

序 言

委託研究計畫是政府機關與學術機構促進技術交流、深化合作及培育專業人才的重要平台。透過夥伴關係的建立，這些計畫不僅促進學術創新與應用研究的結合，也支援政府在科技政策與業務推動上的需求。

國家原子能科技研究院依循政府施政方向，積極推動各項委託研究工作。在各計畫主持人與研究團隊的共同努力下，成果卓著，充分展現了研究院的核心價值與技術實力。

113 年度的委託研究，承蒙國內多所大學與研究機構的大力協助，順利完成涵蓋核醫藥物、分散式配電網、輸變電與電網韌性、原子能科技等 4 大領域的研究，產出 21 項研究成果。這些成果主題明確、內容嚴謹，不僅突顯我國在原子能及相關科技領域的研發實力，也為未來技術創新與產業應用奠定了重要基礎。

本成果彙編匯聚研究精華，作為分享與交流的平台，並彰顯國原院推動原子能科技創新發展的努力與成果，呼應施政目標，進一步突顯政策效益與社會影響力。在此，特別感謝所有研究團隊的辛勤付出，成功完成各項研究任務，並提供高價值的研發成果。

期待未來持續深化合作，拓展研發能量，為社會福祉作出更大貢獻。本次成果發表會共規劃 4 個專場，邀請計畫主持人簡報研究內容，分享重要成果。為珍藏並推廣這些研究結晶，主辦單位特別將各計畫的中、英文摘要彙編成冊，供產官學研各界參考，作為未來發展的借鏡。

院長 高梓木

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會議議程

時 間	議 程	地 點
09:00~09:30	報到	060 館各會場報到
09:30~12:00	上午分組成果發表	各場次
12:00~12:30	綜合討論(供應午餐)	各場次
13:00~16:00	下午分組成果發表(含綜合討論)	各場次

會議場次

Oral 場次	會議地點	發表數
場次 1 核醫藥物領域(上午)	060 館 307 會議室	5
場次 2 分散式配電網領域(下午)	060 館 307 會議室	5
場次 3 輸變電及電網韌性領域(上午)	060 館 311 會議室	5
場次 4 原子能科技領域(下午)	060 館 311 會議室	6

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「113 年度國家原子能科技研究院委託研究計畫成果發表會」議程

辦理時間：114 年 6 月 12 日

辦理地點：國原院 060 館

場次別： <u>場次 1 核醫藥物領域</u> (上午 09:30~12:30)				
主持人暨評審委員：國原院王正忠 副院長			評審委員：林武智、王昱豐	
發表方式：Oral 簡報及 QA (報告 20 分鐘，問答 10 分鐘)			會場地點：會議室 307	
場序	時間	執行機關	計畫主持人	計畫名稱
1	9:30-10:00	長庚大學	謝憬儀	MRI-PDF 系統與影像定量技術輔導建置
2	10:00-10:30	國立陽明大學	簡千栩	人工智慧輔助動脈粥狀硬化血管造影評估
3	10:30-11:00	國立清華大學	許榮鈞	70 MeV 迴旋加速器同位素產製理論產率最佳化探討
4	11:00-11:30	國立成功大學	賴嘉鎮	運用健保資料庫進行核醫藥物安全性分析研究
5	11:30-12:00	中山醫學大學	陳安芝	應用 123I-MIBG 及 99m Tc-MIBI 鑑別糖尿病與退化性神經病變
12:00-12:30 綜合討論 (逾時供應午餐)				
場次別： <u>場次 2 分散式配電網領域</u> (下午 13:00~16:00)				
主持人暨評審委員：國原院張永瑞 副院長			評審委員：魏榮宗、朱家齊	
發表方式：Oral 簡報及 QA (報告 20 分鐘，問答 10 分鐘)			會場地點：會議室 307	
場序	時間	執行機關	計畫主持人	計畫名稱
1	13:00-13:30	中原大學	洪穎怡	分散式區域電網調頻備轉控制研究
2	13:30-14:00	國立清華大學	田孟軒	保護電驛故障訊號分析技術開發
3	14:00-14:30	國立臺灣科技大學	郭政謙	變電所輸變電設備預知維護資產管理系統研究
4	14:30-15:00	國立彰化師範大學	黃維澤	整合饋線運轉資訊之相位切換技術研究
5	15:00-15:30	台灣氢能與燃料電池學會	陳正一	微電網三相不平衡負載與電壓控制之研究
15:30-16:00 綜合討論				

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場次別：場次3 輸變電及電網韌性領域(上午 09:30~12:30)				
主持人暨評審委員：國原院張永瑞 副院長			評審委員：魏榮宗、朱家齊	
發表方式：Oral 簡報及 QA (報告 15 分鐘，問答 10 分鐘)			會場地點：會議室 311	
場序	時間	執行機關	計畫主持人	計畫名稱
1	9:30-10:00	國立臺灣科技大學	連國龍	測距電驛標置設定技術開發
2	10:00-10:30	國立高雄科技大學	辜德典	結合配電資訊模型之設備分析與優化研究
3	10:30-11:00	國立高雄科技大學	詹東昇	配電網與分散式發電之動態保護研究
4	11:00-11:30	國立中正大學	劉祐任	應用於電力交易模式之功率轉換控制研究
5	11:30-12:00	國家災害防救科技中心	柯孝勳	電網韌性災害潛勢資料
12:00-12:30 綜合討論 (逾時供應午餐)				
場次別：場次4 原子能科技領域(下午 13:00~16:00)				
主持人暨評審委員：國原院陳明輝 副院長			評審委員：張廖貴術、李志浩	
發表方式：Oral 簡報及 QA (報告 15 分鐘，問答 10 分鐘)			會場地點：會議室 311	
場序	時間	執行機關	計畫主持人	計畫名稱
1	13:00-13:25	臺北醫學大學	張剛瑋	太空用功率元件輻射可靠度研究
2	13:25-13:50	國立清華大學	曾永信	雙功能中子靶站中子通量率提升方法之評估
3	13:50-14:15	國立交通大學	曾院介	量子拓撲感測器研究
4	14:15-14:40	國立中山大學	蔡宗鳴	量子點記憶元件之材料及電特性量測分析
5	14:40-15:05	國立虎尾科技大學	王文正	節能乾燥除濕轉輪系統氣流特性模擬分析研究
6	15:05-15:30	財團法人成大研究發展基金會	張楷洋	高離子強度系統中流體化床結晶技術用於鈣鎂提取的沉澱機制研究
15:30-16:00 綜合討論				

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場次 1 核醫藥物領域

MRI-PDF 系統與影像定量技術輔導建置	1
人工智慧輔助動脈粥狀硬化血管造影之評估	5
70 MeV 迴旋加速器同位素產製理論產率最佳化探討	7
運用健保資料庫進行核醫藥物安全性分析研究	9
應用 ^{123}I -MIBG 及 $^{99\text{m}}\text{Tc}$ -MIBI 鑑別糖尿病與退化性神經病變	11

MRI-PDFF 系統與影像定量技術輔導建置

Establishment of magnetic resonance imaging-proton density fat fraction (MRI-PDFF) parameters and image quantification technology

(計畫編號：112B018)

謝憬儀¹

¹ 長庚大學放射醫學研究中心

摘要

背景：磁共振影像（MRI）源自質子密度脂肪分數（PDFF）的量化評估，能提供非侵入性肝臟脂肪變性指標。然而，在脂肪肝小鼠模型中，PDFF 的標準參考範圍尚未明確。本研究旨在建立不同高脂飲食階段小鼠肝臟 MRI-PDFF 的基準值。

