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出國報告（出國類別：其他）

赴日本沖繩參加 SOFC XIII 研討會出國報告

服務機關：核能研究所
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派赴國家：日本
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報告日期：102 年 11 月 19 日

摘　要

第十三屆國際固態氧化物燃料電池研討會(13th International Symposium on Solid Oxide Fuel Cells(SOFC-XIII))於 2013 年 10 月 6 ~11 日在日本沖繩縣舉行，會議地點為位於宜野灣市的沖繩會議中心(Okinawa Convention Center)，本次會議主辦單位為日本ＳＯＦＣ協會(The SOFC Society of Japan)與美國電化學學會(The Electrochemical Society) ，該會議為每兩年舉辦一次之大型 SOFC 論壇，會議及展示之主題涵蓋：1. SOFC 電池堆及系統之設計、效能、與耐久性(Stacks& Systems Design, Performance& Durability)、2. 電池片之設計、製程、效能、與耐久性 (Cell Design, Processing, Performance& Durability) 、3.電解質材料、製程、與效能 (Electrolyte Materials, Processing &Performance) 、4. 陽極材料、製程、與效能(Anode Materials, Processing &Performance) 、5. 陰極材料、製程、與效能(Cathode Materials, Processing &Performance) 、6. 連接與封裝(Interconnection & Sealing) 、7. 建模與模擬(Modeling &Simulation) 、8.另類燃料運轉(Operation on Alternative Fuels) 、9. 固態氧化物電解電池(Solid Oxide Electrolysis)等議題。此次 SOFC-XIII 研討會參與學者專家超過 500 人，計發表 373 篇論文，其中包括口頭論文發表 143 篇，海報論文發表 230 篇。

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一、目　的

此次行程主要為參加兩年一度的「第十三屆國際固態氧化物燃料電池研討會」(The 13th International Symposium on Solid Oxide Fuel Cells (SOFC-XIII))，本屆會議於2013年10月6~11日於日本沖繩(Okinawa)宜野灣市沖繩會議中心舉辦。此論壇於24年前(1989)於美國舉辦第一屆，後續於歐洲、北美、日本等三區輪流隔年舉辦，已成為國際SOFC領域最重要的資訊交流平台之一。

配合國家能源科技策略發展，核能研究所自民國九十二年投入SOFC 之研發工作，其目的即在於建構完整的SOFC燃料電池技術能量，希冀國內能建立新興能源產業，並藉由此一高效率能源轉換系統，能有助於能源安全、經濟發展、及環境保護等標的之達成。目前，本所在SOFC專業領域的發展上(包含：電池單元、電池堆及發電系統等相關核心技術)，已陸續獲得具體研發成效，並於國際知名期刊及重要國際會議發表，已成為國際間SOFC發展的重要研究機構之一。有鑑於本項研討會，國際各國主要研究機構之學者、專家及國際知名廠家皆積極參與，藉由參與此一重要國際SOFC會議及論文發表，有助於汲取國際研發經驗、與國際發展現況及未來趨勢接軌、強化與國際之人脈關係、彰顯本所之研發成效及聲譽及提昇國際能見度，並利於後續計畫之發展及規劃作業。

二、過　程

(一)行前準備

本所在SOFC電池單元、電池堆及發電系統等的技術開發上，皆已有良好的成效。於本次會議上，以SOFC之動態模擬及控制設計為題投稿，以拓展研發領域的面向。論文題目：“Dynamic Modeling and Control Design for a Planar Solid Oxide Fuel Cell”，論文接受函如附錄一，全文如附錄二，並收錄於ECS Transactions Vol. 57中。

此次前往日本沖繩參與研討會期間，適逢菲特(Fitow)颱風過境沖繩地區，大會自10月1日起即公告可能之因應事項，並提醒與會者注意(附錄三)。由於該颱風之七級風暴風半徑達250公里，並逐漸轉向西北西方向前進，中央氣象局於10月5日14:30發布陸上颱風警報，並警告10月6日暴風圈將影響臺灣北部及東北部海面。至10月5日下午那霸機場關閉，航空公司取消桃園往那霸的班機。同時，另一個颱風(丹娜絲, Danas)正形成中(圖1)，預測將於10月7日直接侵襲沖繩。

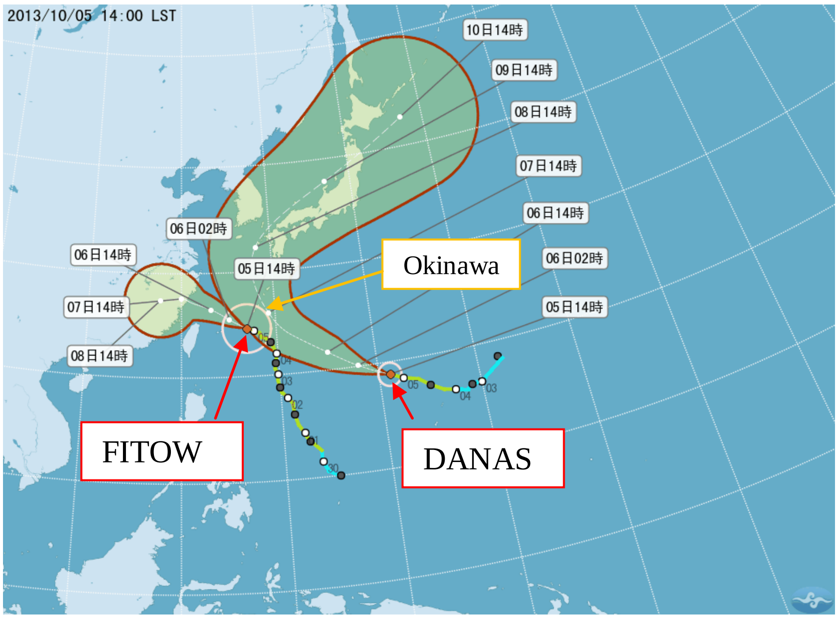

圖1、10/5中央氣象局颱風路徑潛勢預測圖

(二)交通行程

所幸10月6日班機正常起飛，自桃園機場搭乘華航客機直飛沖繩那霸機場，航程約為1小時20分鐘，再搭乘單軌電車至旅館Check in，並至指定地點完成報到程序及領取會議資料。

會議地點位於宜野灣市之沖繩會議中心(Okinawa Convention Center)，該會議中心位於那霸市(Naha)區北邊約11km(圖2)，大會於會議期間備有接駁車供與會者搭乘，乘車時間約為25分鐘。

圖2、沖繩會議中心位置圖

本次大會地點琉球與台灣之間的航程相當近，故邀請前GE公司首席科學家Dr. Nguyen Q. Minh於研討會後順道來台參訪；Dr. Minh現為加州大學聖地牙哥分校能源中心副主任。於本所投入SOFC研發初期，即邀請Dr. Minh參與本所舉辦的幾次台灣SOFC研討會；李員在多次的國際場合上與其互動良好，於技術領域之開發及發展趨勢多所討論。Dr. Minh參與會議及來台參訪的行程，受到颱風因素的干擾，也做了些調整。過程中幸賴本所劉建國博士的多方協助，幾經波折，安排於10 月12 日與本所同仁自那霸機場搭乘同一華航班機來台。

(三)大會議程

大會報到地點位於那霸市中心之Loisir Hotel Naha，10月6日當天大會即宣布，受到丹娜絲(Danas)颱風來襲影響，大會取消10月7日(一)當天議程所有活動，包含口頭報告、海報展示、及展覽活動，該日之所有活動挪移、分散至10月8日(二) 至10月11日(五)進行。由於颱風導致許多班機延誤，部分與會者無法於指定時段完成報到程序，開議期間大會於會議中心另設有報到櫃台(圖3)。

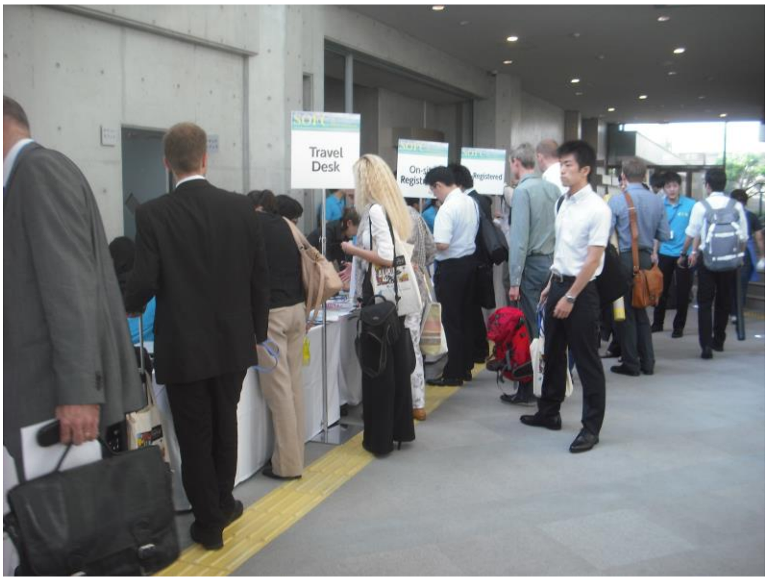

圖3、沖繩會議中心報到區

10月8日早上大會公布新的議程，主要為配合部分簡報者的時間進行小幅修正，原訂之議程(0821)、修訂後之議程(1006)、及再修訂議程(1007)，參見附錄四。本屆會議主席由美國太平洋西北國家實驗室(Pacific Northwest National Laboratory, PNNL)Dr. Subhash C. Singhal 以及日本京都大學(Kyoto University)Prof. Koichi Eguchi 共同擔任，此外各分組議程並邀請兩位協同主席。10 月8 日上午09:00 正式進行大會議程，由大會主席Dr. Subhash報告國際SOFC最新之技術進展與產業劃推廣情況，隨即進入Plenary Session，進行日本與歐盟的發展現況報告。其中日本的SOFC發展狀況由NEDO 主任工程師Dr. Kenji Horiuchi說明，Dr. Horiuchi於淨煤主軸計畫籌辦的「2012 Taiwan Symposium on Carbon Dioxide Capture, Storage and Utilization」會議，受邀參加「High-Efficiency Electricity Generation System」技術議題研討會，對於我國在SOFC的發展狀況也有相當程度的了解。原訂由DOE NETL(National Energy Technology Laboratory) Dr. S. D. Vora報告美國SECA(Solid State Energy Conversion Alliance)發展狀況，由於美國聯邦政府關閉因素，Dr. Vora不克前來，改由Dr. Subhash簡介國際SOFC產業的發展狀況。於10月8日10:40開始分組報告，分別於劇院廳(圖4)、Room A、與Room B同時進行首日之SOFC Stacks & Systems、Anode、Electrolyte/ Thin Film、Metallic Interconnect Coatings、Sealing、及New Application等分組口頭報告議程，10月9日09:00~13:00別進行Cathode、Processing、New Application、及Modeling and Simulation之分組口頭報告，並於該日晚間舉行晚宴，計有400人參加。

圖4、口頭論文發表之劇院廳

10 月10 日09:00~16:30 分別進行SOFC Stacks & Systems、Metal Supported Cells、Durability and Reliability、及Cathode之分組口頭報告；10 月11 日09:00~12:00 進行Electrolysis與Modeling and Simulation之分組口頭報告及閉幕致詞。每位口頭論文發表者之報告時間均為20分鐘。除了口頭報告議程外，在週二與週四晚間時段則安排了兩場海報展示場次(圖5)，讓

與會者能有充裕的時間就技術議題進行深入討論及意見交流。在海報展示館旁並設有展示區(圖6)，此次活動約有24家廠商進行參展。總計本屆SOFC 研討會參與人數約500 人，口頭論文發表143篇，海報論文發表230篇。

圖5、海報展示區

圖6、廠商展示區

會議期間，由於地緣關係，參展者多數為日本廠商，參展者主要為零組件而無整體實體展示者。爰就相關資訊產品之發展進程與推廣現況，簡要摘要如下：

1. 在分散式電源部分，Bloom Energy目前致力於進行該公司ES-5000, ES-5400, ES-5700系列產品之測試，並朝向能以Biogas為燃料達到電效率50%之目標持續

邁進，該等設備主要為供應大型企業體使用，圖7 為Bloom Energy (BE)在NASA及美國聯邦銀行現場測試情形，該等設備可與既有電網併聯或進行可單獨運轉，100kW級ES-5000售價約700~800k美元。目前美國數十家企業體已採用BE的發電系統做為基載；2013年7月日本第三大電信業者SoftBank公司與Bloom Energy公司各出資50%，以引入百kW級的SOFC發電系統，搶攻日本能源市場。2013年11月25日，BE及SoftBank公司宣布，BE第一套國際合作的200kW發電系統成功安裝在位於福岡(Fukuoka) SoftBank 公司的M-Tower 上。

2. 在APU應用方面，Delphi公司近年來致力於第四代ASC系列的小型發電系統，該系統可同時輸出AC110與DC12V；在燃料方面，天然氣、汽油、生質柴油、柴油、及丙烷都可使用，5kW系統發電效率約為50%，圖8為其第四代產品，由其測試數據顯示，當運轉電壓為0.7V時，功率密度約為400mW/cm^2，長時運轉之Degradation rate約為5%/3000hr，在Thermal cycling test方面，歷經60次Thermal cycling (750~100^{o}C)，Degradation rate略小於為5%。目前Delphi與Volvo公司進行合作進行大型卡車測試，可提供長時間之車內輔助電力使用，而不須引擎怠速耗油。

3. 在淨煤主軸議題上，Versa Power與FuelCell Energy(FCE)參與DOE的FE Program，進行以煤氣化合成氣(Coal Syngas)為燃料之SOFC-GT混合系統開發，逐步進行30kW、60kW、250kW模組建置，圖9為Versa Power之60kW模組，該模組由四個電池堆所組成，每個電池堆由96個電池片所組成，最終將完成以MW級IGFC系統概念式驗證為目標。FCE已於2012年12月完全併購Versa Power。此外，在SECA計畫下，Delphi與UTRC (United Technologies Research Center)及Battelle進行合作，致力於推動SOFC-ST及SOFC-GT-ST的50kW_{el}實驗設施，做為後續建立數百MW以上IGFC（Integrated Gasification Fuel Cell）電廠之目標而努力。美國的煤礦蘊藏量豐富，故規劃以煤氣化做為未來能源發展的重點項目，將IGFC集中型發電廠技術開發列為發展的主力；再者美國頁岩氣的蘊藏量相當豐富，而由於近年來頁岩氣開採技術的重大進展，美國本土天然氣價格大幅下降，美國能源部(Department of Energy, DOE)乃就NGFC (Natural Gas Fuel Cell)電廠進行評估；整體而言，IGFC及NGFC的設計概念相近，NGFC與IGFC設計的主要差異為NGFC需要高效能的重組氣，IGFC則需要Coal Gasifier將煤氣化。設立NGFC發電系統所建立的相關技術，大部分都可直接運用在IGFC發電系統上。目前，美國國內工業團隊已完成IGFC的整體概念設計，朝向實體建置方向邁進，DOE規劃在2013/2014年完成30 kW模組的建置，2015~2017完成250 kW~1MW模組的建置，預定在2020年建立MW級的示範展示系統，其具體內容包括：標準化的系統設計、燃料供應系統、空氣環路系統、熱回收系統等等。

圖7、BE在NASA及美國聯邦銀行之現場測試區

[Source: Bloom Energy, www.bloomenergy.com]

