出國報告（出國類別：開會）

赴美國參加 2023 先進功能性材料國際研討會及參訪美國猶他大學出國報告

服務機關： 核能研究所
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派赴國家/地區：美國/洛杉磯
出國期間：112 年 8 月 10 日~112 年 8 月 19 日
報告日期：112 年 11 月 14 日

摘要

本報告為核能研究所物理組楊昇府博士奉派於 2023 年 8 月 10 日至 2023 年 8 月 19 日期間，赴美國加州洛杉磯市參加 2023 先進功能性材料國際研討會(2023 International Conference on Advances in Functional Materials)，口頭發表住商節能關鍵組件技術開發及示範系統研發成果論文“Cellular Desiccant Rotor Produced from Recycling of abrasive slurry”，與一流人才針對解決複合材料結構控制和物理、化學和電學特性設計限制，減少生命週期對環境和成本的影響，二維、三維材料及異質結構材料合成新策略、物理、化學和機械性能基礎研究，從材料、特性分析、元件到系統整合等議題，進行交流當前技術最新進展。

至美國猶他大學分享研究團隊研發之住商節能關鍵組件技術開發及示範系統，厚實原料、元件、系統本土化自製能力，完成資源循環純化碳化矽永續材料及除濕潔淨轉輪元件積層製作，從原料到製作產品和系統整合完整研發，進行節能材料、關鍵元件、循環經濟研究發展領域、關鍵性技術、研發設備、專業人力、分子於固液和固氣界面反應、動力行為、現象及吸脫附行為、等溫吸脫附動力曲線的研究交流，強化本所與國際合作關係，進而瞭解國外研發現況、市場及未來發展方向，建立合作管道及對象。

本次出國行程推廣及拓展研究團隊針對資源循環純化碳化矽永續材料及除濕潔淨轉輪元件積層製作，從原料到製作產品和系統整合完整研發技術、節能乾燥及除濕輪系統整合應用於食品及農作物乾燥取代傳統柴油燃燒器乾燥提供一節能環境友善的替代方案，與一流人才進行技術探討和收集廣泛且深入的技術資訊。參訪美國猶他大學於節能材料、關鍵元件、循環經濟、淨零碳排固碳技術研究發展領域，建立合作管道及對象，有助於計畫之執行。掌握國際相關技術最新發展趨勢，加速計畫研發進程並有利技術開發方向之擘劃，持續強化台灣與國際間之人脈及合作交流關係。

目錄

一、目的

為實現國家能源政策和節能減碳目標，發展符合產業需求節能綠色吸附材料關鍵元件及設備技術，精進循環再生永續材料開發減少礦物開採，針對光電半導體產業矽晶圓切割過程產生切削料，發展純化循環再生和精煉技術，開發碳化矽連續型資源循環製程及創新回收模式，開拓都市礦山。以回收再生材料碳化矽為基材，製作關鍵組件，完成示範系統及場域測試，提升潔淨乾燥能源因數值落實政府淨零科技與節能技術研發目標，推廣及拓展住商節能關鍵組件技術開發及示範系統，遂派員拜訪參加美國加州洛杉磯市參加 2023 先進功能性材料國際研討會(T2023 International Conference on Advances in Functional Materials)，發表論文“Cellular Desiccant Rotor Produced from Recycling of abrasive slurry”進行口頭報告(邀請函和論文接收通知如附錄一、二)。與一流人才針對解決複合材料結構控制和物理、化學和電學特性設計限制，減少生命週期對環境和成本的影響，二維、三維材料及異質結構材料合成新策略、物理、化學和機械性能基礎研究，從材料、特性分析、元件到系統整合等議題，進行交流當前技術最新進展，掌握國際相關技術最新發展趨勢。

拜訪美國猶他大學土木與環境工程學系(邀請函如附錄三)分享研究團隊資源循環純化碳化矽永續材料及除濕潔淨轉輪元件積層製作，從原料到製作產品和系統整合完整研發，加強本所與國際間資訊交流與人脈關係拓展，與學者專家討論建立及強化與國際研究機構關係，深入瞭解循環經濟研究發展領域、關鍵性技術、研發設備、專業人力、等溫吸脫附動力研究交流，強化本所與國際合作關係，進而瞭解國外研發現況、市場及未來發展方向，掌握國際相關技術最新發展趨勢，加速計畫研發進程朝有利技術開發方向擘劃，建立合作管道及對象持續強化台灣與國際間之人脈及合作交流關係。

二、過程

(一) 概要說明

2023先進功能性材料國際研討會(2023 International Conference on Advances in Functional Materials)於2023年8月10日至8月12日在美國加州洛杉磯市加州大學舉行，洛杉磯市為加州第一大城市，也是美國人口第二大都市，僅次於紐約市，相對地理位置如圖1~圖3所示。先進功能性材料國際研討會於2017年開始舉辦，是國際重要先進功能性材料科學與技術會議，會議呈現世界研究成果和最新研究趨勢、增加相關領域研究人員交流的場合，並將研究成果具體化。本屆會議總計共有20場學術研討會，口頭發表約70篇。

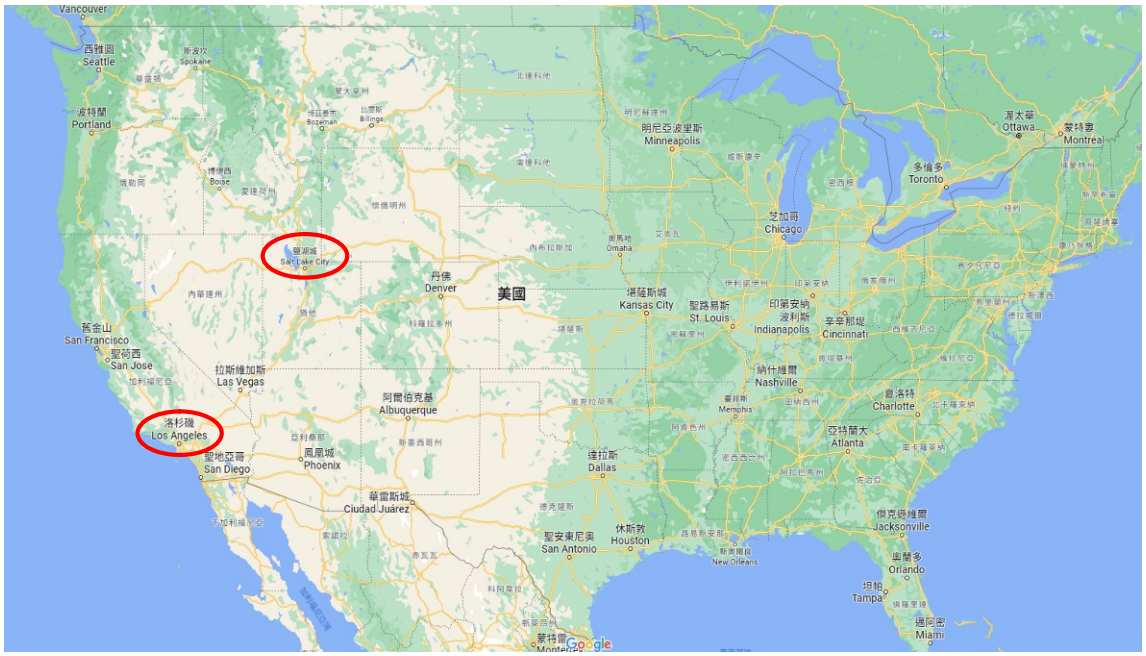


圖 1 美國加州和猶他州地理位置(Google map截錄)

猶他大學是一所位於美國猶他州鹽湖城市公立研究型大學(如圖3)，於1850年建立。楊員於2023年8月14日至8月17日參訪猶他大學土木及環境工程系Professor P.K. Andy Hong和Price College of Engineering Dr. Brian Van Devener(Utah Nanofab 經理和科學家)，進行研究團隊資源循環純化碳化矽永續材料及除濕潔淨

轉輪元件積層製作，從原料到製作產品和系統整合發展現況簡報，簡報結束後於Professor Hong和Dr. Devener引導下參觀土木及環境工程系實驗室及生物醫學工程系的Electron microscopy and surface analysis LAB，了解循環經濟和等溫吸脫附動力研究發展領域、奈米氣泡關鍵性技術和設備研發於環境及淨零碳排的應用，與專業人力交流，促進雙方與合作。

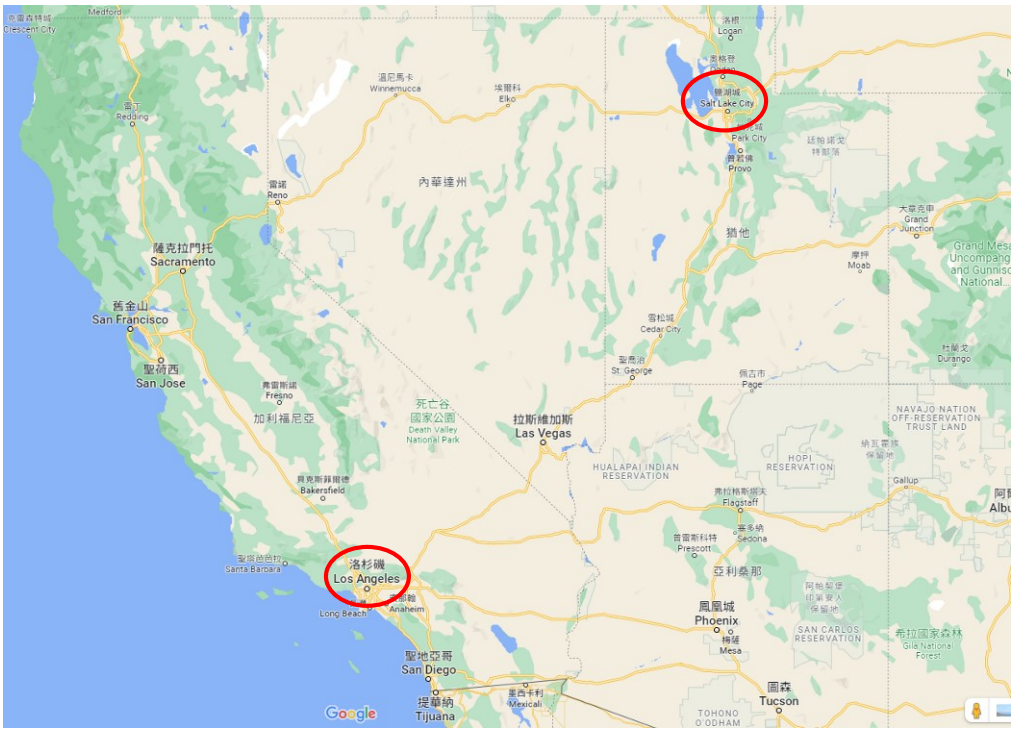


圖 2 加州洛杉磯市和猶他州鹽湖城市地理位置(Google map截錄)

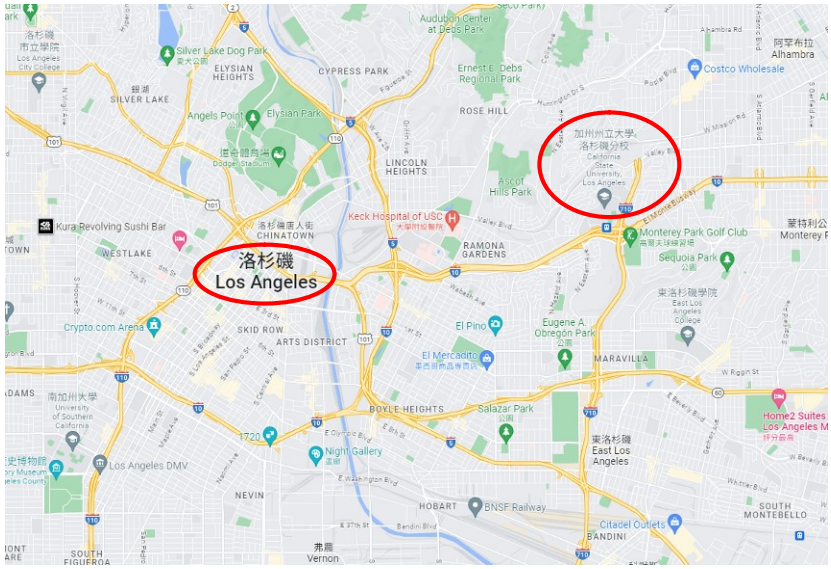


圖 3 會議舉辦地點於洛杉磯市相對地理位置(Google map截錄)

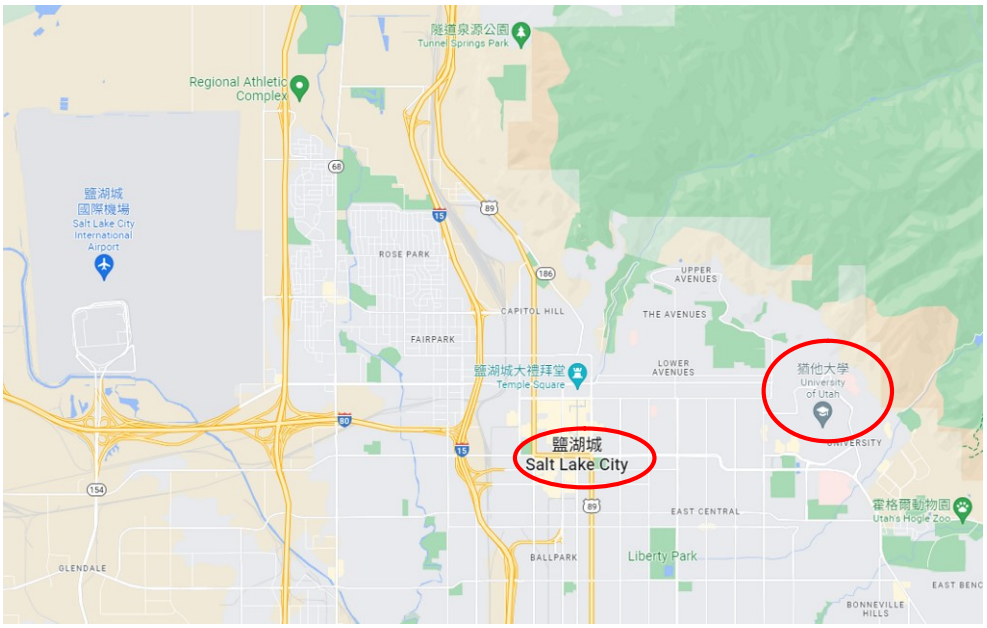


圖 4 猶他大學於鹽湖城市相對地理位置(Google map截錄)

(二) 行程說明

8月10日至8月12日參加2023先進功能性材料國際研討會，口頭發表住商節能關鍵組件技術開發及示範系統研發成果論文及8月14日至8月17日參訪猶他大學土木及環境工程系和Price College of Engineering簡報研究現況，出國行程規劃概述如表1所示。

1. 去程

A. 8月10日(星期四)

8月10日10:10由台灣桃園國際機場搭乘長榮航空BR-6班機(如圖5)起飛前往美國加州洛杉磯，於美國加州時間8月10日早上07:40抵達加州洛杉磯國際機場，辦理完成出關手續後，搭乘計程車前往會議舉辦場地洛杉磯市加州大學，參加2023先進功能性材料國際研討會，口頭發表住商節能關鍵組件技術開發及示範系統研發成果論文。出國行程規劃概述如表1所示，包括參加國際研討會及參訪猶他大學，國際會議為複合材料結構控制和物理、化學和電學特性設計、物理、化學和機械性能基礎研究和材料、特性分析、元件到系統整合領域重要的技術交流論壇，聚集材料、節能、提升能源效率一流人才進行技探討和收錄相當廣泛且深

入的技術資訊，為國際資訊交流重要平台。參訪猶他大學與專業人力交流，促進雙方與合作。

圖5 台灣桃園國際機場搭乘長榮航空班機前往加州洛杉磯國際機場

表1 出國行程規劃概述

日期	行程內容摘述
112/08/10	A. 去程 （台灣 → 美國加州洛杉磯和猶他州鹽湖城） B. 參加國際研討會。出席Functional Materials for Energy Storage and Conversion Devices (FESC) session參與技術探討。
112/08/11	參加國際研討會。出席Functional Composite Materials (FCM)技參與術探討，並於本日口頭發表論文。
112/08/12	出席Fabrication of Low dimensional, Nano and 2D materials (FLNM)和Electronic, Photonic and Magnetic Materials (EPMM) session參與技術探討。
112/08/13	移動至猶他州鹽湖城參訪猶他大學。
112/08/14	準備訪談簡報及報告內容，並與猶他大學土木及環境工程系Professor P.K. Andy Hong見面。
112/08/15	參訪猶他大學土木及環境工程系及簡報研究現況。
112/08/16	參訪猶他大學Price College of Engineering及簡報研究現況。
112/08/17	參訪猶他大學生物醫學工程系的Electron microscopy and surface analysis LAB。
112/08/18~08/19	回程 (美國洛杉磯→ 台灣)

2. 參加會議

2023先進功能性材料國際研討會(2023 International Conference on Advances in Functional Materials)將於112年8月10日至8月12日於美國加州洛杉磯市加州大學(圖6)舉行，原本預定在Ackerman Grand Ballroom，會議當日早上電子郵電通知更改在Kerckhoff State Rooms。該會議包含解決複合材料結構控制和物理、化學和電學特性設計限制，減少生命週期對環境和成本的影響。二維、三維材料及異質結構材料合成新策略、物理、化學和機械性能基礎研究。從材料、特性分析、元件到系統整合，交流當前技術最新進展。

圖 6 會議主辦場地加州大學洛杉磯分校Kerckhoff State Rooms

研討會主要有4個主題包括：

1. 用於能量儲存和轉換的功能性材料：能量儲存和轉換設備仍然是科學和工程研究的重要領域，它們在智慧和互動模式中融入了新穎的特性和功能，代表了消費性產品的進步，例如穿戴式電子產品、醫療保健設備、人工智慧、電動車、智慧型家電用品和太空衛星。然而，在加速能量儲存和轉換設備商業

化基礎研究和理解方面，仍然存在巨大挑戰，其中包括具有高離子電導率的新材料和結構、訂製的混合電子/離子電導率、新穎的界面工程方法、新的裝置概念、用於材料和系統級整合的高效率且可擴展的技術。本次AAAFM-UCLA研討會為從事能量儲存和轉換器件研究的科學家和工程師提供一個論壇，從材料類別、材料特性、裝置到系統整合，交流當前技術的最新進展，並提出下一代解決方案的想法。議程涵蓋用於各種形式的能量收集、轉換和存儲，廣泛功能性材料開發的最新進展，例如便攜式電子產品、電動汽車和智慧電網。本議題論文和重點為新系統和設備開發、現有系統和設備的新穎應用、現有系統和設備的改進以及系統和設備正確應用和操作。

2. 低維度、奈米和二維材料的製造：碳奈米管、石墨烯和過渡金屬二硫化物單層等低維奈米和二維材料由於其獨特的物理和化學性質而成為研究的重點。本次AAAFM-UCLA研討會重點在於如何促進低維度奈米和二維材料及其異質結構的快速進展，從材料合成新策略、物理、化學和機械性能的基礎研究到電子、光電子和光子學等多種應用。大會邀請學者專家及研究人員貢獻與低維奈米和二維材料的基礎和應用相關原創研究工作。本主題包括原子、分子和大分子尺度材料的合成、組裝、特性分析、應用、理論和模擬。
3. 電子、光子和磁性材料：本次研討會涵蓋輕便攜帶式電子產品、電動車和智慧電網等廣泛應用的電子、光子和磁性材料領域的最新發展和創新進展。
4. 功能複合材料：複合材料在海洋和交通運輸等行業的廣泛應用已有50多年的歷史。在某些行業中複合材料近年來成為首選材料。複合材料在建築行業中的使用正在迅速增長。複合材料提供的傳統優勢正在逐一被驗證並被利用來解決設計限制，可用於減少生命週期對環境和成本的影響。先進複合材料的結構控制和物理、化學和電學特性一直在積極研究中，未來將在電子、感測器、能源、環境和資訊設備中具有潛在的應用。本次研討會將為科學家、研究人員、院士、企業家和學生提供一個獨特的平台，分享複合材料技術發展

及其應用最新進展和挑戰。本議題包括複合材料的結構、性能及其在電子、感測器、能源、環境和資訊設備的潛在應用。

議程安排每天至少20個和上述4個主題相關的討論議題(如附錄四)，每個討論議題報告包括討論時間為1~4個小時，每天議程進行至傍晚18:00。參加人員主要來自歐洲、美洲、日本、中國、印度、韓國與台灣等國家。作者參加此2023先進功能性材料國際研討會，並發表“Cellular Desiccant Rotor Produced from Recycling of abrasive slurry”論文一篇，論文摘要如附錄五。作者利用各種交流機會，說明計畫正執行之技術研發及其產業應用潛力，聚焦國際上相關利害關係者的目光，藉此行銷計畫之住商節能關鍵組件技術開發及示範系統研發及共同整合推廣的機會。尋求適合國內情境之資源循環純化永續材料及積層製作技術、從原料到製作產品和系統整合完整研發製造切入的技術整合模式及佈局策略，有助於我國發展上述產業，並進一步協助計畫推動住商節能關鍵組件技術開發及示範系統的產業應用。

圖 7 辦理註冊報到

A. 8月10日(星期四)

早上09:30開始為此國際會議註冊(圖7)報到時間，楊員於美國加州時間8月10

日早上07:40抵達加州國際機場，入境後搭乘計程車前往會議舉辦場地加州大學洛杉磯分校Kerckhoff State Rooms，辦理註冊報到及參加2023先進功能性材料國際研討會。

