RGC Ref.: **X-PolyU/501/14**
(please insert ref. above)

The Research Grants Council of Hong Kong
SFC/RGC Joint Research Scheme
Completion Report

(Please attach a copy of the completion report submitted to the Scottish Funding Council by the Scottish researcher)

Part A: The Project and Investigator(s)

1. Project Title

Development of Nanostructured Solid Oxide Cell for Steam-carbon Dioxide Co-electrolysis

2. Investigator(s) and Academic Department/Units Involved

	Hong Kong Team	Scottish Team
Name of Principal Investigator *(with title)*	Prof. Meng NI	Prof. John T.S. Irvine
Post	Professor	Professor
Unit / Department / Institution	Department of Building and Real Estate, The Hong Kong Polytechnic University	School of Chemistry, University of St Andrews
Contact Information	bsmengni@polyu.edu.hk; Tel: 27664152	jtsi@st-andrews.ac.uk Tel: 01334 463817
Co-investigator(s) *(with title and Institution)*		

3. Project Duration

	Original	Revised	Date of RGC/ Institution Approval *(must be quoted*)
Project Start date	1 December 2014		
Project Completion date	30 November 2015		
Duration *(in month)*	12		
Deadline for Submission of Completion Report	30 November 2016		

Part B: The Completion Report

5. Project Objectives

5.1 Objectives as per original application

1. To fabricate nanostructured SOEC for natural gas-assisted H_2O and CO_2 co-electrolysis using the infiltration method.
2. To characterize and test the SOEC by electron microscopy and electrochemical techniques.
3. To develop a comprehensive 3D multi-physics and multi-scale model for simulating the coupled heterogeneous and elementary reaction, gas transport, electron/ion transport, and heat transfer in the SOEC.
4. To perform parametric simulation to understand the physical/chemical processes in SOEC.

5.2 Revised Objectives

Date of approval from the RGC: _____

Reasons for the change: _____

_____

1.
2.
3. ....

6. Research Outcome

Major findings and research outcome
(maximum 1 page; please make reference to Part C where necessary)

It is found that fuel-assisting is effective in reducing the electrical energy consumption for H_2O/CO_2 co-electrolysis by SOEC. At a high operating temperature and low current density, the CH_4-assisted SOEC can produce syngas and electrical power simultaneously. In addition, different from conventional SOEC whose performance weakly depends on the anode gas flow rate, the CH_4-assisted SOFEC performance is sensitive to the anode gas flow rate (i.e. peak current density is achieved at an anode flow rate of 70 SCCM at 1073 K).

Based on the collaborative research, 1 journal paper has been published in *International Journal of Hydrogen Energy*. Another review paper has been prepared and is in revision for submission.

Potential for further development of the research and the proposed course of action *(maximum half a page)*

Co-electrolysis of H_2O/CO_2 by solid oxide electrolyzer cell provide an interesting option for energy storage. Through the project the PI in HK has established collaboration with the PI in Scotland on this interesting topic. Subsequent collaboration will be explored in more detailed studies on co-electrolysis processes on the catalyst surfaces through comprehensive experimental measurements and atomistic modeling.

7. The Layman's Summary

(describe <u>in layman's language</u> the nature, significance and value of the research project, in no more than 200 words)

The performance of methane-assisted SOEC for H_2O/CO_2 co-electrolysis was evaluated both experimentally by the Scotland team and numerically by the HK team, respectively. It is found that the proposed system is feasible to produce syngas (CO and H_2 mixture) with greatly reduced electrical power consumption. When the operating temperature is sufficiently high (1123K) and the current density is low, the SOEC could even generate electrical power and syngas simultaneously. Different from conventional SOEC whose performance weakly depends on the anode gas flow rate, the CH_4-assisted SOFEC performance is sensitive to the anode gas flow rate. The research findings offer insightful information on the operation behavior of fuel-assisted SOECs and contributed significantly to the SOEC development, which in turn contributed to energy storage and conversion. Mutual visits have been conducted which facilitates academic exchange and collaboration (Prof. Irvine visited HK in October 2015 and Prof. Ni visited Scotland in April 2016). Through the project, the collaboration between the HK team and Scotland team has been strengthened.

<u>Part C: Research Output</u>

8. Peer-reviewed journal publication(s) arising <u>directly</u> from this research project

(Please attach a copy of each publication and/or the letter of acceptance if not yet submitted in the previous progress report(s). All listed publications must acknowledge RGC's funding support by quoting the specific grant reference.))

The Latest Status of Publications	Author(s)	Title and	Submitted	Attached	Acknowledge	Accessible

Year of publication	Year of Acceptance *(For paper accepted but not yet published)*	Under Review	Under Preparation *(optional)*	***(bold** the authors belonging to the project teams and denote the corresponding author with an asterisk*)*	Journal/ Book *(with the volume, pages and other necessary publishing details specified)*	to RGC *(indicate the year ending of the relevant progress report)*	to this report *(Yes or No)*	d the support of this Joint Research Scheme *(Yes or No)*	from the institutional repository *(Yes or No)*
2016	2016			Haoran Xu, Bin Chen, **John Irvine**, **Meng NI***	International Journal of Hydrogen Energy		Yes	Yes	Yes
			In revision, to be submitted	Shijing Wang, **Meng Ni**, Guoxiong Wang, Xinhe Bao, **John T.S. Irvine*** , Kui Xie	High-Temperature Solid Oxide Electrolysers with Oxide-ion Conductors: Recent Advances, Challenges and Possibilities		No	Yes	Not yet, not submitted yet

9. Recognized international conference(s) in which paper(s) related to this research project was/were delivered *(Please attach a copy of each delivered paper. All listed papers must acknowledge RGC's funding support by quoting the specific grant reference.)*

Month/Year/ Place	Title	Conference Name	Submitted to RGC *(indicate the year ending of the relevant progress report)*	Attached to this report *(Yes or No)*	Acknowledged the support of this Joint Research Scheme *(Yes or No)*	Accessible from the institutional repository *(Yes or No)*

10. Student(s) trained *(Please attach a copy of the title page of the thesis.)*

Name	Degree registered for	Date of registration	Date of thesis submission/ graduation
Haoran XU	PhD	August 2014 (this project is part of Mr. XU's PhD work)	Not yet.
Keqing ZHENG	PhD	November 2011	February 2016

11. Other impact *(e.g. award of patents or prizes, collaboration with other research institutions, technology transfer, etc.)*