方法：將 C57BL/6J 小鼠分為五組（每組 15 - 30 隻）：

A（對照組）：普通飼料 8 週；B：高脂飲食 2 週；C：高脂飲食 4 週；D：高脂飲食 6 週；E：高脂飲食 8 週。各組餵養結束後，進行體內肝臟 MRI 掃描，採用雙點 Dixon 序列獲取水相與脂肪相影像。在肝臟感興趣區（ROI）內計算 PDFF（%）：脂肪信號／（水信號）× 100，分別以中位數、四分位距（IQR）及範圍描述各組 PDFF 分布。

結果：對照組（A 組）PDFF 較低（中位數 9.5 %，IQR=5.3%（7.5 - 12.8 %））。高脂飲食 2 週（B 組）顯著升高至中位數 32.0 %，IQR=12.7%（25.8 - 38.5 %）。高飲食 4 週（C 組）時 PDFF 仍高（中位數 25.6 %，IQR=20.4%（12.9 - 33.3 %）），且動物間差異增大，包含一例 ~77% 的高值離群點。隨著進一步餵養（D、E 組），PDFF 部分回落但仍高於對照：D 組 6 週時中位數 18.4 %，IQR =10.2%（14.3 - 24.5

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%)；E 組 8 週時中位數 16.7 %，IQR=7.4% (11.5 – 18.9 %)。

結論：MRI-PDFF 能敏銳檢測小鼠高脂飲食誘導的肝臟脂肪變性，並顯示脂肪累積於 2 週達到峰值，隨後雖有回落但仍高於基線。本研究提供了該脂肪肝模型的 PDFF 參考參數，為後續縱向研究提供定量依據。

Abstract

Background: Proton density fat fraction (PDFF) measured by magnetic resonance imaging (MRI) provides a noninvasive quantitative biomarker of hepatic steatosis. However, standardized PDFF reference parameters in preclinical fatty liver models remain under-defined. This study aimed to establish MRI-PDFF values across a mouse model of diet-induced fatty liver at different stages of high-fat feeding.

Methods: C57BL/6J mice were assigned to five groups (n=15–30 per group): A (control): regular chow for 8 weeks; B: high-fat diet for 2 weeks; C: high-fat diet for 4 weeks; D: high-fat diet for 6 weeks; E: high-fat diet for 8 weeks. At the end of each feeding period, in vivo liver MRI was performed using a two-point Dixon sequence to generate water and fat images. Regions of interest within the liver were used to calculate PDFF (%). Group-wise PDFF distributions were summarized by median, interquartile range (IQR), and range.

Results: Control mice (group A) exhibited low hepatic fat content (median 9.5 %, IQR =5.3% (7.5%–12.8 %)). Two weeks of high-fat feeding (group B) induced a rapid and pronounced increase in PDFF (median 32.0 %, IQR=12.7% (25.8%–38.5 %)). At four weeks (group C), PDFF remained elevated (median 25.6 %, IQR =20.4% (12.9%–33.3 %)) but showed marked inter-animal variability, including a high-end outlier (~77%). With longer exposures (groups D and E), PDFF partially regressed toward baseline but stayed above control levels: at six weeks, median 18.4 % (IQR=10.2% (14.3%–24.5%)); at eight weeks, median 16.7% , IQR=7.4%(11.5%–18.9 %).

Conclusions: MRI-PDFF sensitively detects the onset and progression of diet-induced hepatic steatosis in mice. PDFF peaks by two weeks of high-fat feeding and then gradually declines though remains chronically

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elevated. These data define reference PDFF parameters for this fatty liver model, supporting their use in longitudinal preclinical studies of steatosis and steatohepatitis.

人工智慧輔助動脈粥狀硬化血管造影之評估

Establishment of AI-Assisted Atherosclerosis Angiography Assessment

(計畫編號：113A003)

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科技研究院

摘要

隨著台灣邁入超高齡社會，心血管疾病所帶來的健康衝擊快速升高。其中，動脈粥狀硬化因早期診斷困難且常導致致命性併發症，素有「隱形殺手」之稱。然而，臨床上缺乏能夠非侵入性地判斷其病程變化與輔助診斷的有效工具。因此，本研究聚焦於開發一套人工智慧（AI）輔助之動脈粥狀硬化影像診斷系統，以因應高齡化社會對疾病預測與個別化管理的迫切需求。在放射醫學技術方面，本研究以新興的[68Ga]-APD(Aptamer-based Probe Design)放射性探針，其具有高親和力與目標專一性，能標定動脈粥狀硬化斑塊位置。配合單光子電腦斷層掃描儀 SPECT/CT 影像平台，可實現病灶的高靈敏早期偵測與精確定量。本研究成果包括：(1)建立涵蓋三種病程階段（正常、輕微、嚴重）的小鼠動脈粥狀硬化模型，並成功應用[68Ga]-APD 進行高解析度影像監測；(2)整合單光子電腦斷層掃描儀 SPECT/CT 影像平台，有效呈現病灶之結構與功能特徵；(3)開發基於 Inception-v4 深度學習架構的病程評估模型，並於多組資料中展現出穩定且具高度準確性的預測效能。本研究結合創新放射性探針、非侵入性 SPECT/CT 影像與深度學習分析，顯著提升對動脈粥狀硬化病程變化之理解與偵測能力，未來可望應用於早期篩檢、治療效果追蹤及個人化醫療決策，為精準心血管醫學提供具潛力之診斷工具。

Abstract

As Taiwan gradually enters a super-aged society, the health impact caused by cardiovascular diseases is increasing rapidly. Among them, atherosclerosis is called a “silent killer” because it is difficult to detect early and often causes deadly complications. However, in current clinical practice, there is a lack of effective non-invasive tools to evaluate the disease progression and assist diagnosis. Therefore, this study focuses on developing an artificial intelligence (AI)-assisted imaging diagnosis system for atherosclerosis, aiming to meet the urgent need of disease prediction and personalized management in an aging society. In radiological techniques, this study applies an emerging radioactive probe, [68Ga]-APD (Aptamer-based Probe Design), which has high affinity and target specificity, to label the atherosclerotic plaques. Combined with SPECT/CT imaging platform, it allows high sensitivity early detection and accurate quantification of the lesions. The main achievements of this study include: Establishing a mouse atherosclerosis model that includes three disease stages (normal, mild, and severe), and successfully using [68Ga]-APD for high-resolution imaging monitoring; Developing a disease stage prediction model based on the Inception-v4 deep learning architecture, which shows stable and high accuracy in various datasets; Using SPECT/CT imaging to effectively present the structure and functional features of the lesion areas. In conclusion, this study integrates novel radioactive probe, non-invasive SPECT/CT imaging, and deep learning analysis, significantly improving the understanding and detection capability of atherosclerosis progression. In the future, it may be applied in early screening, treatment response monitoring, and personalized medical decision-making, providing a promising diagnostic tool for precision cardiovascular medicine.