報到完成註冊後，本日出席參與用於能量儲存和轉換的功能性材料和低維度、奈米和二維材料製造技術探討。Asim等人提出活性碳具有多孔結構和高比表面積，被廣泛用作吸附材料，特別是用於有機化合物吸附移除，活性碳用於吸收水份需要不同的修飾來優化非極性的表面，不同的修飾方法例如摻入金屬或非金屬原子。官能基、多孔結構與溫度影響不同碳質材料對水的吸附性能。水吸附過程取決於碳基吸附材料的表面功能和多孔結構。碳官能基的修飾可將材料功能化，改變它們的特性並使它們適用於各種不同應用，如圖8所示。將吸濕鹽類置入碳基多孔基材(如活性碳)中，並用其他常用吸水材料，例如二氧化矽和沸石對其進行改質是提高吸水性的另一種有效方法。活性碳纖維布和氯化鈣複合材料的吸水率比氯化鈣高，且僅2分鐘內達到90%吸附平衡。由煤和椰子殼製備的活性碳和活性碳纖維含浸氯化鋰的複合材料，對於水的吸附量相對於原材料至少增加1 g水/ g吸附材料。所開發的活性碳纖維氯化鈣和矽膠氯化鈣複合材料之間的吸附水能力比較顯示，活性碳纖維氯化鈣吸附劑的性能提高了三倍。使用氯化鋅活化從煙草莖中製備活性碳複合材料，水蒸氣吸附量可達563.4 mg/g具相當潛力。單壁碳奈米管(SWNT)、多壁碳奈米管(MWNT)和石墨由於其高比表面積和穩定性而成為吸附劑應用中潛在的碳基材料。多層壁奈米碳管植入沸石13X和氯化鈣複合材料，吸水量為0.5 g /g，吸水量是沸石13X的5倍，與沸石相比具有更高導熱性，並且能夠將冰水機的能源效率和比冷卻功率性能提高20%以上。金屬有機框架(MOF)置入作為用於吸附應用的結晶多孔材料，它們的高孔隙率、穩定的結構和可依需求調整的成份使其在不同的應用領域中非常有吸引力，例如熱轉換、質子傳導和空氣除濕。另外，超吸收性樹脂(SAR)和超吸水性聚合物(SAP)或超多孔水凝膠(SPH)，它們出色的吸水和保水能力使它們作為乾燥劑和儲水劑的材料，具

有很高潛力。

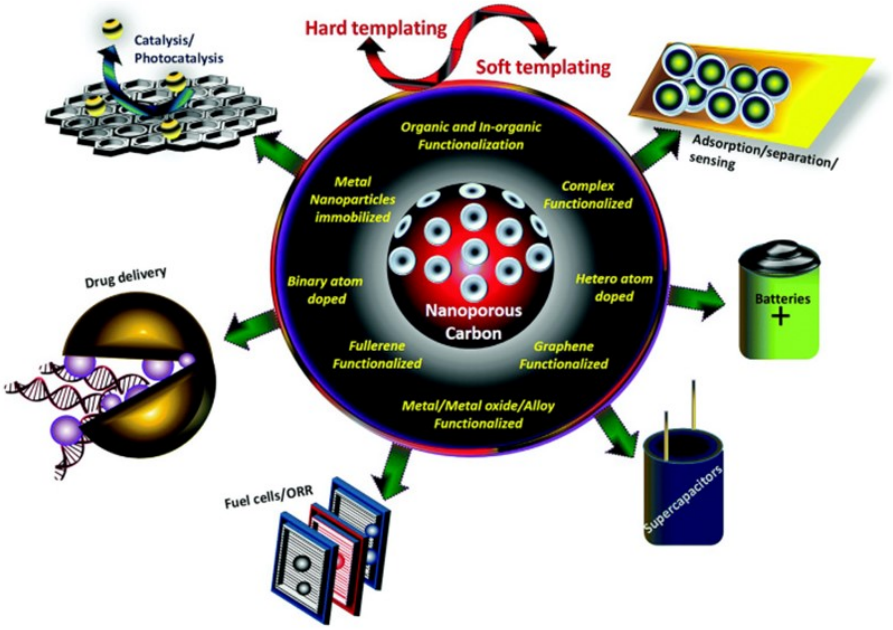


圖8、微孔和介孔碳化合物的合成、功能化官能基置入與應用示意圖

B. 8月11日(星期五)

楊員在8月11日(星期五)下午17:45發表論文" Cellular Desiccant Rotor Produced from Recycling of abrasive slurry "。口頭報告及接受問題回答 (圖9)，本論文是開發材料純化技術包括由篩分、鹼洗、磁力分選與固液分離四個單程序，先以篩分去除大顆粒的切削料，之後藉由鹼洗溶解單晶矽成為離子態而將之從固相中移除，再利用磁力分選單元去除磁性物質，磁選後的混合溶液經固液分離可獲得碳化矽粉末，上述程序可以把光電半導體產業晶圓切削料中的矽、碳化矽以及聚乙二醇個別分離出來，矽可由矽純化工廠、半導體廠或太陽能廠再次運用在矽晶圓上，聚乙二醇可以再次使用在磨漿中，而碳化矽於本研究作為多孔陶瓷的原料，多孔陶瓷製作是在材料成型過程中控制試體孔徑大小和分佈而形成，陶瓷材料試體內部具有彼此連通的氣孔稱為網狀陶瓷，若是孔洞彼此獨立而且封閉則為發泡陶瓷。多孔陶瓷材料具有良好的化學穩定性、機械強度和耐高溫，因此被廣泛的應用在環保、冶金、化工、能源和電子等領域。可運用在熔融金屬過濾材料、氣體的分離和淨化用於電廠排放氣體中粒子的移除、污水生物處理微生物附著和活性

觸媒載體。多孔陶瓷輪於溫度25˚C及相對濕度20%和40%條件下，多孔陶瓷輪對於空氣中水氣的吸附能力是時間的函數，也就是隨著操作時間的增加，環境中水氣的移除量也隨之增加。目前所製作的多孔陶瓷輪在固定環境條件下，操作10分鐘後會達到吸附平衡，直徑8公分和厚度5公分的20、30、40、50和60 PPI多孔陶瓷輪最大吸附量以等溫吸附百分比來表示，介於10~22%。發表過程中展現本所於光電半導體產業晶圓切削料分離純化萃取產生碳化矽材料、轉輪元件製作技術、乾燥除濕輪使用材料、輪體設計、成型方式及如何量化水氣吸脫附能力等進行交流，簡報內容受到與會成員關注並熱烈提問，並於休息時間再與其他專家學者深入討論碳化矽回收純度若可以做到第三代半導體晶圓原料及生產碳化矽晶圓製程研究開發，定義及驗證最佳長晶方式(提拉法或物理氣相輸運法或晶種昇華法)，與業界共同開發高溫設備及精進製程控制如溫度和壓力完成晶圓尺寸放大及商業化生產，落實研發技術及獲得商業化成果，生產更高純度碳化矽純化對於半導體產業會更有效益，利用此交流機會，說明計畫正執行之技術研發及其產業應用潛力，聚焦國際上相關利害關係者的目光，藉此行銷計畫之住商節能關鍵組件技術開發及示範系統研發成果與共同整合推廣的機會，尋求適合國內情境之循環再生永續材料減少礦物開採及節能除濕潔淨轉輪關鍵組件永續智慧製造，提高材料使用率，厚實原料、元件、系統本土化自製能力，節能設備系統整合建立智慧感測監控場域測試驗證有效掌控更加節能，切入技術整合模式及佈局策略，有助於我國發展上述產業，並進一步協助計畫推動住商節能關鍵組件技術開發及示範系統的產業應用。配合國家發展循環經濟與材料高值化之目標，在低污染、低碳排、低能耗及高附加價值的三低一高原則下，結合及整合產研之專業能量，協助國家建構光電產業循環經濟之範型。協助傳統冶煉、陶瓷、資源循環產業，環保化、科技化，達成技術授權與服務，增加產業收益、創新產業、創造產值，推展綠色材料高值化科技。具體解決數量龐大之事業廢棄物處理難題，人民有感，熔融物料再利用，落實循環經濟，建立永續發展生活環境，扶植本土之高科

技環保產業生根，輔導廠商升級，增加企業競爭力。


圖9、論文發表及接受問題回答

C. 8月12日(星期六)

本日為會議進行第三天，早上09:30開始，楊員參加電子、光子和磁性材料和功能複合材料技術探討，瞭解複合材料結構控制和物理、化學和電學特性。Miralbes等人指出積層製造程序可在工件內部產生複雜輕質支架；最近的研究強調了一些3D列印結構，例如晶格結構特別是三週期最小表面結構(TPMS)的高強度和每單位重量吸收能量的高能力。有六種主要不同的TPMS結構包括gyroid、split-p、Schwarz-p、neovious、diamond 和 Lidinoid，所有這些結構均由數學函數定義，可最小化內部表面，從而最大化每單位重量的機械性能。這些結構內部有一些空的空間；所佔體積的百分比從10%到30%之間很常見，因此存在一些空間(90%到70%之間)可以填充另一種結構材料以改善其性能。

3. 參觀訪問美國猶他大學

A. 8月13日(星期日)

10:00搭市區公車前往洛杉磯國際機場，搭乘飛機前往猶他州鹽湖城國際機場，準備參觀訪問猶他大學，下午16:00達猶他州鹽湖城市搭乘火車前往住宿地

點小美國飯店(Little America Hotel Salt Lake City)，辦理住宿等相關事宜。

B. 8月14日(星期一)

本日行程主要上午為準備前往猶他大學土木及環境工程系和Price College of Engineering簡報資料，下午14:00前往猶他大學先行拜訪Professor Andy Hong和Dr. Devener，確認後續三天參訪及簡報地點(圖10)，熟悉附近環境與交通方式，避免隔天因天候或交通因素導致遲到等情形發生，使得參觀訪問能順利完成。

圖10、猶他大學土木及環境工程系系館

C. 8月15日(星期二)

早上09:00由住宿地點出發，搭乘火車前往猶他大學土木及環境工程系，拜訪Professor Andy Hong和他的研究團隊，進行參觀與訪問，09:30抵達土木工程大樓，土木及環境工程系便位於該棟建築物內部，於一樓大廳辦理報到手續，電話通知Professor Andy Hong前來與楊員碰面，簡短寒暄後，帶至其辦公室與會議室進行交流與報告，報告與討論時間為1小時30分鐘，彰顯本所究團隊針對資源循環純化碳化矽永續材料及除濕潔淨轉輪元件積層製作，從原料到製作產品和系統整合完整研發技術、節能乾燥及除濕輪系統整合應用於食品及農作物乾燥取代傳統柴油燃燒器乾燥提供一節能環境友善的替代方案，藉由參訪機會進行交流討論並瞭解猶他國大學最新節能材料、關鍵元件、循環經濟、淨零碳排固碳技術研究發展領域相關研發現況，尋求可能之技術推廣及合作機會，建立與強化彼此合作關係及增益本所研發技術，增益本所研發計畫及執行相關委託研究計畫工作之順利及加速推動。

簡報結束後，在Professor Andy Hong的引導下參觀土木及環境工程系的相關實驗室與貴重儀器設備。此次參訪主要觀摩及學習該實驗室，測試自製循環再生吸附材料對於國防及電子產業作業環境中，移除水氣增加舒適度、維持物料倉儲環境條件穩定度、工業製造程序環境溫濕度控制提升生產良率、移除揮發性有機物保護人體健康的自行組裝測試設備如圖11所示，主要包括霧化水氣產生器、風機和風管。為了此次的參訪與利用其機台進行測試，特地依其機台需求準備自製積層製造除濕潔淨轉輪元件，規格尺寸為：外部直徑為15公分、厚度3公分、孔隙率72%，裝設於測試機台及測試狀況如圖12所示，測試結果顯示15%水氣經過轉輪元件會被移除，蒸氣產生過程因為過飽和會在蒸氣產生處凝結，影響測試的可靠度，8月16日將改變水氣供應方式，再測試自製積層製造除濕潔淨轉輪元件(圖13)，雙方就測試方式進行交流，做為未來技術開發方向建立與調整之重要參考依據，完成此次出國公差主要目的。

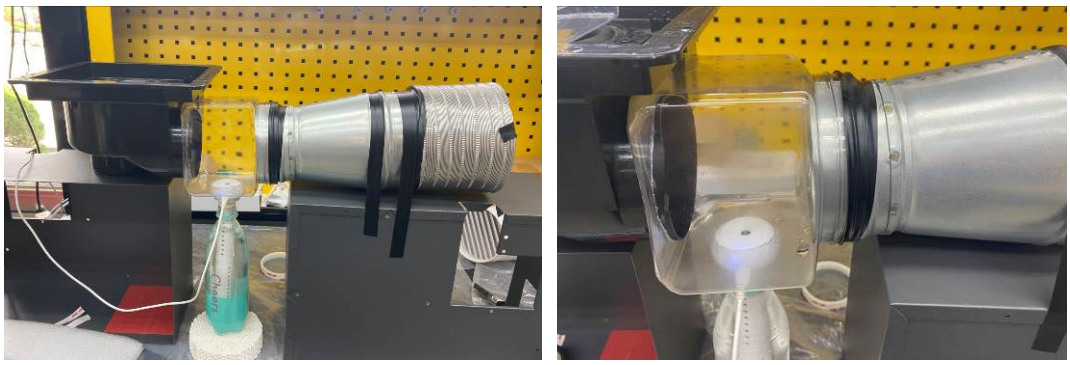


圖11、循環吸附材料移除水氣自行組裝測試設備(送風式)

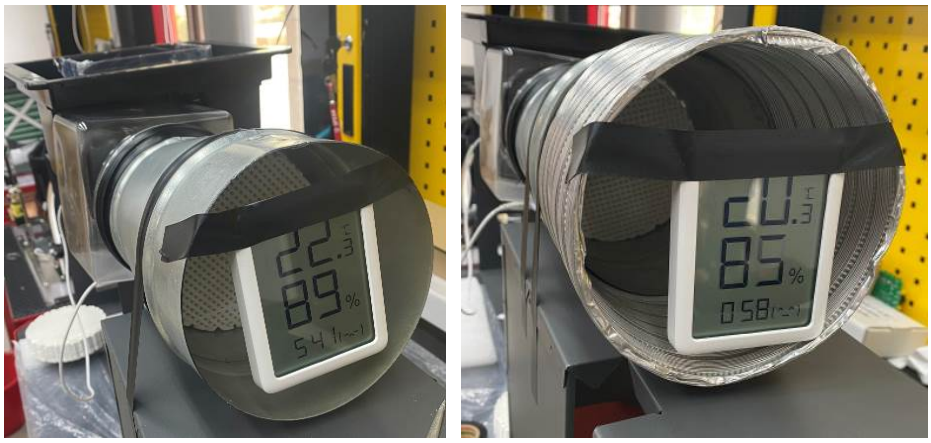


圖12、自製積層製造除濕潔淨轉輪元件裝設於測試機台及測試狀況

圖13、積層製造除濕潔淨轉輪元件

D. 8月16日(星期三)

繼續拜訪猶他大學土木及環境工程系，今日由Professor Andy Hong的博士生協助一同調整量化移除水氣測試設備，將霧化水氣產生器裝置於風機之前，也就是當水霧產生後，藉由風機抽入風管內，經過積層製造除濕潔淨轉輪元件，量測出氣端相對濕度數值，避免蒸氣產生過程因為過飽和產生凝結，影響測試可靠度，抽風式測試機台及測試狀況如圖14所示，測試結果顯示20%水氣經過轉輪元件會被移除。測試交流過程，同時針對積層製造轉輪元件製作技術進行交流，對於加速吸附輪放大積層製作的研發深入討論，期望幫助解決縮短技術瓶頸時間和技轉民間的期程。

圖14、循環吸附材料移除水氣自行組裝測試設備(抽風式)

E. 8月17日(星期四)

早上09:30由住宿地點出發，搭乘火車前往猶他大學，繼續拜訪土木及環境工程系Professor P.K. Andy Hong和Price College of Engineering Dr. Brian Van Devener

進行參觀與訪問，10:00抵達猶他大學生物醫學工程系大樓，UTAH NANOFAB便位於該棟建築物內部，10:10先於其一樓大廳由Dr. Brian Van Devener 介紹UTAH NANOFAB(圖15)的表面分析實驗室和Utah Nanofab無塵室，表面分析實驗室是猶他大學Nanofab的分析部門，建置各式顯微鏡包括光學、電子和離子顯微鏡用來研究和分析材料和元件表面形貌、表面化學以及材料的光學和介電性能。猶他大學Nanofab無塵室是猶他大學Nanofab的各式晶片製造和製程設計部門，在奈米製造技術擁有多年工業和學術經驗的專家團隊，Nanofab無塵室(圖16)具有100/1000/10,000等級潔淨室提供光刻、沉積、蝕刻、封裝、微型3D列印、雷射圖案化等設備，為有需求的產官學研隊提供設計和製造流程所需工具或專家。

圖15、Dr. Brian Van Devener介紹UTAH NANOFAB

圖16、Dr. Brian Van Devener介紹Nanofab無塵室

初步概要性介紹結束後，在Professor Hong和Dr. Brian Van Devener的引導下參觀表面分析實驗室和Utah Nanofab無塵室的相關實驗室與貴重儀器設備。主要包

括KRATOS AXIS ULTRA X射線/紫外線光電子能譜儀、蔡司XRADIA VERSA 620 3D X光顯微鏡/奈米CT、配備Trinity檢測系統的FEI TENEO SEM、安東帕(Anton Paar) SAXS/WAXS/GISAXS/RheoSAXS實驗室光束線(Beamline)-SAXSpoint 5.0和Hysitron TI-Premier微奈米力學測試系統。

(一) KRATOS AXIS ULTRA X射線/紫外線光電子能譜儀

Kratos Axis Ultra (圖17)是一種多重分析技術，可對元素成份及其氧化態進行定量分析和成像。採樣深度取決於樣品組成，但通常不超過10 nm。其他功能包括歐傑電子能譜(Auger electron spectroscopy, AES)、掃描歐傑顯微鏡(Scanning auger microscopy, SAM)、低能離子散射能譜(Low energy ion scattering spectroscopy, LEISS)、紫外光電子能譜(Ultraviolet photoelectron spectroscopy, UPS)。主要應用在電漿處理或其他測試反應後金屬表面氧化分析、表面氧化態成像、使用 紫外光電子能譜測量金屬和半導體的費米能量和功函數、單層表面污染物的定量分析和單層表面污染物的定量分析。

圖17、KRATOS AXIS ULTRA X射線/紫外線光電子能譜儀

(二) 蔡司XRADIA VERSA 620 3D X光顯微鏡/奈米CT

X射線顯微鏡(圖18)以高達600 nm的分辨率對材料進行無損3D成像，支援的晶體成像模式、觀察材料隨時間於熱、冷、機械負荷的變化情形、材料承受高達5kN的負載下即時加熱/冷卻/拉伸/壓縮階段的觀察、透過平板擴展實現大體積樣品成像、斷層重建軟體和3D視覺化與分割軟體(Dragonfly pro)。

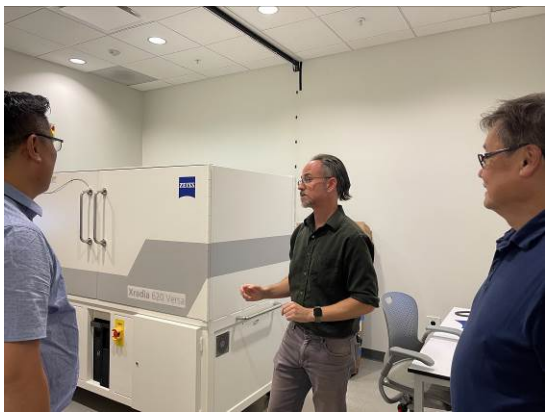



圖18、蔡司XRADIA VERSA 620 3D X光顯微鏡/奈米CT

(三) 配備Trinity檢測系統的FEI TENEO SEM

FEI Teneo™是一個超高解析度分析式掃描電子顯微鏡(圖19)，可為各種磁性和非導電材料樣品提供出色的分析性能。鏡頭內FEI Trinity™偵測器可同時收集所有訊號，從而節省時間並提供明顯不同的對比度以捕捉最大量的資料。無需塗層即可對導電和非導電材料進行約20 nm高解析度成像，更好的Z對比度成像，光束能量低至200 eV和衝擊能量20 eV，表面敏感高解析度成像，使用能量色散光譜(Energy dispersive spectroscopy, EDS)進行元素圖譜和半定量成分分析，使用電子背散射衍射(Electron backscatter diffraction, EBSD)進行晶粒分析包括晶粒尺寸、方向和組織結構。

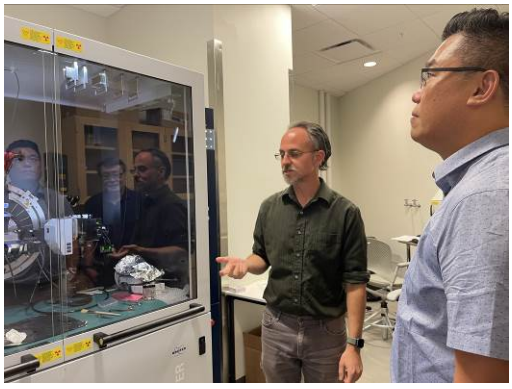



圖19、配備Trinity檢測系統的FEI TENEO SEM

(四) 安東帕(Anton Paar) SAXS/WAXS/GISAXS/RheoSAXS實驗室光束線(Beamline)-SAXSpoint 5.0

SAXSpoint 5.0是SAXS/WAXS/GISAXS/RheoSAXS實驗室光束線(圖20)採用同

步加速器偵測器技術，可在小型系統中實現最高解析度。SAXS系統，可解析高達620 nm的奈米結構。SAXSpoint 5.0可於大氣環境和真空條件下的分析各種材料。藉由自動操作和數據分析的軟體，對材料特性進行非破壞性研究。主要應用在定義單分散大分子的尺寸和形狀、測量孔徑、奈米顆粒尺寸分佈、量測部分有序材料的晶格距離、粒子系統微米級到奈米級結構的一般特性分析包括平均顆粒尺寸、形狀、分佈和表面積與體積比，分析的樣品可以是固體、液體或兩者的混合物。

圖20、安東帕(Anton Paar) SAXSpoint 5.0實驗室光束線

(五) BRUKER Dimension® Icon™原子力顯微鏡(Atomic force microscope, AFM)

AFM(圖21)透過使用探針檢測樣品表面和探針之間的分子間力來提供表面拓撲。主要用來測量奈米級表面粗糙度(<1 nm至~500 nm)、奈米級台階高度的測量、可在流體池和受控環境中進行分析、原子尺度的表面操縱與修飾、表面粗糙度定量測量、彈性模量量測範圍為~1 MPa至50 Gpa和黏附力定量範圍為~10 pN至10 N。

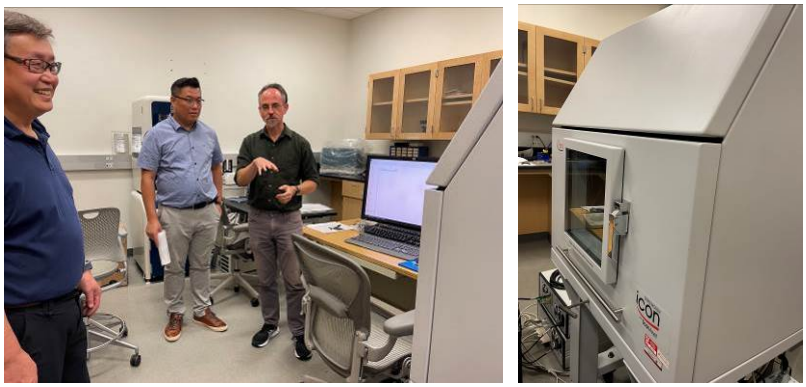


圖21、原子力顯微鏡(Atomic force microscope, AFM)

