出國報告（出國類別：其他）

2015 New Devices for Energy Conversion and Storage 赴大陸(香港)出國報告

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派赴國家：中國大陸(香港)
出國期間：104 年 10 月 1 日~104 年 10 月 4 日
報告日期：104 年 10 月 16 日

摘 要

核能研究所於能源採集、轉換和儲存裝置、電漿環保能源技術、電漿鍍膜元件製備技術之研發卓有成效，而「2015 年 New Devices for Energy Conversion and Storage 國際研討會」探討主題為電催化 (Electrocatalysis)、太陽電池 (Solar Cells)、燃料電池 (Fuel Cells)、液流電池 (Flow batteries) 以及先進電池 (Advanced Batteries) 等能源轉換與儲存新裝置。其中，先進電池與核能研究所之薄膜鋰電池的關鍵技術極有相關，因此前往香港科技大學參加此會議以取得目前各國於能源採集、轉換和儲存裝置技術及元件之最新發展，可以作為核能研究所未來電漿鍍膜技術應用方向之參考。

本次參加研討會同時也以海報的方式發表研究成果，主要成果在提升錳酸鋰的單位體積電容量，提高薄膜鋰電池於微機電系統的應用範圍。參加此會議除了彰顯核能研究所之研發成果外，並能藉由會議專題討論了解大陸 (香港) 與國際間的研發現況，尋求可能引入的技術與相關的應用市場及合作機會，強化合作關係及裨益核能研究所研發技術，以利核能研究所相關計畫工作之加速推動。在本次會議的中，有學者指出富鋰之層狀正極材料為高電容量密度材料，鈉電池於 5-10 年內將會量產，而鋰硫電池乃未來儲能裝置的重點發展項目之一。另外，有學者利用電子奈米成像和 X 射線成像技術來觀察鋰電池於充放電時的成像變化情形，此技術十分的新穎。核能研究所在未來在開發儲能薄膜材料時，可以參考這些研究方法與研究成果，設計出更具競爭力的薄膜材料，結合現有的技術，進而發展出核能研究所的新型獨佔技術。在會議中與其他研究團隊相比較，核能研究所於電漿技術領域已具備良好基礎，也具有設備與技術上的優勢，如以商業化的角度來做改良，必能將此新型獨佔技術予以推廣至民生產業。

目　　次

圖目錄

一、目　的

「2015 年 New Devices for Energy Conversion and Storage 國際研討會」於 2015 年 10 月 1 日至 3 日在香港科技大學舉辦。本屆會議的探討主題為電催化 (Electrocatalysis)、太陽電池 (Solar Cells)、燃料電池 (Fuel Cells)、液流電池 (Flow batteries)以及先進電池 (Advanced Batteries) 等能源轉換與儲存新裝置，其中，先進電池與核能研究所之薄膜鋰電池的關鍵技術極有相關。因此參加本研討會的目的為彰顯核能研究所之研發成果，並能藉由會議專題討論了解大陸 (香港) 與國際間的研發現況，尋求可能引入的技術與相關的應用市場及合作機會，強化合作關係及裨益核能研究所研發技術，以利核能研究所評估未來電漿鍍膜技術發展薄膜鋰電池之參考。

二、過　程

本次公差之行程如下：

10 月 1 日　因受杜鵑颱風後續影響-更改飛機航班為 CI 903
08:50 自桃園國際機場出發，於當地時間 10:40 抵達香港赤鱲角國際機場。
從機場搭乘機場巴士 (A29) 與公車 (91M) 前往會議舉行地點(香港科技大學)，
於 14:30 到達會議場地，並且在 15:20 辦理完會議報到與註冊程序。

10 月 2 日　參加 2015 年 New Devices for Energy Conversion and Storage 國際研討會、
蒐集資研發資料，並於 18:00 海報發表核能研究所研究成果以及會議論文。

10 月 3 日　參加 2015 年 New Devices for Energy Conversion and Storage 國際研討會，
及蒐集資研發資料。

10 月 4 日　因受杜鵑颱風與彩虹颱風後續影響-更改飛機航班為 CI680
於當地時間 10:30 自香港科技大學出發，搭乘計程車與客運
前往香港赤鱲角國際機場。並於 13:30 自香港赤鱲角國際機場起飛
前往桃園國際機場，班機因颱風延遲了 30 分鐘，
返回台灣時間為 16:00，順利完成本次公差任務。

三、心　得

因為目前於核能研究所從事薄膜鋰電池的開發工作，所以投稿參加「2015 年 New Devices for Energy Conversion and Storage 國際研討會」。本次會議在香港科技大學舉辦，主要是探討能源轉換與儲存的新裝置，期望藉由本次的會議，收集有關儲能電池的相關資訊，以做為核能研究所往後研究發展的參考。

香港技大學創辦二十餘載便已連續三年蟬聯英國高等教育調查公司 QS 亞洲最佳大學排行榜之首，長期獲評為香港三所最佳高等學府之一。香港科技大學的位置在香港行政區域的東側(九龍區)，坐落在清水灣半島，面向清水灣，形成一個座山面海的格局，風景十分壯麗。香港科技大學因此有香港最美麗的校園之稱。

因為香港科技大學是一個座山面海的校園，地勢起伏很大，而會議的地點又與用餐處有一段距離，因此一天必須爬上爬下好幾回。往好處想的話，香港科技大學是一個運動的好地方。香港科技大學還有另外一個特色，大部分校園的建築物是由一個教學研究大樓群所組成，棟與棟相互連接形成一個教學研究大樓群，整個面積大約有兩個標準田徑場這麼大。因為人生地不熟，剛到香港科技大學時，詢問當地學生會場位置，學生回答「你知道的，學校就這麼一棟樓」，這棟樓就是-教學研究大樓群。香港科技大學的學生十分地國際化，除了本地香港學生，大陸學生，來自歐美和非洲的學生也非常的多。在香港科技大學內，英語、廣東話是最常聽見的語言，但普通話也慢慢地普遍。

本會議之內容以演講為主，另外有部分以海報的方式呈現，在會議舉辦的過程中，共計有 53 場學者演講，28 篇海報供與會者閱讀討論。發表研究成果演說的學者來自世界各地，以香港和中國大陸的學者最多，而來自台灣的學者有 3 位，來自歐洲、美國和大洋洲的學者也有接近半數 (圖 1)，十分地國際化。

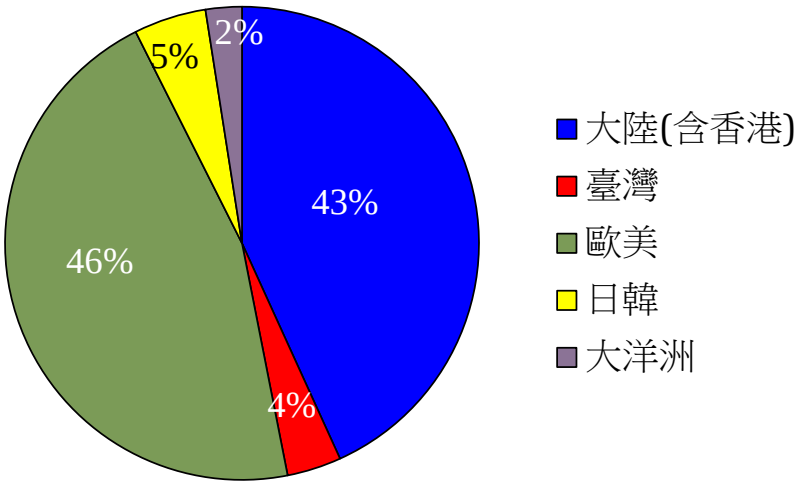


圖 1.參與會議的學者分布。

本研討會的目的為促進能源採集、轉換和儲存裝置的研究發展並進行學術與產業聯結互動，藉由參與研討會的科學家及工程師共同努力，尋求發展電漿鍍膜技術在新型能源元件的應用。會議現場分為兩個會議廳，分別以電催化 (Electrocatalysis)、太陽電池 (Solar Cells)、燃料電池 (Fuel Cells)、液流電池 (Flow batteries) 以及先進電池 (Advanced Batteries) 為討論