70 MeV 迴旋加速器同位素產製理論產率最佳化探討

Studies on optimization of theoretical yields of 70-MeV cyclotron produced radionuclides

(計畫編號：113A008)

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摘要

因應精準醫療之核醫藥物發展趨勢，國家原子能科技研究院(國原院)正在興建一台 70 MeV 迴旋加速器，預定開發新放射性同位素，例如 Ac-225、Cu-67、Sn-117m、Sr-82 等，或是後備現有重要同位素的產製，例如 Tl-201 與 I-123 等。各種同位素產製牽涉不同的核反應管道與靶材設計，如何以最佳條件進行目標同位素的產製是一相當重要的先期分析工作。依據 70 MeV 迴旋加速器之建置目標，本研究透過核物理模型模擬 70 MeV 迴旋加速器產製上述核種的可能情節，針對例如質子射束能量、靶材質與厚度等參數的選擇，進行一系列核反應理論計算的評估，模擬結果可提供上述放射性同位素產製的最適運轉條件，研究成果將有利未來加速器運轉條件選擇、靶材設計與實際製作的配置參考。

Abstract

To meet the requirements of increasing demand for nuclear medicine, the National Atomic Research Institute (NARI) is building a 70 MeV cyclotron to develop new radioactive isotopes, such as Ac-225, Cu-67, Sn-117m, Sr-82, or to back up the production of existing important isotopes, such as Tl-201 and I-123. The production of various isotopes involves different selections of nuclear reaction channels and different designs of target materials. How to produce the isotope of interest with an optimal condition is a critical issue in practice. According to the construction goals of the 70 MeV cyclotron, this research performed a series of nuclear reaction simulations with various production routes and operation conditions, mainly including proton energy, target material and thickness, to evaluate theoretical production yields for the isotopes of interest. The results provide a set of theoretically suggested operating conditions to produce the aforementioned isotopes, which could be used as a reference for future cyclotron operation and target system design.

運用健保資料庫進行核醫藥物安全性分析研究

**Safety analysis of radiopharmaceuticals using health insurance
database**

(計畫編號：113A001)

賴嘉鎮

國立成功大學藥學系

摘要

先前的研究已指出核子醫學暴露可能增加後續罹患惡性腫瘤之風險。透過健保資料庫，我們納入 2009 年至 2020 年的患者進行回溯性世代研究。我們選擇 18 歲以下且曾經暴露過至少一次核子醫學的患者作為治療組，並同時隨機選取 200 萬名未曾接觸核子醫學的患者作為非暴露組。此外，我們亦使用手足對照分析，將治療組患者與其未接觸核醫學的兄弟姐妹作為對照進行比較。在匹配後，我們共納入 43,257 名接受核子醫學檢查的患者及 361,638 名非暴露組患者。治療組與對照組的實體惡性腫瘤發生率分別為每 10 萬人年 100.5 例及 21.5 例；血液惡性腫瘤的發生率分別為每 10 萬人年 20.5 例及 7.8 例。透過校正處理後，實體惡性腫瘤的風險比為 4.70 (95% CI 4.03-5.40)，血液惡性腫瘤的風險比為 2.61 (95% CI 1.91-3.56)。在該結果在所有敏感性分析及依年齡分層分析中均保持一致。醫師在對兒科患者使用核子醫學時應謹慎評估其利益與風險平衡。

Abstract

Prior research has indicated a relationship between exposure to nuclear medicine and the subsequent development of malignancy. Thus, this current is aimed at assessing the risk of developing malignancy following exposure to nuclear medicine during childhood. We conducted a population-based retrospective cohort study using data from the National Health Insurance Research Database from 2009-2020. We selected patients under 18 years old who had been exposed to nuclear medicine as our treatment group and randomly selected 2 million patients who had not been exposed to nuclear medicine to serve as our control group. For the treatment group, we defined the date of the first nuclear examination as index date while randomly assigned an index date for the control group. We followed patients from the index date till the occurrence of outcomes, death, or end of the study period. Additionally, we implemented sibling control analyses where treated patients were compared with controls selected from their unexposed siblings. We enrolled a total of 43,257 patients received nuclear medicine and 361,638 patients as our control group after matching. The incidence rates of solid malignancy were 100.5 and 21.5 per 100,000 person-years in the treatment group and control group, respectively. For the hematological malignancies, the incidence rates were 20.5 and 7.8 per 100,000 person-years in the treatment group and control group, respectively. The adjusted hazard ratios (HR) were 4.70 (with 95% confidence intervals (CIs) 4.03-5.4) and 2.61 (95% CIs 1.91-3.56) for solid malignancies and hematological malignancies, respectively. The results were consistent across all sensitivity analyses and stratified by age. Physicians should carefully assess the benefit-risk balance when using nuclear medicine in pediatrics.

應用 123I-MIBG 及 99mTc-MIBI 鑑別糖尿病與退化性神經病變

123I-MIBG and 99mTc-MIBI dual-isotope tracers in myocardial imaging to differentiating diabetes and neurodegenerative diseases

(計畫編號：113A006)

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摘要

鎘鋅碲化物(cadmium zinc telluride, CZT)半導體偵測頭單光子電腦斷層攝影儀(single photon emission computed tomography, SPECT)，能提升能量與空間解析度。本院研究團隊於民國 107 年起執行以 CZT 探頭，應用假體進行同時 99mTc 及 123I 雙核種 SPECT 造影，以評估影像收錄條件與雙核種間能窗重疊干擾所造成的影響。並於 108 年的科技部研究計畫中，應用 123I-MIBG 及 99mTc-MIBI 雙核種示蹤劑同時時間心肌造影在鑑別診斷巴金森症候群病患神經支配與血流灌注異常共病(計畫編號: MOST 108-2314-B-040-011-MY2)。在這三年期前瞻性研究，研究團隊將針對老年疑似巴金森症候群進行同時 99mTc-MIBI 及 123I-MIBG 心肌造影，以排除伴隨老化冠狀動脈心血管疾病造成心肌血流缺損，影響 123I-MIBG 心肌吸收降低，以鑑別診斷冠狀動脈血管性的疾病與單純交感神經支配的問題。該研究使用 CZT 探頭 SPECT 掃描，採用多能窗同時收錄 99mTc 和 123I 造影。造影分析將計算 99mTc 與 123I 能量重疊干擾，以計算心肌攝取 99mTc-MIBI 及 123I-MIBG 在不同血流灌注部位的心肌攝取比值。該次的研究提升 CZT 探頭 SPECT 造影診療技術，並減少動作障礙患者就診的不便，無不良結果。在研究過程中，發現心血管疾病與單純巴

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金森共症較少，但在部分有血管病史的個案有較多診斷價值。而血管和神經同時會影響的疾病，以糖尿病為首，而之前的研究較少相關的資料。並且，在神經退化的疾病中，糖尿病也是重要的共病之一。因此，本次研究針對糖尿病患者的心臟血流及神經之相關性，可提供臨床更多資料來釐清其中的變化，以利精確治療。本次研究共完成 12 位受檢者的檢查，分析結果中有多位受檢者呈現有病變，心臟與縱膈腔比值(heart to mediastinum ratio, HMR)顯示可能與巴金森氏症患者有關聯性，需要更多的病例進一步證實。

Abstract

Cadmium zinc telluride (CZT) semiconductor detection head single photon emission computed tomography (SPECT) can improve energy and spatial resolution. The research team of our hospital has been using CZT probes and prostheses to perform simultaneous ^{99m}Tc and ^{123}I dual-nucleus SPECT imaging since 1997 to evaluate the impact of image acquisition conditions and overlapped interference between dual-nucleus species. In the 2017 research project of the Ministry of Science and Technology, ^{123}I -MIBG and ^{99m}Tc -MIBI dual-core tracers were used to perform simultaneous myocardial angiography in the differential diagnosis of comorbidities of abnormal innervation and blood perfusion in patients with Parkinson's syndrome (Project No. : MOST 108-2314-B-040-011-MY2). In the three-year prospective study, the research team will conduct ^{99m}Tc -MIBI and ^{123}I -MIBG myocardial angiography at the same time for elderly patients with suspected Parkinson's syndrome to rule out myocardial blood flow defects caused by aging coronary cardiovascular disease and affect ^{123}I -MIBG. Myocardial absorption is reduced to differentiate between coronary vascular disease and simple sympathetic innervation. This study will use CZT probe SPECT scanning, using a multi-energy window to simultaneously capture ^{99m}Tc and ^{123}I contrast. The contrast analysis will calculate the overlapping interference of ^{99m}Tc and ^{123}I energy to calculate the myocardial uptake ratio of ^{99m}Tc -MIBI and ^{123}I -MIBG at different blood perfusion sites. This study improved the CZT probe SPECT imaging diagnosis and treatment technology and reduced the inconvenience of medical treatment for patients with movement disorders. The examination of 36 patients with parkinsonism was successfully completed without adverse results. During the study, it was found that cardiovascular disease has fewer comorbidities with pure

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Parkinson disease but it has more diagnostic value in some cases with a history of vascular disease. Among the diseases that can affect blood vessels and nerves at the same time, diabetes mellitus is the first, and previous studies have limited relevant information. Moreover, among neurodegenerative diseases, diabetes mellitus is also one of the important comorbidities. Therefore, more clinical data can be provided to clarify the changes in cardiac blood flow and nerves in patients with diabetes to facilitate precise treatment.