(六) Hysitron TI-Premier微奈米力學測試系統

Hysitron TI Premier微奈米力學測試系統(圖22)提供定量奈米力學特性。透過非壓痕測量材料硬度、楊氏模量、斷裂韌性和其他機械性能。可以分析各種材料包括半導體、聚合物、金屬、薄膜和多層材料。實驗前後獲取並對比測試區域表面的納米尺度形貌像，透過控制施加在樣品上的負載量進行材料磨損分析，最大適用負載~100 μN，進行材料在800°C高溫下的奈米級機械和摩擦學行為研究，可選惰性氣體流過樣品以防止材料在高溫下氧化。

圖22、Hysitron TI-Premier微奈米力學測試系統

4. 回程

8月17日下午參觀訪問結束後出發至鹽湖城國際機場，楊員於美國猶他州時間8月17日下午19:01於鹽湖城國際機場搭乘精神航空(圖23)前往加州洛杉磯，美國加州時間8月17日下午20:00抵達洛杉磯國際機場，辦理完成出境手續，8月18日凌晨00:50搭乘長榮航空公司BR-11班機返回台灣桃園國際機場。台灣時間8月19日凌晨05:10抵達台灣桃園國際機場，順利完成出國公差任務。

圖23、鹽湖城國際機場搭乘精神航空班機前往加州洛杉磯國際機場

三、心得

(一) 楊昇府博士本次赴美國加州洛杉磯市加州大學參加2023先進功能性材料國際研討會並順利完成口頭論文發表。國際先進功能性材料研討會於2017年開始舉辦，每年舉辦一次，為國際重要先進功能性材料科學與技術重要資訊交流平台。本次大會舉辦總計共有20場學術研討會，來自歐洲、美洲、日本、中國、印度、韓國與台灣等國家專業人士參加，約70篇論文投稿。本所在台灣為住商節能關鍵組件技術開發及示範系統研究與發展的重要角色，在此大型國際會議與重要先進功能性材料議題，站上講台分享研究成果實屬難得，未來應該提供充足經費與支援，持續派人參加此先進功能性材料重要會議，站上國際講台為所與台灣在此研究領域發聲與國際人士進行交流。

(二) 進行住商節能關鍵組件技術開發及示範系統智慧化連續監控系統建置，加裝智慧感測器及連續監控系統，收集運轉時相關參數變化趨勢，進行數據分析作為管理依據。逐年場域驗證工業住商部門除濕乾燥增加舒適度、提升物料倉儲環境穩定度、工業製造程序環境溫濕度有效控制提高生產良率等需求，增進國內除濕乾燥潔淨設備能源使用效率和帶動製造商產業升級為標的，精進循環再生永續材料開發，減少礦物開採及節能除濕潔淨轉輪關鍵組件永續智慧製造，提高材料使用率，厚實原料、元件、系統本土化自製能力，節能設備系統整合建立智慧感測監控場域測試驗證有效掌控更加節能，量化生產場域碳足跡及評估二氧化碳減量效益，完成認證機構碳足跡查驗及碳足跡標章商標申請。協助產業創新提升經濟政策與實踐，落實ESG永續工業生產，達成工業生產低碳產品，完成工業碳盤查及驗證。

(三) 國際先進功能性材料研討會提供國際間從事複合材料結構控制和物理、化學和電學特性設計限制，減少生命週期對環境和成本的影響，二維、三維材料及異質結構材料合成新策略、物理、化學和機械性能基礎研究，從材料、特

性分析、元件到系統整合領域研究的研發人員及產學研界一個優質的交流平台，並建立國際間彼此的連結及促進友好關係。本次公差主要與國際學者進行討論與交流，楊員於會議期間展現資源循環純化碳化矽永續材料及除濕潔淨轉輪元件積層製作，從原料到製作產品和系統整合發展現況與住商節能關鍵組件技術開發及示範系統研究成果，於會後分享研究心得，研發成果受到肯定，同時收集技術資訊實屬難得，未來應該提供充足經費與支援，持續派人參加此先進功能性材料科學與技術會議並與國際人士進行交流。

(四) 美國猶他大學為世界知名大學，於節能材料、關鍵元件、循環經濟研究發展領域、關鍵性技術、研發設備、專業人力、分子於固液和固氣界面反應及動力行為、等溫吸脫附動力曲線研究發展領域等具有相當高的水準。本次參觀與訪問猶他大學土木及環境工程系Professor P.K. Andy Hong和Price College of Engineering Dr. Brian Van Devener (Utah Nanofab 經理和科學家)，進行研究團隊資源循環純化碳化矽永續材料及除濕潔淨轉輪元件積層製作，從原料到製作產品和系統整合發展現況簡報，簡報結束後於Professor Hong和Dr. Devener引導下參觀土木及環境工程系實驗室及生物醫學工程系的Electron microscopy and surface analysis LAB，瞭解循環經濟和等溫吸脫附動力研究發展領域、奈米氣泡關鍵性技術和設備研發於環境及淨零碳排的應用，與專業人力交流，促進雙方與合作及增益本所研發技術。

(五) 藉由此次拜訪猶他大學土木及環境工程系，瞭解如何量化水氣吸附能力，應用自行組裝測試設備時監測乾燥空氣出風口。依據測試機台所需尺寸(直徑15公分、厚度3公分)，攜帶目前開發之自製積層製造除濕潔淨轉輪元件利用其機台進行測試，瞭解技術之異同，學習國外測試設備開發成功經驗及方法，加快本計畫之技術研發能量，提升國內量化移除水氣測試設備、自製循環再生吸附材料及積層製造除濕潔淨轉輪元件技術能力，做為未來技術開發方向建立與調整之重要參考依據。

(六) 自製積層製造除濕潔淨轉輪元件依照飽和水氣供應方式及位置的調整，呈現不同測試的數值，送風式水氣供應方式測試結果顯示15%水氣經過轉輪元件會被移除，蒸氣產生過程因為過飽和會在蒸氣產生處凝結，影響測試的可靠度，抽風式水氣供應方式測試結果顯示20%水氣經過轉輪元件會被移除。測試交流過程，同時針對積層製造轉輪元件製作技術進行交流，對於加速吸附輪放大積層製作的研發深入討論，期望做為未來技術開發方向建立與調整之重要參考依據，幫助解決縮短技術瓶頸時間和技術轉移產業的期程。

(七) 在Professor Andy Hong和Dr. Devener的引導下，分別參觀猶他大學土木及環境工程系實驗室和UTAH NANOFAB表面分析實驗室和無塵室的相關實驗室的貴重儀器設備。主要包括KRATOS AXIS ULTRA X射線/紫外線光電子能譜儀、蔡司XRADIA VERSA 620 3D X光顯微鏡/奈米CT、配備Trinity檢測系統的FEI TENEO SEM、安東帕(Anton Paar) SAXS/WAXS/GISAXS/RheoSAXS實驗室光束線(Beamline)-SAXSpoint 5.0和Hysitron TI-Premier微奈米力學測試系統，研究資源相當充足，對於基礎科學研究相當有幫助。政府於培植重點研究型大學或研究機構在提供經費時可為借鏡，有足夠的且優良的工具，方能培養出一流學生、研究人員、研究單位與品質優良的研究結果。

(八) Professor Hong實驗室奈米氣泡關鍵性技術和設備研發於環境及淨零碳排的應用，可與研究團隊後續開發電漿噴塗應用於二氧化碳分離膜技術開發相結合進行分離後二氧化碳的封存，將工業所排放煙道氣二氧化碳有效分離，減少排放至大氣二氧化碳排放量，達到碳捕捉目的。如圖24所示。

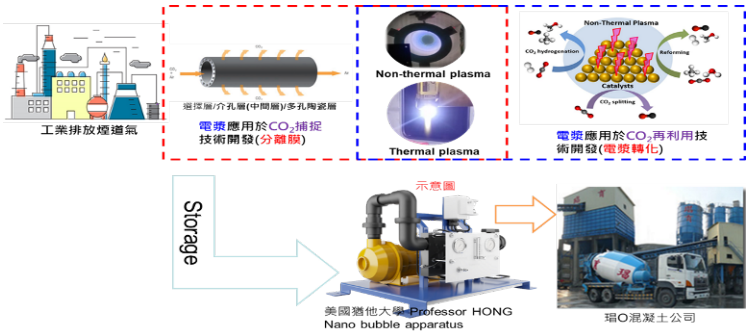


圖24、奈米氣泡關鍵性技術和設備應用二氧化碳封存達減碳目標

四、建議事項

本次出國公差前往美國加州洛杉磯市參加2023先進功能性材料國際研討會口頭發表論文、汲取國際第一手研究內容與參訪美國猶他大學國際一流專家學者討論互動及研究交流，個人建議如下：

(一) 此屆國際會議議程安排每天至少20個，相關的討論議題包括用於能量儲存和轉換的功能性材料、低維度、奈米和二維材料的製造、電子、光子和磁性材料及功能複合材料，由口頭發表論文數量與參加人數與國家(歐洲、美洲、日本、中國、印度、韓國與台灣)可以發現皆逐年增加，世界上對於先進功能性材料的研究及商業化發展的關注持續增加。先進功能性材料國際研討會，儼然成為國際間解決複合材料結構控制和物理、化學和電學特性設計限制，減少生命週期對環境和成本的影響。二維、三維材料及異質結構材料合成新策略、物理、化學和機械性能基礎研究。從材料、特性分析、元件到系統整合技術研究領域相當重要且主要的交流平台。建議計畫未來應持續規劃與派員參加該國際會議，真實呈現國內的研發成果、研究近況、拓展國際人脈關係，加速計畫之進展，使得所內與國內的研發可與國際接軌，並掌握國際間之發展現況及未來趨勢。

(二) 此屆先進功能性材料國際研討會功能複合材料技術探討指出積層製造程序可在工件內部產生複雜輕質支架，對於研究團隊多孔吸附陶瓷積層製造的製圖與漿料配比調製黏度調整相當有助益，未來積層製造3D列印結構將朝三週期最小表面結構(TPMS)的高強度和每單位重量吸收能量高能力去發展，TPMS結構包括gyroid、split-p、Schwarz-p、neovious、diamond 和 Lidinoid，所有這些結構均由數學函數定義，可最小化內部表面，從而最大化每單位重量的機械性能。這些結構內部有一些空的空間所佔體積百分比從10%到30%之間很常見，存在70%~90%空間可以填充另一種結構材料以改善積層製造多孔吸附性

能。經由親身參與口頭發表論文，可以促進及充實本職學能，參與會議期間向與會專家學者請益，發表內容領域議題備受重視及肯定。楊員由在口頭報告時聽講人數，與之後受到與會者們的踴躍提問，可以發現對此研究領域的關注越來越多，本所現具有領先的優勢，建議未來可投入更多人力與經費積極研發，持續掌握領先優勢，朝實用化的角度去發展。

(三) 此次美國出國公差參訪猶他大學土木及環境工程系和Price College of Engineering，為雙方首次彼此互動和交流，利用其機台進行測試，瞭解技術之異同，學習國外產品技術開發之成功經驗及方法，加快本計畫之技術研發能量，提升國內自製吸附劑及基層製造陶瓷轉輪元件技術能力，做為未來技術開發方向建立與調整之重要參考依據。建議未來可以本次所建立的合作管道為基礎，進行互訪、合作或派員交流實習，促進技術與學術交流，掌握關鍵技術，並了解國際趨勢，有助於計畫之執行，並對我國節能材料、關鍵元件、循環經濟、淨零碳排固碳技術研究發展領域有很大的助益。透過雙方緊密的國際交流與專家討論會議，可拓展研究深度與提升國際同業審查應對能力，並提升本所節能及淨零碳排相關技術能力。

(四) 參觀訪問Professor Hong實驗室奈米氣泡關鍵性技術和設備研發於環境及淨零碳排的應用，二氧化碳陶瓷分離膜將工廠煙道氣二氧化碳分離濃縮捕抓，捕抓之二氧化碳經過美國猶他大學土木工程系開發的設備形成二氧化碳奈米氣泡，打入正在拌合的混凝土，形成碳酸鈣結晶增益混凝土品質，達到減碳的目標，建議可進一步進行交流，促進淨零碳排技術合作。

五、附錄

附錄一、第二十一屆表面動力國際研討會邀請函

AAAFM - 9330 LBJ Freeway - Suite 934B - Dallas, Texas 75243, USA

Dr. Sheng-Fu Yang
Institute of Nuclear Energy Research, Atomic Energy Council
Physics Division
No. 1000, Wenhua Rd., Longtan District,
Taoyuan County 32546
Taiwan

American Association for Advances in Functional Materials
9330 LBJ Freeway, Suite 934B Dallas,
Texas 75243, USA

Los Angeles, USA, 18/July/2023

Formal Invitation Letter

To Whom It May Concern

This is to confirm that **Dr. Sheng-Fu Yang** is welcome to participate in **AAAFM-UCLA International Conference on Advances in Functional Materials 2023**, to be held in Los Angeles, USA.

Please note that registration fees, travel, living and accommodation expenses will not be supported by the conference organization.

Last Name / Family Name: Yang
First & Middle Name: Sheng-Fu

Dr. Sheng-Fu Yang is author or co-author of the following presented contribution(s):

Abstract ID: 258
Cellular Desiccant Rotor Produced from Recycling of abrasive slurry
Author(s): Yang, Sheng-Fu; Wang, To-Mai; Chen, Chun-Liang; Chien, Kuang-Li; Liang, Chih-Chao; Chuo, Hsien-Ho
Presenting Author: Yang, Sheng-Fu
Conference Track: Symposium 4: Functional Composite Materials (FCM)
Status: This abstract has been accepted for oral presentation

We look forward to seeing Dr. Sheng-Fu Yang.

Yours sincerely,

Organizing Committee,
Advances in Functional Materials Conference
AAAFM-UCLA, August, 10-12, 2023
https://aaafm.org/ucla2023
aaafm-ucla@aaafm.org

附錄二、會議投稿摘要接受通知

AAAFM 2023 August 10-12 @ UCLA

Organized by: AAAFM

CONFERENCE LOCATION:
University of California, Los Angeles (UCLA)

AAAFM - 9330 LBJ Freeway - Suite 934B - Dallas, Texas 75243, USA

Dr. Sheng-Fu Yang
Institute of Nuclear Energy Research, Atomic Energy Council
Physics Division
No. 1000, Wenhua Rd., Longtan District,
Taoyuan County 32546
Taiwan

American Association for Advances in Functional Materials
9330 LBJ Freeway, Suite 934B Dallas,
Texas 75243, USA

Los Angeles, USA, 18/July/2023

Acceptance Letter

This is to inform you that the **abstract(s)** of **Dr. Sheng-Fu Yang** has/have been accepted for presentation at **AAAFM-UCLA 2023 in Los Angeles, USA**. All technical sessions will be held during August 10 – 12, 2023 in Los Angeles, USA.

The registration is now open. Regular delegates can register for the conference on/before 15th January 2023 to avail of early bird discounts. Make sure that you use your Abstract Approval ID (provided below and in your email as well) while making registration and further communicating with the organizers. Please visit to complete your registration now.https://aaafm.org/ucla2023/registration/. Students and postdocs are required to upload valid ID proof during registration to avail of the discounted rates

Dr. Sheng-Fu Yang is author/co-author of the following accepted contribution(s):

Abstract ID: 258
Cellular Desiccant Rotor Produced from Recycling of abrasive slurry
Author(s): Yang, Sheng-Fu; Wang, To-Mai; Chen, Chun-Liang; Chien, Kuang-Li; Liang, Chih-Chao; Chuo, Hsien-Ho
Presenting Author: Yang, Sheng-Fu
Conference Track: Symposium 4: Functional Composite Materials (FCM)
Status: This abstract has been accepted for oral presentation

For Oral Presenters: A projector and screen will be available in each meeting room, and in most rooms, a lapel microphone and podium will be provided. AAAFM does not provide computers in all function rooms, so please plan to bring a laptop or make arrangements with your session chairs to use their computer and bring your presentation on a flash drive. All technical sessions, scheduled times, and locations will be announced soon.

For Poster Presenters: Posters must be of **A1 size (in portrait)**. Authors should print the poster and bring it with them to the conference. The schedule for the poster presentation will be published soon on our website.

For any further assistance, please feel free to contact us through email at: aaafm-ucla@aaafm.org

With kind regards,

Organizing Committee,
Advances in Functional Materials Conference
AAAFM-UCLA, August, 10-12, 2023
https://aaafm.org/ucla2023
aaafm-ucla@aaafm.org

AAAFM Materials For Life
rican Association for Advances in Functional Materials

附錄三、美國猶他大學邀請函

Andy Hong, Ph.D., P.E.
Professor, Department of Civil & Environmental Engineering

July 18, 2023

Dr. Sheng Fu Yang
Researcher
Physics Division
Institute of Nuclear Energy Research, Atomic Energy Council, Executive Yuan
Taoyuan City, Taiwan

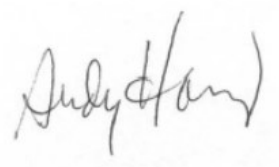
Subject: Invitation to visit

Dear Dr. Yang,

I am pleased to host your three-day visit to our Department of Civil and Environmental Engineering at the University of Utah beginning August 15, 2023. I understand that you will be attending the AAAFM-UCLA meeting in Los Angeles, and we are fortunate to have this opportunity of your visit that I am sure will provide considerable discussion and exploring our mutual interest in environmental research as well as potential collaboration between INER and the University of Utah in the areas of energy efficiency, circular economy, environmental plasma technology, and renewable energy. Several groups that you will be meeting with in the Department and the Price College of Engineering will be quite interested in potential collaboration. Further, we would very much appreciate for you to give a talk on ongoing work at INER, as related to environmental preservation and sustainability.

Thank you for bring us this opportunity to meet and we look forward to welcoming you to Salt Lake City, Utah in August.

Sincerely yours,



Andy Hong, Ph.D., P.E.
Professor
University of Utah

2068 MCE, 110 Central Campus Drive, Salt Lake City, Utah 84112
Phone: (801) 581-7232; FAX: (801) 585-5477; Email: hong@civil.utah.edu; Web: www.civil.utah.edu/~hong/

附錄四、2023先進功能性材料國際研討會相關議題

AAAFM

American Association for Advances in Functional Materials

Materials For Life

AUGUST 10-12, 2023

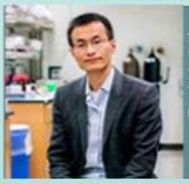
International Conference

functional materials for industrial development

Plenary Speakers

Prof. Alexander Balandin
University of California, Los Angeles

Prof. Andrea C. Ferrari
University of Cambridge united kingdom

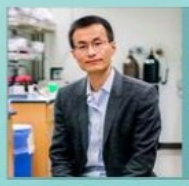


Prof. Peidong Yang
Berkeley College of Chemistry

Prof. Steve Denbaars
UCSB, USA

Prof. Arumugam Manthiram
The University of Texas at Austin

AAAFM Award Winners 2023



Prof. Peidong Yang
Berkeley College of Chemistry

Prof. Alexander Balandin
University of California, Los Angeles

Prof. Jiaxing Huang
Westlake University, Hangzhou, China

Date: Thursday, 10/Aug/2023	
9:30am - 4:00pm Theatre-Lobby	**Reg: Registration** Location: **Theatre-Lobby**
11:00am - 11:10am Theatre	**Open Cerem: Opening Ceremony** Location: **Theatre** Session Chair: **Xiangfeng Duan**
11:10am - 12:00pm Theatre	**Keynote: Keynote Session** Location: **Theatre** Session Chair: **Xiangfeng Duan**
12:00pm - 1:30pm Theatre-Lobby	**Lunch Break: Lunch Break-1** Location: **Theatre-Lobby**
1:30pm - 3:10pm Theatre	**Keynote-1: Keynote Session** Location: **Theatre**
3:30pm - 6:00pm AU 2410	**Invited Talk: Invited Talk** Location: **AU 2410** Session Chair: **Alexander Balandin**
3:30pm - 6:00pm Theatre	**Oral Talk-1: Oral Talk** Location: **Theatre** Session Chair: **Peter Brueggeller**
Date: Friday, 11/Aug/2023	
9:00am - 3:30pm Theatre-Lobby	**Reg-1: Registration-1** Location: **Theatre-Lobby**
9:30am - 11:30am Theatre	**Keynote Session-2: Keynote Session** Location: **Theatre** Session Chair: **Muhammad Imran Shakir**
12:00pm - 1:30pm Theatre-Lobby	**Lunch Break-2: Lunch Break-2** Location: **Theatre-Lobby**
1:30pm - 6:00pm Theatre	**Invited Talk-1: Invited Talk** Location: **Theatre** Session Chair: **Junboum Park**
1:30pm - 6:00pm AU 2410	**Oral Talk-2: Oral Talk** Location: **AU 2410** Session Chair: **Tetyana Budnyak**
Date: Saturday, 12/Aug/2023	
9:00am - 11:30am Theatre-Lobby	**Reg-2: Registration** Location: **Theatre-Lobby**
9:30am - 10:30am Theatre	**Plen Sess: Plenary Session** Location: **Theatre** Session Chair: **Xiangfeng Duan**
10:30am - 1:00pm Theatre	**Invited Talk-2: Invited Talk** Location: **Theatre** Session Chair: **Jonas Johansson**
10:30am - 2:00pm AU 2410	**Oral Talk-3: Oral Talk** Location: **AU 2410** Session Chair: **Kausik Das**

Presentations

Keynote: Keynote Session

Time: Thursday, 10/Aug/2023: 11:10am - 12:00pm · *Location:* Theatre
Session Chair: Xiangfeng Duan

11:10am - 12:00pm

Layered materials as a platform for quantum technologies

Andrea Ferrari
University of Cambridge, UK; acf26@cam.ac.uk

Layered materials are taking centre stage in the ever-increasing research effort to develop material platforms for quantum technologies. We are at the dawn of the era of layered quantum materials. Their optical, electronic, magnetic, thermal and mechanical properties make them attractive for most aspects of this global pursuit. Layered materials have already shown potential as scalable components, including quantum light sources, photon detectors and nanoscale sensors, and have enabled research of new phases of matter within the broader field of quantum simulations. I will discuss opportunities and challenges faced by layered materials within the landscape of material platforms for quantum technologies, with focus on applications that rely on light–matter interfaces[1].