主題，其中以先進電池相關的發表最多約有 30 篇，大約佔了 35 %，其他主題則各有十篇左右 (圖 2)。

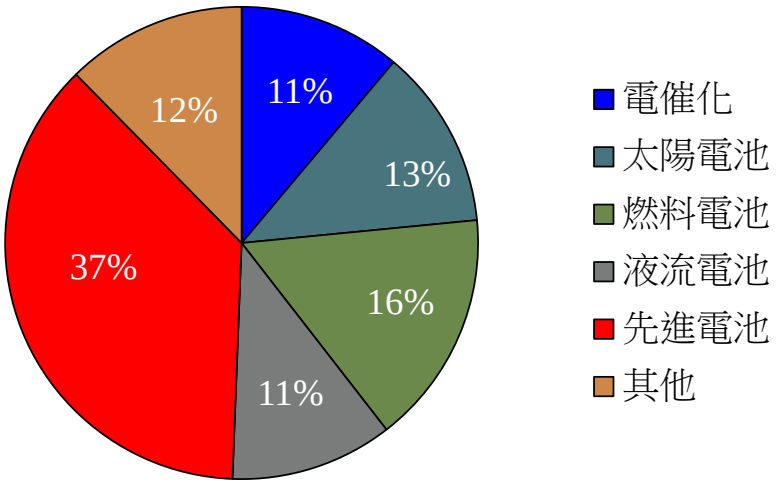


圖 2.參與會議的主題分布。

在先進電池的主題研究部分大約有 30 場，其中，傳統陰極材料只有 3 場，而先進的陰極材料以鈉電池、鋰硫電池與富鋰電池的研究較多 (圖 3)。

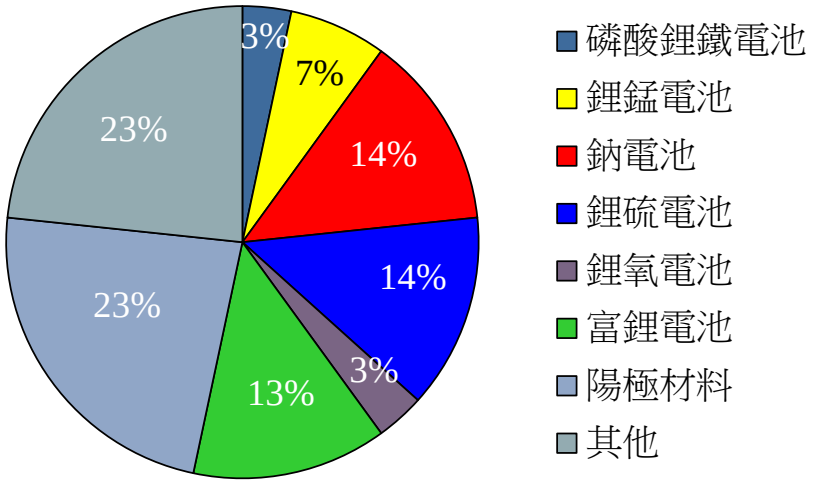


圖 3.先進電池主題研究內容分布。

另外，30 場的先進電池成果發表中，薄膜電池只有 2 場，塊材電池佔 28 場。本次會議沒有針對光電、熱電、壓電為主題的論文，也沒有電漿鍍膜鋰電池方面的論文，另外對全固態電池也很少有著墨 (圖 4)。

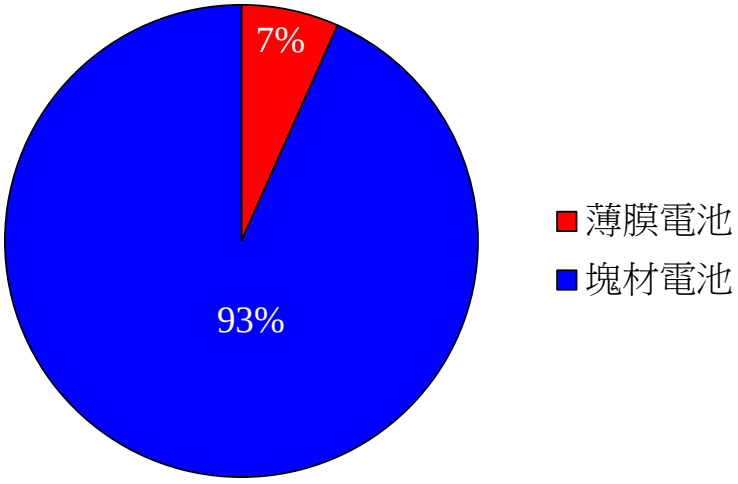


圖 4.電池的型態分布。

在會議現場分為兩個會議廳，同一時間進行演說發表，會議時程如圖 5 所示。每日會議從上午 9 點開始至下午 6 點結束，並於 10 月 2 日晚上 6 點到 7 點舉行海報的發表。先進電池 (Advanced Batteries) 的主題於 10 月 2 日和 10 月 3 日皆有安排演講或海報的發表。

Schedule

Day	Session	Location	Time
October 1	Registration	Lobby, Lo Ka Chung Building	14:00 – 18:00
	Dinner Reception	G/F Chinese Restaurant, Academic Building	18:30 – 20:30
October 2	Registration	Lobby, Lo Ka Chung Building	08:30 – 19:00
	Session A: Opening Remarks and Plenary Lecture I	Lecture Theater, Lo Ka Chung Building	09:00 – 10:20
	Session B: Electrocatalysis	Lecture Theater, Lo Ka Chung Building	10:50 – 12:40
	Session C: Solar Cells I	Room 1038, Lo Ka Chung Building	10:50 – 12:40
	Lunch	G/F Chinese Restaurant, Academic Building	12:50 – 14:00
	Session D: Plenary Lecture II	Lecture Theater, Lo Ka Chung Building	14:00 – 15:00
	Session E: Fuel Cells	Lecture Theater, Lo Ka Chung Building	15:20 – 17:55
	Session F: Solar Cells II	Room 1038, Lo Ka Chung Building	15:20 – 18:00
	Session G: Poster	Lobby, Lo Ka Chung Building	18:00 – 19:00
	Banquet	G/F Chinese Restaurant	19:10 – 21:10
October 3	Session H: Plenary Lecture III	Lecture Theater, Lo Ka Chung Building	09:00 – 10:00
	Session I: Advanced Batteries I	Lecture Theater, Lo Ka Chung Building	10:20 – 12:35
	Session J: Electrocatalysis II	Room 1038, Lo Ka Chung Building	10:20 – 12:40
	Lunch	G/F Chinese Restaurant, Academic Building	12:45 – 14:00
	Session K: Advanced Batteries II	Lecture Theater, Lo Ka Chung Building	14:00 – 17:50
	Session L: Flow Batteries, Supercapacitors, and Li-Air Batteries	Room 1038, Lo Ka Chung Building	14:00 – 17:55
	Session M: Closing Remarks and Poster Award	Lecture Theater, Lo Ka Chung Building	18:00 – 18:20

圖 5.國際研討會會議時程。

本研討會的會場位置在盧家驄薈萃樓 (圖 6)，位於校園的山頂側。這棟大樓是香港富商盧家驄於 20 世紀 90 年代期間捐助香港科技大學新台幣 3 億元，興建盧家驄薈萃樓並成立香港科技大學盧家聰大學中心。

圖 6.國際研討會會場。

研討會的會議現場分為兩個會議廳，而主演講會場為一階梯式的會議廳，可以容納 200 人左右 (圖 7)。

圖 7.國際研討會主演講會場。

研討會的海報會場在盧家驄薈萃樓的大廳舉行，位於主演講會場的出入口，因此海報會場於海報發表時可以看到絡繹不絕的學者或學生在相互討論 (圖 8)。

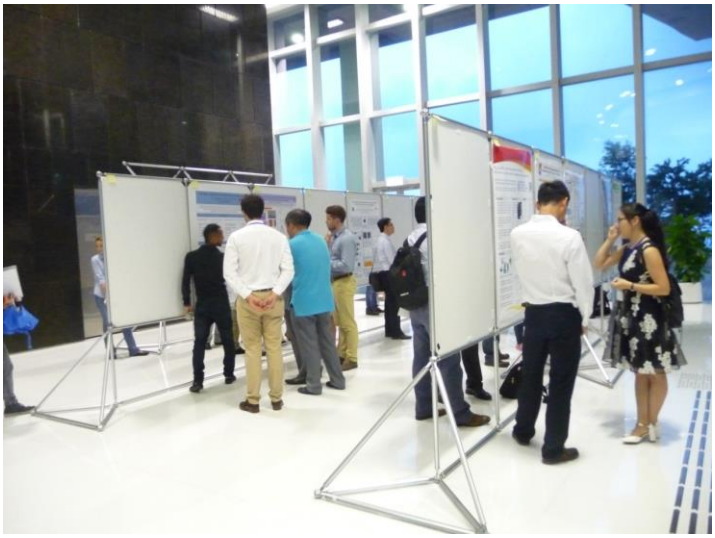


圖 8.研討會海報發表會場。

因為作者僅全程參與先進電池的相關議題，因此心得部分僅於先進電池部分的演講與海報內容進行說明與介紹。首先介紹香港科技大學與法國 De France 大學的 Jean-Marie 客座教授的主題演講，他的題目是如何製作好的鋰與鈉離子電池 (圖 9)，其演講內容是介紹鋰電池最新的發展趨勢，以下圖 10 ~ 圖 16 的部分為其演講的精要部分。

圖 9. 如何製作好的鋰與鈉離子電池。

Jean-Marie 首先介紹地球上的能源有煤，石油，天然氣，核能，太陽能，水力能，風能生質能等。將這些能源儲存起來也是一項重要的課題，而電池是化學能與電能間的轉換裝置。現今常見的商業化鋰電池技術中陰極材料為錳酸鋰 ($LiMn2O_4$)、鈷酸鋰 ($LiCoO_2$) 與磷酸鋰鐵 ($LiFePO_4$) 等，而常見的陽極材料為石墨 (C)、矽 (Si)和鋰鈦氧 ($Li_4Ti_5O_{12}$) 等 (圖 10)。