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分散式區域電網調頻備轉控制研究

Studies on Control for Frequency Regulation Reserve in Zonal Power Grid with Distributed Generation

(計畫編號：113A014)

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摘要

再生能源作為電能來源的使用在近年來變得越來越普遍。太陽能和風能已經逐漸併入到電網中，與其他傳統能源一同存在。這些變化導致了發電系統的去中心化，最終形成多個區域電網。區域電網不同於傳統電網，由多個發電設備組成，為當地區域提供電源。這帶來了多重優勢，例如在停電時能夠與大型電網隔離。然而，也存在一些缺點，包括電壓和頻率穩定性的維護。由於存在多個分散電源，區域電網的控制變得更加複雜，因為存在不同的獨立控制器，每個控制器都影響整個系統性能。這個計畫提出了在分層構建的邊緣和霧計算使用，以協調多個分散電源和區域電網，並保持系統內的頻率穩定。要研究的系統是一個修改過的 IEEE 33 母線系統，分為三個相互連接的區域電網，每個都有分散電源、儲能系統和負載。區塊鏈程式將位於系統的最高層，區域電網之間的交易將在此完成。第二層為霧層，負責為每個區域電網保持頻率穩定性，在此層中部署的預測控制器將負責保持每個區域電網的頻率穩定。系統的最低層包含實際的電網本身，其中包含分散電源和負載。在整個互聯區域電網的每個分散電源上將使用邊緣設備以作為獨立控制器，它可以與第二層霧層通信。

Abstract

The use of renewable energy as sources of electric energy has become more common in the recent years. The addition of solar and wind energy has been increasingly added to the power grid alongside other traditional sources. These have led to the decentralization of energy production, eventually forming microgrids. Microgrids, unlike traditional grids, consist of multiple generators to provide energy to a local area. This offers multiple advantages, such as being able to isolate itself from a large power grid during a power failure. There are also disadvantages however, which include maintenance of voltage and frequency stability. The presence of multiple distributed generators (DGs) makes the control of a microgrid more complex, due to the presence of different standalone controllers that each affects the entire system. This project proposes the use of edge and fog computing constructed in a hierarchical manner to coordinate multiple DGs and microgrids to maintain frequency stability within the system. The system to be investigated is a modified IEEE 33-bus system separated into three interconnected microgrids, each with DGs, energy storage systems (ESS), and loads. A blockchain program will be at the highest level of the system, where transaction between microgrids will be done. The second layer, fog layer, is the one responsible for maintaining frequency stability for each microgrid. A predictive controller deployed in this layer will be responsible for keeping the frequency of each microgrid stable. The lowest layer of the system consists of the physical grid itself, which contains the DGs and loads. Edge devices will be used on each DG in the entire networked microgrid as a replacement to the standalone controller which allows it to communicate with the secondary fog layer.

保護電驛故障訊號分析技術開發

Development of Fault Signal Identification and Classification
Techniques for Relays

計畫編號：113A020

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摘要

本計畫旨在開發電力系統異常的自動辨識技術，以對自然災害於電驛系統帶來的電壓與電流訊號異常狀況進行判斷。面對雷擊、強風或動物干擾等事件，傳統的人工診斷方式因效率低且準確性不足，無法滿足當前電力系統日益增長的監控需求。為此，本計畫引入機器學習技術，透過分析電驛之電壓及電流訊號於各種災害事件中的動態特性，實現電力系統的自動化異常識別。本計畫透過分析電驛之三相電壓與三相電流訊號，利用特徵提取技術定位異常區段，接著以 K 近鄰演算法(K-nearest neighbor, KNN)對不同類型的異常進行分類，並建立異常識別模型，整體研究過程包含資料前處理、識別模型開發、效能評估及系統測試。本計畫開發一套可應用於關鍵能源設備的自動化異常辨識系統，能夠快速準確地識別電力系統中的異常事件類型。此技術將提升電力系統的異常檢測能力，有助於及時掌握故障資訊，進一步提高系統運行的穩定性。

Abstract

This project aims to develop automated anomaly detection technology for power systems to assess abnormal voltage and current signals in relay systems caused by natural disasters. Traditional manual diagnosis methods, faced with events such as typhoons, lightning strikes, strong winds, or animal interference, are inefficient and lack accuracy, unable to meet the growing monitoring needs of modern power systems. To address this, the project incorporates machine learning to analyze the dynamic characteristics of voltage and current signals in relay systems during disaster events, enabling automated anomaly detection in power systems. The project analyzes three-phase voltage and current signals in relay systems and uses feature extraction to identify abnormal segments. Subsequently, the K-nearest neighbor (KNN) algorithm classifies types of anomalies, and an anomaly detection model is established. The overall research process includes data preprocessing, model development, performance evaluation, and system testing. This project develops automated anomaly detection for critical energy equipment, capable of identifying anomaly types in power systems efficiently and accurately. The proposed technique enhances anomaly detection in power systems, facilitating timely fault information acquisition and improving system stability.

變電所輸變電設備預知維護資產管理系統研究

**Research on Predictive Maintenance Asset Management System for
Substation Transmission and Transformation Equipment**

(計畫編號：113A017)

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摘要

輸變電設備一旦故障即損失極大的經濟效益，所以預防更勝於治療，高壓絕緣劣化檢測的有效方法之一就是觀察設備局部放電的現象，且為最初期的特徵，即早發現設備問題就可以提前做預防，而趨勢性觀察更優於週期性的檢查，長時間的觀察有效降低誤判的機率。本計畫採高頻比流器測得局部放電原始放電波形數據進行訊號處理與分析。為了能使診斷系統提升診斷效率與準確性，需繪製相位解析局部放電圖譜，使得對於放電相位、大小、及次數等資訊，以呈現局部放電之分布特徵，本計畫採用原始放電波形與時域、頻域或混合之特徵萃取技術來快速對輸變電設備進行放電類型鑑別與識別。透過此方法可以將系統實際運行數據紀錄原始放電波形，了解此輸變電設備於多次的局部放電量測中之原始放電波形狀況有哪幾種，作為驗證特徵萃取技術之成效。

Abstract

Once power transmission and transformation equipment fails, it leads to significant economic losses, so prevention is better than cure. One effective method for detecting high-voltage insulation degradation is to observe the phenomenon of partial discharge in the equipment, which is an early indicator of issues. Early detection allows for preventative measures, and trend observation is superior to periodic inspections, as long-term monitoring effectively reduces the chances of misdiagnosis. This project proposes the use of high-frequency CTs to capture the original discharge waveforms of partial discharges for signal processing and analysis. To enhance the diagnostic system's efficiency and accuracy, it is necessary to create phase-resolved partial discharge maps that provide information on the discharge phase, magnitude, and frequency, thereby illustrating the distribution characteristics of partial discharges. The project plans to use original discharge waveform data combined with time-domain, frequency-domain, or hybrid feature extraction techniques to rapidly classify and identify discharge types in power transmission and transformation equipment. Through this method, the system can record the original discharge waveforms during actual operation, understanding the various conditions of these waveforms observed in multiple partial discharge measurements, which serves as validation for the effectiveness of the feature extraction technology.