[1] A. R. P. Montblanch et al. Nature Nano 2023, 10.1038/s41565-023-01354-x

Keynote-1: Keynote Session

Time: Thursday, 10/Aug/2023: 1:30pm - 3:10pm · *Location:* Theatre

1:30pm - 2:20pm

Recent Advances in III-Nitrides for UV and Visible Photonics Materials and Devices

Steve Denbaars
Ucsb, United States of America; spdenbaars@ucsb.edu

The developments of high performance InGaN based RGB micro-light-emitting diodes (μLEDs) and Blue and Green Laser Diodes are discussed. Through novel epitaxial growth and processing, and transparent packaging we have achieved external quantum efficiencies as high as 58% EQE at 450nm for microLEDs. The critical challenges of μLEDs, namely full-color scheme, decreasing pixel size and mass transfer technique, and their potential solutions are explored. Recently, we have demonstrated efficient microLEDs emitting in the blue to red at dimensions as small of 1 micron. Using strain relaxation methods we have also extending the wavelength range of the InGaN alloys as into the red with emission as long as 640nm. Red InGaN based red MicroLEDs with efficiencies of 6% has been fabricated, and they display superior temperature performance in comparison to AlGaInP based devices. Recently, we have employed novel ALD passivated deep recessed ridge etching and porous GaN to make novel blue and green laser diodes. Green laser diodes with emission wavelengths as long as 524nm have been achieved using novel porous GaN waveguides. This work was supported by the Solid State Lighting and Energy Electronics Center(SSLEEC) at UC Santa Barbara.

2:20pm - 3:10pm

Two-Dimensional Charge-Density-Wave Quantum Materials and Devices

Alexander Balandin
University of California, United States of America; balandin@ece.ucr.edu

The charge-density-wave (CDW) phase is a quantum condensate consisting of a periodic modulation of the electronic charge density accompanied by a periodic distortion of the atomic lattice in quasi-one-dimensional (1D) or quasi-two-dimensional (2D) metallic van der Waals crystals. Several layered quasi-2D transition metal dichalcogenides (TMDs) exhibit unusually high transition temperatures to various CDW symmetry-reducing quantum phases, opening the possibility for practical applications in electronics and energy conversion. One of the most promising materials, 1T-TaS2, has the CDW transition between the nearly commensurate (NC-CDW) and the incommensurate (IC-CDW) phases at ~350 K. In this talk, I will review our experimental results on controlling the CDW phase transitions in quasi-2D materials with

temperature, electric field, electromagnetic RF waves, and discuss possible device applications of quasi-2D CDW quantum materials. I will describe the room-temperature voltage-controlled oscillators, which operate based on the NC-to-IC CDW transition in the quasi-2D 1T-TaS2 channels [1-2]; discuss exceptional radiation hardness of quasi-2D CDW materials and devices [3-4]; the use of the low-frequency electronic "noise spectroscopy" for monitoring the CDW phase transitions [5-7]; the potential speed of the room-temperature CDW quantum devices [8]; electrical gating of CDW quantum phases [9], and additive manufacturing of quantum devices via 3D printing [10].

This work was supported, in part, by the U.S. DOE Office of Basic Energy Sciences under the contract "Physical Mechanisms and Electric-Bias Control of Phase Transitions in Quasi-2D Charge-Density-Wave Quantum Materials" and by the Vannevar Bush Faculty Fellowship, under the ONR contract "One-Dimensional Quantum Materials".

Key Words: two-dimensional materials; quantum materials; strongly correlated materials

References

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2. A. G. Khitun, et al., IEEE Electron Device Letters, 39 (2018) 1449
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4. A. K. Geremew, et al., Nanoscale, 11 (2019) 8380
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8. A. Mohammadzadeh, et al., Appl. Phys. Lett., 118 (2021) 093102
9. M. Taheri, et al., ACS Nano, 16 (2022) 18968
10. S. Baraghani, et al., ACS Nano, 16 (2022) 6325

Invited Talk: Invited Talk

Time: Thursday, 10/Aug/2023: 3:30pm - 6:00pm · *Location:* AU 2410
Session Chair: Alexander Balandin

3:30pm - 3:55pm

Spin-lattice coupling in yttrium iron garnet studied by neutron scattering under ultrasound injection

Shinichi Shamoto[1,2,3,4], Masato Matsuura[1], Mitsuhiro Akatsu[5], Jun'ichi Ieda[3]

[1]Comprehensive Research Organization for Science and Society, Tokai, 319-1106, Japan; [2]National Cheng Kung University, Tainan 701, Taiwan; [3]Japan Atomic Energy Agency, Tokai, 319-1195, Japan; [4]RIKEN, Wako, Saitama 351-0198, Japan; [5]Niigata University, Niigata, Niigata 950-2181, Japan;
s_shamoto@cross.or.jp

In yttrium iron garnet YIG [1], spin current has been observed as a spin Seebeck effect under a temperature gradient [2] and ultrasound injection [3,4]. The neutron scattering on a YIG single crystal under ultrasound injection has been performed by using near backscattering TOF spectrometer DNA (BL02) with high energy resolution to observe the spin pumping effects. The magnetic Bragg peak at (220) was enhanced with decreasing temperature. Because the lattice vibration enhances the magnetic Bragg peak, the enhancement is expected to closely relate to the spin-lattice coupling. An observed sharp drop above 100 K in the longitudinal mode suggests the degradation of the spin-lattice coupling. It is consistent with the decline of spin Seebeck effect (spin current generation by thermal gradient) with increasing temperature above 100 K [5], proving the degradation mechanism by the spin-lattice coupling. The temperature dependence may be the origins of the other anomalies observed in YIG [6, 7]. In addition, the energy-width of the magnetic Bragg peak increases proportionally to the square root of the sample temperature increase induced by the ultrasound injection. The estimated effective mass based on a liquid model becomes light when magnetic domain walls are removed under a magnetic field [8].

References

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2. T. Kikkawa et al., Phys. Rev. Lett. 117 (2016) 207203.

3. K. Uchida et al., Nature Mat. 10 (2011) 737.

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7. S. Shamoto, Y. Yasui, M. Matsuura, M. Akatsu, Y. Kobayashi, Y. Nemoto, and J. Ieda, Phys. Rev. Research 2 (2020) 033235.

8. S. Shamoto, M. Akatsu, M. Matsuura, S. Ohira-Kawamura, K. Harii, M. Ono, L.-J. Chang, T. U. Ito, Y. Nemoto, and J. Ieda, in preparation.

3:55pm - 4:20pm

Magnetic Nitinol: New Efficient Photothermal Catalyst

Sergey Nikitenko[1], Sara El Hakim[2], Tony Chave[1]

[1]CNRS; [2]University of Montpellier, France; serguei.nikitenko@cea.fr

In progress... Key Words: Hydrogen, Photocatalysis, Photothermal Effect

4:20pm - 4:45pm

Stationary (DC) Pyroelectric Current Induced by Static Temperature Gratings.

Nickolai Kukhtarev, Tatiana Kukhtareva

AAMU, United States of America; nkukhtarev@gmail.com

New method of pyroelectric thermal power conversion to DC (steady state) electrical current is suggested, that do not need temporal modulation of thermal radiation.

Generation of DC current is achieved by illumination of homogeneous pyroelectric semiconductor by the nonionizing spatially structured IR (infrared) radiation that create static temperature, conductivity and electric-field gratings in the sample. Spatial interplay between these gratings results in DC electrical current that is calculated for the sinusoidal modulated IR radiation.

Estimations of pyroelectric DC short-circuit current Jsc and output volume power density PM in SPS (Sn2P2S6) ferroelectric crystal (with pyroelectric coefficient

γ = 8*10-8 C cm-2 K-1, absorption coefficient 103 cm-1) and with period of T-grating ~0.1 cm gives values Jsc=10-5A/cm2, PM = 10 μW/cm3 for IR intensity ~ 1W/cm2. For the input IR intensity 10 W/cm2 current will be 10-3 A/cm2 and power density

0.1 W/cm3 (grow on four orders).

In a popular and cheap PZT piezoelectric/pyroelectric ceramic pyroelectric coefficient is higher than in SPS crystals and similar or higher power density is expected from PZT ceramics and ferroelectric liquid crystals. This study shows that suggested method of pyroelectric power conversion with DC pyroelectric current may compete with traditional (requiring temporal modulation of thermal radiation) methods [1].

Key Words: Stationary Pyroelectric Current, Temperature Gratings, Energy conversion

References.

S. Pandya, J. Wilbur, J.Kim, R. Gao, A. Dasgupta, C.Dames and L W. Martin, Nature Materials, 17 (2018)432-438.

4:45pm - 5:10pm

Removal of Per- and Polyfluoroalkyl Substances (PFASs) using Chitosan Beads

Rahim Shahrokhi, Junboum Park

Seoul National University, Korea, Republic of (South Korea); junbpark@snu.ac.kr

Per- and Polyfluoroalkyl Substances (PFASs) are environmentally persistent halogenated hydrocarbon, which have been widely used in many industrial and commercial applications. Recently, contaminating

the soil and groundwater due to ubiquity of PFAS in environments has raised great concern. Adsorption technology is one of the most promising method for PFAS removal in the subsurface. Chitosan is a biopolymer substance with abundant amine and hydroxyl functional groups, which render it as a good adsorbent. This study, has tried to enhance the adsorption capacity of chitosan by grafting more amine functional groups on its surface for removal of two long (PFOA, and PFOS) and two short-chain (PFBA, PFBS) PFAS substances from aqueous phase. Series of batch adsorption tests have been performed to evaluate the adsorption capacity of the sorbent. Also, sorbent was analyzed by SEM, FT-IR, zeta potential, and XRD tests. The results demonstrated that chitosan beads show significant potential for adsorbing short and long chain PFAS from the aqueous phase

5:10pm - 5:35pm

Quantum separation of 3He isotope from superfluid helium by means of entropy filters

Wojciech Kempiński

Institute of Molecular Physics, Polish Academy of Sciences, Poland; wojkem@ifmpan.poznan.pl

The most important application of 3He is related to cryogenics, where this isotope allows to obtain millikelvin temperatures in dilution refrigerators. Public safety uses 3He detectors to find hazardous radioactive materials in airports or important public buildings. However, one of the most remarkable future applications assumes that the use of the 3He isotope in fusion reactors will make it possible to obtain large amounts of clean energy.

This paper presents the results of a study on the extraction of the isotope 3He from liquid/superfluid helium by quantum separation using entropy filters based on specially prepared carbon nanomaterials: purified multi-walled carbon nanotubes (MWCNTs) and MWCNTs decorated with ZrO2 nanoparticles. Bundled MWCNTs were applied in the form of pressed tablets with fixed sizes. The research was conducted at the low-temperature region, where helium exhibits its quantum properties after transition to the superfluid phase at the lambda temperature: T□ = 2.18 K. Entropy filters work below this temperature [1, 2].

Oral Talk-1: Oral Talk

Time: Thursday, 10/Aug/2023: 3:30pm - 6:00pm · *Location:* Theatre
Session Chair: Peter Brueggeller

3:30pm - 3:45pm

Self-powered Metamaterial Systems with Embedded Mechanoelectrical-logic Functionality for Digital Computation

Qianyun Zhang, Kaveh Barri, Amir Alavi

University of Pittsburgh, United States of America; alavi@pitt.edu

Creating autonomous and intelligent soft and hard robotic systems requires multifunctional responsive materials capable of sensing, energy harvesting, data storage, and digital computation. In this context, integrating computational abilities into the structure of soft robots is in particular a major challenge due to mechanical constraints. Embedded mechanical logic offers a viable solution to tackle this issue through performing local morphological computations. One of the main limitations of the current embedded mechano-logic systems is lack of digital electrical outputs. In this arena, the most recent breakthrough is development of metamaterial switches with conductive ink patterns to translate the metamaterial deformation into reconfigure electrical circuits. However, such mechano-logic switches cannot achieve full robotic autonomy because they need an external power supply to operate and pass electrical currents through the metamaterial structure. To deal with these challenges, we propose the striking concept of mechanoelectrical-logic to create self-powering metamaterial systems capable of transducing external signals directly into electrical outputs to perform digital computations. We develop material systems with mechanoelectrical-logic functionality through the fusion of multi-stable origami-inspired metamaterial composite and energy harvesting technologies. We discuss how nanogenerator origami-inspired metamaterials fabricated via rational architectural material design can translate the mechanical deformations applied to their structural framework into binary and non-binary digital signals without a need to an external power source. Since the output of a mechanoelectrical-logic is a digital signal, it could potentially compete with the speed and information density of electronic logic. Finally, we present

the broad applications of the proposed responsive material systems with embedded mechanoelectrical-logic computational power in the arena of soft and hard robotics.

3:45pm - 4:00pm

A Chemiresitive Gas Sensor Based on SnO2:ZnO Nanostructured Thin Film for the Detection of Hydrogen Peroxide Vapor

Mikayel Seryozha Aleksanyan, Artak Sayunts, Gevorg Shahkhatuni, Vladimir Aroutiounian, Gohar Shahnazaryan

Yerevan State University, Armenia; maleksanyan@ysu.am

Hydrogen peroxide (H2O2) is an odorless and colorless liquid considered an important metabolic product in chemical and food industries. It is used as a fuel, has biological function, domestic uses, as well as therapeutic use, including use as an antimicrobial and oxidizing agent. Due to such a wide range of applications, the demand for developing hydrogen peroxide vapor detection methods is increasing year by year. As fairly cheap and durable materials, metal oxide semiconductors (MOS) based nanostructured materials are greatly used in gas sensor for leakage and monitoring in many occasions. The most used and researched material for gas sensors is tin oxide, a wide gap semiconductor with n-type electrical conductivity. We synthesized SnO2:ZnO target by the solid-state reaction method and a nanaostarctured thin film was obtained by the RF (radio frequency) magnetron sputtering method as a gas sensing layer. The developed SnO2:ZnO nanaostarctured film was investigated as the sensing material toward hydrogen peroxide vapor. The effect of the operating temperature and concentration of hydrogen peroxide vapor on sensitivity, response and recovery time were investigated. The sensor demonstrated a fairly high response (the resistance changed more than 10 times) even to 3 ppm of hydrogen peroxide vapor under UV irradiation at the 100 oC operating temperature. Experimental results showed that SnO2:ZnO sensor had a sufficient response, short response and recovery times, excellent repeatability, high selectivity and low sensitivity toward humidity.

4:00pm - 4:15pm

A cost effective and technical solution to upcycle shredded glass fiber-reinforced plastic composite waste, via sequestration into modular secondary structural elements

Andres Felipe Anaya, Bryn Crawford, Abbas Milani

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Manufacturers of glass-fiber reinforced plastics (GFRPs) for industrial and consumer goods applications experience a myriad of challenges with respect to end-of-life design for their materials and products, due to the non-recyclable and non-biodegradable nature of the materials, in addition to cost, structural and durability performance requirements, ultimately leading to large volumes being disposed in landfills. Hence, these materials have many barriers towards being adopted in the paradigm of the circular economy. To address this, a case study is presented, focusing on the design and production of unsaturated polyester resin (UPE)-based GFRP tub shower units using the spray-up process, where large volumes of waste are generated from trimmings, over-spray and rejected parts that do not meet quality standards. The waste is shredded with all particle sizes <0.5 inches, which has found immediate benefits by increasing the nominal density and reducing total costs for landfill disposal, as well as shipping costs for use in waste-to-fuel applications, such as in cement production kilns. However, the goal of this study is to sequester this shredded GFRP waste into new products, via a technical and cost-effective alternative by producing a structural core material, using the shredding material combined with UPE resin and mineral filler to replace the use of Oriented Strand Board (OSB) wood. A design of experiments approach is used to define a set of alternatives involving different mineral fillers and shredding materials ratios, mechanical properties, process requirement and optimization, which are ultimately discriminated between via a multi-criteria decision-making model accounting for cost, processability, prescribed structural performance, among other factors.

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4:15pm - 4:30pm

Na0.5Ce0.5WO4 self-assembled structures as an efficient photocatalysts and adsorbents under solar light irradiation

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This work reports for the first time the combined effect of the morphology and crystallization degree of the Sodium – Cerium tungstate (Na0.5Ce0.5WO4) scheelite structure on its photocatalytic and photosensitive properties. Self-assembled three-dimensional Na0.5Ce0.5WO4 have been successfully synthesized with three uniform and homogeneous morphologies, such as spindles, spheres and flowers. The obtained structures were characterized by X-Ray diffraction combined to Rietveld refinement and Scanning electron microscopy. The optical properties were done with UV-Vis spectroscopy based on diffuse reflectance mode. Samples crystallization were carried by a heat treatment at 500°C and 800°C. However, thermal treatment showed the evolution of the morphology in size, porosity and surface state. The crystallite size are about 50 nm for samples (spindles and flowers) treated at 500°C and 87-167 nm for those treated at 800°C. In addition, the optical properties showed a band gap of 2.85 eV for treated morphologies at 500°C and around 3.10 eV for shapes treated at 800°C. The photodegradation activities of the self-assembled structures have been investigated by mean of Methylene blue (MB) and Rhodamine B (RhB) under solar light irradiation. The results show two trends, depending on pH of the reaction medium and the crystallization temperature, first adsorption then photocatalysis under illumination. For both dyes (MB and RhB), a stronger adsorption (until 50 %) while passing from the basic to the acid medium; up total adsorption at low pH (≤ 2.5). The photocatalysis activity of MB increases with decreasing pH (up to 40%) when the degradation of RhB remains very weak (≈ 10 %). Furthermore, the adsorption and photocatalysis process are more efficient with catalysts treated at low temperature. It follows that the degradation efficiency of spindles treated at 500°C is clearly higher compared to other morphologies treated at different temperature. More investigation were conducted to study the luminescence properties using fluorescence lifetime spectroscopy.

4:30pm - 4:45pm

Development of sustainable, modified, lignin-based composites: A novel of synthesis scheme, properties and performance towards molecular and metal ion separation

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The development of sustainable materials for the separation of molecules and metal ions is of great importance for environmental and industrial applications. Here, we present the synthesis and characterization of modified lignin-based composites for the separation of molecules and metal ions.

The modified lignin-based composites were synthesized using a simple and sustainable approach, involving the modification of lignin, a widely available byproduct of the pulp and paper industry, with various functional groups, including amines, carboxylic acids, and thiols. The resulting composites exhibited high surface area and abundant functional groups suitable for the separation of molecules and metal ions.

The synthesized composites were characterized using various techniques, including TGA, XPS, FTIR, and BET, to confirm their structural and chemical properties. The performance of the modified lignin-based composites in separation of molecules and metal ions was evaluated using batch adsorption experiments. The results showed that the composites exhibited high selectivity and adsorption capacity towards various molecules, including dyes, pharmaceuticals, as well as heavy metal ions, including Cu(II), Co(II), and Pb(II).

In conclusion, the results obtained in this study demonstrate the potential of modified lignin-based composites as sustainable and efficient materials for separation of molecules and metal ions. The unique properties of the composites, such as high surface area, abundant functional groups, thermal stability, and reusability, make them promising candidates for applications in environmental and industrial separation processes, including the recycling of batteries and e-waste products.

Acknowledgment: Tetyana Budnyak acknowledges financial support from Formas – a Swedish Research Council for Sustainable Development (project: 2020-02321).

4:45pm - 5:00pm

A guide for a lithography-free tunable filter owing to the combination of gold nanoparticle synthesis and sputtering nucleation mechanisms

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Charged beam lithography is the preferred reliable technique to manufacture periodic metallic inclusions. Yet, the realization of such designs requires tedious work and advanced fabrication tools. Accordingly, research interests have shifted toward the realization of filters and absorbers in a lithography-less manner [1,2]. We report herein the possible combination of colloidal chemistry and sputtering to create various sizes and shapes of nanoparticles resulting in new plasmonic coupling pathways. The schematic of the realized combined system including colloidal and vapor deposition-based nucleated nanoparticles is shown in Fig. 1(a). The final fabricated filter is composed of stacked layers of evaporated silver, an atomic layer deposited alumina, sputtered, and consequently dewetted gold nanoparticles together with the drop-cast gold nanocrystals. The sputtered nanoparticles form nucleation sites after the heat application as illustrated in the atomic force microscope scans of Fig. 1(b). The largest aspect ratio change and optimum surface coverage have been aimed with the dewetting process and simulations confirmed the shift in the absorption peak, which causes a visible color change directly on the surface. The fabricated filters with different thicknesses of alumina display distinct colors in Fig. 1(c) due to the differences in plasmonics and Fabry-Perot coupling mechanisms. We have introduced colloidal nanocrystals to the filter with various sizes and aggregation sites as highlighted in Fig. 1(d). The experimental results exhibit a simple method of altering the optical response in Fig. 1(e) with a hybrid of top-down and bottom-up fabrication steps. Furthermore, we have investigated the effects of each layer on the overall optical response by utilizing both experimental and numerical methods. The proposed configuration is considered as an effortless alternative lithography-free tunable filter to the currently employed plasmonic-based designs.

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5:00pm - 5:15pm

Einstein's mass-energy equivalence principle manifested in semiconductors and insulators

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Einstein's mass-energy equivalence relation E=mc2 for a relativistic energy E and moving mass m, becomes dE/E equals dm/m after differentiating it once. The kinetic energy of an electron or hole moving in a silicon crystal has also been shown to possess the same property under a changing thermal energy [1]. The equation is valid for a changing kinetic or potential energy of particles such as electrons or holes in materials as well. Thus, this equation becomes a universal mass-energy equivalence relation for all big and small moving particles in materials and space. The equation also applies to other energy

transformations such as nuclear and chemical. In parabolic semiconductors, dE is the differential potential energy of an electron from the semiconductor's intrinsic Fermi energy level Ei to the semiconductor conduction band (CB), E is the semiconductor bandgap as the total negative potential energy of electrons with reference to the valence band (VB) at zero energy, dm is the differential mass as the longitudinal electron effective mass, and m is the free electron mass. E-dE would be the differential potential energy for holes. In Si, the longitudinal electron effective mass of an electron in one conduction valley in the [100] direction is 0.49m and the bandgap of Si is 1.12 eV. Applying the above equation with dm/m as 0.49 and E as 1.12 eV, one can get dE as 0.49 x 1.12 = 0.55 eV. This is the position of Ei in Si below the CB. It gives an intrinsic defects density Nid in Si of about 1.7 x 1010/cm3. In 4H-SiC, the electron effective mass in the [0001] direction is 0.297m and the experimental band gap is 3.23 eV. This data results in dE as 0.297 x 3.23 = 0.96 eV. This is the energy level Ei below the 4H-SiC CB, and gives Nid in 4H-SiC of 1.1 x 1014/cm3. Similarly, for the thermal SiO2, dm/m for holes is confirmed to be 0.58 [2]. So, dm/m for electrons has to be 0.42. The bandgap E for SiO2 is 8.93 eV, giving dE = 0.42 x 8.93 eV = 3.75 eV. This is the position of Ei in the SiO2. Ei in the three materials is the charge neutrality level (CNL) [3-5]. The manifested universal mass-energy equivalence relation into semiconductors and insulators will facilitate new research in materials.