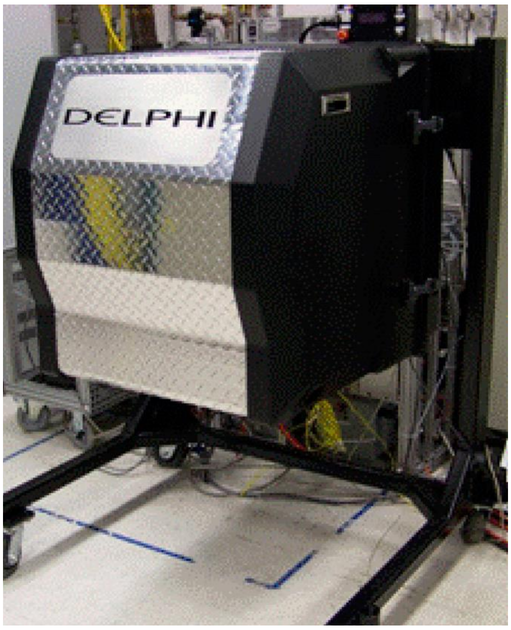

圖8、Delphi第四代APU

[Source:Delphi, www.delphi.com]

圖9、Versa Power之60kW模組

[Source: Proceedings of SECA Workshop 2012]

4. 在電池片發展方面，Elcogen開發電解質層2~4μm的陽極支撐型電池單元，可在600-700℃的操作條件，具有優異的電池效能，同時預估其壽命長達20,000小時以上，由於其材料精簡，其製作及材料成本可以有效降低，可使電池片及電池堆價格顯著降低，有利於其市場之拓展。其在電池堆設計上，儘量使得陰陽兩極之流道壓損降低，以利於陽極氣體回收與燃料使用率提升，圖10為Elcogen之1kW電池堆，圖11為Elcogen之各型式電池片，最大尺寸為20x20 cm^2。

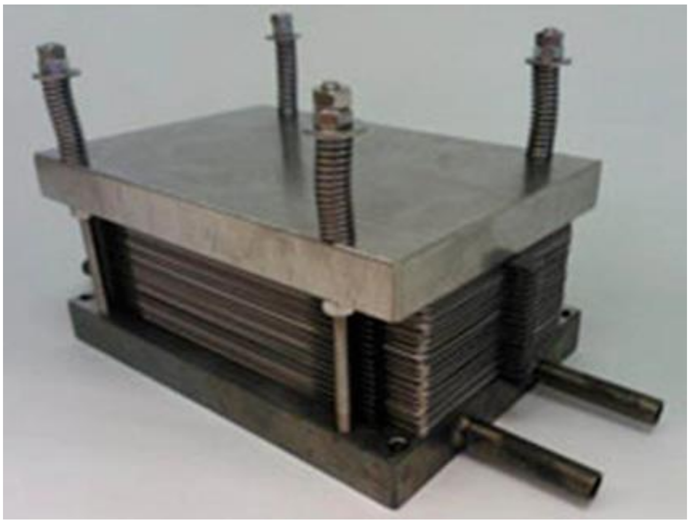

圖10、Elcogen之1kW電池堆
[Source: Elcogen, www.elcogen.com]

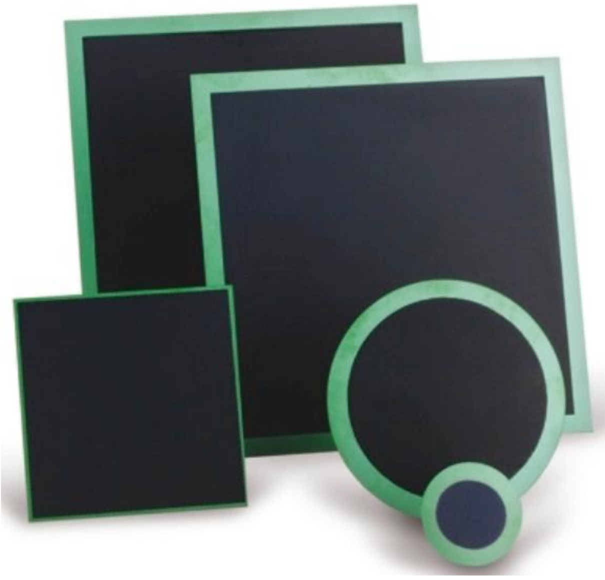

圖11、Elcogen之電池片
[Source: Elcogen, www.elcogen.com]

5. 在CHP發展方面，Hexis近年來致力於發展10kW以下之CHP系統，該電池單元之特徵為採用圓形電池片(圖12)，燃料由電池片中心進入後朝徑向流出，空氣則由外側四個通道進入後導引至電池堆外部，並與燃料進行燃燒，屬開放式設計，最新產品Galileo 1000N規格顯示輸出之電熱比約為1:2，整體熱電合併效率為95%(LHV)；著眼於其高熱效率，德國熱水器製造大廠費斯曼公司於2012年10月收購Hexis公司50%股權，以拓展其熱水器及衍生之能源業務。在日本，Kyocera推出操作在700-750℃的CHP系統，其電效率為46.5%，熱電合併效率為90%(LHV)，使用天然氣為燃料，該產品由Osaka gas以ENE-Farm品牌進行銷售，相關規格請參閱表一。

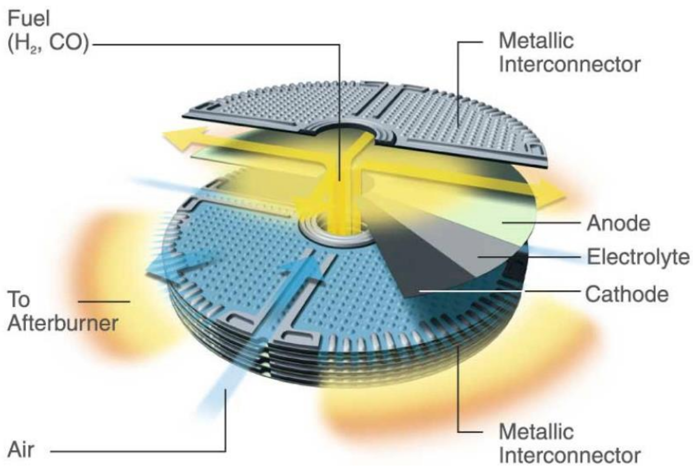

圖12、Hexis圓形電池堆示意圖

[Source: Hexis, www.fuelcellmarket.com]

表 1、 2012 S-Type ENE-FARM 規格表

ENE-FARM RESIDENTIAL FUEL CELL CHP		
Selling date: April 27, 2012		
Basic Function	Rated power output	700 W
	Power output range	0 ~ 700 W
	Power generation efficiency	46.5% (LHV)
	Overall efficiency	90% (LHV)
	Operation temperature range	-5 ~ 40 °C
	Start-up time	~ 130 min
	Operation time	24 hrs continuous
	Hot-water tank capacity	90 litres
	Hot-Water Temperature	~ 70 °C
	Installation	outdoor
	Voltage	100-200 V
Dimensions	Power Generating Unit	563 W × 900 H × 302 D (mm)
	Hot-Water Supply and Heating Unit using Exhausted Heat	740 W × 1,760 H × 310 D (mm)
Weight	Power Generating Unit	92 kg
	Hot-Water storage Unit	94kg (184 @ full capacity)
Installation Space		Approx. 1.9 m^2 (Approx. 1.6 m^2 with side exhaust gas cover)
Maintenance Service Period		10 years
Standard Price (incl. taxes and excl. installation cost)		¥ 2,751,000

***Table 1**. ENE-Farm Type S (SOFC-based) for residential fuel cell CHP specifications.*
[Source: Kyocera, Nippon Oil & Energy, www.global.kyocera.com]

三、心　得

(一)　由PNNL (Pacific Northwest National Laboratory) Dr. Subhash C. Singhal籌辦的國際會議SOFC研討會，每兩年一次輪流於北美、日本及歐洲舉行，大會篩選會議地點的重要考量包括：景觀、氣候、交通、住宿及費用等等。此次研討會地點選定在日本琉球，考量之初已將當地的氣候及颱風等因素納入，故將會議時間定在10月；依據過去的經驗，10月份侵襲日本的颱風數目為1.5，不過今年則高達6個；本次研討會一開始有兩個颱風侵襲，大會結束時，又有另一颱風侵襲，則在預料之外。據推測由於全球暖化，較高的海洋表面溫度，造成颱風形成的機率增加。由於颱風來襲，確實造成了些許不便，部分遠道者由於班機的延誤，不克參加本次大會。因應颱風侵襲，大會主席團機動地將議程做了幾次的調整，考量議題的完整性及報告者的時間調度，將每日的開會時間拉長，並將相關訊息公布於網站、會議地點、並立即email通知大會參與來賓，期使大會順利進行。以國內而言，每年5~10月，亦可能遭受颱風的侵襲；大會於遭遇兩個颱風侵襲時，所做的應變措施，值得國內未來辦理國際大型會議的借鏡。

(二)　依據大會統計，參加本次SOFC-XIII 會議人數超過500人，發表篇數為373篇(Oral:143, Poster:230)，為歷屆參與人數與發表篇數最多的一次(SOFC-XI及 SOFC-XII分別為 363篇及349篇)。而由於颱風侵襲、適逢美國聯邦政府關閉及部分人員未能及時取得日本簽證，計有6篇口頭報告及31篇海報展示未能於現場參與。本項國際會議於1989年第一次舉辦僅有數十人參加，發展成為此一領域最重要的國際會議之一，參與人數達數百人誠屬不易，其中會議主席Dr. Subhash長期經營居功厥偉；從第一屆到目前第十三屆，除Dr. Subhash外，美國Dr. Minh、日本的Prof. Yamaguchi和丹麥Prof. Mogensen，他們為本項會議的創始元老，分別來自產學研各界，每屆會議都親自參加，顯現本項會議的凝聚力及科研領域合作之無遠弗屆。Dr. Subhash於2011年自PNNL退休，持續活耀於國際SOFC舞台；Dr. Minh從GE的首席科學家退休，目前擔任美國加州大學聖地牙哥分校能源中心副主任；Prof. Yamaguchi和Prof. Mogensen則皆為學校的講座教授；從SOFC技術初見端倪即投入此領域之研發，迄今產業萌芽，他們均堅持SOFC技術開發的崗位，對於SOFC技術的持續不懈的堅持令人敬佩。

(三)　本所自2003年投入SOFC技術研發，於2005、2006及2009年舉辦台灣SOFC國際研討會，邀請國際SOFC領域的頂尖專家與會並提供建言，他們不論是仍在產學研各界或已退休均持續活躍於國際SOFC平台上。例如：Dr. Mark Williams 從NETL的Director退休後，目前為國際燃料電池的諮詢顧問；原德國尤利金(Julich)SOFC計畫主持人Dr. Robert Steinberger-Wilckens目前為英國伯明翰(Birmingham)大學化工系氫能及燃料電池研究中心主任。德國國家實驗室IKTS (Fraunhofer Institute for Ceramic Technologies and Systems)SOFC計畫主持人Dr. Mihails Kusnezoff目前負責籌辦明年1月底於美國佛羅里

達代托納比奇市(Daytona Beach)第38屆美國陶瓷協會辦理的第十一屆國際SOFC研討會(11th International Symposium on Solid Oxide Fuel Cells: Materials, Science and Technology, 2014)；以本所SOFC技術已有顯著成效，大會邀請本所為第十一屆SOFC研討會之共同協辦單位，並由李員擔任籌組代表，邀請國內研發團隊共襄盛舉參加明年初於佛州舉行的SOFC國際會議。李員目前並受邀為歐盟燃料電池論壇(European Fuel Cell Forum)的國際諮詢委員(International Board of Advisors)，與國際此領域的專家多所接觸，渠等對於台灣SOFC技術及產業近年的迅速發展多所肯定，並期待能有更進一步的合作。

(四) 參加SOFC國際會議人員，除SOFC領域資深人員外，另有來自研發團隊的中堅幹部、研發人員、學生及廠商等；就技術的長期發展，必須專注及持續挹注新血，才能維持技術的持續進步。依據觀察，代表各國研發團隊參加國際SOFC會議者，皆有其過人之處，假以時日，大致皆能嶄露頭角成為新的領導幹部。例如：與李員在國際會議有長期接觸的法國CEA (Commissariat à l'énergie atomique et aux énergies alternatives)Dr. Julie Mougin及日本AIST (National Institute of Advance Industrial Science and Technology)的田中洋平博士，兩人目前分別升任為Head of Hydrogen Technologies Laboratory及主任研究員，擔任主管職務。

(五) 國際在人才引進及培育的做法，亦有值得國內借鏡的地方。會議期間，有緣認識一些來自不同國家的科研人才，如：Drs. J. Druce、H. T. Lozano、K. D. Bagarinao、Xiufu Sun等等，他們分別來自歐洲、菲律賓、中國大陸，並獲聘於國際知名研究機構服務。例如：Dr. Druce從歐洲至日本九州大學國際研究中心(I^2CNER, International Institute for Carbon Neutral Energy Research)任職，從事hydrogen production 及觸媒開發工作，他表示九州大學提供3年優渥的合約，若執行成效顯著，則可依雙方的意願再做續約；由於研究機構提供穩定的中長期合約，故其可專注於研發工作並展現成效。國內在引進國際優秀專業人才的作為上，在研發領域縱深面向及期程的長度，首重防弊，在相關引進人才的作為上較無彈性，仍有待強化及改善的空間。

(六) 會議主席Dr. Subhash 於大會開幕式中說明目前國際SOFC的發展大致可概分為三個區塊，分別是(1)MW級的集中式發電，如Bloom Energy的百kW系統已成功地提供美國數十家企業體做為基載電源，目前其提供之電力已達75MW以上，並持續地做推展；(2) 1~100 kW級，特別是在1kW的CHP熱電合併系統商業化部分(Kyocera)及100kW的分散式電力部分(Westinghouse, Bloom Energy, Fuel Cell energy, Versa Power, LGFC)，其中LGFC並進行1MW 及發電系統概念設計；(3)1kW以下的可攜式應用。其認為SOFC的成本單價偏高仍為SOFC商品化的最大門檻。對於美國能源部在SECA計畫的投入上，過去幾年經費的額度迭有變動及降低的趨勢。不過，部分人士則持不同的看法，其認為美國能源部提供經費資源不限於SECA計畫，有幾種不同型式的管道及補助方式，例

如：透過DoD (Department of Defense)、國家實驗室及各項專題補助等；例如：對於技術源自NASA的BE公司提供聯邦及州政府資金補助等；再者美國在SOFC領域的專利佈局完整，頁岩氣及煤礦蘊藏量豐富，若SOFC技術產業化的趨勢明朗，美國不會無視於全球的產業市場，隨時可以加碼投入。

(七) Bloom Energy成立於2001年，自2006年~2009年分別進行5kW~25kW系統之現場測試，並累積相當之經驗，提供給企業體的發電系統從100 kW擴大200kW，並正朝向500 kW級邁進。經過過去數年的運轉實績，逐步取得美國及國際各界的肯定，已有約40個美國企業體採用其產品，並不斷有新增的客戶。其財務長宣稱，BE公司自2013年起開始獲利，且市場趨勢對其發展極為有利，除美國本土市場外，並積極爭取國際的能源市場。至於投資者已投入12億美元資金部分，只要其市場正常增長，應可逐步攤還。

(八) 自日本福島事件後，如何發展潔淨及安全能源以填補減核或電廠除役的電力短缺，為各國所面臨的重大課題。因應電力短缺，目前日本將家用型燃料電池CHP發電系統(ENE-FARM)列為發展重點，該系統可產生250~750W之電力，Panasonic、Toshiba、Tokyo Gas及長府是主要生產商，Tokyo gas宣稱該系統可減低37%的能源消耗，並減少49%的CO_2排放量。該設備初期售價350萬日元，政府補貼150萬，消費者實付200萬；其補助方式並依據技術的成熟度逐漸調整。日本結合系統製造商與天然氣供應商推行ENE-FARM之品牌/技術整合與政策補貼推廣策略，可供國內未來推廣家用市場參考。在SOFC技術方面，Kyocera與 Osaka Gas在2011年推出S-type的ENE-FARM，展現SOFC在家用系統推廣與應用的可行性，2012年推出之機型規格請參見附表一，該CHP之電力輸出範圍為0~700W，發電效率為46.5%，整體熱電合併效率為90%，由其規格顯現該系統之熱能管理相當良好。

