

**Chapter 5** (*Carbon dioxide electrolysis in solid oxide electrolysis cell: Active site visualization in Ni-YSZ cathode*) presents an overview and brief discussion of phenomenon discovered from applying the technique of  $^{18}\text{O}$  labelling coupled with subsequent quenching to carbon dioxide electrolysis experiment for the first time. The inhomogeneous  $C(^{18}\text{O})$  distribution was observed near the interface between the Ni-based composite cathode and the electrolyte, indicating the non-uniform flux of oxide ion incorporated from the interface into the electrolyte due to the reduction of the YSZ electrolyte. At high voltage operating condition, the electrolyte made of YSZ was reduced accompanied by some void formation inside the electrolyte around the interface between the cathode and the electrolyte, resulting in a resistance for the oxide ion transport into the electrolyte.

備考：論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note：Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1 copy of 800 Words (English).

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