整合饋線運轉資訊之相位切換技術研究

Study on Phase Switching Techniques with the Integration of Feeder
Operating Information

(計畫編號：113A011)

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摘要

配合當前國內外電力與能源政策之發展，再生能源於電網中的應用正逐步擴大。因此，再生能源發電的不穩定性須作為電網建置及精進過程中的一項考量因素，而饋線三相不平衡便為再生能源發電不穩定引發的情形之一。為因應此情形，本計畫探討配電饋線分歧線相位切換相關技術，並將饋線建模、演算法、潮流解析、相位切換，與運轉資訊整合開發為一套模擬平台，本計畫所開發之模擬分析平台可用於分散式發電與儲能系統高佔比之配電網作為系統化線路連接點相位調整接線方式建議，改善配電線路三相不平衡，進而減緩再生能源發電不穩定引發電網波動以及不平衡，提升電網運轉韌性。

Abstract

In accordance with the current domestic and international developments in power and energy policies, the application of renewable energy in the grid is gradually expanding. Therefore, the instability of renewable energy generation needs to be considered as a factor in the construction and improvement of the grid. Unbalanced three-phase feeder lines are one of the situations that can result from the instability of renewable energy generation. To address this issue, this project aims to explore phase-switching technologies for distribution feeder lines. It will integrate feeder line modeling, algorithms, power flow analysis, phase switching, and operational information into a simulation platform, with the goal of mitigating grid fluctuations caused by the instability of renewable energy generation and enhancing grid operational resilience.

微電網三相不平衡負載與電壓控制之研究

Research on Three-Phase Unbalanced Loads and Voltage Control in
Microgrid

(計畫編號：113A016)

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摘要

隨著全球暖化、溫室氣體排放與能源危機等議題的重視，衍生基於再生能源的分散式發電滲透率在電網中不斷提高；再者，隨著科技高速發展以及各相關產業的進步，許多關鍵或敏感的負載機具使用量急劇增加，是以，電力負載劇烈變化與負載不平衡等不確定性因素問題，都將使得電網電力品質問題受到嚴重挑戰。為了保證微電網的電力品質，需要有效地整合相關不平衡補償控制策略和電壓穩定機制。如果成功實現這樣的整合，將大大提高微電網的運轉穩定性和電力品質。本計畫主要目標為：(1)研析國內外三相不平衡負載與電壓控制相關文獻；(2)研提三相不平衡負載與電壓控制策略；(3)針對所提之三相不平衡負載與電壓控制策略，建立相關模型；(4)進行三相不平衡負載與電壓控制策略模擬，驗證策略可行性。此外，本計畫將依據國原院提供之微電網系統為基礎，建立相關電網模型，並透過模擬軟體驗證相關三相不平衡負載與電壓控制策略之可行性。

Abstract

Nowadays, owing to the growing penetration rate of the renewable energy sources connected with the power system, the power quality issue has become a significant challenge resulted from the inherent intermittency and uncertainty. In other words, the increasing renewable energy sources may lead to the unbalanced grid current and voltage variations and flicker. Moreover, owing to the widespread utilization of the sensitive apparatus, the power quality deterioration seriously occurred. To ensure the power quality of the microgrid, it is necessary to effectively integrate relevant load compensation control strategies and voltage stabilization mechanisms. If successful integration is achieved, it will significantly enhance the operational stability and power quality of microgrid. The main objectives of this project are to: (1) analyze relevant literature on three-phase unbalanced loads and voltage control; (2) develop the three-phase unbalanced current compensation and voltage control strategies; (3) establish relevant models for the proposed strategies on three-phase unbalanced current compensation and voltage control; (4) verify the feasibility of the proposed strategies via the PSIM simulation software. In addition, this project would establish relevant models based on the microgrid system provided by National Atomic Research Institute and verify the effectiveness of the developed unbalanced current compensation and voltage control strategies for the power quality improvement through the simulation results.

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測距電驛標置設定技術開發

Development of Parameter Setting Technology for Distance Relays

(計畫編號：113A019)

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摘要

逆變器資源 (IBR) 是近年來引入電力系統的技術之一，IBR 一詞是指利用逆變器技術來產生或儲存電能，並將這些電能分配到電網的技術。IBR 對電力系統電網的影響已討論多年，因其帶來許多優勢和挑戰。過去的文獻中有針對 IBR 在電網中導致保護電驛誤動作提出了一些解決方案，但這些解決方案通常需要複雜的數學和高計算負荷不適用於分散系統，因為所需的處理時間不短。由於計算複雜性增加，協調丟失的風險也增加，導致一些過去的方法難以應用。本計畫提出並實施了一種基於多代理的保護系統。結果將使用聯合模擬和硬體迴路模擬技術進行驗證。為了實現各種電驛操作，協同工作的對應代理包括匯流排代理、斷路器代理、變壓器代理和區域代理。預期所提方法相比傳統電驛具有更高的準確性和更快的操作響應。

Abstract

Inverter Based Resources (IBR) is one of the technologies that were recently introduced into the electric power system. The term IBR refers to technologies that generate or store electricity for grid power distribution with the inverter-based devices. The impact of IBR integration on the power system grid has been discussed for years as it brings numerous advantages and challenges. The past works of literature have covered some solutions for the protection misoperation issues caused by IBRs; however, these solutions often involve complex mathematical computations and high computational demands, making them unsuitable for distributed systems due to processing time constraints. The increased computational complexity also raises the risk of coordination loss, rendering some traditional methods difficult to implement. To overcome these challenges, a multi-agent-based protection system is proposed and implemented. This system comprises various agents—bus agents, circuit breaker agents, transformer agents, and area agents—that collaborate and coordinate to achieve effective relay operations. Validation of the system's performance will be conducted using co-simulation and Hardware-in-the-Loop (HIL) techniques across various scenarios. The proposed method is expected to offer improved accuracy and faster response times compared to conventional relays.

113年度委託研究計畫成果發表摘要彙編

結合配電資訊模型之設備分析與優化研究

Applications of the Common Information Model in Distribution System Assets

(計畫編號：113A013)

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摘要

本計畫應用通用資訊模型(Common Information Model, CIM)，用以收集配電設備即時運轉資訊，並延伸至區域電網所構成之微電網系統，以 IEEE Std 2030 為基準對其微電網能源管理系統(Microgrid Energy Management System, MEMS)之規範進行探討，同時以此為基準對其性能量化與驗證定義其測試程式，並以交流微電網為標的對其規劃與設計程式提出建議設計方法。此外，本計畫亦針對微電網系統之變壓器末端單元(Transformer Terminal Unit, TTU)及饋線末端單元(Feeder Terminal Unit, FTU)，以 CIM 進行資料交換並取得即時運轉資訊，結合卷積神經網路(Convolution Neural Network, CNN)對其負載樣態進行比對，並在 TTU 或 FTU 設備錯置或發生異常時主動辨識，並回應至系統主站，以達到微電網系統之運轉、維護與管理之目的。

Abstract

This project applies a common information model (CIM) to collect the real-time information of distribution facilities and to the multi-microgrids of distribution systems. The IEEE Std 2030 is a reference for the energy management system of a microgrid to define the testing procedure of performance quantification and certification. Based on IEEE Std 2030, the planning and design procedure of AC microgrid will be proposed in this project. Also, the CIM will be used to exchange the real-time information between the transformer terminal units (TTUs) and feeder terminal units (FTUs) in microgrids. The convolution neural network (CNN) will be used to compare load patterns and detect the abnormal status of TTUs and FTUs when facilities failure or are installed on the wrong locations. After detecting abnormal status, the information is transmitted to the master station based on CIM to support the operation, maintenance, and management of microgrids.