(九) 英國Ceres Power公司成立於2001年，類似於日本的家用型CHP推廣模式，分別與British Gas, Calor Gas等天然氣公司進行合作，其主力為發展中低溫型kW級SOFC-CHP，系統採壁掛式，電池堆係採用金屬支撐型電池片(Metal-Supported Cell, MSC)，屬第三代的SOFC電池單元技術，操作溫度為500~600^{o}C，使用雷射焊及硬焊進行電池堆之封合。該公司宣稱其系統可進行快速啟動，可承受多次Thermal cycles而無明顯之劣化，其電池單元使用CGO (Cerium Gadolinium Oxide)做為電解質材料，以降低操作溫度。目前該公司正建置量產能量，已完成相關先導測試，其SOFC-CHP系統具有相當好的產業優勢。2013年7月該公司並與韓國最大熱水器製造商KD Navien簽訂商業及技術合作協定，以加速其產業拓展。

(十) 澳大利亞Ceramic Fuel Cells Limited (CFCL)於1992年成立，已成功開發2kW的BlueGen SOFC發電系統，發電系統效率最高可達60%。該公司積極拓展歐洲市場，已在德國海因森堡(Heinsberg)設置工廠，組裝電池堆及發電系統，每年可生產1000部。其首席主任工程師Dr. Karl Forger為了推展SOFC技術，風塵僕僕自澳大利亞移居德國。2012年9

月，該公司與中國大陸潮州三環達成融資協議，並委請三環集團代工生產陶瓷基板，提升其營運與量產能力。現階段在策略上並提供免費BlueGen給英國學校及企業試用，申請者必須與其簽定十年合約，透過電力回饋制度，出資者可獲得電價差價的利潤。2013年11月28日，CFCL與Synergy International OÜ (SI)簽約，將在2014及2015年提供1000套的2kW BlueGen SOFC發電系統，其總值超過2千萬歐元，拓展芬蘭、瑞典及挪威的能源市場。

(十一) SOFC燃料電池的特性之一為其可做為基載及儲能，為調節再生能源間歇性的利器；可逆式固態氧化物燃料電池(Reversible Solid Oxide Fuel Cell, RSOFC)可兼具固態氧化物電池(Solid Oxide Fuel Cell, SOFC)之發電模式與電解(Solid Oxide Electrolysis Cell, SOEC) 之產氫模式，達到在一系統中可分別進行電池放電與電解儲能兩種功能。就能源的最佳使用而言，從熱力學的角度，應盡量減少能源的轉換以降低耗損；惟在實務上，間歇性再生能源(如太陽能、風能等)的電力來源依時不同，尖峰及離峰的用電需求可能有相當大的落差，在分散式電力的架構下，SOFC在用電尖峰時刻可進行發電提供電力，而SOEC於離峰時刻可進行產氫儲能，同時也可進行補償作用，對於區域電力調節可提供彈性且經濟的架構，為目前國際發展的重點項目。據了解，積極發展再生能源及核能發達的國家，對於RSOFC的儲能效益都有極高的期待；前者如丹麥、英國、德國等用以填補再生能源的間歇性特性，後者如法國CEA及美國INL(Idaho National Laboratory)國家實驗室運用離峰時段的核能發電產氫，做為Peak Power Shaving之用，以調配電力之供需。

(十二) 我國能源98%需仰賴進口，近年來由於油氣價格持續飆漲，我國能源帳單已由原先2~4%飆升至14%GDP以上，並仍有持續上升的趨勢；國內進口油/氣與煤之每單位熱值價差日趨擴大，此一客觀條件，是我國在選擇能源選項時，必須慎重考量的。依據台灣碳封存地圖集(Atlas)，顯示台灣擁有200億噸二氧化碳地質封存潛能資源，雖然實際可用的封存潛能仍有待更進一步做地質調查評估，但已可確認國內具有碳封存的優質地質條件。以SOFC技術而言，其發展的優勢為其與現有的油氣管路基礎設施相容性高，現有的管線即可提供SOFC所需的燃料源；再者其所可使用的燃料源具多元性，包括：固態化石燃料(煤、木炭等)、液態化石燃料(柴油、甲醇等)、生質燃料及氨氣等。使用不同類型的燃料，其所需的前置處理也略有不同，其與SOFC相關之技術議題為：氣化技術、重組技術、與陽極材料改質等；避免碳沉積、高反應速率、高燃料使用效率、降低組件效能劣化速率，為技術開發的重點。若採用碳氫化合物做為燃料，其尾端所排出的高濃度二氧化碳，有利於後續的碳捕捉及封存作業。國內目前已具有生質燃料及煤炭的氣化技術、碳捕捉技術、並已建立從粉末至SOFC發電系統的技術能量，若能有效整合相關技術，投資並布局次世代及前瞻性的技術(如：煤氣化結合之複循環發電系統，Integrated Gasification Fuel Cell, IGFC)，將可為我國的能源產業創造新的局

勢，建構新的能源產業聚落。

(十三) 整體而言，國際已有多家廠家提出商品化的SOFC發電系統，SOFC技術發展朝向產業化的發展，其態勢相當明顯；國際先進國家挾其財務、資源、人力及專利佈局的優勢，藉由橫縱聯合，逐漸拓展其市場領域；國內若未能在未來數年內建立產業聚落及平台，則由於閉鎖效應(lock-in effect)，未來的市場拓展將受到明顯抑制。建議我國應放眼國際市場，透過國際合作，擴大我國在全球SOFC產業鏈上的占比。政府應盡速將SOFC納為產業扶植的重點項目，訂定並落實獎勵辦法及補助措施，支持國內業者與國際團隊技術之合作與開發，提供必要之租稅優惠及獎勵措施，促進國內技術產業升級及開拓國際通路。有效整合產官學研的量能及資源、擴大台灣在全球SOFC產業鏈之版圖、建構產業聚落、建立自有品牌、創造新興綠能產業，並利於國家節能減碳目標之達成!

四、建　議　事　項

(一) SOFC 技術屬環境友好的新能源技術，在各種化石能源轉換為電力的能源系統中，其具有最高能源轉換效率，也是調節再生能源間歇性的利器，屬於節能減碳新興萌芽之關鍵產業。建議政府將 SOFC 納為產業扶植的重點項目，訂定並落實獎勵辦法及補助措施，提供必要之租稅優惠及獎勵措施，促進國內技術產業升級及開拓國際通路，創造新興綠能產業，並利於國家節能減碳目標之達成。

(二) 國際 SOFC 技術經數十年的耕耘已趨成熟，進展至產業萌芽期；國內目前在 SOFC 技術研發及產業皆已有相當的基礎；建議整合產官學研資源，盡速建立產業聚落，以期在全球 SOFC 產業鏈上占有一席之地。

(三) 厚植國內 SOFC 長期競爭力，產業發展才能可長可久。國內研發團隊需持續經營、精進既有之技術，以維持創新性、進步性及競爭力，協助建構 SOFC 產業平台，並掌握關鍵核心技術，以建立自我品牌及維持產業的長期競爭力。

(四) 國內能源帳單飆漲，進口油/氣與煤之每單位熱值價差日趨擴大，以國內具有碳封存的優質地質條件，政府部門在做能源選項時，必須從多面向考量能源安全、環境保護及經濟成長。建議國內整合相關技術能量，投資並布局次世代及前瞻性的技術(如：煤氣化結合之複循環發電系統， IGFC)，為我國的能源產業創造新的局勢，建構新的能源產業聚落。

(五) 本次研討會期間雖有兩個颱風侵襲，大會主席團機動地將議程做了幾次的調整，並將相關訊息公布於網站、會議地點及立即 email 通知大會參與來賓，使得大會圓滿順利完成。以國內而言，每年 5~10 月，亦可能遭受颱風的侵襲；大會所做的應變措施，值得國內未來辦理國際大型會議的借鏡。

(六) 由美國 PNNL 國家實驗室 Dr. Subhash 所籌辦的 SOFC 國際研討會自 1989 年首度舉辦迄今已逾 24 年，為國際間最為重要之 SOFC 交流平台，下屆會議預定於 2015 年 7 月 26-31 日在英國蘇格蘭 Glasgow 的 Scottish Exhibition and Conference Centre 舉行。建議本所遴派適當人員代表參加，以掌握國際發展趨勢並與國際接軌、維持國際之人脈關係、發展國際合作、呈現研發成果及產業推展作業。

五、附　錄

附錄一：論文接受函

附錄二：論文全文

附錄三：大會因應颱風之因應公告

附錄四：大會議程

附錄五：發表論文之海報

余冬帝

寄件者:	sofc13led@ee.mech.tohoku.ac.jp
寄件日期:	2013年8月8日星期四 上午 6:33
收件者:	余冬帝
主旨:	ECS Transactions: Manuscript #SOFC-0077 Decision Letter

Dear Dr. Dung-Di Yu, Ph.D,

I am pleased to inform you that your manuscript, "Dynamic Modeling and Control Design For a Planar Solid Oxide Fuel Cell", has been reviewed and accepted for publication in the issue of "ECS Transactions" (ECST) from the 13th International Symposium on Solid Oxide Fuel Cells (SOFC-XIII). This issue is scheduled to be published in .

Authors whose papers will be published in ECST are also urged to submit their papers to an ECS journal. ECS recently began publishing three new peer-reviewed scientific journals, which join the Society's flagship Journal of The Electrochemical Society. This exciting news was covered in the spring 2012 issue of Interface magazine. Click here to read about it: http://www.electrochem.org/dl/interface/spr/spr12/spr12_p017_027.pdf. While the expectation is that six months is sufficient time to revise an ECST paper to meet the stricter standards of the journals, there is no deadline for submission. Submissions to the journals must be made using the online submission system. Click here for author instructions: http://ecsdl.org/site/ecs/manuscript_submissions.xhtml.
Thank you for contributing your work to ECST. If you have any questions or comments, please feel free to contact the ECST staff at ecst@electrochem.org.

Sincerely,

Tatsuya Kawada
Editor, 13th International Symposium on Solid Oxide Fuel Cells (SOFC-XIII) "ECS Transactions", Volume 57

Further Reviewer Comments (if any):

ECS transactions, 57 (1) 2705-2713 (2013)
10.1149/05701.2705ecst©The Electrochemical Society

Dynamic Modeling and Control Design for a Planar Solid Oxide Fuel Cell

D. D. Yu and R. Y. Lee

Physics Division, Institute of Nuclear Energy Research
1000, Wunhua Rd., Jiaan Village, Longtan township, Taoyuan county 32546, Taiwan

In this paper, a preliminary control law, on the basis of the model-based analysis, is adopted to allow convenient integrations into a comprehensive power tracking control algorithm. The dynamic modeling methodology is employed to assess the dynamic responses of a SOFC stack under startup and load change conditions. The multi-disciplinary integration method is used to evaluate the stack characteristics. Effects of gas flow rates and differential temperatures between inlet flows and stack are investigated. In accordance with the stack specifications, the results will serve as a practical perception to minimize the heat input and shorten the startup time. While under load change conditions, proper air excess ratios are essential to stabilize the stack temperature profiles and to avoid the occurrence of abrupt temperature gradients in the stack.

Introduction

A typical planar SOFC stack is composed of multiple cells in serial connections with end plates on both sides. Each cell consists of a Positive electrode – Electrolyte – Negative electrode (PEN) as a cermet, current collectors, interconnects, and sealant. While a stack delivers electric power, it also produces thermal heat. Drastic temperature fluctuations might occur during load change conditions, and it could yield substantial thermal stresses as a result of the mismatch of thermal expansion coefficients among components (1). From perspective of normal/abnormal operations, only a slight changes of processing parameters could lead to changes of residual stresses at several hundreds MPa in metallic and oxide thin films (2). For a prolonged operation, depending on the long term stability of the cell components (3) and its resistance to thermal fatigue (4), magnitude and frequency of the thermal cycling would definitely influence the stack performance. Operations under low fuel utilization, temperatures deviated far from normal operating range would lead to low efficiency (5). Transient operating issues such as slow load following and temperature overshoots are evaluated for their dynamic response of SOFC systems (6-8). Dynamic modeling is now widely utilized to characterize the cell response under transient conditions, and to define appropriate control strategies for the SOFC system.

To stabilize and minimize the temperature variations while load is changing, single or multi-loop controllers are developed by many researchers (7, 9-13). Of which, Bi-loop control strategy is commonly used, where simulation is executed by a master controller associated with a typical PID controller. The disturbance of current density, fuel and air flow rates, and temperatures are the major parameters. In addition, fuel utilization is a significant indicator which has to be maintained in a safe range to prevent fuel starvation. Gaynor (14) mentioned that it can be prevented by the use of rate limiter, reference governors, and modifications to the fuel-flow controllers. In a SOFC load tracking process, efforts are made to keep fuel utilization in a steady range or constant. In a dynamic analysis, considerations of multi-physical processes are necessary, for instance, the time constant for the cell temperature dynamics is in the time scale of hundreds of seconds (15) due to relatively large heat capacitance and mass of a stack. Generally, the fuel gas outlet temperature is a good reference but cannot reflect the instant and representative temperature inside a stack. In practice, it is a state-of-art to measure the exact cell temperatures without interfering its dynamics (15). Meanwhile, radiation emission at high temperatures would cause some measurement error (16). Meanwhile, as the SOFC is operated at elevated temperatures, a proper heating process has to be well defined before it starts to deliver electric power. Presumably, the stack can be heated up as quick as possible from the ambient temperature to the operating regime while minimizing net energy consumption and thermal gradient are taken into account (17).

This paper is to investigate a proper operation strategy in corresponding to load change conditions by regulating both fuel utilization and air excess ratios. Effects of temperature differences between inlet and stack temperatures, temperature increment rate of stack temperature, and inlet flow rates are evaluated for a safe and fast start-up during the heat-up process.

Dynamic Modeling

In this study, the dynamic model, as shown in Figure 1, is divided mainly into three parts, namely Energy Balance Module (EBM), Mass Balance Module (MBM), and Electrochemistry Module (ECM). Calculations are carried out based on first principles with assumptions of ideal gases and sub-critical flow. Major parameters are referred to literature (18). System-level parameters are transferred reciprocally among modules to evaluate the stack dynamic characteristics.

Electrochemistry Module (ECM)

Fuel (from MBM) diffused through electrode and dissociated into electrons and positive ions at the anode; while on the cathode side, air (from MBM) is introduced as the oxidant that captures the electrons, via an outer electric conducting loop from anode, to form negative ions (O_2^-) that serve as charge carriers through electrolyte. The electrochemical reactions occur to generate a voltage across a cell and produce a large amount of heat. The cell voltage is less than the Nernst potential due to irreversibility related to activation, ohmic, and concentration losses. Generally, these losses are function of current draw and operating temperatures (from EBM) and cell inherited factors, such as exchange current density (i_0), Area Specific Resistance (ASR), and limiting current density (i_l). The activities of species (from MBM) are available to calculate the concentrations of reactant and product on reaction sites. In the ECM, the power output is calculated under a given current or a resistive load.