Keywords: Mass-Energy equivalence, Semiconductors, Insulators, thermal SiO2, MOS device

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5:15pm - 5:30pm

High-performance biobased epoxy vitrimer for carbon fiber reinforced composites

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The thermosets possess superior mechanical properties and solvent resistance; however, they fail to be reshaped or recycled once they are cured. The fully-recyclable high-performance carbon fiber reinforced composites can be prepared using dynamic imine chemistry. In this study, we synthesized a bio-based epoxy curing agent from lignin-derived vanillin and later fabricated carbon fiber reinforced composites from the resin. The chemical structure was confirmed by FTIR, 1H-NMR, and 13C-NMR. The curing behavior and thermomechanical analysis were studied by DSC and DMA, respectively. The mechanical properties of the CFRCs from uncured prepregs and cured prepregs were examined. Finally, gentle reclamation of carbon fiber was realized by the depolymerization of the resin through transamination.

5:30pm - 5:45pm

3D-printed structurally resilient components manufactured by fused filament fabrication (FFF) from recyclable, intrinsically polymer fiber-reinforced plastics

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To improve the properties of polymers for load-bearing applications, they are classically reinforced with glass or carbon fibers. However, these usually lead to a higher material density and limit the possibilities of mechanical recycling.

The paper shows that this challenge can be solved with a special class of polymeric fiber-reinforced plastics called microfibrillar composites (MFCs). These materials are manufactured according to an idea of M. Evstatiev and S. Fakirov [1]. They combine the advantages of fibrous form for load-bearing capacity with the low density of thermoplastics.

In previous work [2], it became clear that the reinforcing effect of polymer fibers cannot be fully exploited in the production of injection molded components, since this process leads to random alignment of fibers in the component. To better exploit the advantages of MFC, we used fused filament fabrication (FFF) in the final processing step in our current work. For this purpose, blends based on polypropylene (PP) and polyethylene terephthalate (PET) as well as compatibilizers were first compounded, drawn in a specially developed drawing device, and finally the drawn filaments were used to manufacture components. The influences of the printing parameters, the printing strategy, and the geometry-related boundary conditions on the resulting component properties were investigated in a simulation-based and morphology-related manner. As a result, the properties of the printed component were significantly improved compared to the properties of a pure PP/PET blend. The key to reasonable component properties lies in particular in temperature control. On the one hand, temperatures must not be so high at any point that the fiber component relaxes or even melts. On the other hand, the temperature must be high enough to allow good welding when the strand is deposited in the contact area with the previously deposited material. The components produced under optimal conditions were crushed and reprocessed. Properties equivalent to those of virgin material were demonstrated, i.e. mechanical recyclability is given. The combination of material and processing opens a path to sustainable high-performance products.

Key Words: Microfibrillar reinforced composites, additive manufacturing, material efficiency, circular economy

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5:45pm - 6:00pm

Fabrication and Characterization of Photo-Synaptic Devices with YZnO Nanorod/CsPbBr3 Nanocrystal/Polyfluorene Heterostructures

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The high-performance photo-synaptic devices were fabricated in the form of the YZnO nanorod/CsPbBr3 nanocrystal/polyfluorene (YZO/CPB/PFO) heterostructure through a simple technique. Namely, the organic-inorganic hybrid YZO/CPB/PFO photo-synaptic devices were devised by spin-coating of CPB-blended PFO onto hydrothermally grown YZO. Under dark space, the YZO/CPB/PFO devices showed the highly-sensitive fast photo-response characteristics with a high Ion/Ioff ratio up to >105. However, when irradiating the UV light pulses, the devices showed the photo-memristive switching characteristics because of the longer photocarrier lifetime of CPB. In other words, the photo-stimulated conductive states could be memristively retained because the photo-excited carriers in CPB might allow the long-term charge storage and result in the long-term potential gradient in the YZO/CPB/PFO heterostructure. Furthermore, it was also observed that photo-memristive resistance states could be effectively tuned by changing the applied optical pulses (i.e., tuning of synaptic weights by changing optical power, optical pulse duration, optical pulse interval, etc.). Using these unique characteristics, we demonstrated various photo-synaptic functions such as short-term facilitation and long-term facilitation with a good linearity. The results suggest that the YZO/CPB/PFO heterostructure hold great promise for the future neuromorphic applications.

Keynote Session-2: Keynote Session

Time: Friday, 11/Aug/2023: 9:30am - 11:30am · *Location:* Theatre
Session Chair: Muhammad Imran Shakir

9:30am - 10:20am

Sustainable Next-generation Battery Chemistries

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The widespread adoption of battery technologies for electric vehicles and grid electricity storage requires optimization of cost, energy density, power density, cycle life, safety, and environmental impact, all of which are directly linked to severe materials challenges. Among them, cost, sustainability, and supply chain will be the single dominant factor as we march forward with electrification. This presentation will focus on the development of sustainable next-generation battery chemistries and materials. Strategies and approaches for elimination of expensive and scarcely available cobalt, followed by eliminating nickel and ultimately any mined metal, including lithium, will be discussed. As an example, the progress on cobalt-free high-nickel layered oxide lithium-ion cells, lithium-sulfur cells, and sodium-sulfur cells will be presented. The challenges of bulk and interfacial instability and chemical crossover during charge-discharge cycling, dynamics and stabilization of lithium or sodium plating and striping, advanced characterization methodologies to develop an in-depth understanding, and approaches to overcome the challenges will be presented.

10:20am - 11:10am

TBD

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TBD

Invited Talk-1: Invited Talk

Time: Friday, 11/Aug/2023: 1:30pm - 6:00pm · *Location:* Theatre
Session Chair: Junboum Park

1:30pm - 1:55pm

Periodic and disordered mesoscopic media for light scattering control

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Optical surface structuring shows great interest for antireflective or scattering properties. On the other hand, the extraordinary progresses in the design and realization of structures in inorganic or organic thin films, including metallic or dielectric nanoparticles, make it possible to develop devices with very specific properties (realization of new types of absorbers in thin film form working in the visible and infrared band, thermal solar and photovoltaic,more sensitive photodetectors…). In the first part of the talk, we develop high order electromagnetic scattering theories for randomly rough surfaces as small-slope approximation, which can predict new phenomena as satellite peaks and backscattering enhancement. Random surface structures can be designed to distribute the light in different propagation directions as demonstrated by the notion of satellite peaks in the scattering pattern. We will discuss randomly rough surface scattering theory and present a state of art on periodic and randomly rough surface structuration and realization with antireflective functions in the visible and infrared regions.

In the second part of the talk, we describe realizations of complex thin films comprising randomly distributed metallic or dielectric nanoparticles with randomly rough interfaces. The development of research in this field goes through the understanding of the multiple-scattering phenomena on the randomly rough surface and inside the random media illuminated by a polarized electromagnetic wave. We use a general formalism based upon Green's functions to calculate the electromagnetic field scattered by a random medium with rough boundaries. We develop Dyson equations to describe the coherent electromagnetic field propagating inside the random media and scattered by the slab, and a Bethe-Salpeter equation technique, borrowed from quantum field theory for the treatment of multiple scattering of waves. Bethe-Salpeter equations describe the second moment of the scattered electromagnetic field, which determines the incoherent scattered intensity from the complex thin film with randomly rough surfaces. The complexity of the interaction between light and heterogeneous matter highlights the importance of knowing the optical and electronical properties of the nanoscale particles in the medium, to be able to design the optical responses. Plasmon resonances can be excited by a progressing wave on metallic nanoparticles. This addresses the problem of the permittivity of such metallic nanoparticles. The coupling between several metallic nanoparticles induces a field enhancement in the surrounding media, which can increase phenomena like scattering and absorption. We will discuss different aspects of plasmonic with embedded nanoparticles to obtain strong light absorption with very small amount of material in the visible and near-infrared range and we will present examples of scattering by metallic nanoparticles embedded into a bulk.

1:55pm - 2:20pm

Artificial Photosynthesis : is Concerted Proton-Electron Transfer the Right Key?

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Enhanced DuBois-type catalysts for photochemical water splitting show an excellent activity regarding their turnover numbers (TON) for hydrogen production (Brueggeller et al. 2019, 1). They lead the field with regard to phosphine-based water reduction catalysts (WRC). Furthermore, they outperform WRC derived from solid state chemistry by far. A further TON boost of nearly a factor 3 can be achieved via the use of the ligand bis(dianisylphophinoethyl)amine as shown in Figure 1. Based on single crystal X-ray structures, DFT calculations indicate a concerted proton-electron transfer (CPET) for steps 1-5 in Figure 1. This is confirmed by spectroelectrochemical measurements, showing that simple proton or electron transfer (PT or ET) lead to different transient species, which cannot be responsible for the excellent TON values observed. Thus CPET enhances the production of hydrogen to a level of economical feasibility.

Figure 1: Catalytic cycle for photochemical water splitting

Key Words: Artificial Photosynthesis, Water Splitting, Energy Storage

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2:20pm - 2:45pm

Multipolar Exchange Interaction and Complex Order in Insulating Lanthanides: Ab Initio Approach

Naoya Iwahara[1], Veaceslav Vieru[2], Zhishuo Huang[3], Liviu Chibotaru[4]

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Magnetic materials containing metal ions with unquenched orbital momentum such as lanthanides exhibit multipolar exchange interaction quantified by dozens of exchange parameters which are hardly extracted from experiment. We developed a methodology based on a multiconfigurational ab initio approach and DFT calculations for first-principles derivation of anisotropic multipolar exchange interaction in lanthanide (Ln) complexes and insulating materials. Application of this methodology to a family of radical-bridged binuclear lanthanide complexes with the core Ln3+-N23—Ln3+ allowed to explain the origin of the giant Ln-R exchange interaction and of the strong magnetization blocking effect as function of Ln= Gd, Tb, Dy, Ho and Er [1]. Extension of this approach to a full treatment of Ln-Ln exchange interaction [2] allowed to derive the multipolar exchange interaction in neodymium nitride, to establish its complex order described by primary and secondary order parameters and to describe from the first principles the magnetic and thermodynamic properties in both ordered and paramagnetic phases. This study indicates that the developed first-principles framework for the calculation of multipolar exchange parameters can become an indispensable tool in future investigations of lanthanide and actinide based magnetic insulators.

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2:45pm - 3:10pm

Tailoring Quantum Oscillations of Excitonic Schrodinger's Cats as Qubits

Amit Bhunia[1], Mohit Kumar Singh[1], Maryam Al Huwayz[2,3], Mohamed Henini[2], Shouvik Datta[1]

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We report [1] experimental detection and control of Schrodinger's Cat like macroscopically large, quantum coherent state of a two-component Bose-Einstein condensate of spatially indirect electron-hole pairs or excitons. These excitons are artificial atom like quasi particles within solids which can be generated with optical and/or electrical excitations. Achieving Bose-Einstein condensate within an optoelectronic device can provide access to millions of excitons as qubits. Coherent resonant tunneling in this well-dot heterostructure restricts the available momentum space of the charge carriers within this quantum well. Consequently, the average electric polarization vector of the associated indirect excitons collectively orients along the direction of applied bias and these excitons undergo Bose-Einstein condensation below ~100 K. In addition, collective Rabi oscillations of these macroscopically large, 'multipartite', two-level, coupled and uncoupled quantum states of excitonic condensate as qubits are also observed. Therefore, our study not only brings the physics and technology of Bose-Einstein condensation within the reaches of semiconductor chips, but also opens up experimental investigations of the fundamentals of quantum physics using similar techniques.

Operational temperature of such Bose-Einstein condensate of excitons can be raised further using similar 0D-2D heterostructure having more densely packed, ordered array of QDs and/or using materials having larger excitonic binding energies. Therefore, further efforts towards fabrications of single crystals of such

0D-2D heterostructures using materials having higher excitonic binding energies like transition metal di-chalcogenides, oxides, perovskites can be very promising. Nonetheless, these 0D-2D heterostructures can be scaled up even now for mass production of miniaturized, portable quantum optoelectronics devices using the existing III-V and/or Nitride based semiconductor fabrication technologies. So it can bring in a paradigm shift in optoelectronics for faster and wider adaptation of quantum technologies in terms of miniaturization and portability.

Key Words: Exciton, Bose-Einstein Condensation, Quantum Material

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3:10pm - 3:35pm

Understanding Kinking of Semiconductor Nanowires

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Semiconductor nanowires are promising building blocks for a broad range of applications, including photovoltaics, solid state lighting, biosensing, as well as applications in quantum technology. Successful growth of nanowires can only be performed within a certain, materials specific parameter window, where the temperature at the growth interface and the reactant pressures are the most important parameters. Attempted nanowire growth outside of this window often lead to undesired growth features, such as tapering, kinking, or even ceased growth.

Kinking means a sudden change in nanowire growth direction. Several reasons for kinking have been reported. In heteroepitaxial nanowires, kinking at the heterointerface has been attributed to surface and interface energetic effects and been discussed in terms of the classical growth modes for heteroepitaxy [1]. In homoepitaxial nanowires, it can occur if the surface forces holding the particle at the nanowire tip are brought out of balance. Another reason is planar defects in the nanowire. Kinking can also be an effect of too low or too high reactant pressures or temperature. There is no conclusive understanding of why kinking occurs under these conditions. It has been suggested that at too low temperature the nanowire growth becomes unstable and at too high temperature the metal particle can be displaced [2].

In this investigation we focus on kinking in nanowires grown at too low temperature and too high reactant pressures. We propose that the reason for kinking at these conditions is related to an onset of 3D nucleation instead of 2D nucleation. Using nucleation modeling with realistic, thermodynamically assessed chemical potentials, we show that nanowire growth at certain conditions can lead to a situation where the supersaturation is high enough for 3D nucleation to be favourable over 2D nucleation. There is a high risk that 3D nucleation will lead to kinking while 2D nucleation is much more likely to result in straight nanowires. Our calculations indicate that the cross-over supersaturation for 2D-3D nucleation in gold catalyzed GaAs nanowires can be reached at easily attainable growth conditions. This means that kinking can indeed result from fluctuations or other sudden changes in growth parameters if the growth is carried out sufficiently close to this cross-over supersaturation. Finally, our modeling suggests promising routes for predictive control of kinking, which is of great benefit for advanced nanostructure design.

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3:35pm - 4:00pm

Characterization of hybrid composite materials generated by additive manufacturing and foaming process

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Additive manufacturing process (AM) has allowed to generate intricate lightweight scaffolds inside a piece; recent studies has highlighted the high strength and the high capability to absorb energy per unit

of weight of some 3D printed structures such as the lattice structures and specially the triple periodic minimal surface structures (TPMS). There are six main different TPMS structures: gyroid, split-p, Schwarz-p, neovious, diamond and lidinoid and all them are defined by mathematical functions that minimize the internal surface and so, maximize the mechanical properties per unit of weight. It must be pointed that these structures have some empty space inside them; the volume fraction specifies the percentage of occupied volume and volume fractions between 10 and 30% are common so there is some space (between a 90 and a 70%) that could be filled with another structural material to improve their properties.

It must also be highlighted that some TPMS has some anisotropy that produces undesirable failures in non-obvious direction and thus lower strength and lower capability to absorb energy.

An analysis of possible methods to reduce anisotropy has revealed the possibility to create hybrid composite structures that combines TPMS AM structures with a foam inside the empty space. The selection of foam was due to its low density and the possibility to be manufactured in an industrial process.

Consequently, this article studies comparatively the mechanical properties and the capability to absorb energy during an impact of hybrid TPMS-foam composite materials with non-foamed ones. Thus, it has been printed different TPMS structures made of acrylonitrile styrene acrylate (ASA) and some of them have been filled with polyurethane foam (PU). Afterwards, using a uniaxial INSTRON test machine, different specimens have been tested under compression efforts according with the UNE-EN ISO 844:2015 standard to obtain the stress-strain curve. These results have been obtained to determine main mechanical properties and the mechanical properties per unit of volume and per unit of weight, as well as some other index such as the effectivity and the ideality. Additionally, some videos and photos have been taken to compare failure mechanism.

The results have revealed a substantial increase of the mechanical properties of these hybrid composite materials and of the capability to absorb energy with a low increase of the final weight; additionally, it has been observed a reduction of some undesirable modes of failure.

4:00pm - 4:25pm

Nanophotonic Engineering of Upconversion Luminescence for Biosensing

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Upconversion nanoparticles (UCNPs) absorb infrared light and emit visible or ultraviolet luminescence. UCNPs exhibit many advantageous characteristics for bioimaging and sensing such as no photobleaching, no blinking, and no background autofluorescence. Furthermore, UCNPs emit multiple colors, allowing ratiometric sensing which reduces the sensing error due to variations in excitation intensity, nanoparticle concentrations and/or other environmental variations. Conjugation with a functional dye is an effective way to exploit the favorable characteristics of UCNPs for sensing.

A major problem that that has not been fully addressed is that there exist two different mechanisms that can induce changes in signal in a dye-conjugated UCNP sensor: Förster Resonant Energy Transfer (FRET) and photon reabsorption. To achieve purely local sensing, one needs to remove the effect of photon reabsorption. We used NaYF4:Yb3+,Tm3+ UCNPs coated with pH-responsive dye Fluorescein Isothiocyanate (FITC) to elucidate this issue. 1 The key insight is that both 475 and 646 nm emission bands arise from the same energy level, 1G4 of Tm3+ ion, and are thus affected equally by FRET, while photon reabsorption only affects the 475 nm emission which directly overlaps the absorption band of FITC. Thus, by taking the ratio of 475 and 646 nm emission, we can eliminate the effect of FRET and enable a sensor responsive solely to photon reabsorption. On the other hand, 646 and 800 nm emission intensity ratio produces a signal that depends only on FRET. This is the first FRET-based UCNP sensor that allows truly localized sensing unaffected by the long-range photon reabsorption.

The performance of the sensor can be further enhanced by coupling with a plasmonic nanostructure. By designing a plasmonic nanostructure whose resonance overlaps with one of the emission lines of UCNP, one can enhance the intensity ratio, thereby increasing both sensitivity and dynamic range. Using the principle, we designed a mechanical force sensor composed of UCNPs, flexible polymer and plasmonic nanostructure. The sensor's fluorescence signal changes under external force due to the changes in the

coupling between UCNP and plasmon resonance. Mechanical force plays a critical role in biology, affecting a wide variety of processes including stem cell differentiation, cell migration, malignancy, etc. However, there are few options for force sensing, particularly in live, intact tissues. Our sensor is the first that can be directly embedded in live animals, enabling in vivo force sensing.

Oral Talk-2: Oral Talk

Time: Friday, 11/Aug/2023: 1:30pm - 6:00pm · *Location:* AU 2410
Session Chair: Tetyana Budnyak

1:30pm - 1:45pm

A Multiscale 3D Plasmonic Hotspot-Rich Nanostructured Substrate for SARS-COV-2 Biomolecular Detection

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The enriched and uniformly distributed hotspots from three-dimensional Surface Enhanced Raman Scattering (SERS) substrates offer superior advantages over their one- and two-dimension counterparts. Herein, we have constructed a single component-based multiscaled three-dimensional plasmonic hotspot-rich (3D-PHS) nanostructure substrate from silver nanowires (AgNWs), the plasmonic partition and plasma induced hotspot formation were evaluated by Finite Integration Technique (FIT) based electromagnetic field simulations and CST Studio Suite. The efficiency of 3D-PHS chip was investigated toward their detection enhancements from Bovine Serum Albumin, Human Serum Albumin and two SARS-COV-2 antibodies, respectively. Apart from nanomolar sensitivity, we observed SERS enhancements from such 3D-PHS system to be layer dependent, irrespective of different probe molecules or variation in excitation sources. Experimental SERS carried out in such multilayered 3D SERS substrates matched well with the theoretical simulations results. The results are explained in terms of variations in the number and distances in nanogaps, and 3D plasmons arising from the vertical and lateral directions respectively.

1:45pm - 2:00pm

Filler Effect on Water Absorption and Subsequent Mechanical Properties of Hemp-Reinforced Biocarbon Filled Biopolymer Composites

Raj Kumar Dahal[1], Bishnu Acharya[2], Animesh Dutta[1]
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While hemp fiber increases the mechanical properties of a polymer composite1, on the contrary, it increases the water absorption behaviour of the material. Biochar as a natural filler can be useful in controlling the water absorptivity and water diffusivity of the composite material to improve the material's physical properties. We have studied the effect on water absorption property of the biocarbon and its subsequent effect on the mechanical and physical properties of biocarbon filled hemp reinforced biopolymer composite materials. We performed the design of experiments to optimize the biocarbon filler formulation in the hemp reinforced biopolymer composite materials based on the water absorptivity of the material. We prepared biocarbon from the inhouse pyrolysis of hemp and switchgrass at three temperatures: 450, 550, and 650 °C. We fabricated the composite samples with the filler loading of 10 wt.%, 15%, and 20 wt.%. We varied the filler particle size between 50 microns, 75 microns, and 100 microns. At the optimized water absorption condition, the determined mechanical properties in wet and dry conditions were compared and discussed. We found that regardless of the source of biocarbon fillers (hemp/switchgrass), water absorptivity was minimum when the composite samples contained 20 wt.% biocarbon obtained at 650 °C with particle size of 50 µm. The effect on properties due to change in filler amount, filler type, filler size, and the pyrolysis temperature has been discussed in this work.

