

MERIT Corporate Internship Report

MERIT 6th member

Department of Chemical System Engineering D1

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Outline

- Institute: **Nippon Shokubai Co., Ltd. Research Center** (in Himeji Plant)
- Period: 2018/11/1~12/21
- Theme: Development of Intermediate-temperature electrochemical cells using proton-conducting electrolytes

Activities

I was engaged in the development of solid oxide electrochemical cells, especially with proton-conducting electrolytes. The main topics which I worked on were;

- Analysis of AC impedance data for the detailed evaluation of the cell properties
- Investigation of electrode fabrication conditions for the electrode structure optimization
- Examination and synthesis of new electrode materials

AC impedance measurement is one of the techniques to evaluate the performance of electrochemical cells. In the measurement, impedance data are recorded with sweeping the frequency of AC signal applied to the cell. Obtained impedance data contain information about various electrochemical or physicochemical processes inside the cell, such as charge transfer reactions and gas diffusion in the electrodes. However, the interpretation of the impedance data is difficult and complicated, so they have not been fully utilized in the company. This time, I measured the AC impedance with changing cell operation conditions (gas partial pressure, flow rate, temperature) systematically. By analyzing the results, frequency regions where the impedance was affected by the change of each parameter were figured out. The impedance data measured in a certain frequency range reflects the corresponding chemical process. Therefore, the information about the relationship between the frequency range and the chemical process will help to discuss the cell performance in detail.

To investigate the optimized electrode structure, fabrication procedures of electrodes were modified. Cross-sectional structures of the cells were observed by using SEM, and current-voltage characteristics were also measured. In addition, the abovementioned impedance analysis method was applied, and the contributions of electrodes were extracted to evaluate the effects of the electrode modification.

Suggestions of new electrode materials were made based on literature survey. I proposed a plan to modify the current electrode material. I also pointed out that certain materials with a different crystal structure from that of the present material can be used for the electrode. Then I tried to synthesize one of the materials and confirmed the formation of the desired crystal structure by XRD measurement.

At the end of the internship period, I reported my achievements to researchers in the company including the director of the Research Center. I also had opportunities to visit the manufacturing sites in the Himeji Plant and laboratories in the Suita Research Center.

Impressions

The theme of this internship was closely related to my research topic in master's course, so I could readily compare the research in the company with the research in academia and could learn differences between them.

It was characteristic of the company to set research topics by carefully considering the usefulness of the technology. The costs regarding the future practical implementation of the technology was more seriously discussed in the company than in the university.

Also, there was a difference in the scales of experiments. For instance, the amount of electrode slurry prepared at one time was about ten times larger in the company than in the UTokyo laboratory. In addition, some steps in the cell fabrication procedure were mechanized in the company, avoiding human error. These aspects can lead to the high reproducibility of experiments. Furthermore, the technical know-how about the cell fabrication was accumulated in Nippon Shokubai, which indicated that a large number of experimental trials were made in the company.

Safety is of the highest priority in any case. In the company, safety management was carried out more strictly than in the university. For example, the apparatus for cell evaluation was equipped with a safety device which can automatically shut down the apparatus when hydrogen leakage is detected. In my laboratory in UTokyo, gas sensors are used but the operation cannot be stopped automatically. One of the additional advantages of equipping the safety device is that unattended overnight experiments becomes permissible. I found out that safety precautions sometimes help to increase the efficiency of the experiments.

The experience in this internship made me to take an objective view of my own research in the university. Through the discussions with the researchers in Nippon Shokubai I rethought the various methods used in the university, and was able to find some points which should be improved. At the same time, my knowledge and skills acquired in UTokyo were sometimes very helpful in carrying out the internship. This fact brought me confidence.

Acknowledgements

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Finally, I express my gratitude to the MERIT program for motivating me to experience this fruitful internship.