CONCERT-Japan

Efficient Energy Storage and Distribution

"Development of Advanced and Innovative metal supported Cells using proton conducting ceramics to foster Hydrogen society Implementation"

DAICHI

INTERIM REPORT

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Electrochemical energy conversion from electricity to chemicals is a promising route to store the renewable energy to valuable chemical resources. We propose an innovative concept of metal supported cells using proton conducting ceramics (MS-PCC) as flexible electrochemical energy conversion devices, including fuel cell and steam electrolysis operation, working at moderate temperatures (400-600°C). Utilization of inexpensive porous metal substrates secures robustness of the cell and reduces material cost, and MS architecture could significantly improve the stability under thermal and red-ox cycling during operation. Challenge is to synthesize thin and dense PCC electrolyte layer on the non-shrinking porous metal support. Development of promising oxygen+steam electrode materials for PCC is also crucial to realize highly efficient devices. The international project DAICHI can facilitate the progress in MS-PCC development and reinforces the researchers network to exchange expertise and knowledge for future collaborations.

As promising candidate materials for oxygen+steam PCC electrode, $Ba(Gd,La)Co_2O_{6-\delta}$ and $Ba_{0.5}La_{0.5}CoO_{3-\delta}$ have been studied for their thermodynamic stability and electrode activity. The reaction mechanisms were clarified by using patterned thin film model electrodes, from which the designs for high performance electrodes were proposed.

A new improved composition of the electrolyte, Ba0.85Sr0.15Zr0.7Ce0.1Y0.2O3- , with smaller thermal expansion mismatch, was developed by UiO, by adding Sr and Ce dopants into Ba(Zr,Y)O3 (BZY), which was achieved in collaboration with the national project AH2A supported by the Norwegian Research Council.

Elastic properties of BZY electrolytes in the intermediate temperature range have been evaluated based on the modified ultrasonic method, which will be used for more precise stress conditions evaluation.

It was demonstrated that a few μm-thick dense electrolyte layer with reasonable ohmic resistance were successfuly synthesized on the porous metal supports by pulsed laser deposition (PLD). The key to facilitate dense and thin electrolyte layer is gradual pore size reduction from several tens of μm in the porous metal support to nm range in the intermediate layer by engineering wet chemical process. All the processing were made under non-oxidizing conditions of the metal support.

From this project, 15 presentations, including 3 invited (Prof.Amezawa) and 2 keynote talks (Prof. Amezawa, Prof. Matsumoto), were given in international conferences and workshops, one of which poster presented by the group of Prof. Amezawa on patterned thin film model electrodes was given a Best Student Poster Award at PACRIM13 (2019, Okinawa, Japan). Two papers on MS-PCC half cell development and one paper on mechanical property investigation of the component materials have been published in ECS Transactions (Vol. 91, issue 1, Sep. 2019).

Two PCC workshops have been organized in Oslo, Norway (Oct.2018) and Sendai, Japan (Sep.2019), not only for scientific discussion among experts of PCC research, but also to involve young scientists and to strengthen the network of PCC community.