2:00pm - 2:15pm

Solar Driven Interfacial Evaporation in Nano-structured End Grain Wood

Kijjiketchme Southern-Fox[1], Calli Cunningham[2], Sudarsan Kundu[3], Kausik Das[4]

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One of the biggest problems on our planet today is the scarcity of freshwater. At present more than four billion people on earth are facing severe freshwater shortage [1]. World Economic Forum identifies this problem as one of the largest global risk in terms of its impact potential to destabilize global balance leading to sever food crises and enhancing the risk of ecological and economic disasters [2]. In order to combat global water scarcities and create clean drinking water, solar driven interfacial evaporation has been successful, although they are mostly unsustainable and expensive. In recent years, solar-driven interfacial evaporation by localization of solar-thermal energy conversion to the air/liquid interface has been proposed as a promising alternative to conventional bulk heating-based evaporation, potentially reducing thermal losses and improving energy conversion efficiency. In this work we have shown that we can increase the efficiency of solar evaporation to 85% by using laser scribed micro-structured porous end grain wood. Wood transforms into graphene under laser irradiation in vacuum which acts as solar absorber. However, unscribed wood remains as a good insulator, thereby localizing the heat absorbed by the graphene region. This simple, bio-degradable, inexpensive method may create solar driven evaporation plants and solve the drinking water scarcity problem via solar driven desalination.

2:15pm - 2:30pm

Shear flow-controlled alignment in 3D neuronal matrices in vitro

Lens Martijn Dedroog[1], Olivier Deschaume[1], Christian Abrego[1], Erin Koos[2], Yovan de Coenen[3], Anja Vananroye[2], Wim Thielemans[4], Carmen Bartic[1,5], Minne Paul Lettinga[1,6]

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Mimicking the material anisotropy displayed by natural extracellular matrices is essential for developing clinically relevant tissue constructs [1-2]. Multiple approaches have been proposed in order to obtain aligned (anisotropic) fibrillar matrices suitable for in vitro research, however, controlling fiber alignment in 3D with high tunability and reproducibility, as required for applications, remains highly challenging [3].

In this work, we report a stress-controlled shear flow procedure capable of orienting self-assembling fibrillar hydrogel networks in a controlled manner, while preserving the network integrity and viability of embedded cells. The effects of the most critical parameters (e.g., applied stress, temperature, stiffness, etc.) are studied to infer the mechanisms directing network formation. Furthermore, using time-lapse fluorescence microscopy combined with second harmonic generation microscopy, neurite orientation and migration direction of embedded GFP-expressing SH-SY5Y cells are evaluated in function of the local degree of matrix anisotropy.

Using this approach we will increase our understanding regarding the relationships between flow parameters, network structure, and the phenotype of embedded cells which will allow for significant advances in developing physiologically relevant scaffolds for tissue engineering applications.

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2:30pm - 2:45pm

Encapsulation of tin selenide 1D crystals in single-walled carbon nanotubes

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Vibrational and electronic properties of tin selenide (SnSe) nanowires encapsulated in single-walled carbon nanotubes (SWCNT) have been studied by combining high-resolution transmission electron microscopy (HR-TEM), Raman spectroscopy, and density functional theory (DFT) calculations. The two theoretically investigated standalone SnSe nanowires can be described by a repetition of square (2 × 2) Sn4Se4 units and by a periodic hexagonal Sn6Se6 motif with a Mo6S6-like structure, both deduced from HR-TEM images. Raman data support the theoretical prediction that the square (2 × 2) nanowires possess specific modes at 151 and 185 cm-1, whereas the hexagonal Sn6Se6 structure is characterized by a mode appearing at ~ 235 cm-1. Calculations predict that the (2 × 2) nanowire has an electronic gap of 1.5 eV and the Sn6Se6 nanowire presents a semi-metallic character. Raman spectra of composite SnSe@SWCNT samples show that the radial breathing mode of the nanotubes is strongly suppressed indicating an interaction between SWCNT and the encapsulated SnSe nanowire.

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Research Infrastructure INFRAMAT, supported by the Bulgarian Ministry of Education and Science.

2:45pm - 3:00pm

Offset Nanoslot Pattern for Phonon Transport Suppression within Si Thin Films

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The lattice thermal conductivity of a material can be dramatically decreased by nanoporosity, with the increased phonon boundary scattering at pore edges. This method can benefit thermoelectric materials when bulk-like electrical properties can be conserved. In practice, the characteristic length of the introduced nanoporous pattern should be comparable or smaller than the majority phonon mean free paths. However, fabricating ultra-fine patterns is always challenging and costly. For the same spatial resolutions, the geometry of the nanoporous patterns should thus be optimized to minimize the characteristic length.

In this work, thermal measurements were carried out on the thermal conductivity of a 70-nm-thick Si film with different nanoslot configurations. It is found that an offset nanoslot pattern could further reduce the thermal conductivity for nanoporous patterns with a short characteristic length. For ~100 nm feature sizes, a 30% thermal conductivity reduction was found by offsetting the nanoslot patterns. Bulk-like specific heat was measured for all samples, indicating negligible wave effects. All experimental results were compared to phonon Monte Carlo simulations that tracked the phonon movement and scattering to yield the solution of the Boltzmann transport equation. This approach can be widely used for other thin films and 2D materials to tailor their thermal properties.

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3:00pm - 3:15pm

Interlayer Coupling and Strain Localization in Twisted Bilayer Graphene

Vahid Morovati[1], Ganbin Chen[1], Zhiming Xue[2], Kenneth Liechti[1], Rui Huang[1]

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Twisted bilayer graphene (TBG) exhibits a wide range of intriguing physical properties, such as superconductivity, ferromagnetism, and superlubricity. Depending on the twist angle, periodic moiré superlattices form in twisted bilayer graphene, with inhomogeneous interlayer coupling and lattice deformation. For a small twist angle (typically < 2°), each moiré supercell contains a large number of atoms (>10,000), making it computationally expensive for first-principles and atomistic modeling. In this work, a finite element method based on a continuum model is used to simulate the inhomogeneous interlayer and intralayer deformations of twisted graphene flakes on a rigid graphene substrate. The van der Waals interactions between the graphene layers are described by a periodic potential energy function, whereas the graphene flake is treated as a continuum membrane with effective elastic properties. Our simulations show that structural relaxation and the induced strain localization are most significant in a relatively large graphene flake at small twist angles, where the strain distribution is highly localized as shear strain solitons along the boundaries between neighboring domains of commensurate AB stacking. Moreover, it is found that there exist many metastable equilibrium configurations at particular twist angles, depending on the flake size. The nonlinear mechanics of twisted bilayer graphene is thus expected to be essential for understanding the strain distributions in the moiré superlattices and the strain effects on other physical properties.

3:15pm - 3:30pm

Gas-Phase Synthesis of highly sophisticated nanomaterials: Products for Future Energy Applications

Sophie Marie Schnurre, Tim Hülser

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Rapidly developing markets such as catalysis materials, energy harvesting and storage, electronics and environmental remediation are potential key applications for nanomaterials. The production of nano scaled materials in the gas phase is a so called bottom-up method, advantages this synthesis route are process control, high purity products and the opportunity to design a continuous process. Generally, the highly specific properties of particulate systems are directly correlated with the size of each particle and, therefore, require defined shape to bring them into application.

In this work we provide an overview of: combustion, thermal decomposition and plasma assisted material synthesis on the pilot plant scale. Furthermore, direct transfer of materials into processable liquids using wet electro scrubber technology will be presented.

The combustion based spray flame synthesis is a common technology for the synthesis of nanomaterials, however, industrial methods suffer from broad size distribution. Here, we present the generation of particles using easy available metal nitrates and demonstrate their conversion into defined nanoparticles by combustion. The composition of the particles can be adjusted and range from single metal oxides like Titania to complex Lanthanum Strontium Manganite (LSM or LSMO) Perovskite particles with adjusted metal ratios. The materials are typically used in catalysis applications like hydrogen generation in electrolysis or the decomposition of versatile oxide components.

Thermal decomposition is used for the generation of highly pure silicon material, which is a promising candidate for battery application. The decomposition of Silane in a nitrogen/hydrogen atmosphere leads to the formation of highly crystalline material, which can be doped on demand. Production rates of up to 2kg/h material can be achieved using this method. Battery tests reveals cycle stabilities of more than 100 cycles.

The plasma based system decomposes precursors at high temperatures (T > 2000K) into atoms, while a subsequent high temperature gradient leads the nanomaterial formation. As an example we present the formation of graphene, since it offers high potential to improve a wide range of energy applications. Unfortunately, the combination of high production rates and highly sophisticated material is a major

challenge. To address this, we performed continuous gas-phase synthesis of graphene on a pilot plant scale using easy available ethanol as precursor material. For this purpose, ethanol is evaporated and subsequently passes through an argon-hydrogen plasma generated by the microwave radiation. The graphene powder is collected on filter membranes and ex-situ analyzed by scanning and transmission electron microscopy as well as Raman spectroscopy. Results reveal that a throughput of 200g/h and even lower plasma energy supports the formation of generate graphene structures and, therefore, paves the way for energy efficient synthesis.

3:30pm - 3:45pm

Research on Enhanced Thermal Insulation and Improved Heat Absorption by Combining Moss and Cement

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The current situation in cities and urban areas generally makes the living and health conditions of dwellers difficult and unstable. Efficient reduction of Greenhouse Gas emissions has become an important urban policy. The heat island effect also causes irreversible temperature increases in highly dense urban areas. Widespread distribution of green envelopes in cities can provide an opportunity to improve urban environmental conditions and reduce the negative impacts of climate change. According to the concepts above, this study aims to provide more efficient ways to cultivate moss(Ceratodon, Sphagnum, and Funaria) on artificial construction materials such as cement; using afterward the same as a coating material for buildings. The natural features of the moss will act as mitigation of the impact of the building in the urban area and would provide also a significant effect against traffic pollution and dust deposition on the sides of streets. To reach this result this study will focus on creating a successful and efficient mode to grow moss on cement homogenously, trying to enhance the growing possibilities using a natural fertilizer such as coffee to find the optimum conditions of growth, The moss and cement coat will be then analyzed to provide reliable data on the features added to the building, in terms of insulation and heat absorption. Special analyses will be provided on the integrity and stability of the structure, to define whether the moss coat on the surface of the cement layer will not affect the features of the construction material.

The best option was to use the samples kept in stable conditions samples were in the University's lab site. This time the simple tiles were used, not requiring a complex structure to obtain the normal surficial temperature. Originally the thermometer read 22.7°C for the plain cement, 23.5°C for the samples cement-moss and 23.1 °C for the sample cement-coffee-moss ,and after 5 hours read 24.9°C for the plain cement, 24.4°C for the samples cement-moss and 23.8 °C for the sample cement-coffee-moss. The date shows a significant increment of heat absorbed by the plain cement sample, while the other two samples, cement-moss and cement-coffee-moss follow a similar trend, with a significantly small increment of heat.

3:45pm - 4:00pm

High-performance BaTi0.975Sn0.025O3 thin film for tunable microwave applications

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Dielectric tunable devices such as phase shifters, antennas, and electrically tunable resonators have played an irreplaceable role in current communication technology. The lead-free and environmental-friendly barium titanate based ferroelectric tunable thin films are being widely investigated in electrical tunable devices owing to their merits such as large tunability and low power consumption. We developed dense and homogeneous BaTi0.975Sn0.025O3 (BTS) thin film on Pt/Ti/SiO2/Si substrate with thickness of 600 nm by sol-gel and spin-coating soft chemistry, which is a simple, repeatable, and quality controlled method. By sintering the film at 850°C for 15 minutes, a great enhancement of dielectric tunable properties is achieved. The high tunability of 50.2% and low loss of 0.023 are obtained at a very low bias electric field (13.3 kV/mm) at 1 MHz, and consequently a low applied voltage (8 V) is required, which can avoid the potential hazards, prevent the breakdown of BTS thin films and increase the reliability.

According to the PFM (Piezoresponse Force Microscopy) characterization of this sample, the high tunability should come from the large amount of nano polar region inside the film and the low loss is due to the large grain size. The results obtained in this work show that BaTi0.975Sn0.025O3 thin film is very promising material for electrically tunable components and devices. We are going to deposit the gold transmission line pattern on the BaTi0.975Sn0.025O3 thin film through the lift-off process to measure its tunable properties at GHz frequencies with probe station and PNA-L.

4:00pm - 4:15pm

Experimental Study on Two Types of Magnetic Refrigeration Apparatus at Room Temperature Using Concentric Halbach Cylinders

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Magnetic refrigeration, which utilizes the magnetocaloric effect of the magnetic material, is a promising alternative refrigeration technology. It is an eco-friendly refrigeration technology using solid refrigerants instead of CFC/HCFC or HFC refrigerants. Also it is regarded as an energy-efficient refrigeration system to generate temperature difference between high- and low-temperature sides using the temperature change of magnetic refrigerants according to the change of magnetic field, without using power-consuming and noisy compressors. This paper presents some experimental results obtained from two types of magnetic refrigeration apparatus, which has two sets of concentric Halbach cylinders composed of permanent magnets. One is pump-driven type, in which heat transfer fluid was circulated by a pump. In that study, temperature variations at inlets and exits of two AMR beds were measured without cooling load and the maximum temperature difference of 30.9℃ was obtained when heat transfer time is 2 s. A steady-state was reached faster when heat transfer time is 3 s, while the operation of the system became unstable when heat transfer time is 4 s. The other is piston-driven type, in which the fluid circulation system was modified to use a piston instead of a pump. In this study, the performance of a piston-driven magnetic refrigeration apparatus using permanent magnets in concentric cylindrical Halbach arrays was tested by varying the piston stroke (travel distance) and the piston speed (travel speed), and the temperature changes at inlets and exits of two AMR beds were measured in real time and experimental results are summarized as follows: 1) The piston stroke was changed from 60 to 100 mm by 10 mm, and the largest temperature difference was obtained at 80 mm. 2) The piston speed was changed from 10 to 40 mm/s by 10 mm/s, and the largest temperature difference was obtained at 20 mm/s.

4:15pm - 4:30pm

Synthesis and Characterization of titanium dioxide nanocomposites using biological extracts of Persea americana seeds

Citlali Ekaterina Rodriguez-Perez[1], Ingrid Noemí Fuentes-Helguera[1,2], Gustavo Jardón-Guadarrama[3], Maria Elena Manríquez-Ramírez[4], Emma Elisa Ortiz-Islas[1]

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Green synthesis is an alternative technique for the bioproduction of nanomaterials that uses chemical compounds contained or produced by organisms such as bacteria, algae, fungi, yeasts, and plants. The biosynthetic route to obtain metallic nanoparticles consists in the chemical bioreduction of metallic salts or precursor metallic oxides (of gold, silver, iron, among others), that is observed by biomolecules with reducing power, allowing the release of metallic ions. These monovalent or divalent metal ions are reduced to metal atoms, forming nanocomposites that can adopt different morphologies. The objective of this study was to produce titanium dioxide nanoparticles by biogenic synthesis from natural extracts of Persea americana seeds. The obtained nanocomposites were characterized by Brunauer-Emmett-Teller (BET) analysis, Infrared Fourier Transform (FT-IR), UV-Vis absorbance spectroscopy and field emission scanning electron microscopy (SEM).

4:30pm - 4:45pm

Improving stabilities of perovskite nanocrystals toward the application of Micro-LED

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Micro-LED (μ-LEDs) coupled to color conversion phosphors are considered amongst the most promising technologies for future display and artificial light sources. However, currently available emitters suffer from intrinsic limitations mostly due to excessively large particle sizes resulting in poor micron-scale processability and/or low stability that hampers the device lifetime. Here, we aim at contributing to this progress by demonstrating a new type of down-conversion μ-LED phosphors based on CsPbBr3 perovskite nanocrystals directly grown inside mesoporous silica nanospheres.1 These multi-component emitters were synthesized via a smart calcination procedure at high temperature, which simultaneously enables to boost the emission efficiency (PLQY>87%) and perfectly isolate the CsPbBr3 nanocrystals from the outer environment without causing particle cross-linking and aggregation.2 This results in finely solution dispersible, ultra-stable and highly emissive CsPbBr3-SiO2 nanospheres that perfectly fit the technological requirements of photolithographic inks for the fabrication of μ-LED color conversion patterns with pixel smaller than 20 μm. With additional anions treatment, we could further improve their thermal quenching resistance and γ-ray radiation hardness.3-5

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4:45pm - 5:00pm

Simulations, growth and characterization of graphene for photonic applications

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Integrating graphene into Silicon complimentary-metal-semiconductor (CMOS) technology for photonic applications is a promising route but remains challenging in developing wafer scale graphene processes [1-3]. This includes graphene growth by CVD, transfer, encapsulation, and contacting graphene in a 200mm wafer pilot line routinely used for the fabrication of the integrated circuits. Towards these goals, this work focuses on the full spectra of graphene research aspects in 200mm pilot line We developed several concepts towards the challenges by fabricating test proof-of-concept devices like TLMs, Hall bars or Kelvin bridge structures and more complex photonic graphene based devices.

In this study, graphene synthesis was targeted on the surface of epi-Ge(100)/Si(100) substrates (grown in the pilot line of IHP), which showed the potential to provide good quality graphene over 200 mm wafers. Alternatively, different orientation (110) were employed to increase the mobility of the graphene, which is in the range of 2300cm2/Vs at the current state. Furthermore, we systematically investigate the quality, thickness, and homogeneity of graphene by Raman, AFM, SEM, ellipsometry and THz time domain spectroscopy. In addition, simulations of the graphene modulator, on the component level as well

as on the device level was performed based on the realistic graphene properties. Our simulation demonstrate a modulation depth of 0.17db/μm, a 3dB bandwidth of 40 GHz and power consumption less than 1Pj/bit.

Acknowledgment

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5:00pm - 5:15pm

Use of wastewater as curing medium and wastewater sludge for lightweight concrete

KOBE SAMUEL MOJAPELO, WILLIAMS KEHINDE KUPOLATI, JULIAS MUSYOKA NDAMBUKI, ROTIMI SADIKU, IDOWU DAVID IBRAHIM

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The increasing population growth has contributed to the increased domestic and industrial wastewater sludge generation. Sludge is discarded in designated land areas, making the land unusable. Due to the low density of dry sludge, the search for lightweight construction materials has resulted in the use of sludge as a feasible substitute for the composition of concrete. The dry sludge collected from the Polokwane Wastewater Treatment Works in Limpopo Province was used as a partial substitute of sand in concrete. The sludge content in the sand was varied from 2.5, 5, 7.5, 10, to 12.5%. The partial replacement of sand with sludge in the concrete mix is viable and useful. The SEM image revealed a porous nature and irregular surface morphology of sludge and concrete. The result showed that up to 7.5% of sand could be replaced with sludge in concrete for structural applications. In addition, wastewater can be used as a curing medium due to sludge having lower density than water, therefore, decrease in the concrete unit weight.

5:15pm - 5:30pm

Computational screening and experimental validation of binary and ternary metal nitrides for the solar-driven thermochemical production of green ammonia

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The current conventional production of ammonia relies on the well-known Haber-Bosch process, involving a catalytic high-pressure reaction between H2 and N2. Due to the production of H2 and N2 based on highly energy-intensive processes using fossil fuels, the worldwide ammonia production is responsible for 1.2% of the anthropogenic global greenhouse gas emissions. Furthermore, the high pressures needed to increase the yield and the large recycle flows of the unreacted H2 and N2 impose demanding requirements on the equipment, increasing the cost and complexity of the process and favouring large, centralized plants. Multi-step thermochemical cycles based on metal nitrides stand as a promising alternative to this process, since they can substantially mitigate or even eliminate the concomitant CO2 emissions linked to ammonia production. In such cycles, concentrated solar energy is used to supply the high-temperature heat required in the endothermic reaction steps. Previous studies have proven successful synthesis of ammonia at much lower pressures – even around ambient conditions. Nevertheless, the availability of literature and experimental data on the metal nitrides involved in these cycles is scarce. In an effort to investigate a broader range of candidates, this works presents the results of a screening of different metal nitride compounds using DFT (Density Function Theory) calculations from open-access databases. The probable reaction pathways encompassing either the

hydrogenation (H2) or the hydrolysis (H2O) of such nitrides, as well as their re-nitridation to recycle the pristine metal nitride were identified through a Gibbs free energy minimization algorithm. The experimental validation of the selected candidates was conducted both through dynamic thermogravimetric analysis (TGA) and in a high-pressure reactor. Finally, the different fresh and spent materials were submitted to physicochemical characterization, to evaluate the chemical, structural and morphological changes inferred through hydrogenation/hydrolysis/re-nitridation and aiming to assess their performance under cyclic operation.

5:30pm - 5:45pm

Speed up medical products' release to market

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It is a challenge in the medical industry to attain appropriate qualification protocols for medical devices. The manufacturers necessitate device storage that lasts for an extended period of time. Single-use devices may need storage for up to 6 years before their functional lifetime actually starts. In other words, every medical product completes its unique journey before it can be functionally used by the customer. At this point, the manufacturers need to provide a quality certificate that guarantees the device's safety and robustness throughout its life cycle. Likewise, package material aging information is needed to ensure package integrity, satisfy FDA validation requirements, and provide evidence of sterility and fitness for use over a product's life cycle. To decrease the time necessary for testing prior to commercialization, or in other words to speed up product's market release; manufacturers perform accelerated-aging studies on the product/ package combination. These studies are performed at elevated temperatures, so to simulate the realistic life span of the product. Life span of every product is unique in line with its application requirements and consists of sections such as storage of components, assembly and irradiation, storage of the irradiated product and finally application. Polymers are similar to living organisms and their properties are time, temperature and stress dependent, making the job of simulating the life cycle very complicated and difficult. As Sartorius Stedim Biotech, we are taking this big challenge and turning it into something that the medical industry would certainly fancy: Speed up product's release to market.

5:45pm - 6:00pm

Cellular Desiccant Rotor Produced from Recycling of abrasive slurry

Sheng-Fu Yang, To-Mai Wang, Chun-Liang Chen, Kuang-Li Chien, Chih-Chao Liang, Hsien-Ho Chuo

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Abrasive slurry waste is generated during the ingot-cutting step in the manufacturing of silicon-based semiconductors or solar cell wafers. Silicon carbide (SiC) is widely employed as an abrasive material in aqueous media for sawing silicon or silicon carbide ingot into individual wafers in photovoltaic and semiconductor industry. The research to recycle abrasive slurry waste into useful resources has received increasing interest. The used SiC can be preferably recovered and reused for dehumidification application, rather than disposed of as waste. In this study, the cellular ceramic desiccant rotor is manufactured using SiC derived from abrasive slurry waste with a three dimensional random cellular structure and applied to adsorb humidity from the atmosphere. The equilibrium time for the cellular desiccant rotor and humidity is determined by observed kinetics in the adsorption experiment. The adsorption capacity of solid desiccant rotor with different porosity ranged from 20 to 60 pores per inch (PPI) is a function of time at 20% and 30% relative humidity (@25°C). The adsorption equilibrium time of desiccant wheel with 8 cm diameter and 5 cm thickness is ten minutes. The cellular desiccant rotor dehumidifier will be installed and applied for drying agricultural products.