配電網與分散式發電之動態保護研究

Study of Feeder Dynamic Protection of the Distribution Network by
Considering Distributed Generation Resources

計畫編號：113A012

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摘要

本計畫針對分散式電源併接於配電網路後之配電系統保護協調問題進行研究與分析，提出類神經網路為基礎之保護電驛動態參數決策系統。本系統以改良式基因演算法針對不同的分散式電源滲透率與負載量之變化，求解出最佳保護電驛設定參數組合作為訓練資料。透過模擬測試之結果得以驗證所提出之決策系統能根據系統中即時分散式電源發電量、負載量以及故障電流值，快速的輸出系統每個電驛的參數設定組合，作為電力系統運轉操作員調整之參考。

Abstract

This project focuses on the protection coordination challenges in distribution systems with integrated distributed generation (DG). A neural network-based decision-making system for dynamic protective relay parameter setting is proposed. The training data for the network is generated using an improved immune algorithm, which solves for optimal relay setting combinations under varying levels of DG penetration and system load conditions. Simulation results validate that the proposed decision-making system can rapidly provide recommended relay settings based on real-time data, including DG output, load demand, and fault current levels. This capability provides valuable decision support for power system operators in maintaining protection coordination and ensuring operational reliability.

113年度委託研究計畫成果發表摘要彙編

應用於電力交易模式之功率轉換控制研究

The research on control strategies of distributed generation in micro-grid for providing frequency regulation reserve service

(計畫編號：113A015)

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摘要

近年來，隨著大量再生能源併入電網，其間歇性特性對電力供需平衡的穩定性造成挑戰，例如太陽能發電受日照變化影響明顯。為了維持電力系統的穩定與安全，電網日益仰賴微電網與儲能系統等新興技術來提供輔助服務。目前，透過台電電力交易平台，各界皆可成為服務提供者，參與這些輔助服務。本計畫將以國原院的微電網系統及相關設備為研究對象，依據台電對輔助服務的規範，建置一套 MW 級微電網輔助服務模擬系統，進行調頻輔助服務之模擬研究。年度研究重點包括：(1) MW 級微電網執行靜態調頻（採需量態樣方式）之系統評估與分析；(2) 建立 MW 級微電網在靜態調頻（採需量態樣方式）下的多電源協同調控策略；(3) 針對 MW 級微電網執行靜態調頻（採需量態樣方式）進行緊急調控輸出模擬，並提出適當之模擬方法與效益評估。

Abstract

In recent years, with the large-scale integration of renewable energy into the power grid, its intermittent nature has posed challenges to the stability of power supply and demand balance—for example, solar power generation is greatly affected by sunlight intensity. To maintain the stability and security of the power system, emerging technologies such as microgrids and energy storage systems are increasingly relied upon to provide ancillary services. Currently, through Taipower's electricity trading platform, various stakeholders can participate as service providers in these ancillary services.

This project focuses on the microgrid system and related equipment at the National Atomic Research Institute (NARI). Based on Taipower's regulations for ancillary services, the project aims to develop a simulation system for MW-scale microgrid ancillary services and conduct studies on frequency regulation support. The main research tasks for this year include:(i) System assessment and analysis of MW-scale microgrid performing static frequency regulation using a demand profile-based approach;(ii) Development of multi-power source coordination strategies for static frequency regulation in MW-scale microgrids using a demand profile-based approach;(iii) Simulation of emergency regulation output for MW-scale microgrids performing static frequency regulation using a demand profile-based approach, along with proposing appropriate simulation methods and benefit evaluations.

電網韌性災害潛勢資料

Potential Impacts of Seismic Hazards on Power Grid Resilience

(計畫編號：113A018)

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摘要

本計畫協助「電網韌性分析計畫」，旨在提升電力韌性。本計畫整合地震動、土壤液化、坡地崩塌等危害資料，建立天然災害風險潛勢資料。由地質調查及礦業管理中心與台灣地震模型計畫(Taiwan Earthquake Model, TEM)資料，彙整台灣活動斷層屬性資料，建置地震衝擊分析所需的斷層基礎資料庫，透過 500×500 公尺的地理網格為基礎單元，利用工程風險量化評估技術，進行大規模地震衝擊分析，共分析 26 條單獨斷層和 2 條斷層組合，求得最大地震規模情境導致的災害衝擊與重要電力設施損壞機率，分析項目含地震動參數、土壤液化潛勢、坡地崩塌潛勢，及地震動影響下電力設施的損壞狀態。分析成果為電網韌性天然災害圖資，可作為本計畫後續模式開發和補強工作提供重要參考依據。

Abstract

This study aimed at enhancing power grid resilience. The project integrates data on seismic activity, soil liquefaction, and slope instability to establish natural disaster risk potential data. This serves as a critical basis for subsequent model development and grid resilience reinforcement. The project collaborates with the Geological Survey and Mining Management Agency and Taiwan Earthquake Model (TEM) to compile Taiwan's active fault attributes, constructing a fault database necessary for seismic impact analysis. Using geographic information systems, simulations are conducted on a 500×500m grid to quantitatively assess post-earthquake disaster scenarios. The study selects 26 individual faults and combinations of two faults for earthquake scenario simulations, analyzing potential disaster impacts and infrastructure failure effects. Key analyses include seismic activity, soil liquefaction, slope instability potential, and the damage status of power facilities under seismic influence. These analytical findings will provide natural disaster resilience maps for the grid, serving as crucial references for subsequent model development and reinforcement efforts.

場次 4 原子能科技領域

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太空用功率元件輻射可靠度研究

Radiation Effects for Radiation Reliability on Low Earth Orbit Satellite in Space

(計畫編號：113A009))

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臺北醫學大學實驗動物中心

摘要

在太空探索日益增多的時代，為了降低電子元件在高輻射環境下造成系統失效問題，評估元件輻射劣化程度及抵抗能力是重要議題。可藉由輻射照射模擬太空的環境，評估對物質造成暫時性或永久性的傷害，或是在運作過程中造成邏輯錯誤與功能失效等太空輻射效應。本計畫包含兩個工作目標，分別為(1)研究了質子輻射照射對單層 Ta_2O_5 和 WO_3 以及透過溶膠-凝膠法製備的雙層 $\text{Ta}_2\text{O}_5/\text{WO}_3$ 和 $\text{WO}_3/\text{Ta}_2\text{O}_5$ 薄膜的結構、振動、光學和電致變色性能的影響；(2)輻射照射於奈米金溶液之製備分析。本研究結果：(1) Ta_2O_5 可作為 WO_3 薄膜的保護層，質子照射引起的電致變色薄膜電子結構變化，導致其電化學性能響應呈衰退趨勢，雙層薄膜在電致變色應用有較佳的潛力與性能表現；(2)奈米金試樣經輻射照射處理後，利用循環伏安法(cyclic voltammetry, CV)測定試樣電化學性質，顯示無顯著之氧化還原電流波峰，且達到市售奈米金大小標準。