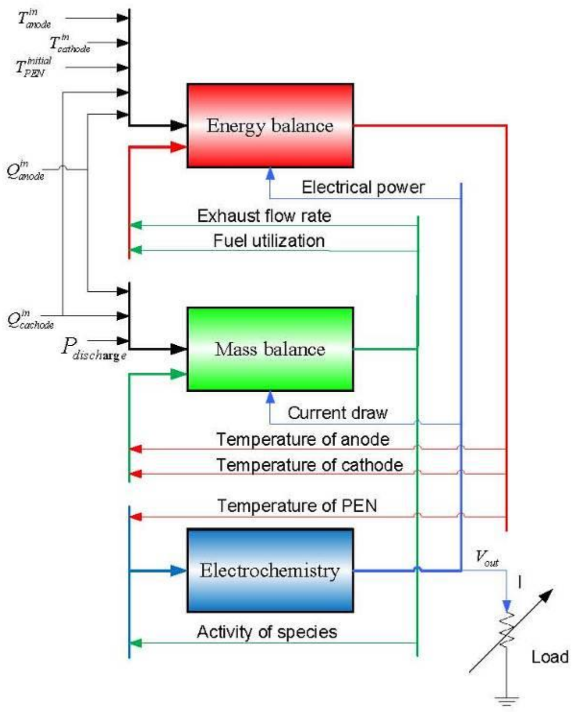

Figure 1. The model of a planar SOFC stack

Energy Balance Module (EBM)

EBM is divided into several Control Volumes (CVs) corresponding to the most representative parts of a stack assembly including gases channels, PENs, and interconnects. The energy conservation principle is utilized to calculate the heat flux among CVs, where species interact energetically with one another. The generated heat is obtained in accordance with the energy difference between the enthalpy of formation (from MBM) and the electric power generated (from ECM). On the basis of gas properties and flow rates, temperatures of CVs are subsequently calculated.

Mass Balance Module (MBM)

. Based on the mass conservation principle, rate of discharge is computed by nozzle flow equations, where the ideal gas law and sub-critical flow are employed. The reaction rates are calculated by the rules of electrochemistry. With temperature of channels provided from EBM, the activity of individual species inside channels is then attained for cell voltage calculation in ECM. For a given fuel flow rate, fuel utilization is provided to EBM according to the current draw required from ECM.

Proposed Control Scheme

Startup Process

As shown in Figure 2, the overall control system is composed of a main loop for temperature increment rate control by the gas mass flow controller and a sub-loop for inlet temperature regulation. By virtue of a current regulator connected to the output terminal of stack, the current increment rate is gradually achieved during the start-up stage. The temperature increment rate of stack should meet to its specifications as well as the capacity of peripheral facility such as fuel processing and heat recovery units. In this study, the time span to heat up the stack, through regulating the inlet gas temperature and gas flow rates, is investigated for an optimized control scheme.

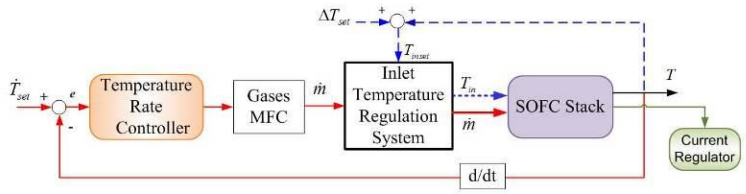

Figure 2. Scheme for control of temperature increment rate

The inlet temperature T_{in_set} is obtain by the summation of stack temperature T and the given temperature difference ΔT_{set} , as shown in Eq. [1]. The temperature difference ΔT_{set} is the driving force to heat up the stack.

$$T_{in\_set} = T + \Delta T_{set} \quad [1]$$

The inlet temperature control system is constructed by a Splitter/Mixer mechanism, where the ratio of hot gas and cold gas is calculated by Eq. [2] to adjust the splitter value. The schematic flow diagram of inlet temperature control system is shown in Figure 3.

$$x = \frac{n_1}{n_2} = \frac{h_2 - h_{T_{in}}}{h_{T_{in}} - h_1} \quad [2]$$

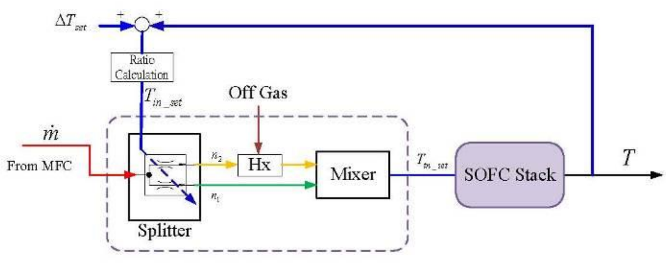

Figure 3. Block diagram for inlet temperature control

To satisfy the power requirement, the current is raised to certain level for operation as the stack temperature reaches to 800 °C. To prevent the stack from cracking due to dramatic temperature gradient attributed to abrupt increase of current, a limiter for the current increment rate is set to 15 mA/sec.

Dynamic Operation Process

During the operation stage, the heat has to be handled in an integrated heat management system. To deal with the heat produced in the stack, it can be done by adjust the magnitude of current and flow rates of oxidant gas which enters the stack at lower temperatures. A proposed control strategy scheme is shown in Figure 4. The air flow rate, in correspondence to the change of fuel flow rate under transient conditions, is regulated to keep air excess ratio constant by MPC λ controller in the cathode loop. Meanwhile, a constant fuel utilization loop is employed in the anode loop to produce electrical power efficiently. The regulated fuel and air flows are then enter heat exchangers and being heated up to the target temperatures.

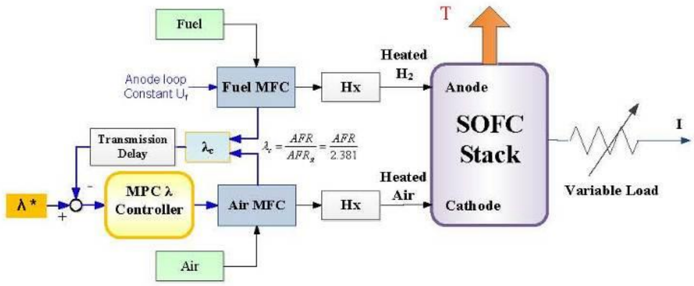

Figure 4. Scheme for SOFC operation

The scheme is applicable for both constant fuel utilizations and constant temperatures regardless of the disturbance of current demand. Higher fuel utilization implies higher efficiency, as defined by Eq. [3] (19). As fuel utilization increases in the stack, the partial pressure of hydrogen in the anode side decreases. If the fuel starvation occurs, it could cause irreversible damages due to excessive oxidation in anode side (20). Lower fuel utilization means lower efficiency of stack as the definition

$$\eta_s = \frac{Power\ output}{\Delta H} = \eta_{ideal} \frac{V}{V_{ideal}} \times U_f \qquad [3]$$

Simulation Results & Discussions

Startup Process

To investigate the effect of temperature difference between inlet and stack temperatures ΔT and temperature increment rate $\dot{T}_{set}$, an ΔT set to 20 K and $\dot{T}_{set}$ 0.15 K/s are assumed for a base case. A parameter sensitivity study is carried out in this study.\

Temperature Difference. Two alternative temperature differences 10K (Kelvin) and 30 K are used for comparison with the base case, where the temperature increment rate is the same at 0.15 K/s. Figure 5(a) shows that, at a higher temperature difference of 30 K, it has only slightly effect to shorten the time span for the heat up process. However, at a lower temperature difference of 10 K, a much longer time span is required for the heat up process. A good practice would be to have a temperature difference between 10~20 K as the temperature increment rate at 0.15 K /sec.

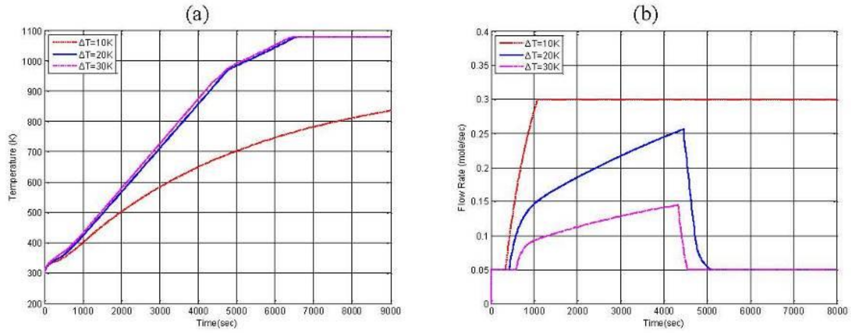

Figure. 5 (a) ΔT effect on temperature of stack, (b) ΔT effect on air flow rate

Figure 5(b) shows a much higher flow rate is required for the temperature difference of 10 K. As a whole, it requires a longer time span and more energy consumed under such conditions. A higher temperature difference of 30 K, however, does not shorten the time span at the given temperature increment rate. Apparently, the appropriate temperature difference has to be accommodated with the specifications of allowable temperature gradient of a stack.

Temperature Increment Rate. Two alternative temperature rates 0.1 K /sec and 0.2 K /sec are used for comparison with base case, where the temperature difference is the same at 20 ^{K}. Figure 6(a) shows the higher temperature increment rate, the shorter the time span required to heat up. Figure 6(b) indicates higher inlet flow rates are required to achieve a higher temperature increment rate, which is normally determined by design specifications, material property, and operation requirement.

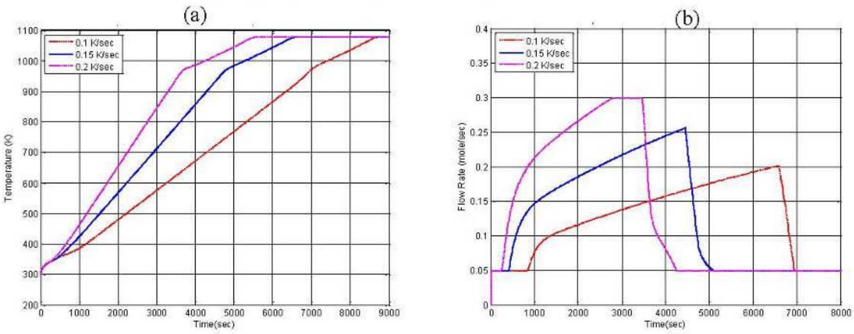

Figure 6. (a) Effect of temperature increment rate effect on the stack temperature, (b) Effect of temperature increment rate on air flow rate

Load Following Process

In the study, the current is initially kept at a constant current of 30 amperes as a steady state condition. At 500 sec, the magnitude of current is decreased by 0.03A/sec for 500 seconds. It is then kept at 15A till 1500 seconds. Subsequently, by the same current rate and time span, a pre-defined current profile ranging from 15A to 45A, as illustrated in Fig. 7(a), is imposed for investigation. As shown in Fig. 7(a), the stack current follows the current demand properly with certain time delay, attributed to the resistive load regulator on account of sluggish response of temperature and fluid as compared to the current demand. The current limiter provides a preliminary protection to stack, which is usually implemented in the algorithm of digital signal processor (DSP) for PWM control by a PI controller inside DC converter.

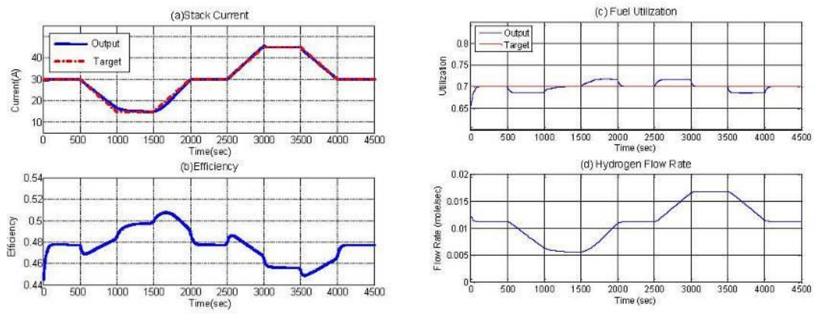

Figure. 7 Simulation results of constant fuel utilization control under ramp current demand change: (a) stack current, (b) efficiency, (c) fuel utilization, (d) hydrogen flow

In Figs. 7 (c) and (d), the fuel utilization and the hydrogen flow rate are shown. Apparently, the fuel utilization varies in comply with the current demand radically. The deviation of the fuel utilization is attributed to the different response time between current demand and gas flow rates. Though the current demand changes dramatically, the fuel utilization is maintained between 0.67 and 0.73, as shown in Figure 7(c). The corresponding fuel flow rate is shown in Fig. 7(d). The efficiency during load tracking process, as shown in Fig. 7(b), ranges from 45%~51%.

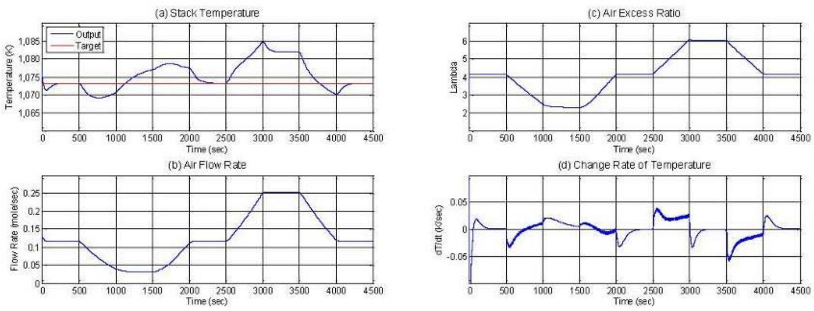

Figure 8. Simulation results of various lambda: (a) stack temperature, (b) air flow rate, (c) air excess ratio, (d) change rate of temperature

Fig. 8 (a) shows the stack temperature response under load ramp conditions, in which varied air excess ratio control strategy is employed. The deviation of stack temperature is around 15 K, which is much lower than that of an open-loop dynamic response with fixed air flow rate. The results indicate the stack temperature is relatively higher in the peak load condition but lower in low-load state. In Figs. 8 (b) and (c), the air flow rate and the air excess ratio under load ramp conditions are shown. Though the current changes are imposed from 15A to 45A in ramp, the change rate of temperature is less than 0.06 K/sec, as shown in Fig. 8(d) by regulating the λ from 2.3 to 6, as shown in Fig. 8(c). The corresponding air flow rate is shown in Figure 8(b). In addition, a comparison between the proposed Advanced Temperature Control (ATC), the Fixed λ control, and the Direct Temperature Feedback (DTF) control is shown in Fig. 9. The temperature response by ATC strategy, as compared to that of fixed λ, possesses the advantage of benign deviations of stack temperatures. The proposed Advanced Temperature Control possesses a viable and comprehensive way for implementation.

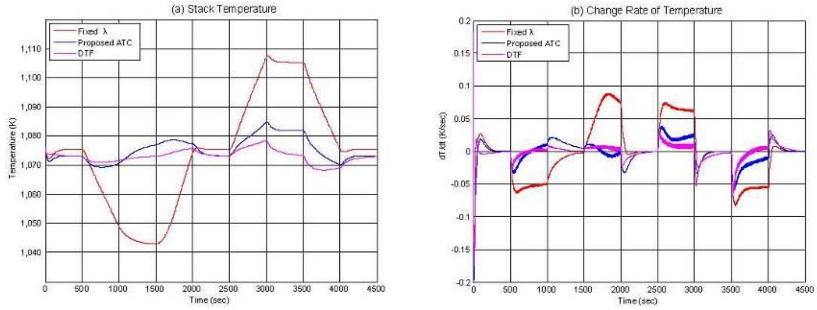

Figure 9. Comparisons among Proposed ATC, Fixed λ, and Direct Temperature Feedback (DTF) control on (a) temperature response, (b) temperature change rate

Conclusions

From perspective of system operation, the development of control strategies is an imperative issue in pursuing successful system implementation. Model-based design provides an efficient approach to set up a collective platform for rapid strategy development and validation. For the dynamic simulation, the first principle modeling is appropriate because of the intuitive interactions and fast calculations. A good dynamic model not only provides a tool to facilitate analysis and optimization of SOFC, but also grants a bridge toward rapid control prototypes for SOFC operation.

In this paper, the effectiveness of the proposed control scheme for the stack temperature increment rate during startup and load change conditions are investigated. A low temperature difference will yield a much longer time span and consume massive energy to heat up the stack. By using an enhanced load tracking technique, the advanced temperature control strategy is employed in this study. The strategy, eliminating unpractical thermo-sensing from cell or exhaust, explores a simple relationship between the current draw and the modified air excess ratio. A significant alleviation in temperature variations provides the advantage to minimize operation risk and enhance the dynamic response during transient conditions.