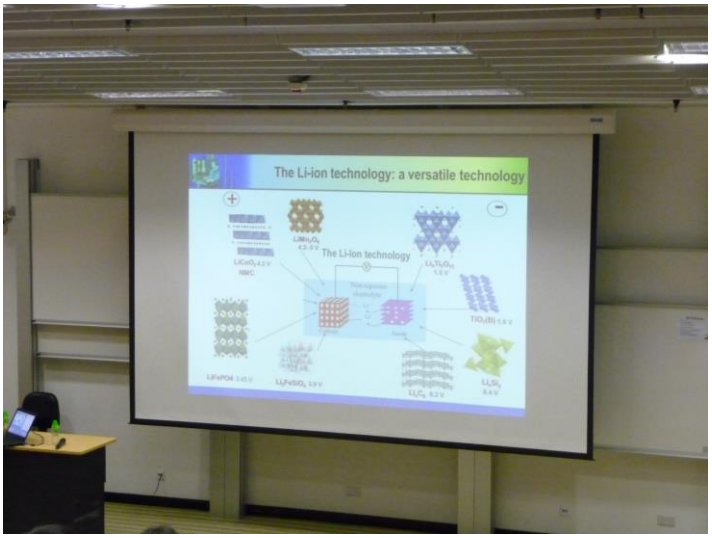


圖 10. 鋰電池商業化材料。

鋰電池不論是在手機或汽車等市場都已經成為不可缺少的零組件，也就是說鋰電池的市場呈現大而且多樣的趨勢(圖 11)，電池的市場很大，其進入市場的要件是低成本、高能量密度和環境的可持續發展。

圖 11. 鋰電池市場。

鋰等儲能電池的發展趨勢有二，一為增加能量密度，另一個為降低製造成本，前者乃研發新的活性材料，後者則是創造新的工程觀念。Jean-Marie 教授認為層狀結構的正極材料可以創造較高的電池能量密度，而特斯拉於 2015 年 4 月 30 日 採用多陰離子化合物 $Li(NiMnCo)O_2$ (NMC)為商用電池的陰極材料，其能量密度可以達到 180 $mAhg^{-1}$，而 $Li(LiNiMnCo)O_2$。此材料簡稱為 LLNMC，能量密度更可以高達 280 $mAhg^{-1}$ 以上，其原子排列可作為下一代鋰電池正極材料的範本 (圖 12)。

圖 12. NMC 原子排列。

另外，由於材料成本的考量，鈉的產量豐富，價格低廉及對環境友善 (圖 13)，自 2010 年起，鈉電池的研究如雨後春筍般的展開，然而，因為鈉離子的體積較鋰離子大，濃度極化效應較大，故電池的效能普遍低於鋰電池，目前比電容量可以達到 100 $mAhg^{-1}$ 左右，與錳酸鋰電池相當。因為成本的因素，鈉電池有機會在 5 - 10 年內進行量產，進而取代鋰電池。

圖 13. 鈉離子電池。

汽車的市場中，以性能來講是要求跑得遠和跑得快。目前的電動車的里程數與速度還是沒有汽燃車優異 (圖 14)，電動車無論是在能量密度和功率密度方面皆比汽油車還要差。而且相同里程數電動車比汽燃車還要重，這會降低電動車的性能。因此，電動車必須有更高電容量密度的電池材料。

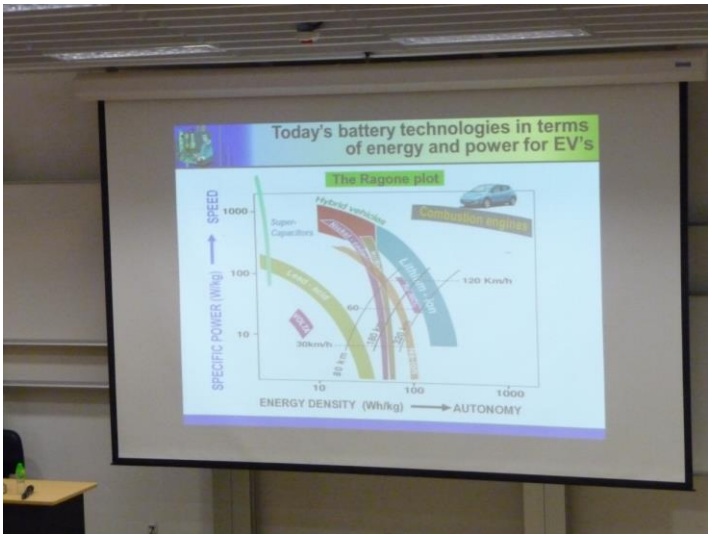


圖 14. The Ragone plot-汽車用電池。

可喜的是發展中的鋰硫電池與尚在研發中的鋰氧電池有機會突破儲能電池的劣勢。鋰硫電池的電位 2.2 V，其理論電容量密度可以高達 2567 $whkg^{-1}$ (1675 $mAhg^{-1}$)，而鋰氧電池的電位 3.0 V，其理論電容量密度更可以高達 3505 $whkg^{-1}$ (3828 $mAhg^{-1}$)(圖 15)。

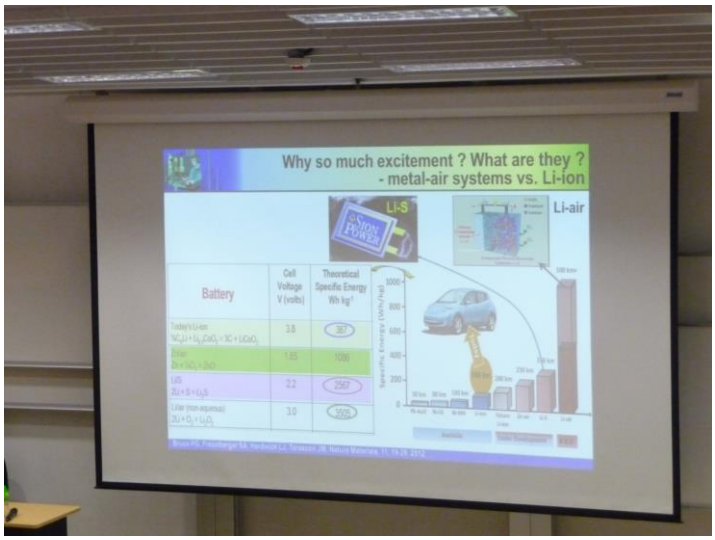


圖 15. 鋰硫電池與鋰氧電池。

總而言之，下一世代的鋰基電池將會進入富鋰多元系電池、鈉電池、陰極有機材料鋰電池、液流電池、鋰硫電池與鋰氧電池的世代 (圖 16)，其中任何一種電池都有可能完全或部分取代目前商業化鋰電池的地位。

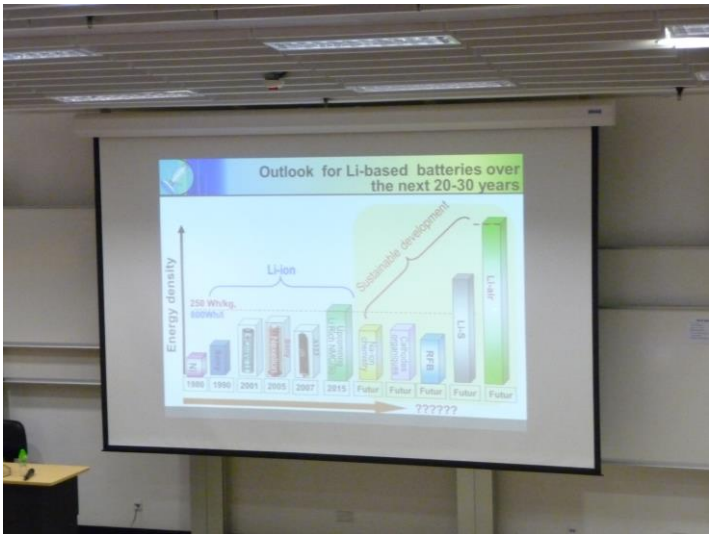


圖 16. 下一世代鋰基電池。

除了 Jean-Marie 教授有關鋰電池的主題演講，本會議有關先進電池的研究可以分為兩部分，一個為新的材料，另一個為新的分析技術。首先，新材料的部分來自大陸上海的上海交通大學 Zi-Feng Ma 教授鈉離子電池相關的研究成果 (圖 17)。

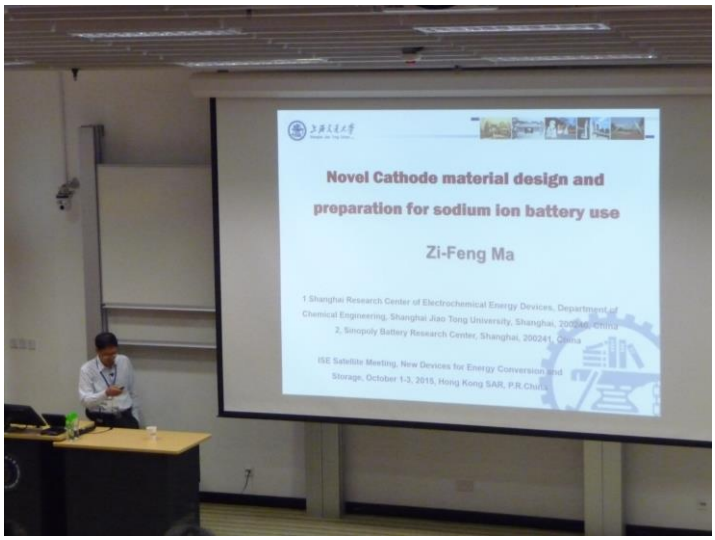


圖 17. 鈉離子電池設計。

鈉離子電子的主要訴求就是產量豐富、成本低與永續性高，而 Zi-Feng Ma 教授的研究團隊的鈉離子電池其比電容量可以達到 90 $mAhg^{-1}$。於 800 圈的充放電下，電容僅下降約 10 % (圖 18)。