Abstract

The new era of the space exploration, it is critical the effects of system failure caused by electronic components in high radiation environments. In order to avoid problems, evaluating the deterioration and radiation resistance degree of component radiation degradation and resistance is an important issue. Radiation exposure can be used to simulate the space environment and evaluate the effects of space radiation, causing temporary or permanent damage to materials, causing logical errors, functional failures and other consequences during operation. This project contains two work objectives, (1) To study the structure, vibration, and related influence of optical and electrochromic properties of single-layer Ta_2O_5 and WO_3 as well as double-layer $\text{Ta}_2\text{O}_5/\text{WO}_3$ and $\text{WO}_3/\text{Ta}_2\text{O}_5$ thin films prepared by sol-gel method; (2) Preparation and analysis of radiation - irradiated gold nanoparticle (Au NPs) solution solutions. The noteworthy about the results of this study (1) Ta_2O_5 can serve as a protective layer for WO_3 films, and the electronic structure of electrochromic thin films induced by proton irradiation changes, resulting in a decline in the electrochemical performance response. Double-layer thin films have better potential and performance in electrochromic applications; (2) Through the radiation irradiation of the gold nanoparticle sample, the electrochemical properties were measured by cyclic voltammetry (CV), showing no significant redox current peaks and reaching the standard size of commercially available nanoparticles.

雙功能中子靶站中子通量率提升方法之評估

Studies for increasing the neutron flux at a dual-purpose neutron target station

(計畫編號：113A002)

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摘要

為能提升雙功能中子靶站之中子通量，本研究除了藉由熱傳分析評估增加質子束電流量對靶材熱傳之影響外，亦針對靶材鍍膜對中子產率之影響進行評估。研究結果指出受限於金屬鈹加工不便之限制，採用高流量、具次冷度工作流體並調節射束分布以降低熱源峰值的設計將有助於改善靶材散熱進而提高中子通量。此外，利用 MCNP 模擬具保守鍍膜厚度之靶材亦可確認靶鋁表面鍍金或鋁並不會導致中子產率的降低，故未來亦可視需要進行鍍膜以提升靶材耐用度。

Abstract

This study aims to enhance neutron flux in a dual-function neutron target station. In addition to thermal analysis evaluating the impact of increased proton beam current on target heat transfer, the effects of target coating on neutron yield were also investigated. Results indicate that, due to the processing challenges associated with beryllium metal, employing high-flow, sub-cooling working fluids combined with electromagnetic field-assisted beam spreading can effectively reduce peak heat flux, thereby improving heat dissipation and increasing neutron flux. Furthermore, Monte Carlo N-Particle (MCNP) simulations with conservative coating thicknesses suggest that gold or aluminum coatings on the target surface do not significantly reduce neutron production, implying that coating strategies can be employed in future designs to enhance target durability without compromising neutron yield.

量子拓撲感測器研究

Research and Applications of a Quantum Topological Sensor

(計畫編號：113A004)

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摘要

本研究計畫將引入量子拓撲材料，開發新穎二維層狀量子材料，二碲化鎢(WTe_2)，該材料被認為可具有鐵電性質，代表可在電場調控下改變其電子結構，進而可能為新型電子元件的設計提供更多靈活性和可調性。其無需單晶基板限制且相容於現有半導體製程技術之特性有望克服過去量子材料應用受限的問題，實現更廣泛的應用範圍。發展新穎材料、新的元件架構、以及探索新的物理機制被視為至關重要的基礎，以提供下一代電子元件與電子感測元件，其無需單晶基板限制且相容於現有半導體製程技術之特性有望克服過去量子材料應用受限的問題，實現更廣泛的應用範圍。本計畫開發出的自旋閥結構之磁阻率可達 80%。透過全面的表徵分析和深入的研究，我們將探索在單一系統中實現拓撲、電子自旋和鐵電性之間耦合的可能。同時，這項研究也將為下一世代節能電子元件和人工智慧運算提供一條可能的道路。

Abstract

In this proposal, we will develop quantum topological sensors with a novel two-dimensional layered quantum material, tungsten telluride (WTe_2), which is believed to have coexisting ferroelectric properties and spin-orbit coupling effect. This material can change its electronic structure under electric field modulation, which may provide more flexibility and tunability to design new electronic components. The absence of a single crystal substrate and its compatibility with existing semiconductor CMOS processing are expected to overcome the limited applications of quantum materials in the past and enable a wide spectrum of applications. The development of novel materials, new component architectures, and the exploration of new physical mechanisms are considered critical foundations for the next generation of electronic components and sensors. The spin-valve structure developed in this work has reached a magnetoresistance ratio of 79.3%. Through comprehensive characterization and in-depth study, we will explore the possibility of realizing the interplay among crystal structure, spin-electronic and ferroelectricity in a single system. At the same time, this research will provide a possible pathway for next-generation energy-efficient electronics and artificial intelligence computing.

量子點記憶元件之材料及電特性量測分析

Measurement and analysis of material and electrical properties of
quantum dot memory devices

(計畫編號：113A005)

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摘要

隨著人工智慧 (AI) 技術的快速進步，對於記憶體的需求逐漸凸顯出來。傳統的記憶體技術，包括 DRAM 和 SRAM 雖然能夠滿足計算需求，但仍然存在著限制。AI 應用中常見的計算對於記憶體的速度、密度和能效提出了更高的要求。因此，開發新型記憶體技術變得至關重要。新型浮動閘極記憶體，尤其是與矽半導體製程相匹配的浮動閘極記憶體，在使用量子點作為浮動閘極材料後，能夠增加記憶體的電荷儲存量並提高可靠度。而本計畫將專注於新型量子點記憶體之開發，藉此提升量子點記憶體之特性。本計畫將運用電性量測設備來探究量子點記憶體的記憶特性。首先，透過電容量測系統分析元件的記憶窗口及可靠度，並通過調整電容掃描偏壓，觀察元件在不同的寫入與抹除操作條件下的表現。此外，本計畫預計搭配材料分析儀器，如能量散射 X 射線譜(Energy-dispersive X-ray spectroscopy, EDS)、原子力顯微鏡(Atomic Force Microscopy, AFM)，進一步分析元件的奈米結構和材料分布。最後，我們將整合上述結果，建立記憶體元件性能與物理機制模型，以開發具有穩定寫入抹除特性的記憶體元件。

Abstract

With the rapid advancement of artificial intelligence (AI) technology, the demand for memory has become increasingly prominent. Traditional memory technologies, including DRAM and SRAM, although capable of meeting computational requirements, still have limitations. The common calculations in AI applications impose higher requirements on memory speed, density, and efficiency. Hence, the development of new memory technologies has become crucial. Emerging floating gate memories, especially those aligned with silicon semiconductor processes, can increase the charge storage capacity of memory and enhance reliability when utilizing quantum dots as floating gate materials. This project will focus on novel quantum dot memories to enhance memory write-erase characteristics. This project will utilize electrical measurement equipment to investigate the degradation mechanisms of quantum dot memories. Initially, through capacitance measurement systems, the analysis of memory characteristics will be conducted. By adjusting the capacitance scanning bias, the performance of components under different write and erase conditions will be observed. Additionally, the project plans to complement with material analysis instruments such as Energy-dispersive X-ray spectroscopy, (EDS), and Atomic Force Microscopy, (AFM) to further analyze the nanostructure and distribution. Finally, the integration of the above results will establish a physical mechanism model for memory component performance and reliability degradation, facilitating the development of memory components with stable write-erase characteristics.