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Welcome to SOFC-XIII

13th International Symposium on Solid Oxide Fuel Cells (SOFC-XIII) will be held in Okinawa, Japan, Oct. 6-11, 2013. This symposium will provide an international forum for the presentation and discussion of the latest developments on solid oxide fuel cells (SOFCs) and related topics.

You are welcomed to join the SOFC-XIII symposium and to have fruitful discussion on recent R&D achievements of SOFC in the beautiful tropical island.

CAUTION!!

The executive comittee decides to canel all the presentations and exhibitions on Oct. 7 Monday due to the typhoon, DANAS. The revised programs are available here: (oral, poster: updated at 9:30pm, Oct. 7).

News

***1. Another strong ttyphoon (DANAS) is approaching to Okinawa. Therefore, Monday programs are canceled.**
We'll post the updated information on this website. Please check this website

***2. Welcome reception and banquet will be held not at the conference venue but at Loisir Hotel Naha (12km from the conference venue).**

***3. Place and opening hour of onsite registration desk:**
Oct. 6: 15:00~19:00 at 3rd floor foyer, Loisir hotel Naha
Oct. 7: Canceled due to the typhoon
Oct. 8-11: 8:00~ at Theater, Okinawa Convention Center

Typhoon-FITOW Information:
Weather forecast:Typhoon-DANAS, Hourly forecast (Naha)
Domestic flight status: ANA(flight no. ANAxxx or NHxxx), JAL(flight no. JALxxx or JLxxx), ANA twitter
***ANA:Flights from/to Okinawa Naha airport may be affected on October 7. Morning Flights**

from/to Okinawa Naha airport may be affected on October 8. (as of 0am, Oct. 7)
****JAL: Okinawa (Naha) airports may experience flight delay, cancellation, or diversions on Oct. 7.***

Oct. 11, 2013: SOFC-XIII is closed successfully due to your kind cooperation. See you again in Glasgow in 2015!
Oct. 7, 2013: The technical program is updated at 9:30pm, Oct. 7 (Oral, Poster). Please check these hyperlinks.
Oct. 7, 2013: The revised schedule of conference bus is uploaded. Please check it.
Oct. 7, 2013: Operation of pubclic transportation in Okinawa will be stopped due to typhoon (Bus from 11:30am; Monorail from 1:00pm). Even a taxi might be not operated as well. Stay indoors for your safety this afternoon. Check the hourly weather forcast.
Oct. 7, 2013: Strong typhoon, DANAS, probably hits Okinawa this afternoon. It'll be very windy (max. wind speed 70m/s) from afternoon to night. For those who in Okinawa, please keep yourself safe (stay indoors) until the typhoon passes away.
Oct. 6, 2013: ***The executive comittee decides to canel all the presentations and exhibitions on Monday due to the typhoon, DANAS. The revised programs are available here (oral, poster).***
Oct. 6, 2013: Schedule of conference buses will change and upload on this site.
Oct. 6, 2013: Due to the typhoon, company exhibition will start at lunch break on Tuesday**.** The company exhbitors can start to setup their booth in the morning (from 8am) on Tuesday.
Oct. 6, 2013: The typhoon, DANAS, becomes unexpectedly strong (<970hPa) and may hit Okinawa tomorrow afternoon. We'll inform you of the updated information on this website by 5pm.
Oct. 6, 2013: The satellite seminar and welcome reception will be held as scheduled.
Oct. 5, 2013: Another typhoon, DANAS, is also approaching Okinawa, which is expected to pass through Okinawa from Monday toTuesday. We suppose it may not affect the symposium much because it is not as strong as FITOW. We recommend you to fly to Okinawa on Oct.6.
Oct. 4. 2013: At this moment, executive committee thinks symposium will be held as planned.
Typhoon will hit Okinawa on Oct. 5. So we'd recommend you to fly to Okinawa on Oct. 6.
Oct. 4, 2013: Company exhibition will open in the evening poster session on Monday.
Oct. 3. 2013: At this moment, executive committee thinks symposium will be held as planned.
The symposium schedule is subject to change due to the typhoon.
Oct. 2. 2013: As of Oct. 2, the symposium will be held as planned. Further information will be daily updated on this page. The symposium schedule is subject to change.
Oct. 1, 2013: Tropical Cyclone (FITOW) is approaching to Okinawa. In case it hits Okinawa, we may change the technical program and upload it to this website.

(一)8/21 原排定議程

Monday, October 7, 2013

Theater
Plenary session
Co-Chair(s): Tatsuya Kawada and Subhash Singhal

9:50		**Opening Remarks**
10:10	OT-01	**Current Status of National SOFC Projects in Japan** K. Horiuchi (New Energy and Industrial Technology Development Organization, Japan)
10:30	OT-02	**SECA Program Overview and Status** S.D. Vora (U. S. DOE, National Energy Technology Laboratory, USA)
10:50	OT-03	**The Status of SOFC R&D in the FCH JU Program** B. De Colvenaer, M. Atanasiu (Fuel Cells and Hydrogen Joint Undertaking, Belgium)
11:10-11:20		Break

Stacks and Systems I
Co-Chair(s): Tatsuya Kawada and Subhash Singhal

11:20	OT-04	**Overview on the Jülich SOFC Development Status** L. Blum, P. Batfalsky, L.G.J. de Haart, J. Malzbender, N.H. Menzler, R. Peters, W.J. Quadakkers, J. Remmel, F. Tietz, D. Stolten (Forschungszentrum Jülich, Germany)
11:40	OT-05	**Introduction of Solid Oxide Fuel Cell Research in SICCAS** S.R. Wang, Z.L. Zhan, T.L. Wen (Shanghai Institute of Ceramics, Chinese Academy of Sciences, China)
12:00-13:30		Lunch & Poster Session

Stacks and Systems II
Co-Chair(s): Karl Föger and Nguyen Minh

13:30	OT-06	**Status of the Solid Oxide Fuel Cell Development at Topsoe Fuel Cell A/S and DTU Energy Conversion** N. Christiansen, S. Primdahl (Topsoe Fuel Cell A/S, Denmark), M. Wandel, S. Ramousse, A. Hagen (Danish Technical University, Denmark)
13:50	OT-07	**Recent Progress of SOFC Combined Cycle System with Segmented-in-Series Tubular Type Cell Stack at MHI** Y. Kobayashi, Y. Ando, M. Nishiura, H. Kishizawa, M. Iwata, N. Matake, K. Tomida (Mitsubishi Heavy Industries, Ltd., Japan)
14:10	OT-08	**Development of Solid Oxide Fuel Cells at Versa Power Systems and FuelCell Energy** B. Borglum (Versa Power Systems, Canada), H. Ghezel-Ayagh (FuelCell Energy, Inc., USA)
14:30	OT-09	**Solid Oxide Fuel Cell – Gas Turbine Hybrid Power Plant** M. Henke, C. Willich, M. Steilen, J. Kallo, K.A. Friedrich (German Aerospace Center, Germany)
14:50-15:10		Coffee Break
15:10	OT-10	**Hexis' SOFC System Galileo 1000 N – Lab and Field Test Experiences** A. Mai, B. Iwanschitz, J.A. Schuler, R. Denzler, V. Nerlich, A. Schuler (Hexis Ltd., Switzerland)
15:30	OT-11	**Development and Manufacturing of SOFC-Based Products at SOFCpower SpA** O. Bucheli (HTceramix SA, Switzerland), M. Bertoldi, S. Modena, A.V. Ravagni (SOFCpower SpA. Italy)

15:50	OT-12	**CFY-Stacks for Use in Stationary SOFC and SOEC Applications** S. Megel, C. Dosch, S. Rothe, M. Kusnezoff, N. Trofimenko, V. Sauchuk, A. Michaelis (Fraunhofer Institute for Ceramic Technologies and Systems, Germany), C. Bienert, M. Brandner, A. Venskutonis, W. Kraussler, L.S. Sigl (Plansee SE, Austria)
16:10	OT-13	**Comparative Experimental and Technical-Economic Evaluation of a 1 kW_{el} vs. 2.5 kW_{el} Tubular SOFC System for Residential Applications** C. Boigues-Muñoz, S.J. McPhail (ENEA. Italy), G. Cinti, D. Penchini (Università degli Studi di Perugia, Italy), F. Polonara (Università Politecnica della Marche, Italy)

16:30-18:30 Poster Session (Co-Chairs: Kazuhisa Sato and André Weber)

Room A

Metal Supported Cells I

Co-Chair(s): Sergey Bredikhin and Xiao-Dong Zhou

11:20	OA-04	**Low-Cost, REDOX-Stable, Low-Temperature SOFC Developed by Ceres Power for Multiple Applications: Latest Development Update** R. Leah, A. Bone, M. Lankin, A. Selcuk, R. Pierce, L. Rees, D. Corcoran, P. Muhl, Z. Dehaney-Steven, C. Brackenbury, M. Selby, S. Mukerjee (Ceres Power Ltd., UK)
11:40	OA-05	**The Status of Metal-Supported SOFC Development and Industrialization at Plansee** T. Franco, M. Haydn (Plansee SE, Austria), A. Weber (Karlsruhe Institute of Technology, Germany), W. Schafbauer (Plansee SE, Austria), L. Blum, U. Packbier, D. Roehrens, N.H. Menzler (Forschungszentrum Jülich, Germany), J. Rechberger (AVL List GmbH, Austria), A. Venskutonis, L.S. Sigl (Plansee SE, Austria), H.-P. Buchkremer (Forschungszentrum Jülich, Germany)

12:00-13:30 Lunch & Poster Session

Room A

Metal Supported Cells II

Co-Chair(s): Sergey Bredikhin and Xiao-Dong Zhou

13:30	OA-06	**Metal Supported Solid Oxide Fuel Cells: From Materials Development to Single Cell Performance and Durability Tests** J. Mougin, A. Brevet (CEA-LITEN, France), J.C. Grenier (CNRS, Université de Bordeaux, ICMCB, France), R. Laucournet (CEA-LITEN, France), P.O. Larsson (HÖGANÄS AB, Sweden), D. Montinaro (SOFCpower, Italy), L.M. Rodriguez-Martinez, M.A. Alvarez (IKERLAN, Spain), M. Stange (SINTEF, Norway), S. Trombert (BAIKOWSKI, France)
13:50	OA-07	**Progress in Metal-Supported SOFCs Using Hydrogen and Methane Fuels** O. Kesler, M. Cuglietta, J. Harris, J. Kuhn, M. Marr, C. Metcalfe (University of Toronto, Canada)
14:10	OA-08	**R&D and Commercialization of Metal-Supported SOFC Personal Power Products at Point Source Power** M.C. Tucker, B. Carreon, J. Charyasatit, K. Langston, C. Taylor, J. Manjarrez, N. Burton, M. LaBarbera, C.P. Jacobson (Point Source Power, Inc., USA)
14:30	OA-09	**Coating Developments for Metal-Supported Solid Oxide Fuel Cells** M. Stange, C. Denonville, Y. Larring, C. Haavik (SINTEF, Norway), A. Brevet, A. Montani, O. Sicardy, J. Mougin (CEA-LITEN, France), P.O. Larsson (HÖGANÄS AB, Sweden)

14:50-15:10 Coffee Break

Metal Interconnects

Co-Chair(s): Manfred Martin and Katsuhiko Yamaji

15:10	OA-10	**Oxidation Behavior of Fe-Cr Ferritic Alloy for SOFC Interconnects ZMG232G10 in Air and H_2/H_2O** K. Yamamura, T. Uehara, S. Tanaka, N. Yasuda (Hitachi Metals, Ltd., Japan)
15:30	OA-11	**Nano Coated Interconnects for SOFC (NaCoSOFC)** J. Froitzheim (Chalmers University of Technology, Sweden), A. Magraso (University of Oslo, Norway), T. Holt (Topsoe Fuel Cells, Denmark), M.W. Lundberg (AB Sandvik Materials Technology, Sweden), H.F. Windisch (Chalmers University of Technology, Sweden), R. Berger (Sandvik Materials Technology, Sweden), R. Sachitanand (Chalmers University of Technology, Sweden), J. Westlinder (Sandvik Materials Technology, Sweden), J.E. Svensson (Chalmers University of Technology, Sweden), R. Haugsrud (University of Oslo, Norway)
15:50	OA-12	**Improvement of Oxidation Resistance of Crofer 22 APU with Modified Surface for Solid Oxide Fuel Cell Interconnects** N. Demeneva, S. Bredikhin (ISSP RAS, Russia)
16:10	OA-13	**Long Term Performance of Stacks with Chromium-Based Interconnects (CFY)** M. Brandner, C. Bienert (Plansee SE, Austria), S. Megel, M. Kusnezoff, N. Trofimenko, V. Sauchuk (Fraunhofer Institute of Ceramic Technologies and Systems, Germany), A. Venskutonis, W. Kraussler (Plansee SE, Austria), A. Michaelis (Fraunhofer Institute of Ceramic Technologies and Systems, Germany), L.S. Sigl (Plansee SE, Austria)

16:30-18:30 Poster Session (Co-Chairs: Kazuhisa Sato and André Weber)

Tuesday, October 8, 2013

Theater

Stacks and Systems III

Co-Chair(s): Massimo Santarelli and Robert Steinberger-Wilckens

9:00	OT-14	**Saint-Gobain's All Ceramic SOFC Stack: Architecture and Performance** S. Giles, G. Lin, A. Mohanram, Y. Narendar, J. Pietras, F.C. Qi, W.R. Robbins, R.J. Sliwoski (Saint-Gobain NRDC, USA)
9:20	OT-15	**Development of a New Concept SOFC at Murata** Y. Tomoshige, N. Mori, M. Iha, T. Takada, T. Konoike (Murata Manufacturing Co., Ltd, Japan)
9:40	OT-16	**Microtubular Solid Oxide Fuel Cells (mSOFCs)** M. Kendall (Adelan Ltd., UK), A.D. Meadowcroft, K. Kendall (University of Birmingham, UK)
10:00	OT-17	**Development of Microtubular SOFCs for Portable Power Sources** H. Sumi, T. Yamaguchi, K. Hamamoto, T. Suzuki, Y. Fujishiro (AIST, Japan)
10:20-10:40		Coffee Break
10:40	OT-18	**AVL SOFC Systems on the Way of Industrialization** J. Rechberger, M. Reissig, M. Hauth (AVL List GmbH, Austria)
11:00	OT-19	**Alternative Fuels and Perspectives Solid Oxide Fuel Cells Usage in Air Transport** L.S. Yanovskiy, A.V. Baykov, V.V. Raznoschikov, I.S. Averkov (Central Institute of Aviation Motors, Russia)
11:20	OT-20	**Eneramic® Power Generator – A Reliable and Cycleable 100W SOFC System** S. Reuber, A. Pönicke, C. Wunderlich, A. Michaelis (Fraunhofer Institute for Ceramic Technologies and Systems, Germany)
11:40	OT-21	**SOFC System Using a Hot Gas Ejector for Offgas Recycling for High Efficient Power Generation from Propane** R.-U. Dietrich, A. Lindermeir, C. Immisch (CUTEC Institut GmbH, Germany), C. Spieker, C. Spitta (Zentrum für BrennstoffzellenTechnik, Germany), S. Stenger, R. Leithner (TU Braunschweig, Germany), T. Küster, A. Oberland (TU Clausthal, Germany)
12:00-13:30		Lunch & Poster Session