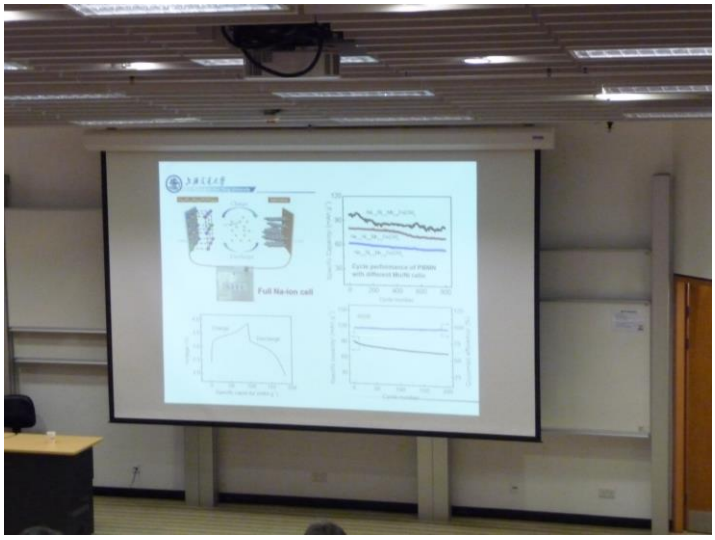


圖 18. 鈉離子電池效能。

另外，澳洲 University of Wollongong 的 Jiazhao Wang 教授所發表的相關研究 (圖 19)，主題是薄膜與自立式之可撓式電池。其概念為將可撓式薄膜型電池嵌在高分子織布上，而可撓式薄膜型電池的陰極為氧化鋰鐵磷 (LiFePO4)、陽極為鋰鈦氧 ($Li_4Ti_5O_{12}$) 、電解質為聚氧化乙烯 (Polyethylene oxide, PEO)。

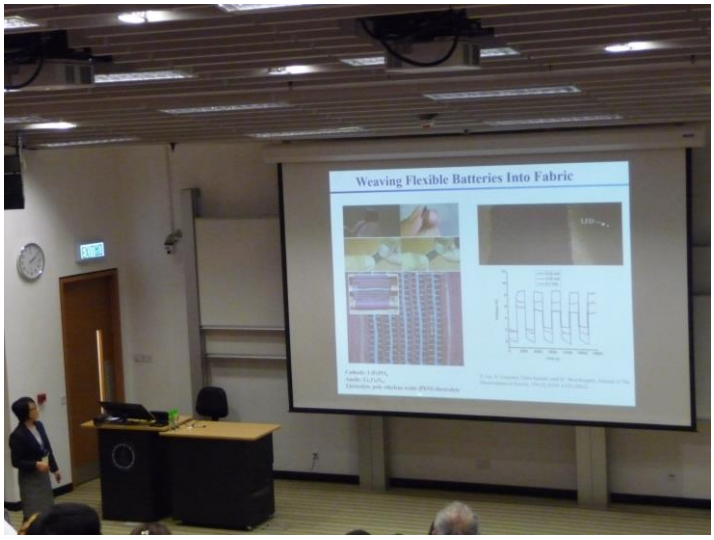


圖 19. 薄膜型可撓式電池。

來自香港科技大學的 Guohua Chen 教授所發表的高效能鋰硫電池相關研究，主題是 3D 架構的鋰硫電池。鋰硫電池優點為高能量密度、過充的耐受力強、價格便宜；缺點為循環性差、低硫的使用率。其研究的概念為改變集電層的表面結構並利用其 3D 結構的特色 (圖 20)，如此可以改善鋰硫電池的缺點並增加其電化學效能。

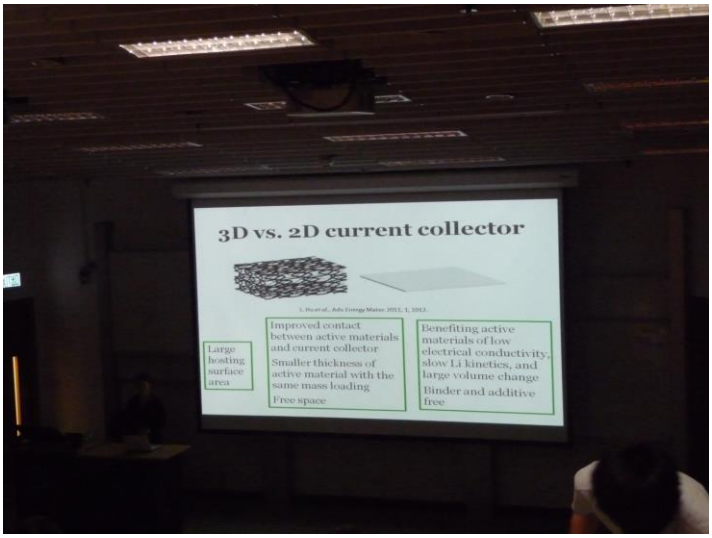


圖 20. 3D 集電層的特色。

來自臺灣科技大學 Fu-Ming Wang 教授發表的研究成果為高電容量的富鋰電池。此研究是在富鋰多元素的陰極下，研發耐高電位的液態電解質，在 5 V 的充放電條件下，有穩定的電化學表現，其電容量可以高達 300 $mAhg^{-1}$ (圖 21)。

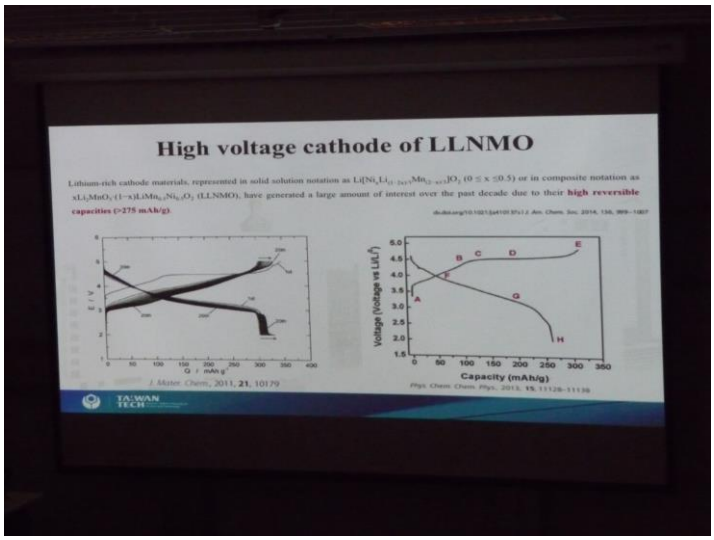


圖 21. 富鋰電池電化學效能

另外一個新材料的發表為來自大陸南寧大學的 Jianguo Liu 教授所發表釩酸鋰基電池 (圖 22)。釩酸鋰基電池為層狀結構的鋰電池，具有高的比電容量。然而，因為其氧化數多，所以充放電的電壓範圍較大 (1.5 ~ 4 V)。

圖 22. 釩酸鋰基電池

由於釩酸鋰基材料為層狀結構，層狀結構在充放電後並不穩定，加入鹼金族鈉，可以使層狀結構趨於穩定。如進一步加入鹼土族鎂，層狀結構會更加穩定，釩酸鋰基電池加入鹼土族鎂，其電容量可達 250 mAhg-1 (1.5 V - 4 V)，而充放電 1000 圈之電容量衰退僅< 10 % (圖 23)。

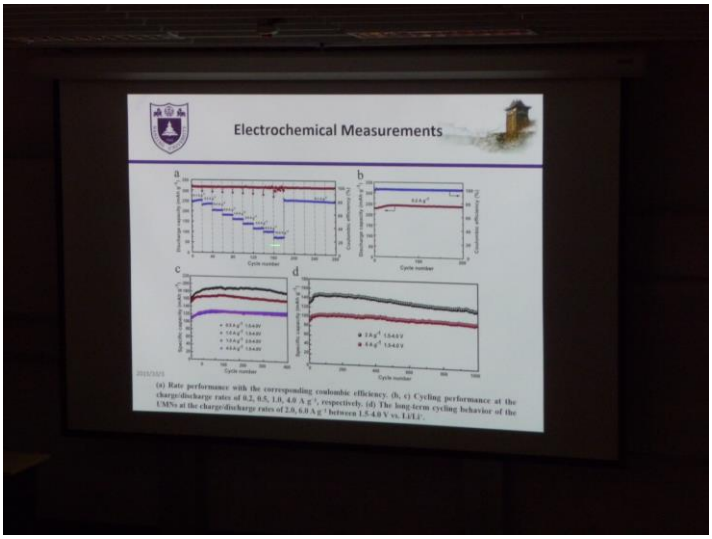


圖 23. 釩酸鋰基電池電化學效能

除了新材料的發表，先進電池相關的發表還有新的分析技術。來自美國 University of California San Diego 的 Ying Shirley Meng 教授所發表的相關研究是層間化合物的鹼性可充式鋰離子電池奈米成像。其概念為利用電子奈米成像 (圖 24) 與 X 射線成像技術 (圖 25) 來觀察鋰電池於充放電時的陰陽極材料成像變化的情形。

