

A22-053



作品摘要

由於飲食習慣與生活型態的改變，加上國人普遍用藥習慣不良，臺灣人罹患慢性腎臟病的人口數逐年上升。據美國腎臟病登錄系統2020年公布的年報顯示臺灣末期腎臟病發生率（523人/百萬人口）全球第二與洗腎率（3429人/百萬人口）全球第一，全台已有高達9萬4千人需定期接受洗腎，故臺灣於國際間有「洗腎王國」的惡名。洗腎盛行，主要和慢性腎臟病和糖尿病變相關，而此兩項疾病初期症狀會出現微白蛋白尿（ $30 \text{ mg/g} < \text{UACR} < 300 \text{ mg/g}$ ），此一時期可通過改善生活型態、飲食習慣與健康干預，即可避免惡化成需洗腎維生的末期腎臟病。

全球受到COVID-19疫情影響下，大幅減少民眾前往醫院檢查或非必要醫療行為之意願與需求，慢性疾居家健康監測器材需求隨之提升。臨床研究顯示SARS-CoV-2 病毒會直接侵犯腎臟，導致急性腎小管損傷，有近34%~63%的病患會發生嚴重蛋白尿。在全球進入與病毒共存的趨勢下，由於新冠病毒造成的腎病變可能會導致急性腎衰竭，而病毒入侵腎臟的重要病徵即為出現蛋白尿，需要一個可居家監控腎功能（UACR）的檢測工具。

本作品係由一電化學感測電路、一感測元件（UACR）、一使用者介面（APP）與一檢測基台所組成。電化學感測電路主要由恆電位儀以及類比數位轉換器所組成。系統大致分為前端電化學感測電路（恆電位儀，Potentiostat）、數位訊號處理單元（微控制器，MCU）、無線藍芽模組（Bluetooth）以及電源管理模組（Regulator）。恆電位儀包含數位類比轉換器以及運算

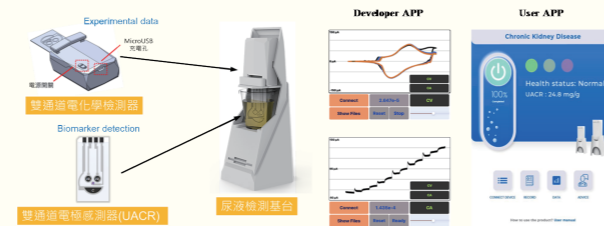
具可攜式無線尿液檢測與預防糖尿病腎病變與慢性腎臟病之系統與平台 Portable and Wireless Urine Detection System and Platform for Prevention of Diabetic Kidney Disease and Chronic Kidney Disease

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放大器，以提供不同電化學感測方式所需之各種工作電位波型，並將UACR感測器氧化/還原電流訊號放大，再透過類比數位轉換器進行訊號擷取，系統微控制器對數位訊號進行初步運算，並進行編碼封包與無線藍芽傳輸，最後再透過客製化APP來顯示檢測結果與歷史資料。

本計畫提出一可應用於診所定點照護檢驗（POCT）、社區快篩與居家照護之尿液檢測UACR系統平台，讓使用者可於診所、社區或居家定期監控UACR指數，在疾病發展初期即進行有效預防，系統平台亦將提供長期追蹤的歷史數據與個人化健康建議，使疾病的預防與監控更為完善。



圖一 電化學尿液檢測系統雛型機與 APP 示意圖

指導教授

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研究領域

類比、混合訊號與射頻通訊積體電路、生醫監控晶片系統與穿戴式物聯網系統與平台、植入式與穿戴式神經調控晶片系統

Abstract

Due to change in eating habits, lifestyles, as well as poor medication habits, the number of people suffering from chronic kidney disease (CKD) is increasing year by year. According to the 2020 annual report released by the United States Renal Data System (USRDS), there are the second highest incidence of end-stage renal disease and the highest dialysis rate in Taiwan. Here are over 94,000 Taiwanese are required to undergo the dialysis on a regular basis. Therefore, Taiwan has the infamous title of "Kidney Dialysis Island.". Fortunately, there is an effective index, urine albumin to creatinine ratio (UACR), to detect the kidney damage at the early stage, which the microalbuminuria ($30 \text{ mg/g} < \text{UACR} < 300 \text{ mg/g}$) appears as the initial symptom of CKD. The patients at the microalbuminuria stage could avoid the progression to end-stage renal disease simply by doing some health interventions, such as improving lifestyle and dietary habits.

This project proposes a system and platform for urine detection of UACR that can be used in homecare and community rapid screening, allowing users to regularly monitor the UACR easily, and effectively prevent the disease at the early stage of CKD development. The proposed system and platform, shown in the Figure 2, consists of an electrochemical sensing circuit, an UACR sensing electrode, a portable urine detection device and an user-friendly APP. It provides long-term tracking of historical data and personalized health advice, making disease prevention and monitoring more feasible and practical. The system is divided into front-end electrochemical sensing circuit



(Potentiostat), digital signal processing unit (microcontroller, MCU), wireless Bluetooth module (Bluetooth) and power management module (Regulator). The potentiostat consists of a digital-to-analog converter and an operational amplifier to provide various working potential waveforms required by different electrochemical sensing methods, amplify the current signal of oxidation/reduction reaction, and then capture the signal through the analog-to-digital converter. The system microcontroller performs preliminary operations on the digital signals, encodes packets, transmits the processed data by Bluetooth, and finally displays the test results and historical data through a custom-designed user interface.

Prevention is better than cure. Recently, it's known to find the risk of initial CKD by detecting UACR. In the future, we plan to promote this system and platform from community and local clinics to home-care. Expectedly, the numbers of severe CKD and dialysis patients would decrease, and we can wipe out Taiwan's notorious name of being the "Island or Kingdom of Dialysis".

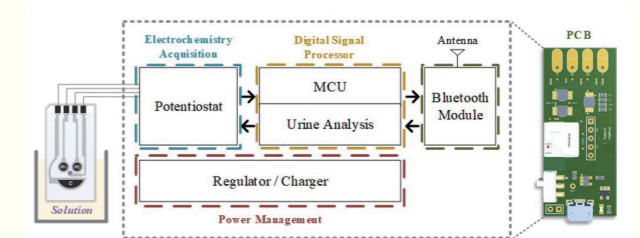


Fig. 2 The system block diagram of the proposed urine detection system and platform