Plen Sess: Plenary Session

Time: Saturday, 12/Aug/2023: 9:30am - 10:30am · *Location:* Theatre
Session Chair: Xiangfeng Duan

9:30am - 10:30am

Nanowire Photoelectrochemistry

Peidong Yang

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Liquid sunlight can be considered as a new form of chemical energy converted and stored in chemical bonds from solar energy. Efficient capture and storage of solar energy can provide unlimited renewable power sources and drive the capture and conversion of greenhouse gases such as CO2 into valuable chemicals. Solar-to-chemical production using a fully integrated system is an attractive goal, but to-date there has yet to be a system that can demonstrate the required efficiency, durability, or be manufactured at a reasonable cost. One can learn a great deal from the natural photosynthesis where the conversion of carbon dioxide and water to carbohydrates is routinely carried out at a highly coordinated system level. There are several key features worth mentioning in these systems: spatial and directional arrangement of the light-harvesting components, charge separation and transport, as well as the desired chemical conversion at catalytic sites in compartmentalized spaces. In order to design an efficient artificial photosynthetic materials system, at the level of the individual components: better catalysts need to be developed, new light-absorbing semiconductor materials will need to be discovered, architectures will need to be designed for effective capture and conversion of sunlight, and more importantly, processes need to be developed for the efficient coupling and integration of the components into a complete artificial photosynthetic system. In this talk I will introduce the original nanowire-based photochemical diode system design, and discuss the challenges associated with fixing CO2 through traditional chemical catalytic means, contrasted with the advantages and strategies that biology employs through enzymatic catalysts to produce more complex molecules at higher selectivity and efficiency. Introducing microorganisms as whole-cell catalysts into the overall photochemical diode system led to the generation of powerful photosynthetic biohybrids capable of converting sunlight, H2O and CO2 into food, fuels, pharmaceuticals, and materials. Finally, I will outline the future of this field, opportunities for improvement, and its role in sustainable living here on Earth, and beyond.

Invited Talk-2: Invited Talk

Time: Saturday, 12/Aug/2023: 10:30am - 1:00pm · *Location:* Theatre
Session Chair: Jonas Johansson

10:30am - 10:55am

Anisotropic nanoparticles and DNA coatings for colloidal self-assembly

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The assembly of low volume fraction percolating structures at the colloidal scale is a challenging problem with applications in photonics and in the emerging field of metamaterials. DNA coated particles have been proposed and successfully applied as a versatile tool for programming the self assembly of micrometer size particles. Recently, strategies to access some valuable structures such as the diamond lattice have been reported,(1, 2) opening to way to the assembly of functional materials and the realization of materials that can exhibit exotic phenomenon like light localization. Nevertheless highly a myriad of valuable materials are still in need of assembly pathways and one of the main limitation experimentally is the preparation of the required building blocks with designed shapes and programmed interactions to guide their assembly.

In this context, we report strategies to design and synthesize building blocks with controlled geometries and encoded directional interactions. More precisely we prepare patchy nanoparticles, i.e. nanoparticles presenting chemical or topological surface discontinuities that are the starting point for the self-assembly clusters, chains or periodic superlattices. The synthetic pathway includes sol-gel nucleation and growth and seed-growth emulsion polymerization of styrene, leading to the formation of ~100 nm to 1 µm silica nanoparticles with polystyrene patches at their surface.(3)

To guide the assembly, we rely on DNA coatings as a programmable glue to encode the interactions between particles. An amphiphilic azide terminated block copolymer is anchored at the surface of PS patch through a selective swelling-deswelling process. Short DBCO-terminated DNA strands are then coupled to the resulting azidated patches through click-chemistry via a strain-promoted azide-alkyne cycloaddition (SPAAC) reaction. We show the fine-tuning of the nucleobases sequence of these short DNA strands, and especially the introduction of mismatch base pairs, can induce the sequential assembly of core shell colloidal crystals from a homogeneous suspension.

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10:55am - 11:20am

Low-Resistance Laser-Induced Graphene (LIG) for Sensing in 3D Printed Structures

Gerd Grau[1], Aamir Minhas-Khan[1], Mehraneh Tavakkoli Gilavan[1,2], Mohammad Nazeri[1], Mohamad Idris[1], Milad Ghalamboran[1]

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Fabricating patterned graphene electrodes with a scalable, low-cost method is an important step towards large-area devices such as micro-supercapacitors or sensors. One way to address this challenge is to directly convert a polymeric substrate into laser-induced graphene (LIG) using a scanned CO2 laser in a one-step process. No separate steps are needed to chemically synthesize the graphene, formulate an ink, or use lithography to pattern the material. In order to achieve the desired electrical performance, it is important to understand how the laser interacts with the substrate to be able to optimize the laser parameters. In this talk we will describe our recent work to understand the LIG process experimentally and by simulation to achieve low sheet resistance. Various different polymeric substrates have been

successfully converted to LIG. Most commonly, flexible substrates such as polyimide (PI) have been used and we will present our results on PI. More recently, LIG has been fabricated on 3D printed polymers as well. This is promising as it allows electrical functionality such as sensing to be integrated into 3D printed objects that are otherwise purely mechanical. Here, we will show that LIG on 3D printed polymers exhibits lower resistivity and sheet resistance than conductive 3D printing filaments in addition to being a very simple fabrication process. Finally, we will show how LIG can be employed in devices such as micro-supercapacitors and sensors as well as more complex semiconductor devices. We have fabricated organic electrochemical transistors (OECT) using LIG for all electrodes for the first time, which simplifies the fabrication of these transistors that could be used for sensing or amplification. In summary, this talk will describe how to achieve high-quality LIG and show the versatility of LIG as a material for different devices and applications including the integration of electronics with 3D printing.

11:20am - 11:45am

Inorganic Nanomaterials to Achieve Efficient Hydrogenation Reactions for Energy Storage and Materials Conversion

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Hydrogenation reactions using green hydrogen are indispensable for the energy storage and material synthesis without a great deal of CO2 emission. Electrochemical CO2 hydrogenation (eCO2H) attracts much attention as a technology for carbon circulation on the earth and the selective eCO2H into high value-added chemicals is increasingly demanded. We demonstrated variable selectivity using Hydroxide-derived copper (OH/Cu) electrodes having a controlled OH amount; three OH/Cu electrodes realized their distinct selectivity such as Faradaic efficiency (FE) for the production of CH4 (CH4 FE) of 78%, C2+ FE of 71%, and the ratio of C2+-to-CH4 >355 based on computational investigations concerning work functions of the surface [1]. Furthermore, CuPd nanocatalysts were found to exhibit unique selectivities depending on the mixing pattern of the alloy [2]. Highly efficient electric power storage is possible by using a structure controlled TiO2 catalysts. Glycolic acid (GC), a monovalent alcoholic compound and oxalic acid (OX), a divalent carboxylic acid, are focused as a redox couple due to their stability and transportability as energy-storage media [3]. The oxide based electrocatalysts for oxygen evolution reaction were also developed [4, 5]. Furthermore, we demonstrated electrochemical synthesis of amino acids from an organic acid with a nitrogen source by applying the TiO2 electrode highly efficiently.[6]

Efficient thermal hydrogenation reactions such as ammonia synthesis are also demanded. We conducted the highly sensitive in-situ IR measurement, named as modulation-excitation infrared spectroscopy, under reaction conditions for Ru based ammonia synthesis catalysts, which elucidated detailed reaction mechanism of ammonia synthesis.[7]

Key Words: Nanocatalysts, CO2, alcohol, Amino acids, Ammonia

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11:45am - 12:10pm

Subphthalocyanines: Singular, aromatic and chiral, non-planar compounds

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Subphthalocyanines: Singular, aromatic and chiral, non-planar compounds

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Subphthalocyanines (SubPcs) are well-known cone-shaped chromophores consisting of three 1,3-diiminoisoindole units assembled around a boron atom. As a result of their 14 pi-electron aromatic core and their tetrahedral geometry, SubPcs exhibit outstanding physical and optoelectronic properties (e.g., strong dipole moment, excellent light absorption in the 550-650 nm, rich redox features, and excellent charge transport capabilities), that have been skillfully used in variety of applied fields, such as molecular photovoltaics, among others. SubPcs were used by us as non-fullerene acceptors in bulk heterojunctions (BHJ) solar cells. On the other hand as part of our systematic investigation in the preparation and study of novel SubPc-based D–A systems, we have used 1,1,4,4-tetracyanobuta-1,3-diene (TCBD) as partner for SubPcs. Moreover, in the case of unsymmetrically substituted SubPcs (i.e., prepared by cyclotrimerization of a phthalonitrile with no C2v symmetry), they present inherent chirality and the corresponding couple of enantiomers can be isolated. Columnar aggregates based on chiral SubPcs have been also prepared, giving rise to ferroelectric self-assembled molecular materials showing both rectifying and switchable conductivity. These chromophores have been incorporated in multicomponent systems showing a panchromatic response and allowing the tuning and controlling intramolecular FÖRSTER Resonance Energy Transfer for Singlet Fission.

Key Words: Subphthalocyanines, Chirality, Aromaticity, Molecular Photovoltaics

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12:10pm - 12:35pm

Multi Direction Interests of UHPC enrichment for bridge structures applications

Beata Stankiewicz

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The adoption of UHPC (Ultra-High Performance Concrete) is advancing rapidly for the bridges due to its high strength and durability properties. It is to be expected that additional advancements in innovating and refining the UHPC enrichment would provide knowledge for the materials' performance. This paper presents the UHPC implementation possibilities in the new bridge structures or during modernization of old bridges as well as for the light, elegant footbridges. The present research study also discusses the multi direction interests of UHPCs' enrichment to achieve better technical parameters for its bridge elements with expected long life durability of 150 years. The important focus of presented paper is the importance of the superplasticizer on workability and structure of UHPC, analysed by individual tests and comparison, comprehensive study. Independently of great progress in the production of different kinds of superplasticizers the problem of their compatibility with cement is still key issue. The use of UHPC for pretensioned bridge girders is appealing to bridge engineers given its superior mechanical properties and durability. UHPC provides an opportunity for pretensioned girders to span greater lengths or use shallower structural depths while delivering more durable girders compared with conventional concrete solutions. Two different receipts of UHPC for bridge structures, based on developed technology will be presented as result of laboratory research.

12:35pm - 1:00pm

Long-term barrier property of PMMA-silica nanocomposites on Al alloys clarified: a thousand-days study

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The excellent anti-corrosion performance of poly(methyl methacrylate) (PMMA)-silica nanocomposite coatings has been reported in several studies. When deposited on carbon steel and aluminum AA7075, the thin films (2 to 10 µm) showed long-term protection against water and ion permeation with almost no degradation for more than 600 days1. In this work, PMMA-silica coatings were deposited on AA2024 and AA7075 aluminum alloys by dip coating resulting in ~ 10 µm films. The coated substrates were immersed in 3.5% NaCl solution and five independent methods were used to comparatively determine the water intake during an immersion period of more than 1000 days. The uptake values were calculated from electrochemical impedance spectroscopy data using the Brasher-Kingsbury model and from the high-frequency impedance values using the linear rule of mixtures. The water uptake values were compared to those determined for freestanding coatings obtained by gravimetric and thermogravimetric measurements. X-ray photoelectron and ATR-FTIR spectroscopies were used to study the composition and bonding structure of the surface region of the coatings before and after immersion, while cross-sectional information was obtained using scanning electron microscopy and energy-dispersive X-ray spectroscopy maps. Small angle scattering revealed an increased distance between silica domains after immersion. A slight surface leaching was observed due to a decrease in the thickness of coatings and a corresponding increase in roughness was detected by atomic force microscopy. The slow erosion of the silica phase observed corresponds to the water interaction with the polymer chains. Finally, the comparative study showed that water uptake is a very slow process for both compositions. The values obtained by gravimetry are consistent with those obtained by a linear rule of mixtures, but the Brasher-Kingsbury model overestimates the water uptake. Summing up, the slow permeation rate of PMMA-silica coatings (about 5 Å per day) is explained by a highly crosslinked structure with evenly distributed silica nanoparticles that contract the polymeric segments. Consequently, the uptake values remained below 0.5% for both formulations even after 1000 days of immersion in a harsh environment.

Oral Talk-3: Oral Talk

Time: Saturday, 12/Aug/2023: 10:30am - 2:00pm · *Location:* AU 2410
Session Chair: Kausik Das

10:30am - 10:45am

Fabrication of Electrospun PCL/PCL-Gelatin/TPU-ZnO-NPs Multilayered Nanocomposite Scaffold for Vascular Tissue Engineering

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Recently, multilayered nanocomposite vascular scaffolds based on synthetic and natural polymers have attracted increasing attention due to their better mechanical properties with improved bioactivity and higher volume expansion than single-layer structures. In this study, with the aim of developing a novel nanocomposite scaffold for artificial blood vessel production, tri-layered scaffolds were fabricated using layer-by-layer electrospinning on a rotating type collector. In order to mimic the mechanical properties of natural blood vessels with biocompatible materials, a new type of tri-layered vascular graft with antibacterial activity comprised of a polycaprolactone (PCL) inner layer, PCL/gelatin middle layer, and thermoplastic polyurethane (TPU)/ZnO-nanoparticle outer layer was fabricated, sequentially. In the present study, zinc oxide nanoparticles (ZnO-NPs) were synthesized by the microwave assisted chemical reduction method. The content of ZnO nanoparticles in the TPU outer layer of the scaffold was varied between different concentrations related to the polymer weight. Nanoparticle size and morphology of ZnO nanoparticles, the effects of the ZnO nanoparticle concentration on the fiber morphology and the layer attachments of the produced multilayered scaffolds were evaluated by using scanning electron microscope (SEM). ZnO nanoparticles analyzed by using EDX attachment to determine the presence of zinc (Zn) in nanostructure. Furthermore, biocompatibility, cytotoxicity and antibacterial activity of the produced samples were evaluated. Overall results showed that the electrospun PCL/PCL-Gelatin/TPU-

ZnO-NPs tri-layered vascular graft presents appropriate characteristics to be considered as a potential candidate for vascular tissue engineering applications.

10:45am - 11:00am

Forcespun Polymers as Precursors to Boron Nitride Fibers

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The need for multifunctional materials in aerospace technologies is currently driving the development of new novel composite materials. Specifically, insulation materials with high thermal conductivity, high electrical resistivity, and are chemically inert are needed for high voltage power applications. Boron nitride (BN) nanomaterials fit these criteria and can be incorporated into composites for further material design. The synthesis of boron nitride through a polymer derived ceramic route allows for the morphology of the resulting BN to be tailored. This is especially beneficial since the polymers can be shaped or spun into fibers prior to the ceramic conversion. This project utilizes the Forcespinning technique to produce boron-containing polymer fibers that are converted to boron nitride through a heat treatment. The chemical compositions and fiber morphologies were studied and reported here.

11:00am - 11:15am

A Novel Flexible and Stretchable Photonic Crystals Film with Sensitive Structure Color Change Property

Do Thi Vien Thao[1], Nguyen Van Hieu[2], Cheng-Chung Chang[1], Gou-Jen Wang[1]

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Conventional electronic and photonic devices are inherently two-dimensional and rigid limited by the substrates on which they are fabricated. However, there are many emerging applications such as soft robotics, electronic skin, wearable devices, and flexible display, prefer soft devices and nonplanar geometries. Therefore, flexible and stretchable optical devices that can be mechanically deformed without losing their useful optical properties are desired.

In this study, a novel flexible and stretchable polymer films with photonic crystals of uniformly distributed nano-hemispheres that enable both periodicity and diffraction change with small strain is proposed. In addition to the periodicity changes, simultaneous change of the diffraction in photonic crystals arise from the change of the incidence angle resulting from the shape change of the nano-hemispheres due to stretch and bending strain. Thermoplastic polyurethane (TPU) that is thermalplastic and stretchable was used as the substrate for the photonic crystal structure. The back-barrier layer with regular nano-array structure of an anodic aluminum oxide (AAO) film was used as the template for forming the nickel mold through electroforming. The nano hemisphere array of the AAO barrier layer was then transferred onto the TPU substrate through nano-imprinting to form a strain controllable photonic crystals (SCPC) structure on the TPU film. The sensitive structural color change property of the proposed SCPC TPU films was further employed for the detection of spoiled milk by attaching the SCPC TPU film on the orifice of a milk container (Kirkland's 1 Liter whole milk). For fresh milk, without any gas pushing from the container (no curvature change), the SCPC TPU film illustrated a blue structural color. When the milk has spoiled, the SCPC TPU film was pushed to a curved surface by the spoilege generalized gas inside the container and exhibited green and red structure color at the opposite edge. The spoiled milk detection results demonstrated that the proposed SCPC TPU films is highly feasible smart biosensor for the detection of spoiled foods in a container.

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11:15am - 11:30am

Investigation of reduced graphene oxide/PMMA polymer nanocomposites for optoelectronic device applications

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Reduced graphene oxide (rGO) is an attractive carbon material in the applications of electronics and optoelectronics devices, energy storage systems, bio-sensors, fuel cells, batteries, and supercapacitors. In the research nanoparticles of rGO were synthesized using inexpensive, improved Hummer's method of graphene oxide at room temperature. The field emission scanning electron microscopy (FESEM), energy-dispersive X-ray (EDX), X-ray diffraction (XRD), Fourier transformed IR (FTIR), and UV–visible spectroscopy confirmed the successful fabricates of rGO. The rGO/PMMA nanocomposites were synthesized with different five concentrations of rGO nanoparticles. The surface morphology and crystallinity of rGO/PMMA nanocomposites were investigated via FESEM and XRD patterns. The linear refractive indices, extinction coefficients, linear absorption coefficients, band gap energy, optical conductivity, dispersion parameters and dielectric constant of rGO/PMMA nanocomposites were estimated from absorption, Transmission, and reflection spectra in the range of 190 -2700 nm wavelength. The results show that the polymer nanocomposites have a high transmission in the range of telecommunication application. These results also indicate that PMMA/rGO nanocomposites are good candidates for optoelectronics device applications.

11:30am - 11:45am

Investigation on Leeb Hardness Distribution and Damage Prediction Model of Cementitious Materials Subjected to High-pressure Water

Xiyao Zhao, Jikai Zhou

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Hydraulic structures, which utilize cementitious materials as the primary construction materials, are subjected to a pressurized water environment for a long-term during service. Changes in the mechanical properties of cementitious materials under high-pressure water over time require further explorations. In this study, the Leeb rebound hardness and splitting tensile strength of cementitious materials were measured in order to characterize the variations in cementitious materials' local and global mechanical properties. The influence of pressure value, loading duration, and moisture content were considered as well. The results showed a more significant deterioration in surface hardness induced by higher water pressure and longer loading duration, with the former factor having a more substantial impact. In addition, the rate of hardness deterioration was analyzed as a function of measured point-to-surface distance. The mechanism of high-pressure damage was clarified based on pore structure changes, and relationships between average hardness, tensile strength, and porosity were examined. A model for predicting the deterioration of cementitious materials exposed to high-pressure water was developed, and it showed good agreement with experimental results.

11:45am - 12:00pm

Engineered Nanostructures with Various Morphologies for Advanced Electrocatalysis

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The morphology of nanostructures greatly influences their catalytic performance due to the exposed facets, specific surface area, surface defects, and so on. In conventional synthesis, surfactants play a pivotal role in altering the surface energy of different facets and increasing the colloidal stability, giving nanostructures with different morphologies. However, the adsorbed surfactants would block the intrinsic active sites of nanostructures, thus reducing their catalytic performance. Therefore, it is crucial to develop a method for altering the morphology of nanostructures without any surfactant.

In our work, we have developed a surfactant-free method to fabricate various kinds of surfactant-free nanostructures via concentration depletion and oxidation etching process. The as-prepared nanostructures have shown a significant enhancement in catalytical activities, clearly demonstrating the superiority of surfactant-free nanostructures over surfactant-coated counterparts. These surface-clean catalysts and their derivatives are expected to exhibit excellent performance in catalytic applications such as the degradation of pollutants, electrochemical reduction of CO2, photoelectrochemical water splitting, electroreduction of CO, catalytic organic synthesis, and catalytic sensing.

12:00pm - 12:15pm

Bilateral Piezoelectric Charge Modulation——A Perspective of Piezo-Phototronic Effect in Multi-Layer Structured Optoelectronic Devices

Wenbo Peng[1,2], Fangpei Li[3], Chenhong Wang[1,2], Yongning He[1,2]

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Piezo-phototronic effect utilizes the strain induced piezoelectric charges inside the piezoelectric semiconductors to modulate the local energy band diagram at the interface of junctions, thus controlling the photo-generated carriers' behaviors and the performance of optoelectronic devices. Since its invention in 2010, piezo-phototronic effect is vastly demonstrated in photodetectors, light-emitting diodes, and solar cells, where only one interface is modulated by piezoelectric charges. In 2018, we first propose to construct multi-layered structure for efficient utilization of piezoelectric charges with both polarities and obtain better performance optimization by piezo-phototronic effect [1], which we recently name as Bilateral Piezoelectric Charge Modulation. Here, we summarize the recent progresses of our researches on bilateral piezoelectric charge modulation, including both experimental results and analytical theories.

An n-ZnO/p-Si/n-ZnO double heterojunction bipolar phototransistor is designed, and the regulation of bilateral piezoelectric charges on bipolar phototransistor's performances is studied from the perspectives of theoretical derivation and experimental research simultaneously. A theoretical model of n-ZnO/p-Si/n-ZnO double heterojunction bipolar phototransistor is established, and the influence of four polar combinations of piezoelectric charges induced by different strains formed at the interface of two heterojunctions on the characteristics of phototransistor is carefully studied. The theoretical calculation results show that, when positive piezoelectric charges are generated at both two interfaces, the regulation of strain on the phototransistor is a superposition of two positive effects, which can significantly improve the performances of phototransistor. Then an n-ZnO/p-Si/n-ZnO double heterojunction bipolar phototransistor is experimentally prepared. By rationally designing the device structure, positive piezoelectric charges could be simultaneously generated at the two heterojunction interfaces when an external compressive strain is applied. The saturation current of phototransistor is significantly improved, and the photoresponsivity is also improved to a certain extent by the applied compressive strain. To further optimize the performances, the effects of interdigitated electrode's size, substrate and ZnO layer on the strain regulation of device performance are carefully studied. At a compressive strain of -1.37%, the photoresponsivity is enhanced from 0.96 A/W to 20 A/W with an increase of about 2000%, indicating the significant modulation of applied strain on the performances of heterojunction bipolar phototransistor.