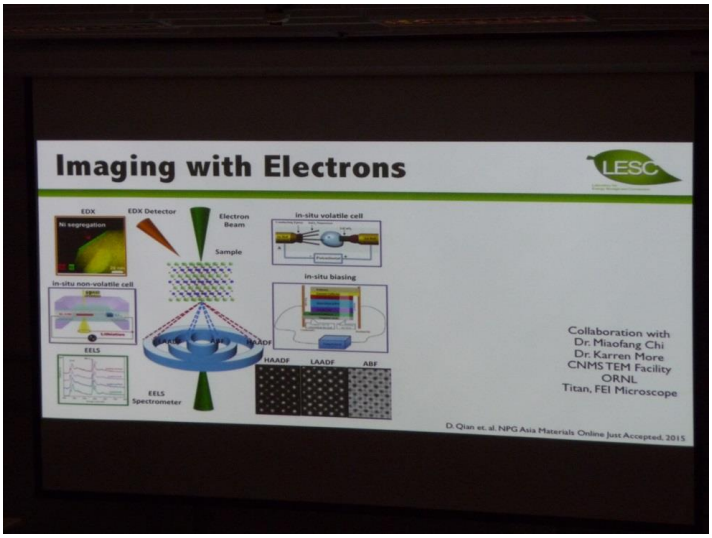


圖 24. 電子奈米成像。

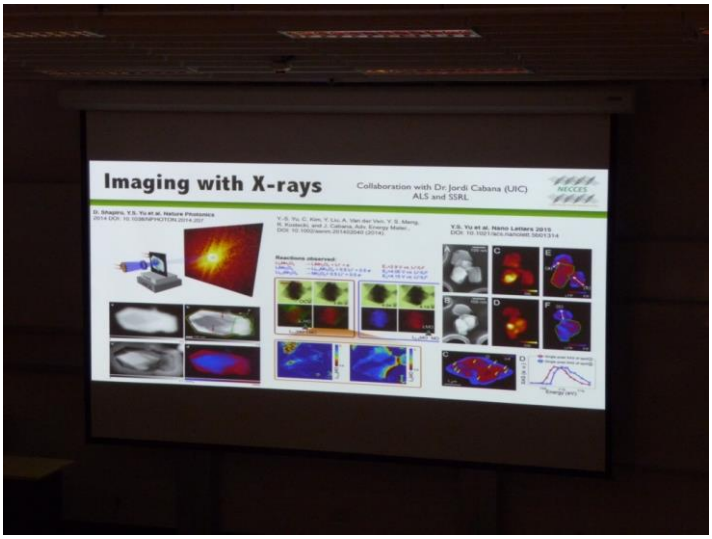


圖 25. X 射線成像。

另外，韓國成均館大學的 Won-Sub YOON 教授所發表加熱型 XRD 鋰電池材料分析研究。該團隊使用加熱型 XRD 分析儀解析在不同溫度下 NMC 陰極材料的晶格變化情形 (圖 26)。

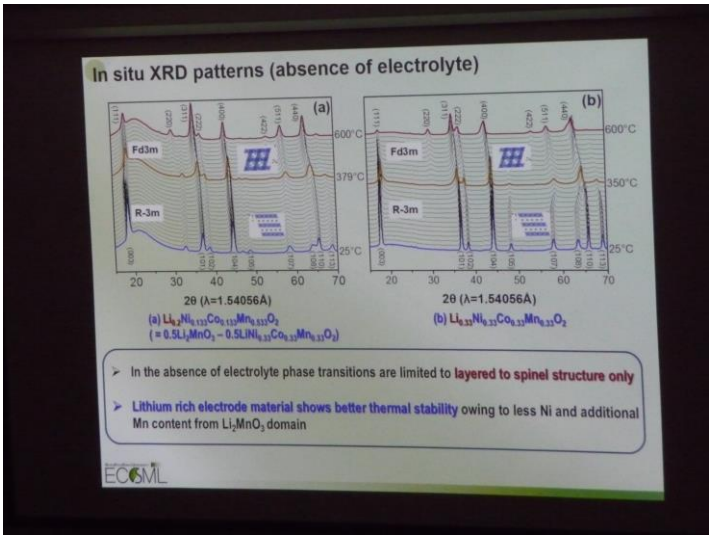


圖 26. 加熱型 XRD 分析。

本研討會海報發表 (圖 27) 的部分共分為三大主題，分別為電催化、太陽電池和電池(燃料電池和鋰電池等)。作者的海報發表題目是「Lithium manganese oxides as high volumetric-energy density thin film cathode for lithium batteries」，海報的發表其間有數位學者感到興趣並且提了一些問題，其問題包括電漿鍍薄膜鋰電池的成本與核能研究所的研究領域(香港大學的 Kwong Yu Chan 教授) 等。

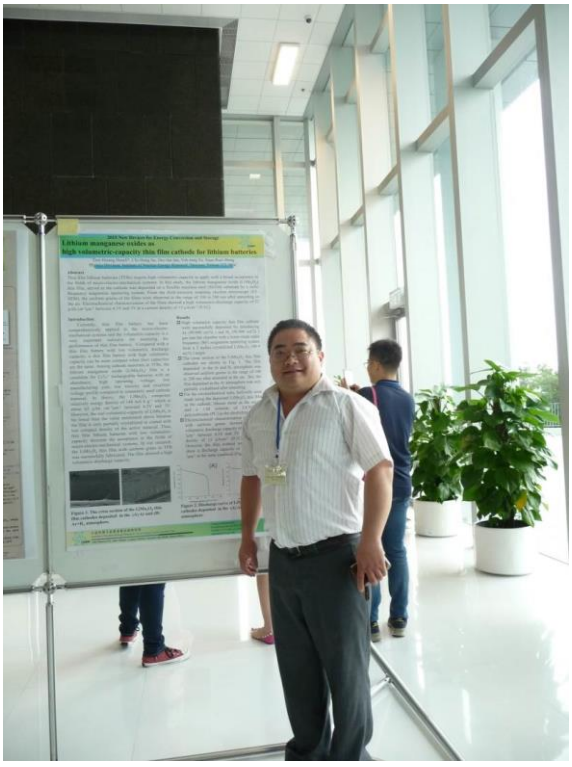


圖 27. 研討會海報發表

所有參與海報發表論文的內容與全固態薄膜鋰電池或能源採集整合有高度相關性的並不多，其中有一個比較值得一提的是瑞士洛桑聯邦理工學院之 Marko Stojanovic 團隊發表鋁空

電池的研究成果 (圖 28)，該團隊開發出鋁空氣電池應用於電動汽車上面。鋁空氣電池以高純度鋁 Al (含鋁 99.99 %) 為負極、氧为正極，以氫氧化鉀 (KOH) 或氫氧化鈉 (NaOH) 水溶液為電解質。鋁攝取空氣中的氧，在电池放電時產生化學反應，鋁和氧作用轉化為氧化鋁。鋁空氣電池的理論比能量可達 8100 $Whkg^{-1}$ (5400 $mAhg^{-1}$)，2014 年的鋁空氣電池的實際比能量為 350 $Whkg^{-1}$，與鋰電池的相近。鋁空氣電池 (1.5 V) 用於電動車，其主要的訴求里程數高、價格不貴、快速更換與可循環使用。

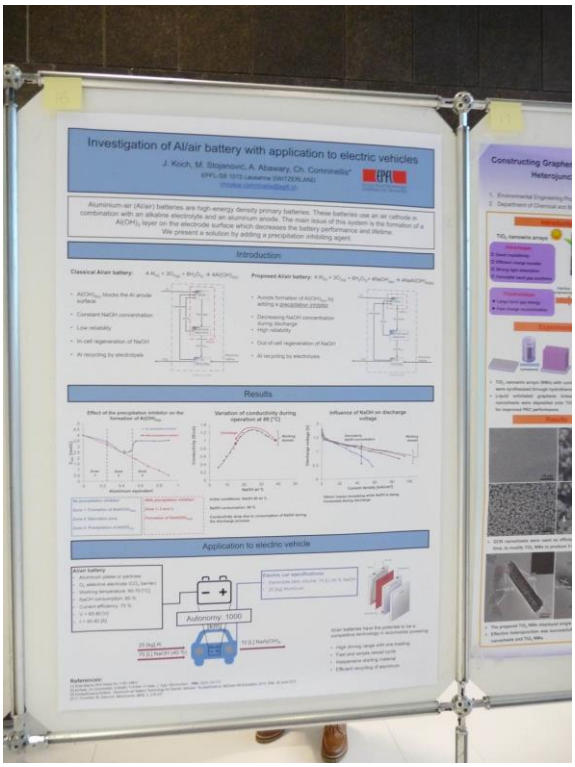


圖 28. 鋁空氣電池於汽車應用

四、建　議　事　項

2015年New Devices for Energy Conversion and Storage國際研討會是一場高水準的能源轉換與儲存的研討會，有許多薄膜鋰電池相關的技術值得我們參考。