節能乾燥除濕轉輪系統氣流特性模擬分析研究

Research on the simulation and analysis of airflow characteristics in the energy-saving dehumidifying rotary wheel system

(計畫編號：113A007)

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摘要

本研究針對雙氣流系統中的除濕輪進行數值模擬與實驗分析，探討不同孔隙度（10 PPI 與 60 PPI）、結構類型（連通孔洞與直通道）及流速條件對氣流特性、壓差與熱交換效率的影響。結果顯示，10 PPI 結構具有良好的動能保持能力，在高流速條件（10 m/s）下，氣流速度的損失較小，熱穩定性較高；而 60 PPI 結構則展現顯著的氣流減速與熱交換效果，適合高效熱交換場景。壓差分析顯示，兩種結構在不同孔隙度下的壓差均值極低（ <0.01 bar），系統運行穩定。封裝設計中，支架的數量、寬度與厚度對結構應力分佈具有重要影響。支架厚度的增加對降低應力效果顯著，數量的增加則有助於應力分散，但可能引起應力集中效應。本研究為除濕輪的優化設計提供理論依據，建議根據應用需求選擇合適的孔隙度與結構類型，並通過合理設計封裝結構實現性能與材料利用效率的平衡。本成果可為除濕輪在工業除濕與熱交換領域的應用提供重要參考。

Abstract

This study conducted numerical simulations and experimental analyses on desiccant wheels in a dual airflow system to investigate the effects of different porosities (10 PPI and 60 PPI), structural types (interconnected pores and straight channels), and airflow velocities on flow characteristics, pressure drop, and heat exchange efficiency. The results indicate that the 10 PPI structure exhibits excellent kinetic retention, with minimal airflow velocity loss and high thermal stability under high-speed conditions (10 m/s). In contrast, the 60 PPI structure demonstrates significant airflow deceleration and superior heat exchange efficiency, making it suitable for high-efficiency heat exchange applications. Pressure drop analysis revealed extremely low average values (<0.01 bar) for both structural types across different porosities, ensuring stable system operation. In the enclosure design, the number, width, and thickness of supports significantly influence the stress distribution. Increased support thickness effectively reduces stress, while additional supports aid in stress distribution but may lead to stress concentration effects. This study provides a theoretical basis for optimizing desiccant wheel design, recommending the selection of appropriate porosities and structural types based on application requirements and the rational design of enclosure structures to balance performance and material utilization efficiency. These findings offer valuable insights for industrial applications of desiccant wheels in dehumidification and heat exchange processes.

高離子強度系統中流體化床結晶技術用於鈣鎂提取之沉澱機制研究

Study on the Precipitation Mechanism for Calcium and Magnesium Extraction Using Fluidized Bed Crystallization Technology in High Ionic Strength Systems

(計畫編號：113S162)

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摘要

隨著全球極端氣候變遷的影響，台灣洪旱的發生機率有逐漸加劇的趨勢，再加上近年來台灣製造業及高科技產業蓬勃發展，水資源需求量不斷提升。為了解決水資源告急議題，政府近年來積極推廣廢水回收再利用並將再生水作為新興水源，利用地球上最大的水體進行海水淡化技術來彌補各行業的水資源量不足。針對海水淡化的議題，本團隊以海水淡化中鹵水排放之議題，進行海洋鈣鎂離子之物質回收及再利用技術開發及研究。基於以上對於海水淡化機組改善與後續鹵水的處理，本計畫旨在以本團隊之流體化床均質結晶 (Fluidized-Bed Homogeneous Crystallization, FBHC) 技術為基礎，開發適合應用於海水及鹵水廢水之硬度處理模組。計畫初期使用化學沉澱法來研究序列式分別去除鎂離子及鈣離子的可行性，利用氫氧化鈉來沉澱鎂離子以產出氫氧化鎂，再以碳酸離子沉澱鈣離子而成碳酸鈣；在於計畫中期藉由流體化床均質結晶技術，實驗出最佳操作參數並合成出高純度及高結晶度之顆粒，以達到廢棄物再利用的循環經濟。計畫末期，則從貴院提取可行性之廢水，並建置模型廠進行較大規模之測試，且同時也會進行處理效率評估與設廠成本考量，以期能將此開發技術應用

113年度委託研究計畫成果發表摘要彙編

至實場。

第一階段氫氧化鎂回收之流體化床實驗個別以實場製鹽鹵水以及鹽鹵操作，製鹽鹵水總操作量為 100 L，總鎂去除率為 99%、鎂結晶去除率為 93.8%；然而，以實場鹽鹵操作無法使流體化床系統順利運行，因其鹽鹵中的鎂濃度過高導致大量沉澱物堵塞系統，故以鹽鹵回收氫氧化鎂在流體化床系統不可行。第二階段碳酸鈣回收之流體化床實驗以實場製鹽鹵水操作，製鹽鹵水操作總量為 100 L，總鈣去除率為 89%，鈣結晶去除率為亦為 89%，顯示良好的結晶效果。由於鹽鹵無法應用在第一階段氫氧化鎂回收，故此階段便未使用鹽鹵進行實驗。此兩階段產物以 XRD、FT-IR、SEM、SEM-EDS 分析後，確認兩者分別為氫氧化鎂以及碳酸鈣，顯示流體化床均質結晶技術可用於製鹽鹵水回收氫氧化鎂以及碳酸鈣。

Abstract

With the increasing impact of extreme climate change, Taiwan has been experiencing more frequent and severe floods and droughts. At the same time, the rapid growth of manufacturing and high-tech industries has led to rising water demand. To address water scarcity, the government has promoted wastewater recycling and reuse in recent years, and has positioned reclaimed water as a new alternative water source. In addition, seawater desalination—using the largest water source on Earth—has become an important way to supplement industrial water supplies. Focusing on the challenges of seawater desalination, our team has been developing and studying technologies to recover and reuse calcium and magnesium ions from the brine discharged during the desalination process. These efforts aim to improve system efficiency and reduce the environmental impact of brine. To achieve this, we use a technology called fluidized-bed homogeneous crystallization (FBHC) to develop a hardness treatment module specifically designed for seawater and brine wastewater.

In the early phase of the project, we tested chemical precipitation methods to remove magnesium and calcium ions in sequence. Magnesium ions were first removed using sodium hydroxide, forming magnesium hydroxide, followed by calcium removal through carbonate precipitation to form calcium carbonate. In the mid-phase, we applied the FBHC technique to identify the best operating conditions and successfully produced high-purity and well-crystallized particles, contributing to circular economy goals by turning waste into reusable materials. In the final phase, we obtained actual wastewater samples from your institution and built a pilot-scale system to carry out large-scale tests. We also evaluated treatment performance and construction costs, aiming to apply the technology in real industrial settings. In the first-stage experiment for

magnesium hydroxide recovery, we used both solar salt brine and salt-concentrated brine from Taisugar. Using 100 liters of solar salt brine, we achieved a 99% total magnesium removal rate and 93.8% crystallization removal efficiency. However, the test with salt-concentrated brine failed because the very high magnesium content caused excessive precipitation, clogging the system. Therefore, magnesium recovery from this type of brine was not feasible using the fluidized-bed approach. In the second stage, we focused on recovering calcium carbonate using 100 liters of solar salt brine. Both the total calcium removal and crystallization efficiencies reached 89%, showing good performance. Since salt-concentrated brine could not be used in the magnesium recovery stage, it was also excluded from this part of the study. The solid products from both stages were analyzed using XRD, FT-IR, SEM, and SEM-EDS, confirming that the recovered materials were magnesium hydroxide and calcium carbonate. These results demonstrate that the FBHC technique is effective for recovering valuable minerals from solar salt brine and offers potential for sustainable water treatment and resource recovery.