New Applications I

Co-Chair(s): Alan Atkinson and Tohru Yamamoto

13:30	OT-22	**SOFCOM Project: Proof-of-Concept of WWTU Plant Feeding a SOFC CHP System Integrated with CO_2 Removal** M. Santarelli (Politecnico di Torino, Italy), J. Kiviaho (Technologian Tutkimuskeskus VTT, Finland), L. Meucci (Società Metropolitana Acque Torino, Italy), L. Vega (MATGAS 2000 A.I.E., Spain), V. Chiodo (CNR-ITAE, Italy), J. Jevulski (Instytut Energetyki, Poland), H. Spliethoff (Technical University of Munich, Germany)
13:50	OT-23	**SOFC Operation: Direct Fuel Utilization, Pressurization and Reversibility** N.Q. Minh (University of California, San Diego, USA)
14:10	OT-24	**Stack Temperature Estimation in System Environment by Utilizing the Design of Experiments Methodology** M. Halinen, A. Pohjoranta, J. Pennanen, J. Kiviaho (VTT Technical Research Centre of Finland, Finland)
14:30	OT-25	**Pressurized Solid Oxide Fuel Cells: Measurements of Impedance Spectra and Anodic Concentration Polarization** P.C. Wu, H.S. Jheng, S.S. Shy (National Central University, Taiwan)
14:50-15:10		Coffee Break

15:10	OT-26	**An Innovative SOFC Hybrid Based Prime Supply for Telecom Applications** M. Ferraro, G. Brunaccini, G. Napoli, F. Sergi, G. Dispenza, N. Randazzo, V. Antonucci (National Research Council of Italy, Italy)
15:30	OT-27	**2-D Simulation of Heat and Mass Transfer Effects on Charge/Discharge Characteristics of a Solid Oxide Redox Flow Battery** H. Ohmori (Konica Minolta, Inc., Japan), H. Iwai (Kyoto University, Japan)
15:50	OT-28	**Coupling and Modeling an SOFC System with a High-Performing Metal Hydride Storage** A.M. Pour, R. Steinberger-Wilckens, A. Dhir (University of Birmingham, UK)
16:10	OT-29	**Power-to-Storage – The Use of an Anode-Supported Solid Oxide Fuel Cell as a High-Temperature Battery** N.H. Menzler, A. Hospach, L. Niewolak, M. Bram, O. Tokariev, C. Berger, P. Orzessek, W.J. Quadakkers, Q. Fang, H.P. Buchkremer (Forschungszentrum Jülich, Germany)

16:30-18:30 Poster Session (Co-Chairs: Fumitada Iguchi and Bilge Yildiz)

Room A

Anode I

Co-Chair(s): Ellen Ivers-Tiffée and Yusuke Shiratori

9:00	OA-14	**Full Ceramic Fuel Cells Based on Strontium Titanate Anodes, an Approach Towards More Robust SOFCs** P. Holtappels (Technical University of Denmark, Denmark), J.T.S. Irvine (University of St Andrews, UK), B. Iwanschitz (Hexis AG, Switzerland), L.T. Kuhn (Technical University of Denmark, Denmark), L.Y. Lu (University of St Andrews, UK), Q. Ma, J. Malzbender (Forschungszentrum Jülich, Germany), A. Mai (Hexis AG, Switzerland), T. Ramos (Technical University of Denmark, Denmark), J. Rass-Hansen (Topsoe Fuel Cell A/S, Denmark), B.R. Sudireddy (Technical University of Denmark, Denmark), F. Tietz, V. Vasechko (Forschungszentrum Jülich, Germany), S. Veltzé (Technical University of Denmark, Denmark), M.C. Verbraeken (University of St Andrews, UK)
9:20	OA-15	**Investigation of Microstructure of Sr-Doped Lanthanum Vanadium Oxide Anode Based on SDC Electrolyte** K. Tamm, R. Raudsepp, R. Kanarbik, P. Möller, G. Nurk, E. Lust (University of Tartu, Estonia)
9:40	OA-16	**Performance of LST-GDC Composite Anodes for Solid Oxide Fuel Cells** L.Q. Fan, Y.W. Wang, H. Huo, Y.P. Xiong (Harbin Institute of Technology, China)
10:00	OA-17	**Fabrication of Low Ni-Containing SOFC Anode Using Mixed Ionic and Electronic Conductors** R. Kikuchi, T. Minami, A. Takagaki, T. Sugawara, S.T. Oyama (The University of Tokyo, Japan)

10:20-10:40 Coffee Break

10:40	OA-18	**Improving the Performance of SOFC Anodes by Decorating Perovskite with Ni Nanoparticles** S. Boulfrad (King Abdullah University of Science and Technology, Saudi Arabia), M. Cassidy (University of St Andrews, UK), E. Traversa (King Abdullah University of Science and Technology, Saudi Arabia), J.T.S. Irvine (University of St Andrews, UK)
11:00	OA-19	**Effects of Metal Additives on Power Generating Property of Direct Hydrocarbon Type SOFC Using $LaGaO_3$ Electrolyte** T. Ishihara, T.H. Shin, S. Ida (Kyushu University, Japan)
11:20	OA-20	**Capabilities and Challenges for Tungsten Carbide Anodes** A. Torabi (University of Toronto, Canada), T.H. Etsell (University of Alberta, Canada)
11:40	OA-21	**Ni-$Zr_{0.75}Ce_{0.25}O_{2-\delta}$ Composite as Steam Methane Reformable SOFC Anode** S. Biswas, A.D. Sharma (CSIR-Central Glass & Ceramic Research Institute, India), A. Buragohain, C.V. Stayanarayana (CSIR-National Chemical Laboratory, India), R.N. Basu (CSIR-Central Glass & Ceramic Research Institute, India)

12:00-13:30 Lunch & Poster Session

Anode II

Co-Chair(s): Min-Fang Han and John Irvine

13:30 OA-22 **Development of Redox Resistant Infiltrated Tubular SOFCs**
A.R. Hanifi, X. Chen, J. Seens (University of Alberta, Canada), P. Sarkar (Alberta Innovates-Technology Futures, Canada), T.H. Etsell (University of Alberta, Canada)

13:50 OA-23 **Carbon-Resistant Micro Tubular SOFCs Fabricated by Co-Spinning Process Based on a Phase-Inversion Method**
X. Meng (Shanghai Jiao Tong University, China), X. Gong, N. Yang, X. Tan (Shandong University of Technology, China), Y. Yin, Z.-F. Ma (Shanghai Jiao Tong University, China)

14:10 OA-24 ***In situ* Spectroscopic Studies of Carbon Formation in SOFCs Operating with *Syn-gas***
M.D. McIntyre, J.D. Kirtley, D.M. Halat, K.W. Reeping, R.A. Walker (Montana State University, USA)

14:30 OA-25 **Beneficial Effects of Low ppm Levels of H_2S on the Performance of Ni-YSZ SOFC Anodes in Syngas Fuels**
A. Singh, S. Paulson, J.M. Hill, V. Birss (University of Calgary, Canada)

14:50-15:10 Coffee Break

Alternative Fuels

Co-Chair(s): Min-Fang Han and John Irvine

15:10 OA-26 **Fuel-Flex SOFC Running on Internal Gradual Reforming**
S.D. Nobrega, F.C. Fonseca (Instituto de Pesquisas Energéticas, Brazil), P. Gelin (CNRS-Université de Lyon, France), F.B. Noronha (Instituto Nacional de Tecnologia, Brazil), S. Georges, M.C. Steil (CNRS-Université de Grenoble, France)

15:30 OA-27 **Biomass Gasifier–SOFC Systems: From Electrode Studies to the Development of Integrated Systems and New Applications**
P.V. Aravind, M. Liu, L. Fan, E. Promes, S.Y. Giraldo, T. Woudstra (Delft University of Technology, Netherlands)

15:50 OA-28 **Methanol as an Oxygenated SOFC Fuel: An *in situ* Optical Analysis of the Fuel Utilization Chemical Mechanism**
M.B. Pomfret (U.S. Naval Research Laboratory, USA), D.A. Steinhurst (Nova Research, Inc., USA), J.C. Owrutsky (U.S. Naval Research Laboratory, USA)

16:10 OA-29 **Performance Characteristics of Liquid Antimony Anode Direct Carbon Fuel Cell**
H. Wang, Y. Shi (Tsinghua University, China), W. Yuan (Shenhua Ningxia Coal Industry Group Co. Ltd., China), T. Cao, N. Cai, X. Liang (Tsinghua University, China)

16:30-18:30 Poster Session (Co-Chairs: Fumitada Iguchi and Bilge Yildiz)

Room B

Metallic Interconnect Coatings

Co-Chair(s): Haruo Kishimoto and Nigel Sammes

9:00 OB-14 **Effect of Thermal-Sprayed $Mn_{1.5}Co_{1.5}O_4$ Coating on Oxidation Suppression of Metallic Interconnects**
K.-Z. Fung, S.-Y. Tsai, H.-C. Ho (National Cheng Kung University, China)

9:20 OB-15 **Electrodeposition Method for SOFC Interconnector Coating**
S. Inoue, H. Nonaka, T. Saito, M. Yoda, Y. Takuwa (Osaka Gas Co, Ltd., Japan)

9:40 OB-16 **Novel Multilayered PVD-Coating in a Roll to Roll Mass Production Process**
M.W. Lundberg, R. Berger, J. Westlinder, N. Folkeson, H. Holmberg (AB Sandvik Materials Technology, Sweden)

Electrolyte/Thin Film I

Co-Chair(s): Haruo Kishimoto and Nigel Sammes

10:00 OB-17 **Evaluation of Stress Condition of Operated Anode Supported-Type SOFC under Operating Conditions Based on Raman Scattering Spectroscopy**
S. Onuki, S. Onodera, F. Iguchi, M Shimizu, T. Kawada, H. Yugami (Tohoku University, Japan)

10:20-10:40 Coffee Break

Electrolyte/Thin Film II

Co-Chair(s): Haruo Kishimoto and Nigel Sammes

10:40 OB-18 **Sol-Gel Thin-Film Electrolyte Anode-Supported SOFC – From Layer Development to Stack Testing**
N.H. Menzler, F. Han, D. Sebold, Q. Fang, L. Blum, H.P. Buchkremer (Forschungszentrum Jülich, Germany)

11:00 OB-19 **Ultimate Performance of Anode-Supported SOFC by Realizing Thin-film Electrolyte and Nano-Structure Electrode**
H.-S. Noh, K.J. Yoon, B.-K. Kim, H.-J. Je, H.-W. Lee, J.-H. Lee, J.-W. Son (KIST, Korea)

11:20 OB-20 **YSZ Films Prepared by Reactive Magnetron Sputtering: Effect of the Thickness on the Electrical Properties**
P. Briois (IRTES-LERMPS, UTBM, France), L. Yu (LEPMI, INPG-ENSEEG, France), M.A.P. Yazdi (IRTES-LERMPS, UTBM, France), S. Georges (LEPMI, INPG-ENSEEG, France), A. Billard (IRTES-LERMPS, UTBM, France)

11:40 OB-21 **Atomic Layer Deposition, a Key Technique for Processing Thin-Layered SOFC Materials - Case of Epitaxial Thin Layers of CeO_2 Catalyst**
A. Marizy, T. Désaunay, D. Chery (CNRS, ENSCP Chimie-Paristech, PSL, France), P. Roussel (CNRS, Ecole Nationale Supérieure de Chimie de Lille, France), A. Ringuedé, M. Cassir (CNRS, ENSCP Chimie-Paristech, PSL, France)

12:00-13:30 Lunch & Poster Session

Electrolyte/Thin Film III

Co-Chair(s): Enrico Traversa and Shaorong Wang

13:30 OB-22 **Performance of Ultra-Thin Film Solid Oxide Fuel Cells in Methane and Natural Gas Fuels: The Role of Electrode Microstructure**
Y. Takagi, K. Kerman, S. Ramanathan (Harvard University, USA)

13:50 OB-23 **Electrical Characterization of YSZ Thin Films Using a Calibrated Platinum Micro-Electrode**
S. Georges, N. Bailly, E. Djurado (LEPMI, CNRS-Grenoble INP-Université de Savoie-Université Joseph Fourier, France)

Proton Conducting Fuel Cells

Co-Chair(s): Enrico Traversa and Shaorong Wang

14:10 OB-24 **Advanced Electrodes for Intermediate Temperature Proton Conducting Fuel Cell**
G. Taillades, P. Pers, P. Batocchi, M. Taillades (Université Montpellier 2, France)

14:30 OB-25 **Micro-Protonic Ceramic Fuel Cells with Y:$BaZrO_3$ Electrolyte Prepared by Pulsed Laser Deposition (PLD)**
K. Bae, D.Y. Jang, H. Jung, J.W. Kim (Korea University, Korea), J.-W. Son (KIST, Korea), J.H. Shim (Korea University, Korea)

14:50-15:10 Coffee Break

Sealing

Co-Chair(s): Enrico Traversa and Shaorong Wang

15:10	OB-26	**Effect of Ceramic Filler Particles on the Sealing Capability of a SrO-Based Glass Seal** H.-J. Je, K.J. Yoon, J.-W. Son, J.-H. Lee, B.-K. Kim, H.-W. Lee (KIST, Korea)
15:30	OB-27	**SOFC Sealing with Thermiculite 866 and Thermiculite 866 LS** J.R. Hoyes (Flexitallic Ltd., UK), M. Rautanen (VTT, Finland)
15:50	OB-28	**Long Term Behavior of Viscous High-Temperature Sealing Glasses** J. Suffner, C. Dobler (Schott AG, Germany)
16:10	OB-29	**Glass Ceramic Seal for Electrochemical Devices** S.T. Reis (Saint-Gobain Innovative Materials, USA), M. Schwartz (Saint-Gobain Recherche, France)

16:30-18:30 Poster Session (Co-Chairs: Fumitada Iguchi and Bilge Yildiz)

Wednesday, October 9, 2013

Theater

New Applications II

Co-Chair(s): Norbert Menzler and Gyeong Man Choi

9:00 OT-30 **300 W SOFC-Generator with Endothermic Reforming of Propane and Other Innovative Concepts**
C. Szepanski, A. Lindermeir, R.-U. Dietrich (CUTEC Institut GmbH, Germany), S. Stenger, R. Leithner (TU Braunschweig, Germany), R. Deichmann, L. Dörrer, G. Borchardt (TU Clausthal, Germany)

9:20 OT-31 **Direct Flame Fuel Cell Performance Using a Multi-Element Diffusion Flame Burner**
Y.Q. Wang, Y.X. Shi, X.K. Yu, N.S. Cai, S.Q. Li (Tsinghua University, China)

Cell Design and Performance I

Co-Chair(s): Norbert Menzler and Gyeong Man Choi

9:40 OT-32 **Development of Medium-Temperature Solid Oxide Fuel Cell Materials and Single Cells in Estonia**
E. Lust, G. Nurk, P. Möller, I. Kivi, R. Kanarbik, K. Tamm, A. Heinsaar (University of Tartu, Estonia)

10:00 OT-33 **Performance of Tubular Direct Carbon Fuel Cell Based On a Anode Support Solid Oxide Fuel Cell**
T.-H. Lim, J.-W. Lee, S.-B. Lee, S.-J. Park, R.-H. Song (KIER, Korea)

10:20-10:40 Coffee Break

10:40 OT-34 **"Evolved Materials and Innovative Design for High Performance, Durable and Reliable SOFC Cell and Stack" Presentation and Status of the European Project EVOLVE**
R. Costa, A. Ansar (German Aerospace Center, Germany)

11:00 OT-35 **Fabrication of Laminate-type SOFC; Printed Fuel Cell**
S. Suda (Shizuoka University, Japan), J.P. Wiff, S. Shimada (FCO Power Inc., Japan)

11:20 OT-36 **Fabrication and Performance of Ceramic Anode-Supported Solid Oxide Fuel Cells**
Z. Yang, Z. Pang, T. Zhu, Z. Zheng, M. Han (China University of Mining and Technology, China)

11:40 OT-37 **Cathode Supports of SOFCs with a Hierarchical Pore Structure**
D.H. Dong, X. Shao, Z.T. Wang, G.M. Parkinson, C.-Z. Li (Curtin University of Technology, Australia)

12:00-18:30 Excursion (optional)
18:30-21:00 Banquet

Room A

Processing

Co-Chair(s): Jean-Marc Bassat and San Ping Jiang

9:00 OA-30 **Microstructural Engineering of SOFC and SOEC Electrode Interfaces**
J.T.S. Irvine (University of St Andrews, UK)