12:15pm - 12:30pm

Blue-light Emissive Type II ZnO@5-Amino-2-Naphthalene Sulfonic Acid and Quasi Type II ZnO@1-Aminopyrene Hybrid Quantum Dots

Won Kook Choi[1], Hong Hee Kim[2]

[1]Korea Institute of Science Technology, Korea, Republic of (South Korea); [2]Korea Institute of Science Technology, Korea, Republic of (South Korea); wkchoi@kist.re.kr

Non-toxic heavy metal, low-cost indium-free blue emissive quantum dots (QDs) are critical for the realization of self-emissive electroluminescent quantum dot (ELQD) LED displays. We report a facile and an effective hybridization of ZnO QDs with functionalized polyaromatic hydrocarbons (f-PAHs) to

synthesize a very bright and stable blue-light emissive QLED using non-toxic type II ZnO@5-Amino-2-Naphthalene Sulfonic Acid (ANSA) and quasi type II ZnO@1-Aminopyrene hybrid QDs. Blue emissions from ZnO@ANSA QDs are well elucidated by the charge transfer from CB of ZnO QDs to lowest unoccupied molecular orbital (LUMO) of ANSA and from shallow donor Zn interstitial (Zni) or extended Zni states to C=O, C=N, C=S (pi*)-states, and then the electronic transitions to non-bonding C=O, C=N, C=S (pi)-states of ANSA. EPR signal g=1.96 of ZnO QDs appears only by illumination of light □< 400 nm and completely disappears in ZnO@ANSA QDs. Electrons trapped in CB or Zni's are unveiled to participate in green luminescence and the paramagnetic defect to derive EPR signal g=1.96 of ZnO. The estimated spin-spin relaxation time (T2) of ZnO QDs was about 32.5 ns, which is two orders of magnitude longer than known values for bulk or thin-film ZnO. The optimized QLEDs of ITO/PEDOT:PSS/TFB/ZnO@1-Aminopyrene/TPBi/LiF/Al demonstrate very bright deep blue-light electroluminescence (EL) of 3379 cd/m2 centered at λ = 441 nm with a full-width-at-half maximum of 41.7 nm and CIE 1931 color coordinates of 0.17 and 0.09, a luminous efficacy (LE) of 3.32 cd/A, power efficiency (PE) of 2.45 lm/W, external quantum efficiency (EQE) of 2.35%, and a remarkably long lifetime T50 of >17830 h at 100 cd/m2, which is the most stable and long lifetime blue QD-LEDs to date

12:30pm - 12:45pm

Fabrication and Characterization of Memristive Synapse Devices with an Al/LiNbO3/Pt Ferroelectric Tunnel Junction

Sejoon Lee[1,2], Youngmin Lee[1,2], Deuk Young Kim[1,2], Woochul Yang[3], Moon-Deock Kim[4]

[1]Department of Semiconductor Science, Dongguk University, Seoul 04620, Korea; [2]Quantum-functional Semiconductor Research Center, Dongguk University, Seoul 04620, Korea; [3]Department of Physics, Dongguk University, Seoul 04620, Korea; [4]Department of Physics, Chungnam National University, Daejeon 34134, Korea; sejoon@dongguk.edu

The LiNbO3 layers were grown onto the (111) Pt/SiO2/Si substrates at 150 – 250 °C by radio-frequency magnetron sputtering. The samples displayed a smooth surface with no hillocks and pits, and showed a nonlinear lossy-type ferroelectric characteristic with the remnant polarization of 3 – 4 μC/cm2. The memristors, comprising the top-to-bottom two-terminal device scheme of Al/LiNbO3/Pt, clearly exhibited the polarization-dependent asymmetric memristive hysteresis loops in their current-voltage characteristic curves. When repeating the current-voltage sweep at an appropriate program voltage range, the on-state current was gradually increased with increasing sweep number. This could be attributable to the increased potential gradient inside the LiNbO3 layer because the electrical polarization in ferroelectric LiNbO3 would tenaciously increase upon applying the continuous voltage stresses. In other words, the increased electrostatic polarization field in LiNbO3 gives rise to the increase in the tunneling probability through the LiNbO3 potential barrier; and it eventually leads to the increase in tunneling current of the Al/LiNbO3/Pt memristor. In addition, it was also observed that the polarization-dependent memristive switching characteristics (e.g., data storage speed, multiple resistance states, data retention, etc.) could be effectively modulated by changing the pulse magnitude and the pulse duration of the program/erase voltages. Using these unique characteristics, we demonstrated various synaptic functions such as a long-term potentiation/depression and a spike-timing dependent plasticity. The results suggest that the ferroelectric LiNbO3 based memristors hold great promise for the future neuromorphic applications.

12:45pm - 1:00pm

Characteristics of the Composite Material Obtained by Low-Temperature Sintering of Polyethylene Terephthalate (PET) with Crushed Basalt.

Jesús Agüero, Marina Vlasova, Pedro Márquez

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The work considers the properties of the PET-basalt composite as a structural material. The composite was synthesized from crushed waste PET and crashed basalt with a particle size of 0.595 mm. The content of PET in mixtures was changed from 90 to 10 wt%. The processing temperature of mixtures placed in metal molds was 280 oC. The heat treatment time was 2 hours. The samples after cooling in the furnace were removed and subjected to tests for strength, deformation under load, water absorption, and changes in the volumes of the tested bodies in the temperature range of 25-70 oC. The results

obtained showed that as the PET content in the mixtures decreases, the compressive strength changes from 18 MPa to 12 MPa, the fracture strength from 0.86 MPa to 3.3 MPa, and the water absorption from 0.26 to 1.41. When the samples are heated in the above range, their size does not change. Since for standard building bricks made of clay, the compressive and fracture strength is ~ 7.5-15 MPa and ~ 1.8-2.8 MPa, water absorption is not more than 8% [1, 2], the blocks obtained from composites PET-basalt at very low sintering temperature can be used in the construction industry as a structural material for various destination.

Key words: PET, basalt, sintering, structural material

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1:00pm - 1:15pm

Fabrication of Self-Powered Touch-Free Sensors Using III-Nitride Nanowires as Response Media

Jinseong Lee[1], Siyun Noh[1], Jaehyeok Shin[1], Sangmoon Han[2], Hyung-Kee Seo[3], Jin Soo Kim[1]

[1]Department of Electronic and Information Materials Engineering, Division of Advanced Materials Engineering, and Research Center of Advanced Materials Development, Jeonbuk National University, Korea, Republic of (South Korea); [2]Mechanical Engineering and Materials Science, Washington University in St. Louis, USA; [3]School of Chemical Engineering and Future Energy Core Convergence Center, Jeonbuk National University, Korea, Republic of (South Korea); kjinsoo@jbnu.ac.kr

We report the successful operation of self-powered touch-free sensors (TFSs) fabricated with III-nitride (InN, GaN, and InN/GaN) nanowires (NWs) as response media. The NWs with high structural uniformity and crystal quality as well as unidirectional growth behavior were formed on Si(111) substrates using a new growth technique with a plasma-assisted molecular beam epitaxy.[1-3] The TFSs with a size of 1×1 cm2 were fabricated by sputtering a Pt/Cu electrode on the reverse side of substrates. For the characterization of the TFSs, a human hand initially maintains a constant distance of 40 cm from the top surface of the TFS to obtain the initial condition. And then, the hand approaches to the surface of the TFS without touching it. The distance between the hand position and the TFS surface is defined as the operating distance, which was varied, specifically at 1, 5, 10, 20, and 30 cm. The open circuit voltage (OCP) of the TFS with 700-nm-long InN NWs was measured as 0.81 V at an operating distance of 1 cm. The TFS clearly detected the periodic hand movement even at an operating distance of 30 cm without using an external power supply. The OCP values of the device with InN NWs were higher than that (0.46 V) of the TFS based on 1000-nm-long GaN NWs. This result is attributed to the difference in spatial displacement of charges between InN and GaN. The device performances were also measured by systematically varying the experimental conditions such as motion frequency and target materials. To increase the amplitude of output signals, photo-generated carriers were additionally supplied to NWs before approaching a hand to the surface of the TFSs. The OCP value of the InN/GaN-NW TFS under light illumination was measured to be 7.44 V, which is 67.6 times higher than that obtained under dark condition. These results will be discussed with a theoretical model based on spatial distribution and movement of carriers, confirmed by electrical analysis using an equivalent circuit of the TFSs.

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1:15pm - 1:30pm

Modification of Hexagonal Boron Nitride with Metal Oxides

Sean Patrick McDarby, Diana Santiago-deJesus

NASA Glenn Research Center, United States of America; sean.p.mcdarby@nasa.gov

The development of multifunctional hexagonal boron nitride (hBN) materials aims to capitalize on the intrinsic properties of hBN which include being electrically insulating, thermally conductive, and chemically and thermally stable at high temperatures. The creation of novel composite materials that include these properties is required to address our current aerospace and space engineering challenges. Researchers at NASA Glenn have done significant prior work which has produced processes to intercalate, exfoliate, coat, and functionalize various hBN materials. This presentation covers our recent progress towards the integration of titanium oxides into hBN utilizing our previous methods along with optimizing and producing new methods to create novel functional hBN nanomaterials.

1:30pm - 1:45pm

Reduced vibrational mobility induced ultra-low thermal conductivity in Ruddlesden-popper (Ban+1ZrnS3n+1) phases of perovskite chalcogenide BaZrS3

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University of Virginia, United States of America; mh5yw@virginia.edu

Understanding the microscopic origin of ultralow thermal conductivities in crystalline materials has been the central goal of condensed matter and materials physics for the past decade, with many questions still unanswered. Here, we report on the observation of amorphous-like ultralow thermal conductivities in the Ruddlesden-popper (Ban+1ZrnS3n+1, n = 3 and 4) phases of inorganic perovskite chalcogenide BaZrS3. The thermal conductivity of BaZrS3 and Ruddlesden-popper phases exhibit an amorphous-like trend due to factors intrinsic to crystal structures. The presence of intra-unit-cell interfaces-like rock-salt blocks induce a large fraction of localized and low velocity vibrational modes in the Ruddlesden-popper phases, leading to ultra-low thermal conductivity. Our study provides significant insight into the interaction between structural interfaces and vibrational modes that can cause ultra-low thermal conductivities in inorganic crystals.

1:45pm - 2:00pm

Blue Emissive ZnO@GO and ZnO@f-PAHs hybrid QDs-based QLEDs with Longlife time

Hong Hee Kim[1], Soohyung Park[1], Won Kook Choi[1,2]

[1]Korea Institute of Science Technology, Korea, Republic of (South Korea); [2]University of Science and Technology (UST), Republic of (South Korea); wkchoi@kist.re.kr

A self-emissive electroluminescent quantum dots (ELQDs) LED display is highly expected as a next generation flexible display as well as flat panel display after color filter (OLED and LCD) or on-chip (LCD and microLED) type display. To implement ELQDs display, not only high-resolution pixel manufacturing methods but also high-efficient and stable blue-emissive QDs should be developed together. High efficient non-harmful Cd and inexpensive In-free blue QDs are highly demanded for achieving ELQDs. Eco-friendly ZnO semiconductors has a band gap of 3.37 eV and large exciton binding energy (~60 meV) at RT and thus expected to be good candidates for UV and blue emissive QDs. ZnO QDs are hybridized with graphene oxide QDs (GO) and functionalized poly aromatic hydrocarbonds (f-PAHs) to synthesize ZnO@GO[1] and ZnO@f-PAHs[2] to control the intrinsic defects mainly located on ZnO surfaces. Photoluminescence (PL) reveals that Type I ZnO@GO QDs show blue emission centered at 432 nm independent of excitation wavelength from 300-410 nm without green emission observed in ZnO QDs. Further ZnO@GO QLEDs show deep-blue electroluminescence (EL) at 438 nm, brightness of 1980 cd m-2, and an external quantum efficiency (EQE) of 2.78% with CIE (0.16, 0.11). In a similar way, ZnO@1-aminopyrene hybrid QDs as one of ZnO@f-PAHs are synthesized and show PL at 430 nm and is proved as quasi Type II QDs. ZnO@1-aminopyrene QLEDs show EL of 3379 cd m-2 at λ = 441 nm with a full width at half maximum of 41.7 nm, a luminous efficacy (LE) of 3.32 cd/A, EQE of 2.35%, and remarkably long lifetime T50 of >17830 h at 100 cd/m2, which is the most stable and long lifetime blue QD-LED to data, including In- and Cd-based ones.

2:00pm - 2:15pm

Behaviour of Geopolymer Interlocking Bricks and Wall Panels using Waste Glass

Kumutha Rathinam, Karthick Kumar P V, Srikiruthiga S, Vijay P

Sri Venkateswara College of Engineering, India; kumuthar@yahoo.co.in

An attempt has been made to develop sustainable, eco-friendly and cost effective geopolymer interlocking bricks using waste materials like fly ash, Ground Granulated Blast Furnace Slag (GGBS) and waste glass. The source materials were activated using alkaline activators comprising of Hydroxides and silicates of sodium. The cement is totally replaced by powder materials like fly ash and GGBS and for fine aggregates, M-Sand is used in combination with waste glass. Seven mix ratios were tried as follows: Bricks with 100% M-Sand, 90% M-Sand and 10% waste glass, 80% M-Sand and 20% waste glass, 70% M-Sand and 30% waste glass, 60% M-Sand and 40% waste glass, 50% M-Sand and 50% waste glass and 40% M-Sand and 60% waste glass. Physical tests were conducted for all the materials used in this project. The size of interlocking bricks is 300 mm x 200mm x 125mm. In total, sixty-three interlocking bricks were cast and after casting, the bricks were kept in room temperature for 28 days. After 28 days, the interlocking bricks were tested for density, compressive strength and water absorption. Then the interlocking brick wall panels of length 600 mm, height 375 mm and width 200 mm were constructed using three layers of interlocking bricks and tested under compression using Universal Testing Machine. The results of Interlocking Bricks and wall panels are discussed in detail. Interlocking bricks with 70% M-Sand and 30% Waste glass exhibited maximum compressive strength and low water absorption. Interlocking brick wall panel with 70% M-Sand and 30% Waste glass has maximum ultimate load carrying capacity and energy Absorption.

附錄五、楊昇府等人之論文發表議程與摘要

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Session Overview

Date: Thursday, 10/Aug/2023	
11:10am - 12:00pm	Keynote: Keynote Session Location: Theatre
3:30pm - 6:00pm	Invited Talk: Invited Talk Location: AU 2410
3:30pm - 6:00pm	Oral Talk-1: Oral Talk Location: Theatre
Date: Friday, 11/Aug/2023	
9:00am - 3:30pm	Reg-1: Registration-1 Location: Theatre-Lobby
9:30am - 11:30am	Keynote Session-2: Keynote Session Location: Theatre
2:00pm - 5:30pm	Invited Talk-1: Invited Talk Location: Theatre
2:00pm - 5:30pm	Oral Talk-2: Oral Talk Location: AU 2410
Date: Saturday, 12/Aug/2023	
9:00am - 11:30am	Reg-2: Registration Location: Theatre-Lobby
9:30am - 10:30am	Plen Sess: Plenary Session Location: Theatre
10:30am - 1:00pm	Invited Talk-2: Invited Talk Location: Theatre
10:30am - 1:00pm	Oral Talk-3: Oral Talk Location: AU 2410

5:45pm - 6:00pm

Cellular Desiccant Rotor Produced from Recycling of abrasive slurry

Sheng-Fu Yang, To-Mai Wang, Chun-Liang Chen, Kuang-Li Chien, Chih-Chao Liang, Hsien-Ho Chuo

Institute of Nuclear Energy Research, Atomic Energy Council, Taiwan; sfyang@iner.gov.tw

Abrasive slurry waste is generated during the ingot-cutting step in the manufacturing of silicon-based semiconductors or solar cell wafers. Silicon carbide (SiC) is widely employed as an abrasive material in aqueous media for sawing silicon or silicon carbide ingot into individual wafers in photovoltaic and semiconductor industry. The research to recycle abrasive slurry waste into useful resources has received increasing interest. The used SiC can be preferably recovered and reused for dehumidification application, rather than disposed of as waste. In this study, the cellular ceramic desiccant rotor is manufactured using SiC derived from abrasive slurry waste with a three dimensional random cellular structure and applied to adsorb humidity from the atmosphere. The equilibrium time for the cellular desiccant rotor and humidity is determined by observed kinetics in the adsorption experiment. The adsorption capacity of solid desiccant rotor with different porosity ranged from 20 to 60 pores per inch (PPI) is a function of time at 20% and 30% relative humidity (@25°C). The adsorption equilibrium time of desiccant wheel with 8 cm diameter and 5 cm thickness is ten minutes. The cellular desiccant rotor dehumidifier will be installed and applied for drying agricultural products.

Abstract of Contribution 258

Abstract ID: 258
Symposium 4: Functional Composite Materials (FCM)
Oral Presentation
Topics: Porous and cellular materials
Keywords: Abrasive slurry, Silicon carbide, Cellular desiccant rotor

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Contribution Details

Conference Track: Symposium 4: Functional Composite Materials (FCM)
Format: Oral Presentation

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Cellular Desiccant Rotor Produced from Recycling of abrasive slurry

Sheng-Fu Yang, **To-Mai Wang**, **Chun-Liang Chen**, **Kuang-Li Chien**, **Chih-Chao Liang**, **Hsien-Ho Chuo**
Organization(s): Institute of Nuclear Energy Research, Atomic Energy Council, Taiwan

Submitted by: **Dr. Sheng-Fu Yang (Institute of Nuclear Energy Research, Atomic Energy Council, TW)**, *ID: 1154*
Presenting Author: Yang, Sheng-Fu sfyang@iner.gov.tw

Topics: Porous and cellular materials
Keywords: Abrasive slurry, Silicon carbide, Cellular desiccant rotor

Abstract

Abrasive slurry waste is generated during the ingot-cutting step in the manufacturing of silicon-based semiconductors or solar cell wafers. Silicon carbide (SiC) is widely employed as an abrasive material in aqueous media for sawing silicon or silicon carbide ingot into individual wafers in photovoltaic and semiconductor industry. The research to recycle abrasive slurry waste into useful resources has received increasing interest. The used SiC can be preferably recovered and reused for dehumidification application, rather than disposed of as waste. In this study, the cellular ceramic desiccant rotor is manufactured using SiC derived from abrasive slurry waste with a three dimensional random cellular structure and applied to adsorb humidity from the atmosphere. The equilibrium time for the cellular desiccant rotor and humidity is determined by observed kinetics in the adsorption experiment. The adsorption capacity of solid desiccant rotor with different porosity ranged from 20 to 60 pores per inch (PPI) is a function of time at 20% and 30% relative humidity (@25°C). The adsorption equilibrium time of desiccant wheel with 8 cm diameter and 5 cm thickness is ten minutes. The cellular desiccant rotor dehumidifier will be installed and applied for drying agricultural products.

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附錄五、楊員口頭發表論文簡報檔案

Conference paper, #34638

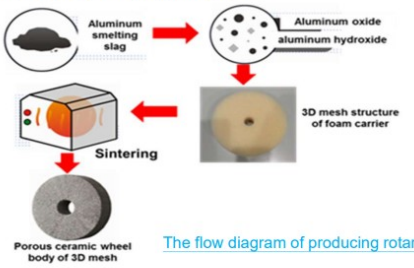
Rotary Desiccant Wheel System As an Alternative to Traditional Diesel Burner in Green Garlic Drying Technology

Institute of Nuclear Energy Research (INER), Taiwan.
Correspondence: Dr. SHENG-FU YANG
E-mail: sfyang@iner.gov.tw

Learning Objectives

Objectives

- In Taiwan, diesel burner drying technique is generally employed to dry the garlic and many issues are caused such as time and energy consumption, noise and environmental pollution.
- The rotary desiccant wheel dehumidification system is applied to remove parts of moisture content from garlic for better storage stability, shortening drying time, energy saving, minimizing drying process noise and air pollution contaminant emission.



The flow diagram of producing rotary desiccant wheel

Acknowledgements

- Energy Saving Division, Bureau of Energy, Ministry of Economic Affairs, Taiwan.

Outline/Agenda

Key parts of procedures and methods

- The solid desiccant wheel is manufactured using activated alumina derived from aluminum dross with random porous structure.
- The equilibrium time for the solid desiccant wheel and humidity is determined by observed kinetics in the adsorption kinetic experiment.
- The adsorption capacity of solid desiccant wheel is a function of time at 25°C and 30%~80% relative humidity.
- The adsorption equilibrium time of desiccant wheel (60 PPI) with 15 cm diameter and 5 cm thickness is twelve minutes.
- The maximum adsorption capacity is 61.2 g (12 minutes) and per gram of desiccant wheel can adsorb 0.24 g water.

Outline/Agenda

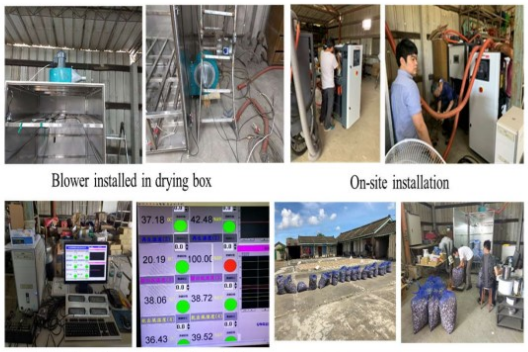
Results and Discussion

- The desiccant wheel is divided into two working area e.g., adsorption and desorption.
- As the adsorption capability of desiccant wheel is saturated, the wheel is rotated to regeneration area to remove water by heat.
- A batch drying experiment with capacity of 500 kg garlic is executed, 30% of water from the garlics is removed in the period of 10 days.
- The operation time is 15 days shorter than the traditional diesel burner drying process.
- The noise and air pollution derived from the diesel burner drying process can be avoided.

Test of Rotary Desiccant Wheel System in laboratory

Conclusion

- A garlic drying field test was completed in a garlic farmhouse in Yunlin County (Taiwan).
- The air flow rate for drying process was magnified by 5 times, from 40 m^3/h (2021) to 200 m^3/h (2022).
- During the test, the heat pump completely replaced the electric heater as the heat source for the regeneration of the desiccant wheel, and operated continuously without failure.
- No diesel is used at all, so no derivative air pollutant emissions are produced; the noise level is reduced from the 92 dB to 55 dB.



Blower installed in drying box | On-site installation

Monitoring of temperature and humidity | Garlic Weighing and Recording

A garlic drying field test

Questions?

Sheng-Fu Yang, PhD
sfyang@iner.gov.tw