參加本次會議的建議事項如下：

(1)富鋰之層狀正極材料為高電容量密度材料，另外鈉電池於5-10年內將可能會量產，而高理論電容密度的鋰硫電池是未來儲能裝置的重點發展項目之一。因此，未來原能會核研所儲能裝置的研究方向是否也應注意此一趨勢。

(2)有學者利用電子奈米成像和X射線成像技術來觀察鋰電池於充放電時的成像變化情形，此技術十分的新穎。未來的原能會核研所對儲能裝置的研究方法是否也應注意此一趨勢。

(3)未來在開發薄膜材料時，必須從商業化角度思考，設計出更快的鍍膜速度更便宜的鍍膜設備與更具競爭力的電漿鍍膜材料，結合現有的技術，進而發展出原能會核研所的新型獨佔技術。

五、附　錄

附錄一、會議議程
附錄二、本次會議發表摘要
附錄三、本次會議海報發表之論文內容

附錄一、會議議程

ISE Satellite Meeting

New Devices for Energy Conversion and Storage

The Hong Kong University of Science and Technology

Clear Water Bay, Kowloon, Hong Kong SAR, P.R. China

October 1-3, 2015

Organizing Committee:

Guohua Chen (Chair)

The Hong Kong University of Science and Technology

Christos Comninellis (Co-chair)

École Polytechnique Fédérale de Lausanne

Gerardine G. Botte (Co-chair)

Ohio University

Minhua Shao (Secretariat)

The Hong Kong University of Science and Technology

Kwong Yu Chan

The University of Hong Kong

Francesco Ciucci

The Hong Kong University of Science and Technology

Haitao Huang

Hong Kong Polytechnic University

Jang Kyo Kim

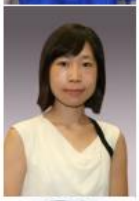
The Hong Kong University of Science and Technology

Quan Li

The Chinese University of Hong Kong

Fude Liu

The University of Hong Kong



Yichun Lu

The Chinese University of Hong Kong

Shihe Yang

The Hong Kong University of Science and Technology

Denis Yu

City University of Hong Kong

Limin Zhou

Hong Kong Polytechnic University

ISE Satellite Meeting

New Devices for Energy Conversion and Storage

Technical Program

Friday, October 2

Session A, Opening Remarks and Plenary Lecture I, Lecture Theater (Lo Ka Chung Building)

Chair: Minhua SHAO

Time	Presenter (Affiliation)	Title
09:00-09:20	Joseph Hun-wei LEE (Vice-President for Research and Graduate Studies, HKUST) Christos COMNINELLIS (Ecole Polytechnique Fédérale de Lausanne)	Opening Remarks
09:20-10:20	Nenad M MARKOVIC (Argonne National Laboratory)	Plenary Lecture I: Electrocatalysis and Electrochemical Interfaces
10:20-10:50	Photo Taken/Tea Break (Lobby)	

Session B: Electrocatalysis, Lecture Theater (Lo Ka Chung Building)

Co-Chairs: Mark MATHIAS, Zidong WEI

Time	Presenter (Affiliation)	Title
10:50-11:25	Piotr ZELENAY (Los Alamos National Laboratory)	Oxygen Reduction on Non-Precious Metal Electrocatalysts (Keynote)
11:25-11:50	Zidong WEI (Chongqing University)	Pt-Free Catalyst for Oxygen Reduction Reaction in Fuel Cells (Invited)
11:50-12:15	Xing-Hua XIA (Nanjing University)	Bio-Inspired Electrocatalysts for Oxygen Reduction Reaction (Invited)
12:15-12:40	Shijun LIAO (South China University of Technology)	Binary Transition Metal Nitride Nanoparticles as Promising Catalyst for Oxygen Reduction Reaction (Invited)
12:50-14:00	Lunch (G/F Chinese Restaurant)	

Friday, October 2

Session C: Solar Cells I, Room 1038 (Lo Ka Chung Building)

Co-Chairs: Shihe YANG, Qingbo MENG

Time	Presenter (Affiliation)	Title
10:50-11:25	Bunsho OHTANI (Hokkaido University)	Fundamental Aspects on Photocatalysis--Role of Electron Traps and Influence of Particle Size (Keynote)
11:25-12:00	Qingbo MENG (Institute of Physics Chinese Academy of Sciences)	Materials and Interfacial Engineering for Quantum Dots Solar Cells and Perovskite Solar Cells (Keynote)
12:00-12:20	Aicheng CHEN (Lakehead University)	Synthesis and Photoelectrochemical Study of WO_3-Based Nanostructured Materials
12:20-12:40	Lo GORTON (Institute of Chemistry, Lund University)	Trapping Solar Energy on Electrodes Modified with Photosynthetic Membranes/Cells
12:50-14:00	Lunch (G/F Chinese Restaurant)	

Session D, Plenary Lecture II, Lecture Theater (Lo Ka Chung Building)

Chair: Guohua CHEN

Time	Presenter (Affiliation)	Title
14:00-15:00	Jean-Marie TARASCON (College de France and HKUST)	Plenary Lecture II: How to Make Better Li(Na) Ion Batteries via Chemistry
15:00-15:20	Tea Break (Lobby)	

Friday, October 2

Session E: Fuel Cells, Lecture Theater (Lo Ka Chung Building)

Co-Chairs: Piotr ZELENAY, Jiujun ZHANG

Time	Presenter (Affiliation)	Title
15:20-15:55	Mark MATHIAS (General Motors Fuel Cell Research and Development)	High-Current-Density Performance of PEM Fuel Cells at Low Platinum Loading- Practical Importance and Fundamentals (Keynote)
15:55-16:30	Jiujun ZHANG (National Research Council of Canada)	PEM Fuel Cell Catalysis: Efforts to Enhance Performance (Keynote)
16:30-16:55	Zhigang SHAO (Dalian Institute of Chemical Physics, CAS)	High-Performance Electrocatalysts and Oriented Electrodes for Proton Exchange Membrane Fuel Cell (PEMFC) (Invited)
16:55-17:15	Judith RISHPON (Tel-Aviv University)	Microbial Fuel Cells for Waste Water Treatment
17:15-17:35	Scott NASH (Lancaster Engineering)	The Development of Anode Electrocatalysts for the Use in Direct Borohydride Alkaline Fuel Cells
17:35-17:55	Konstantin PETROV (Institute of Electrochemistry and Energy Systems)	Hydrogen Sulfide/Air Fuel Cell in the Black Sea Waters
19:10-21:00	Banquet (G/F Chinese Restaurant)	

Friday, October 2

Session F: Solar Cells II, Room 1038 (Lo Ka Chung Building)

Co-Chairs: Bunsho OHTANI, Yun Hang HU

15:20-15:55	Yun Hang HU (Michigan Technological University)	3D Graphene for Solar Energy Conversion and Electrical Energy Storage (Keynote)
15:55-16:30	Al-Jassim MOWAFAK (NREL)	Limitless Photovoltaic Technology: from the Laboratory to the Market Place (Keynote)
16:30-16:55	Shihe YANG (HKUST)	Nanostructure and Interface Engineering for Low-Cost and High-Performance Solar Energy Devices (Invited)
16:55-17:20	Yuegang ZHANG (i-Lab, Institute of Nano-Tech and Nano-Bionics, Chinese Academy of Sciences)	Functional Nano-structures for Highly Efficient Solar Energy Conversion (Invited)
17:20-17:40	He Yan (HKUST)	Temperature-Dependent Aggregation Enables Multiple Cases of Polymer Solar Cells with Efficiencies >10% (Invited)
17:40-18:00	Pauline BORNOZ (Ecole Polytechnique Fédérale de Lausanne)	Solution Processed Semiconductor Thin Film for Tandem Photoelectrochemical Cells
19:10-21:00	Banquet (G/F Chinese Restaurant)	

Friday, October 2

Session G: Poster, 18:00-19:00, Lobby (Lo Ka Chung Building)

Co-Chairs: Minhua SHAO, Francesco CIUCCI

No.	Presenter (Affiliation)	Title
1	Vincent CHAU (The University of Hong Kong)	DFT Studies of Li_2O_2 Dissolution on Different Carbon Structures
2	Chi CHEN (HKUST)	$Ba_{0.95}La_{0.05}FeO_{3-\delta}$-Multilayer Graphene as a Low-Cost and Synergistic Catalyst for Oxygen Evolution Reaction
3	Zhaofeng DENG (The University of Hong Kong)	Electrochemical Impedance Study of Hollow Core Mesoporous Shell Hierarchical Carbon Applied in Lithium
4	Lior ELBAZ (Bar-Ilan University)	Evidence of Enhanced Activity of In-Situ Formed Pt Nano-Rafts on Molybdenum Carbide Support
5	Liang GAO (The University of Hong Kong)	Polystyrene Sulfonate Threaded in MIL-101 Cr(III): a Cationic Poly-Electrolyte Synthesized Directly into a Metal-Organic Framework
6	Yang GAO (HKUST)	A High Performance Anode Material for Solid Oxide Fuel Cells: Ni Exsolution on A-Site Deficient $La_{0.4}Sr_{0.4}Sc_{0.9}Ni_{0.1}O_{3-\delta}$
7	Ching Kit HO (The University of Hong Kong)	Mesoporous Lithium Titanate-Carbon Composite ($Li_4Ti_5O_{12}$-Carbon) with Controlled Microstructure as Anode in Lithium Ion Batteries for Wide Temperature Range
8	Tien-Hsiang HSUEH (Institute of Nuclear Energy Research)	Aluminum Doped Lithium Manganese Oxide Films with High Volumetric Capacity Deposited on Stainless Steel Substrates for Lithium Ion Batteries
9	Tomas KAZDA (Brno University of Technology)	Influence of the Used Carbons and Binders to the Electrochemical Properties of High Voltage Spinel Cathodes
10	Doohun KIM (Korea Electrotechnology Research Institute)	Crystalline Iron Oxide Nanotube Arrays Grown through Anodization as Anode for Li-Ion Battery
11	Chi Ying Vanessa LI (The University of Hong Kong)	TiO_2 (B) Composite as Durable Anode Materials for Lithium Ion Batteries
12	Jeny-Yu LIN (Tatung University)	High-Performance Hybrid Supercapacitors Based on Metal Sulfide/Carbon Nanotube Composites Cathode Materials