9:20 OA-31 **SOFC Anode Fabricated by Magnetically Aligning of Ni Particles**
K. Nagato, N. Shikazono (The University of Tokyo, Japan), A. Weber, D. Klotz (Karlsruher Institut für Technologie, Germany), M. Nakao (The University of Tokyo, Japan), E. Ivers-Tiffée (Karlsruher Institut für Technologie, Germany)

9:40 OA-32 **Core-Shell Structured $Sr_{0.88}Y_{0.08}TiO_3$-$Ce_{0.8}Sm_{0.2}O_{1.9}$ Composite as an Anode for Solid Oxide Fuel Cells Operating with CH_4**
W. Yang, Z. Ma, C. Sun, L. Chen (Key Laboratory for Renewable Energy, Chinese Academy of Sciences, China)

10:00 OA-33 **Novel In-situ Sintering Spinel Composite Cathodes for Metal Supported SOFCs**
E. Dietzen, N. Trofimenko, M. Kusnezoff, V. Sauchuk, C. Belda, A. Michaelis (Fraunhofer Institute of Ceramic Technologies and Systems, Germany)

10:20-10:40 Coffee Break

Cathode I

Co-Chair(s): Jean-Marc Bassat and San Ping Jiang

10:40 OA-34 **Oxygen Electrode Kinetics and Surface Composition of Dense $(La_{0.75}Sr_{0.25})_{0.95}MnO_3$ on YSZ**
Y. Wu, K.V. Hansen, K. Norrman, T. Jacobsen, M.B. Mogensen (Technical University of Denmark, Denmark)

11:00 OA-35 **Impact of Chemical Composition of Strontium-Doped Lanthanum Manganite Cathode on Microstructural Change and Performance During Long-Term Operation of SOFCs**
T. Matsui, Y. Mikami, H. Muroyama, K. Eguchi (Kyoto University, Japan)

11:20 OA-36 **Equivalent Circuit Model Analysis of LSM/ScSZ Composite Cathodes Prepared by Impregnating LSM/ScSZ Powder Slurry into a Prefabricated Porous ScSZ Layer**
H. Shimada (Tokyo Institute of Technology, Japan), A. Hagiwara (Tokyo Electric Power Company Inc., Japan), M. Ihara (Tokyo Institute of Technology, Japan)

11:40 OA-37 **The Application of Ion Beam Analysis to Mass Transport Studies in Mixed Electronic Ionic Conducting Electrodes**
J.A. Kilner, H.T. Lozano, M. Burriel, S. Cook (Imperial College London, UK), J. Druce (Kyushu University, Japan)

12:00-18:30 Excursion (optional)
18:30-21:00 Banquet

Room B

Modeling and Simulation I

Co-Chair(s): Olaf Deutschmann and Tomofumi Tada

9:00 OB-30 **Ab Initio Calculation of the Defect Structure of Ceria**
M. Martin, T. Zacherle, A. Schriever, R.A. De Souza, S. Grieshammer (RWTH Aachen University, Germany)

9:20 OB-31 **Computational Studies on Ionic and Electronic Conduction of Rare-Earth-Based Oxides Based on Density Functional Theory**
M. Sakaue, H. Kasai (Osaka University, Japan), T. Ishihara (Kyushu University, Japan)

9:40 OB-32 **Determining Surface Chemistry and Vibrational Properties of SOFC Anode Materials Through Ab Initio Calculations**
M. Parkes (Imperial College London, UK), K. Refson (Rutherford Appleton Laboratory, UK), M. d'Avezac (University College London, UK), G. Offer, N. Brandon (Imperial College London, UK), N. Harrison (Rutherford Appleton Laboratory, UK)

10:00 OB-33 **First-Principles Calculations of the Anodic Oxidation Reactions of Solid Oxide Fuel Cell: Oxygen Potential Effect on Nickel (111) Surface**
S. Liu, T. Ishimoto, H. Kohno, M. Koyama (Kyushu University, Japan)

10:20-10:40 Coffee Break

10:40 OB-34 **Parallelized Meso-Scale Kinetic Monte Carlo Simulations for SOFC Characterization**
T. Tada (Tokyo Institute of Technology, Japan), N. Watanabe (Mizuho Information and Research Institute, Inc., Japan)

11:00	OB-35	**Coverage Dependent Thermodynamics for Sulfur Poisoning of Ni Based Anodes** D.S. Monder (IIT Hyderabad, India), K. Karan (University of Calgary, Canada)
11:20	OB-36	**Theoretical Study on the Effect of Three-Dimensional Porous Structure on the Sintering of Nickel Nanoparticles in the Ni/YSZ Anode** J. Xu, Y. Higuchi, N. Ozawa, K. Sato, T. Hashida, M. Kubo (Tohoku University, Japan)
11:40	OB-37	**Cellular Automata Modelling of Microstructure Evolution of Ni Cermet Anode** X. Wang, A. Atkinson (Imperial College London, UK)

12:00-18:30 Excursion (optional)
18:30-21:00 Banquet

Thursday, October 10, 2013

Theater

Durability and Reliability I

Co-Chair(s): Mark Williams and Harumi Yokokawa

9:00 OT-38 **A Global Framework for Examination of Degradation in SOFC**
K. Gerdes (U.S. DOE, NETL, USA), M.C. Williams (URS Corp., USA), R. Gemmen, B. White (U.S. DOE, NETL, USA)

9:20 OT-39 **Report of Five-Year NEDO Project on Durability/Reliability of SOFC Stacks**
H. Yokokawa (AIST / The University of Tokyo, Japan)

9:40 OT-40 **Durability Verification of Residential SOFC CHP System**
M. Suzuki, Y. Takuwa, S. Inoue, K. Higaki (Osaka Gas Co., Ltd., Japan)

10:00 OT-41 **Chemical Degradation of SOFCs: External Impurity Poisoning and Internal Diffusion-Related Phenomena**
K. Sasaki, T. Yoshizumi, K. Haga, H. Yoshitomi, T. Hosoi, Y. Shiratori, S. Taniguchi (Kyushu University, Japan)

10:20-10:40 Coffee Break

10:40 OT-42 **Multimodal Assessment of Durability and Reliability of Flattened Tubular SIS Stacks**
Y. Matsuzaki, K. Nakamura, T. Somekawa, K. Fujita (Tokyo Gas Co., Ltd., Japan), T. Horita, K. Yamaji, H. Kishimoto (AIST, Japan), M. Yoshikawa, T. Yamamoto, Y. Mugikura (Central Research Institute of Electric Power Industry, Japan), H. Yokokawa, N. Shikazono (The University of Tokyo, Japan), K. Eguchi, T. Matsui (Kyoto University, Japan), S. Watanabe, K. Sato, T. Hashida, T. Kawada (Tohoku University, Japan), K. Sasaki, S. Taniguchi (Kyushu University, Japan)

11:00 OT-43 **Durability Testing of a Short SOFC Stack under Direct Internal Steam Reforming of Methane**
Q. Fu (European Institute for Energy Research, Germany), P. Freundt (ElringKlinger AG, Germany), J. Bomhard (European Institute for Energy Research, Germany), F. Hauler (ElringKlinger AG, Germany)

11:20 OT-44 **Local Activation and Degradation of Electrochemical Processes in a SOFC**
Z. Wuillemin, Y. Antonetti, C. Beetschen, O. Millioud (HTceramix SA, Switzerland), S. Ceschini (SOFCpower SpA, Italy), H. Madi, J. Van herle (Ecole Polytechnique Fédérale de Lausanne, Switzerland)

11:40 OT-45 **Intelligent Analysis for Evaluating Physical Degradation using Acoustic Emission**
K. Fukui (Osaka University, Japan), K. Sato, T. Hashida, J. Mizusaki (Tohoku University, Japan), M. Numao (Osaka University, Japan)

12:00-13:30 Lunch & Poster Session

Durability and Reliability II

Co-Chair(s): Viola Birss and Jong-Ho Lee

13:30 OT-46 **Application of FIB-TOF-SIMS and FIB-SEM-EDX Methods for the Analysis of Element Mobility in Solid Oxide Fuel Cells**
R. Kanarbik, P. Möller, I. Kivi, E. Lust (University of Tartu, Estonia)

13:50 OT-47 **Microstructural Change of Ni–YSZ Anode under Thermal Cycles with Redox Treatments**
M. Kubota, H. Muroyama, T. Matsui, K. Eguchi (Kyoto University, Japan)

14:10 OT-48 **Surface Segregation and Chromium Deposition and Poisoning on $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ Cathodes of Solid Oxide Fuel Cells**
L. Zhao (Curtin University, Australia), J. Drennan (The University of Queensland, Australia), C. Kong (The University of New South Wales, Australia), S. Amarasinghe (Ceramic Fuel Cells Ltd., Australia), S.P. Jiang (Curtin University, Australia)

14:30	OT-49	**Chromium Poisoning of $La_2NiO_{4+\delta}$ Cathodes** S.-N. Lee, A. Atkinson, J. Kilner (Imperial College London, UK)
14:50-15:10		Coffee Break
15:10	OT-50	**Sulfur Poisoning of Ni/Stabilized-Zirconia Anodes – Effect on Long-Term Durability** A. Hauch, A. Hagen, J. Hjelm, T. Ramos (Technical University of Denmark, Denmark)
15:30	OT-51	**Cubic-Tetragonal Phase Transformation of YSZ Electrolyte in SOFCs** T. Shimonosono, H. Kishimoto, M. Nishi, M.E. Brito, K. Yamaji, H. Yokokawa, T. Horita (AIST, Japan)
15:50	OT-52	**The Effect of Ferroelasticity of $La_{1-x}Sr_xCo_{1-y}Fe_yO_{3-\delta}$ on the Mechanical Stability of Solid Oxide Fuel Cells** Y. Kimura (Tohoku University, Japan), J. Tolchard, M.-A. Einarsrud, T. Grande (Norwegian University of Science and Technology, Norway), K. Amezawa, S. Hashimoto, T. Kawada (Tohoku University, Japan)
16:10	OT-53	**Chemical Expansion in SOFC Materials: Ramifications, Origins, and Mitigation** S.R. Bishop (Kyushu University, Japan), D. Marrocchelli (Massachusetts Institute of Technology, USA), N. Perry (Kyushu University, Japan), H.L. Tuller (Massachusetts Institute of Technology, USA), G. Watson (Trinity College Dublin, Ireland), B. Yildiz (Massachusetts Institute of Technology, USA), K. Amezawa (Tohoku University, Japan), J. Kilner (Imperial College London, UK)
16:30-18:30		Poster Session (Co-Chairs: Shin-ichi Hashimoto and Yueping Xiong)

Room A
Cathode II
Co-Chair(s): John Kilner and Keiji Yashiro

9:00	OA-38	**Defect Structure of $BaCo_{0.7}Fe_{0.22}Nb_{0.08}O_{3-\delta}$** T. Lee, H.-I. Yoo (Seoul National University, Korea)
9:20	OA-39	**Influence of Donor Doping on Cathode Performance: $(La,Sr)(Ti,Fe)O_{3-\delta}$ Case Study** N.H. Perry (Kyushu University, Japan), D. Pergolesi (Paul Scherrer Institut, Switzerland), K. Sasaki, S.R. Bishop, H.L. Tuller (Kyushu University, Japan)
9:40	OA-40	**Electrochemical Properties of $Sm_{0.5}Sr_{0.5}Co_{1-x}Nb_xO_{3-\delta}$ (x = 0, 0.1) as Cathode Materials in Intermediate Temperature-Solid Oxide Fuel Cells** S. Yoo, A. Jun (Ulsan National Institute of Science and Technology, Korea), J. Shin (Dong-Eui University, Korea), G. Kim (Ulsan National Institute of Science and Technology, Korea)
10:00	OA-41	**$Tb_xCe_{0.95-x}Gd_{0.05}O_{2-\delta}$ ($0.15 \leq x \leq 0.40$) Cathode Materials Prepared through Solid State Route for Low Temperature SOFC** R. Chockalingam, S. Basu (IIT Delhi, India)
10:20-10:40		Coffee Break
10:40	OA-42	**Surface Chemistry and Non-Stoichiometry of $Nd_2NiO_{4+\delta}$ Epitaxial Thin Films with Different Orientation and Strain** N. Tsvetkov, Q. Lu, Y. Chen, B. Yildiz (Massachusetts Institute of Technology, USA)
11:00	OA-43	**Highlights on the Anisotropic Oxygen Transport Properties of Nickelates with K_2NiF_4-Type Structure: Links with the Electrochemical Properties of the Corresponding IT-SOFC's Cathodes** J.M. Bassat (CNRS, Université de Bordeaux, ICMCB, France), M. Burriel (Imperial College London, UK), M. Ceretti (Institut Charles Gerhardt, France), P. Veber, J.C. Grenier (CNRS, Université de Bordeaux, ICMCB, France), W. Paulus (Institut Charles Gerhardt, France), J.A. Kilner (Imperial College London, UK)

11:20 OA-44 **Compatibility of Praseodymium Nickelates with Various Cathode Current Collectors and Electrolytes**
E. Dogdibegovic (University of South Carolina, USA), J. Templeton (Pacific Northwest National Laboratory, USA), J. Yan (University of South Carolina, USA), J.W. Stevenson (Pacific Northwest National Laboratory, USA), X.-D. Zhou (University of South Carolina, USA)

11:40 OA-45 **Lanthanide Nickelates $Ln_2NiO_{4+\delta}$ (Ln = La, Pr or Nd): Promising Cathode Materials for Metal Supported Cells**
J.C. Grenier, A. Flura, S. Dru, C. Nicollet, V. Vibhu, S. Fourcade, A. Rougier, J.M. Bassat (CNRS-Univ. Bordeaux, ICMCB, France), A. Brevet, J. Mougin (CEA-Grenoble, France)

12:00-13:30 Lunch & Poster Session

Cathode III

Co-Chair(s): Jean-Claude Grenier and Naoki Shikazono

13:30 OA-46 **Electronic Activation at Oxide Hetero-Structure at Elevated Temperatures – Source of Markedly Accelerated Oxygen Reduction Kinetics**
Y. Chen, Z. Cai, Y. Kuru, H.L. Tuller, B. Yildiz (Massachusetts Institute of Technology, USA)

13:50 OA-47 **(La,Ba)CoO_3 and $Pr_{1.9}$(Ni,Cu,Ga)O_4 Composite Oxide as Active Cathode for Intermediate Temperature Solid Oxide Fuel Cells Using Doped $LaGaO_3$ Electrolyte Films**
J.-E. Hong, J. Xie, S. Ida, T. Ishihara (Kyushu University, Japan)

14:10 OA-48 **Effect of Cation Nonstoichiometry on Surface Reactivity of $LaCoO_3$-Based Cathode**
A. Takeshita, S. Miyoshi, S. Yamaguchi (The University of Tokyo, Japan), T. Kudo, Y. Sato (JX Nippon Oil & Energy Corporation, Japan)

14:30 OA-49 **The Effect of Cation Substitution on Chemical Stability of $Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_{3-\delta}$-Based Mixed Conductors**
F. Wang, T. Nakamura, K. Yashiro, J. Mizusaki, K. Amezawa (Tohoku University, Japan)

14:50-15:10 Coffee Break

Modeling and Simulation II

Co-Chair(s): Jean-Claude Grenier and Naoki Shikazono

15:10 OA-50 **Internal Multi-Physics Phenomena of SOFC with Direct Internal Reforming**
V. Menon (Karlsruhe Institute of Technology, Germany), V.M. Janardhanan (IIT Hyderabad, India), S. Tischer, O. Deutschmann (Karlsruhe Institute of Technology, Germany)

15:30 OA-51 **Three-Dimensional Design Optimization of an Anode-Supported SOFC Using FEM**
M. Andersson, J. Yuan, B. Sundén (Lund University, Sweden)