13	Peng LIU (Changsha University of Science and Technology)	Preparation and Electrochemical Performance of $Ba_{0.8}La_{0.2}FeO_{3-\delta}$ Cathode for Intermediate-Temperature Solid Oxide Fuel Cell
14	Guadalupe RAMOS-SANCHEZ (Universidad Autonoma Metropolitana – Iztapalapa)	N-Doped Carbon Nanofibers: a Highly Stable Support for Fuel Cell Applications
15	Iwona RUTKOWSKA (University of Warsaw)	Mixed-Metal Oxides as Active Supports for Dispersed Pt and PtRu Nanoparticles during Electrocatalytic Oxidations of Small Organic Molecules
16	Suzana SOPCIC (Faculty of Chemical Engineering and Technology)	Improvement of Supercapacitive Properties of Manganese (IV) Oxide Electrodes
17	Marko STOJANOVIC (Ecole Polytechnique Fédérale de Lausanne)	Investigation of Al/Air Batteries with Application to Electric Vehicles
18	Jingyang SU (HKUST)	Constructing Graphene Linked Graphitic Carbon Nitride/TiO_2 Nanowire Arrays Heterojunction for Efficient Solar-Driven Water Splitting
19	Bernard John TONGOL (University of Santo Tomas)	Electrochemically Exfoliated Graphene as Support Material for PdNi for Direct Ethanol Fuel Cell Application
20	Wenju WANG (Nanjing University of Science and Technology)	Mechanism of Oxygen Reduction Reaction (ORR) on Pristine and Kinked Carbon Nanotube: a Density Functional Theory (DFT) Study
21	Wonchang CHOI (Korea Institute of Science and Technology)	Carbon-Coated Lithium Titanate for Anode Material in Sodium-Ion Batteries
22	Zelong XING (HKUST)	Core-Shell Electrocatlaysts for Ethanol Electrooxidation
23	Lulu ZHANG (HKUST)	Co-N-C Composites as Electrocatalysts for Hydrogen Evolution Reaction
24	Ming ZHOU (The University of Hong Kong)	Iron-Nitrogen-Doped Carbon into a Hollow-Core-Mesoporous-Shell (HCMS) Structure Toward Oxygen Reduction Reaction
25	Xiaoyan LI (The Hong Kong Polytechnic University)	Porous TiO_2.C Nanofibers Filled with Sn Nanoparticles for Lithium Ion Batteries
26	Jingjing TANG (The Hong Kong Polytechnic University)	Porous Graphene-carbon Nanowire/SnO_2 Anode for Lithium Ion Batteries
27	Zenglong Xu (HKUST)	Structural design and fundamental understanding of high-capacity Si-based anodes for lithium ion battery

Saturday, October 3

Session H: Plenary Lecture III, Lecture Theater (Lo Ka Chung Building)

Chair: Christos COMNINELLIS

Time	Presenter (Affiliation)	Title
09:00-10:00	Hubert GIRAULT (Ecole Polytechnique Fédérale de Lausanne)	Plenary Lecture III: Redox Flow Batteries for E-Mobility
10:00-10:20	Tea Break (Lobby)	

Session I: Advanced Batteries I, Lecture Theater (Lo Ka Chung Building)

Co-Chairs: Andrew GEWIRTH, Robert ARMSTRONG

Time	Presenter (Affiliation)	Title
10:20-10:55	Zifeng MA (Shanghai Jiao Tong University)	Novel Cathode Materials Design and Preparation for Sodium Ion Batteries Use (Keynote)
10:55-11:20	Robert ARMSTRONG (University of St Andrews)	Layered Sodium Manganese Oxides for Na-Ion Batteries (Invited)
11:20-11:45	Andrew GEWIRTH (University of Illinois)	Electrochemical Stiffness in Lithium Ion Batteries (Invited)
11:45-12:10	John WEIDNER (University of South Carolina)	Solar-Hydrogen Production via the Hybrid Sulfur Process (Invited)
12:10-12:35	Denis YU (City University of Hong Kong)	Metal Sulfides as Anodes for Battery Applications (Invited)
12:45-14:00	Lunch (G/F Chinese Restaurant)	

Saturday, October 3

Session J: Electrocatalysis II, Room 1038 (Lo Ka Chung Building)

Co-chairs: Shelley MINTEER, Pawel J. KULESZA

Time	Presenter (Affiliation)	Title
10:20-10:45	Pawel J. KULESZA (University of Warsaw)	Importance of Specific Interactions between Active Centers and Nanostructured Supports in Catalytic Processes for Electrochemical Energy Conversion and Storage (Invited)
10:45-11:10	Shelley MINTEER (University of Utah)	Plasmonic Enhancement of Glycerol Fuel Cell Performance (Invited)
11:10-11:35	Wen-Bin CAI (Fudan University)	B-Doped Pd Catalyst for Efficient Formic Acid Dehydrogenation (Invited)
11:35-12:00	Francesco CIUCCI (HKUST)	$Ba_{0.95}La_{0.05}FeO_{3-\delta}$ for Solid Oxide Fuel Cell Cathodes: Experimental and Theoretical Investigations Using Single-crystal Thin Films and Atomistic Simulations (Invited)
12:00-12:20	Kelsey STOERZINGER (Massachusetts Institute of Technology)	Orientation-Dependent Oxygen Evolution Activities of RuO_2 Films
12:20-12:40	De Andrade ADALGISA (University of Sao Paulo/FFCLRP-USP)	Effect of Iron Oxide on the Catalytic Activity of Pt-Based Catalyst towards Ethanol Electrooxidation
12:45-14:00	Lunch (G/F Chinese Restaurant)	

Saturday, October 3

Session K: Advanced Batteries II, Lecture Theater (Lo Ka Chung Building)

Co-chairs: Quan LI, Jiazhao WANG

Time	Presenter (Affiliation)	Title
14:00-14:35	Jiazhao WANG (University of Wollongong)	Thin Film and Free-Standing Electrode Materials for the Bendable Batteries (Keynote)
14:35-15:10	Ying Shirley MENG (University of California San Diego)	Nanoscale Imaging of Intercalation Compounds for Rechargeable Alkaline Ion Batteries (Keynote)
15:10-15:35	Margret WOHLFAHRT-MEHRENS (ZSW Laboratory for Battery Technology)	Spinel Type Materials as High Voltage and High Capacity Cathode Materials for Advanced Lithium Ion Batteries (Invited)
15:35-15:55	Tea Break (Lobby)	
15:55-16:20	Quan LI (The Chinese University of Hong Kong)	Three-Dimensional Architectures for Li-Ion Battery Electrode (Invited)
16:20-16:45	Won-Sub YOON (Sungkyunkwan University)	The Structural Behavior of Li- and Mn-Rich Cathodes for Li-Ion Batteries Investigated by Synchrotron-Based X-Ray Techniques (Invited)
16:45-17:10	Jianguo LIU (College of Engineering and Applied Sciences, Nanjing University)	Ultralong Metahewettite $CaV_6O_{16}•3H_2O$ Nanoribbons as Novel Host Materials for Lithium Storage: Towards High-Rate and Excellent Long-Term Cyclability (Invited)
17:10-17:30	Fu-Ming WANG (National Taiwan University of Science and Technology)	Novel Electrolyte Systems for Lithium-Rich ($Li_{1.2}Ni_{0.2}Mn_{0.6}O_2$) High-Capacity Cathode of Lithium Ion Battery
17:30-17:50	Jianqiu HUANG (HKUST)	Performance-Enhanced Lithium-Sulfur Batteries with an Optimized Graphene Oxide/Carbon Nanotube Interlayer

Saturday, October 3

Session L: Flow Batteries, Supercapacitors, and Li-Air Batteries, Room 1038 (Lo Ka Chung Building)