15:50 OA-52 **Impact of Manifolding on Performance of a Solid Oxide Fuel Cell Stack**
R.T. Nishida (Queen's-RMC Fuel Cell Research Centre, Canada), S.B. Beale (National Research Council, Canada), J.G. Pharoah (Queen's-RMC Fuel Cell Research Centre, Canada)

16:10 OA-53 **Three-Dimensional Numerical Simulations of Heat and Mass Transfer and Degradation in a SOFC Cell Stack**
T. Mori, K. Nishimura, M. Suzuki (Osaka Gas Co., Ltd., Japan)

16:30-18:30 Poster Session (Co-Chairs: Shin-ichi Hashimoto and Yueping Xiong)

Friday, October 11, 2013

Theater

Electrolysis

Co-Chair(s): Mogens Mogensen and Rak-Hyun Song

9:00	OT-54	**Biogas Upgrading: By Steam Electrolysis or Co-Electrolysis of Biogas and Steam?** J.B. Hansen (Haldor Topsøe A/S, Denmark), F. Fock, H.H. Lindboe (Ea Energianalyse A/S, Denmark)
9:20	OT-55	**Performance and Stability of High Temperature Solid Oxide Electrolysis Cells (SOECs) for Hydrogen Production** K.J. Yoon, J.-W. Son, J.-H. Lee, B.-K. Kim, H.-J. Je, H.-W. Lee (KIST, Korea)
9:40	OT-56	**Performances of Doped Ceria Hydrogen Electrodes with Highly Dispersed Ni-Based Nanoparticles for Solid Oxide Electrolysis Cells** H. Uchida, P. Puengjinda, K. Miyano, H. Nishino, K. Kakinuma, S. Deki, M. Watanabe (University of Yamanashi, Japan)
10:00	OT-57	***In-Operando* Raman Spectroscopy Study of Passivation Effects on Ni-CGO Electrodes in CO_2 Electrolysis Conditions** V. Duboviks, R.C. Maher, G. Offer, L.F. Cohen, N.P. Brandon (Imperial College London, UK)
10:20-10:40		Coffee Break
10:40	OT-58	**Carbon Deposits and Pt/YSZ Overpotentials in CO/CO_2 Solid Oxide Electrochemical Cells** Y. Yu, A. Geller (University of Maryland, USA), B. Mao, R. Chang, Z. Liu (Lawrence Berkeley National Laboratory, USA), B.W. Eichhorn (University of Maryland, USA)
11:00	OT-59	**Reversing and Repairing Microstructure Degradation in Solid Oxide Cells During Operation** C. Graves (Technical University of Denmark, Denmark)
11:20	OT-60	**Stability of Interface between YSZ Electrolyte and GDC Interlayer in Solid Oxide Electrolysis Cell** S.J. Kim, G.M. Choi (POSTECH, Korea)
11:40	OT-61	**Innovative Dual Membrane Architecture for Reversible Fuel Cells** M. Viviani (CNR-IENI, Italy), A.S. Thorel (Mines-Paris Tech, France), A. Barbucci (University of Genoa, Italy), D. Vladikova (IEES-BAS, Bulgaria), A. Chesnaud (Mines-Paris Tech, France), I. Genov, G. Raikova (IEES-BAS, Bulgaria), E. Mercadelli, A. Sanson (CNR-ISTEC, Italy), M.P. Carpanese (University of Genoa, Italy), Z. Stoynov (IEES-BAS, Bulgaria), S. Presto (CNR-IENI, Italy), P. Piccardo (University of Genoa, Italy)
12:00-12:20		Closing (Tatsuya Kawada and Subhash Singhal)

Room A

Modeling and Simulation III

Co-Chair(s): Toshiaki Matsui and Steven Shy

9:00	OA-54	**Characteristic Length of Oxide-Ion Conduction for Prediction of Active Thickness in SOFC Anode** M. Kishimoto, H. Iwai, M. Saito, H. Yoshida (Kyoto University, Japan)
9:20	OA-55	**Microstructural Modeling and Effective Properties of Infiltrated SOFC Electrodes** A. Bertei (University of Pisa, Italy), J.G. Pharoah, D.A.W. Gaweł (Queen's-RMC Fuel Cell Research Centre, Canada), C. Nicolella (University of Pisa, Italy)
9:40	OA-56	**Recent Developments of 3D Coupled Multiphysics SOFC Modelling at Forschungszentrum Jülich** M. Peksen, A. Al-Masri, R. Peters, L. Blum, D. Stolten (Forschungszentrum Jülich, Germany)

10:00	OA-57	**Three-Dimensional Performance Model for Oxygen Transport Membranes** A. Häffelin, C. Niedrig, S. Wagner, A. Weber, E. Ivers-Tiffée (Karlsruhe Institute of Technology, Germany)
10:20-10:40		Coffee Break
10:40	OA-58	**Advanced 3D Imaging and Analysis of SOFC Electrodes** F. Tariq, M. Kishimoto, S.J. Cooper (Imperial College London, UK), P. Shearing (University College London, UK), N. Brandon (Imperial College London, UK)
11:00	OA-59	**Electrode Reoxidation in Solid-Oxide Cells: Detailed Modeling of Nickel Oxide Film Growth** J.P. Neidhardt (German Aerospace Center, Germany), R.J. Kee (Colorado School of Mines, USA), W.G. Bessler (Offenburg University of Applied Sciences, Germany)
11:20	OA-60	**Enhancing SOFC-Stack Performance by Model-Based Adaptation of Cathode Gas Transport Conditions** H. Geisler, M. Kornely, A. Weber, E. Ivers-Tiffée (Karlsruhe Institute of Technology, Germany)
11:40	OA-61	**Developing 3-D Model of Intermediate-Temperature SOFC with GDC Electrolyte** L. Wang (University of Maryland, USA), G.S. Jackson (Colorado School of Mines, USA), B.M. Blackburn (Redox Power Systems LLC, USA)

(二)10/6 修改之議程

	Oct. 8 (Tue.)			Oct.9 (Wed.)			Oct. 10 (Thu.)			Oct. 11 (Fri)		
	Theater	Room A	Room B	Theater	Room A	Room B	Theater	Room A	Room B	Theater	Room A	Room B
9:00-9:20	Opening			OT-30	OA-30	OB-30	OT-04	OT-38	OA-38	OT-54	OA-54	OA-06
9:20-9:40	OT-01 (Plenary-1)			OT-31	OA-31	OB-31	OT-05	OT-39	OA-39	OT-55	OA-55	OA-07
9:40-10:00	OT-02 (Plenary-2)			OT-32	OA-32	OB-32	OT-06	OT-40	OA-40	OT-56	OA-56	OA-09
10:00-10:20	OT-03 (Plenary-3)			OT-33	OA-33	OB-33	OT-07	OT-41	OA-41	OT-57	OA-57	
10:20-10:40	Break			Break			Break			Break		
10:40-11:00	OT-18	OA-18	OB-17	OT-34	OA-34	OB-34	OT-08	OT-42	OA-42	OT-58	OA-58	OA-10
11:00-11:20	OT-19	OA-19	OB-19	OT-35	OA-35	OB-35	OT-09	OT-43	OA-43	OT-59	OA-59	OA-11
11:20-11:40	OT-20	OA-20	OB-20	OT-36	OA-36	OB-36	OT-10	OT-44	OA-44	OT-60	OA-60	OA-12
11:40-12:00	OT-21	OA-21	OB-21	OT-37	OA-37	OB-37	OT-11	OT-45	OA-45	OT-61	OA-61	OA-13
12:00-12:20				OT-16	OA-16	OB-18				Closing		
12:20-12:40	Lunch & Poster (12:00-13:30)			OT-17	OA-17		Lunch & Poster (12:00-13:30)					
12:40-13:30				Free time (Excursion)						Free time		
13:30-13:50	OT-22	OA-22	OB-22				OT-12	OT-46	OA-46			
13:50-14:10	OT-23	OA-23	OB-23				OT-13	OT-47	OA-47			
14:10-14:30	OT-24	OA-24	OB-24				OA-04	OT-48	OA-48			
14:30-14:50	OT-25	OA-25	OB-25				OA-05	OT-49	OA-49			
14:50-15:10	Break						Break					
15:10-15:30	OT-26	OA-26	OB-26					OT-50	OA-50			
15:30-15:50	OT-27	OA-27	OB-27					OT-51	OA-51			
15:50-16:10	OT-28	OA-28	OB-28					OT-52	OA-52			
16:10-16:30	OT-29	OA-29	OB-29					OT-53	OA-53			
16:30-16:50	OT-14	OA-14	OB-14									
16:50-17:10	OT-15	OA-15	OB-15				Poster (16:30-19:00)					
17:10-17:30												
17:30-17:50												
17:50-18:10	Poster (17:10-19:30)											
18:10-18:30												
18:30-18:50												
18:50-19:10												
19:10-19:30				(18:30-21:00)			Free time					
19:30-	Free time			Banquet								

(三)10/7 修改之議程

The revised oral program (as of Oct. 7)

	Oct. 8 (Tue.)			Oct.9 (Wed.)			Oct. 10 (Thu.)			Oct. 11 (Fri)		
	Theater	Room A	Room B	Theater	Room A	Room B	Theater	Room A	Room B	Theater	Room A	Room B
9:00-9:20	Opening			OT-30	OA-30	OB-30	OT-05	OT-38	OA-38	OT-54	OA-54	
9:20-9:40	OT-01 (Plenary-1)			OT-31	OA-31	OB-31	OT-06	OT-39	OA-39	OT-55	OA-55	
9:40-10:00	OT-02 (Plenary-2)			OT-32	OA-32	OB-32	OT-09	OT-40	OA-40	OT-56	OA-56	
10:00-10:20	OT-03 (Plenary-3)			OT-33	OA-33	OB-33	OT-10	OT-41	OA-41	OT-57	OA-57	
10:20-10:40	Break			Break			Break			Break		
10:40-11:00	OT-18	OA-18	OT-07	OT-34	OA-34	OB-34	OT-11	OT-42	OA-42	OT-58	OA-58	
11:00-11:20	OT-19	OA-19	OB-19	OT-35	OA-35	OB-35	OT-12	OT-43	OA-43	OT-59	OA-59	
11:20-11:40	OT-20	OA-20	OB-20	OT-36	OA-36	OB-36	OT-13	OT-44	OA-44	OT-60	OA-60	
11:40-12:00	OT-21	OA-21	OB-21	OT-37	OA-37	OB-37	P192	OT-45	OA-45	OT-61	OA-61	
12:00-12:20	Lunch & Poster (12:00-13:30)			OT-16	OA-16	OA-05	Lunch & Poster (12:00-13:30)			Closing		
12:20-12:40				OT-17	OA-17	OA-13						
12:40-13:00				OA-04	P048	OB-17						
13:00-13:30				Free time (Excursion)						Free time		
13:30-13:50	OT-22	OA-22	OB-22				OA-06	OT-46	OA-46			
13:50-14:10	OT-23	OA-23	OB-23				OA-07	OT-47	OA-47			
14:10-14:30	OT-24	OA-24	OB-24				OA-09	OT-48	OA-48			
14:30-14:50	OT-25	OA-25	OB-25				OA-10	OT-49	OA-49			
14:50-15:10	Break						Break					
15:10-15:30	OT-26	OA-26	OB-26				OA-11	OT-50	OA-50			
15:30-15:50	OT-27	OA-27	OB-27				OA-12	OT-51	OA-51			
15:50-16:10	OT-28	OA-28	OB-28					OT-52	OA-52			
16:10-16:30	OT-08	OA-29	OB-29					OT-53	OA-53			
16:30-16:50	OT-14	OA-14	OB-14				Poster (16:30-19:00)					
16:50-17:10	OT-15	OA-15	OB-15									
17:10-17:30	Poster (17:10-19:30)											
17:30-17:50												
17:50-18:10												
18:10-18:30												
18:30-18:50												
18:50-19:10												
19:10-19:30												
19:30-	Free time			(18:30-21:00) Banquet			Free time					

Dynamic Modeling and Control Design for a Planar Solid Oxide Fuel Cell

Dung-Di Yu* and Ruey-Yi Lee

Physics Division, Institute of Nuclear Energy Research, Taiwan

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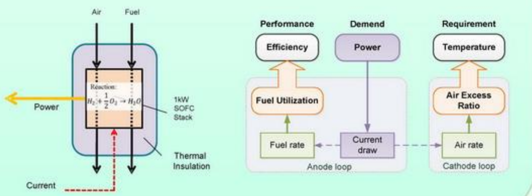
INTRODUCTION

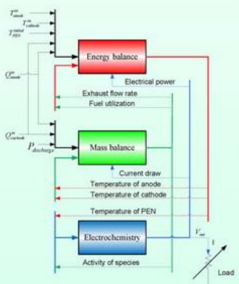
A preliminary control law, on the basis of the model-based analysis, is adopted to allow convenient integrations into a comprehensive power tracking control.

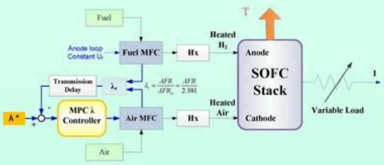
Under load change conditions, proper air excess ratios are regulated to stabilize the temperature of the stack and to avoid the occurrence of abrupt temperature gradients in the stack.



METHOD

Dynamic modeling methodology is utilized to develop the multi-disciplinary integration for assessment of characteristic of dynamic response as well as evaluation of strategy for startup process and of capacity for load tracking.





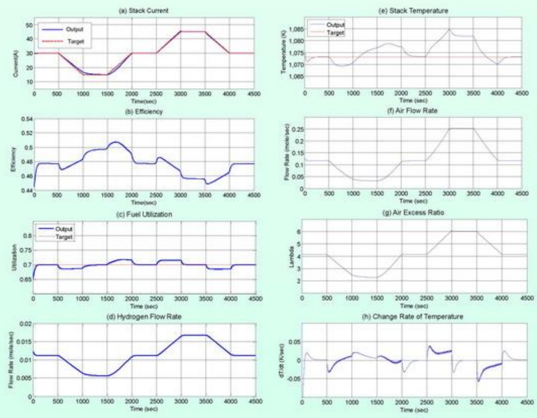
A methodology on regulating fuel utilization (U_f) and air excess ratio (λ) is implemented to validate alleviation of temperature fluctuation during variable load changing.

RESULTS

A predefined load profile ranging from 15A to 45A by 0.03A/sec for 500 seconds is imposed for investigation.

Anode: The stack current follows the current demand properly with little time delay, which is caused by the resistive load regulator on account of sluggish response of temperature and fluid, compared with current demand.

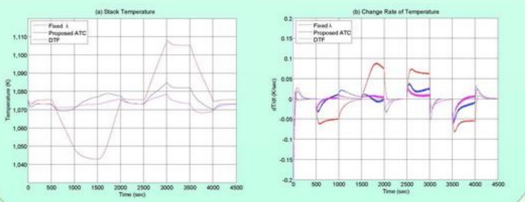
Cathode: Even though the current changes are imposed from 15A to 45A in ramp, the change rate of temperature keeps less than 0.06 K/sec by regulation of λ from 2.3 to 6.



A comparison between the proposed Advanced Temperature Control (ATC), the Fixed λ control, and the Direct Temperature Feedback (DTF) control is shown.

(1) The variation of the stack temperature can be effectively reduced compared with that by Fixed λ.

(2) Although not as good as DTF control, the proposed Advanced Temperature Control possesses a viable and comprehensive way for implementation.



CONCLUSION

The advanced temperature control strategy is employed in this study. The strategy, eliminating unpractical thermo-sensing from cell or exhaust, explores a simple relationship between the current draw and the modified air excess ratio. A significant alleviation in temperature variations provides the advantage to minimize operation risk and enhance the dynamic response during transient conditions.

Model-based design provides an efficient approach to set up a collective platform for rapid strategy development and validation. From perspective of system operation, the development of control strategies is an imperative issue in pursuing successful system implementation.

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