Co-chairs: Kwong Yu CHAN, Yi-Chun LU

Time	Presenter (Affiliation)	Title
14:00-14:25	Huamin ZHANG (Dalian Institute of Chemical Physics, CAS)	Development and Application on Vanadium Flow Battery (Invited)
14:25-14:45	Veronique AMSTUTZ (Ecole Polytechnique Fédérale de Lausanne)	Strategies for Enhancing the Energy Density of Redox Flow Batteries
14:45-15:05	Xu WU (Huazhong University of Science and Technology)	A Preliminary Study on Lead Acid Flow Battery with Secondary Lead
15:05-15:25	Francois BEGUIN (Poznan University of Technology)	New Composite Electrodes for In-Situ Pre-Lithiation of Graphite in Lithium Ion Capacitors
15:25-15:45	Krzysztof FIC (Poznan University of Technology)	Redox Phenomena for Energy Enhancement in Aqueous Electrochemical Capacitors
15:45-16:05	Tea Break (Lobby)	
16:05-16:25	Elzbieta FRACKOWIAK (Poznan University of Technology)	Hybrid Electrolytes for High Energy Aqueous Supercapacitors
16:25-16:45	Elham KAMALI HEIDARI (HKUST)	Freestanding, Three Dimensional Supercapacitor Electrodes Made from Ni_3S_2/Graphene Foam Nanocomposites
16:45-17:10	Kwong Yu CHAN (The University of Hong Kong)	Tunable Hierarchical Porous Carbon Structure for Studying Electrochemical Energy Conversion (Invited)
17:10-17:35	Yi-Chun LU (The Chinese University of Hong Kong)	Probing the Enhanced Mechanism of Redox Mediator on Decomposing Li_2O_2 via Electrochemical Impedance Spectroscopy (Invited)
17:35-17:55	Jiaqiang HUANG (HKUST)	Freestanding Electrospun Co-Ni@Graphitic Carbon Nanofiber Electrodes for Li-O_2 Batteries

Saturday, October 3

Session M: Closing Remarks and Poster Award, Lecture Theater (Lo Ka Chung Building)

Chair: Minhua SHAO

Time	Presenter (Affiliation)	Title
18:00-18:20	Gerardine G. Botte (Ohio University) Guohua CHEN (HKUST)	Closing Remarks and Poster Award
18:20-	Free Time	

附錄二、本次會議發表摘要

Al-doped lithium manganese oxides as high-volumetric-capacity thin film cathode for lithium-ion batteries

Tien-Hsiang Hsueh*, Chi-Hung Su, Der-Jun Jan, Yuh-Jenq Yu, Yuan-Ruei Jheng

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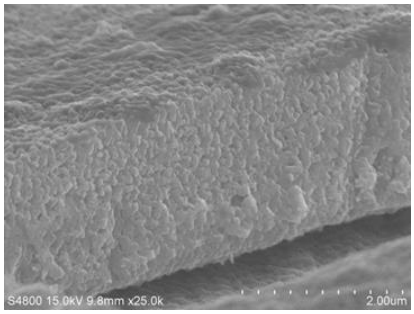
Thin film lithium ion batteries require high volumetric capacity to apply with a broad acceptance in the fields of micro-electro-mechanical systems. In this study, the cathode of aluminum doped lithium manganese oxide ($LiAl_{0.1}Mn_{1.9}O_4$) films for lithium ion batteries (LiBs) were deposited on flexible stainless steel (SS304) substrates by a radio frequency magnetron sputtering system. From the field-emission scanning electron microscope (FE-SEM), the uniform grains of the films were observed in the range of 100 to 200 nm after annealing in the air. Electrochemical characterization of the films showed a volumetric discharge capacity of 52 $\mu Ah\mu m^{-1}cm^2$ between 4.3V and 3V at a current density of 15 $\mu A/cm^2$ (0.1C). The capacity retention was achieved 95% after 50 charge-discharge cycles between 4.3V and 3V at a current density of 150$\mu A/cm^2$ (1C).



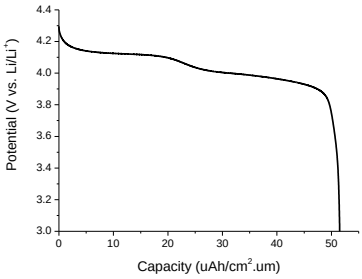


Figure L. The cross section of $LiAl_{0.1}Mn_{1.9}O_4$ thin film.

Figure R. The discharge curve of $LiAl_{0.1}Mn_{1.9}O_4$ thin film.

References

[1] Tomy MR, AnilKumar KM, Anand PB, Jayalekshmi S (2012) Effect of annealing on the electrochemical properties of the Li–Mn–O thin films, prepared by high frequency RF magnetron sputtering. J.Phys.Chem.Solids 73:559-563, doi : 10.1016/j.jpcs.2011.12.008

[2] Guo DL, Li B, Chang ZR, Tang HW, Xu XH, Chang K, Shangguana EB, Yuanb XZ, Wang HJ (2014) Facile synthesis of $LiAl_{0.1}Mn_{1.9}O_4$ as cathode material for lithium ion batteries: towards rate and cycling capabilities at an elevated temperature. Electrochim. Acta 134:338-346, doi:10.1016/j.electacta.2014.04.117

2015 New Devices for Energy Conversion and Storage

Lithium manganese oxides as high volumetric-capacity thin film cathode for lithium batteries

Tien-Hsiang Hsueh*, Chi-Hung Su, Der-Jun Jan, Yuh-Jenq Yu, Yuan-Ruei Jheng
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Abstract

Thin film lithium batteries (TFBs) require high volumetric-capacity to apply with a broad acceptance in the fields of micro-electro-mechanical systems. In this study, the lithium manganese oxide ($LiMn_2O_4$) thin film, served as the cathode was deposited on a flexible stainless steel (SS304) substrate by a radio frequency magnetron sputtering system. From the field-emission scanning electron microscope (FE-SEM), the uniform grains of the films were observed in the range of 100 to 200 nm after annealing in the air. Electrochemical characterization of the films showed a high volumetric-discharge capacity of 52 μAh $cm^{-2}μm^{-1}$ between 4.3V and 3V at a current density of 15 μAcm^{-2} (0.1C).

Introduction

Currently, thin film battery has been comprehensively applied to the micro-electro-mechanical systems and the volumetric-capacity is a very important indicator for assessing the performance of thin film battery. Compared with a thin film battery with low volumetric discharge capacity, a thin film battery with high volumetric capacity can be more compact when their capacities are the same. Among cathode materials in TFBs, the lithium manganese oxide ($LiMn_2O_4$) film is a candidate for Li/Li^+ rechargeable batteries with an abundance, high operating voltage, low manufacturing cost, low toxicity and excellent voltage profile compared to commonly used cathode material. In theory, the $LiMn_2O_4$ comprises relatively energy density of 148 mA h g^{-1} which is about 63 μAh $cm^{-2}μm^{-1}$ between 4.3V and 3V. However, the real volumetric-capacity of $LiMn_2O_4$ is far lower than the value mentioned above because the film is only partially crystallized or coated with low compact density of the active material. Thus, thin film lithium batteries with low volumetric-capacity decrease the acceptance in the fields of micro-electro-mechanical systems. In our research, the $LiMn_2O_4$ thin film with uniform grans in TFB was successfully fabricated. The film showed a high volumetric-discharge capacity.

Results

- High volumetric capacity thin film cathode were successfully deposited by introducing Ar (99.999 vol.%) and H_2 (99.999 vol.%) gas into the chamber with a home-made radio frequency (RF) magnetron sputtering system from a 3 inches crystallized $LiMn_2O_4$ (99.9 wt.%) target.
- The cross section of the $LiMn_2O_4$ thin film cathodes are shown in Fig. 1. The film deposited in the Ar and H_2 atmosphere was observed uniform grains in the range of 100 to 200 nm after annealed in the air. But, the film deposited in the Ar atmosphere was only partially crystallized after annealing.
- For the electrochemical tests, half-cells were made using the deposited $LiMn_2O_4$ thin film as the cathode, lithium metal as the anode, and a 1-M solution of $LiClO_4$ in polycarbonate (PC) as the electrolyte.
- Electrochemical characterization of the film with uniform grains showed a highly volumetric discharge capacity of 52 μAh $cm^{-2}μm^{-1}$ between 4.3V and 3V at a current density of 15 μAcm^{-2} (0.1C) (Fig. 2B). However, the film without uniform grains show a discharge capacity of 35 μAh $cm^{-2}μm^{-1}$ at the same condition (Fig. 2A).

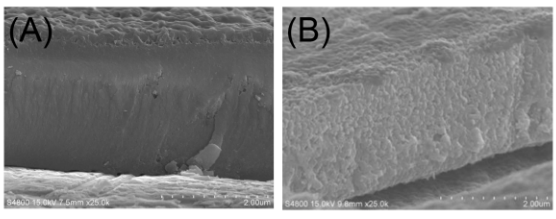

Figure 1. The cross section of the $LiMn_2O_4$ thin film cathodes deposited in the (A) Ar and (B) Ar+H_2 atmosphere.

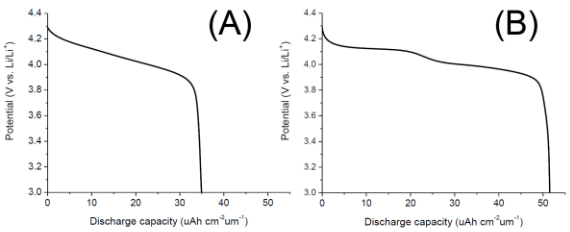

Figure 2. Discharge curve of $LiMn_2O_4$ thin film cathodes deposited in the (A) Ar and (B) Ar+H_2 atmosphere.

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