

以溶膠-凝膠法製作二氧化鋯感測層在電解質-絕緣層 -半導體結構對pH及尿素生物感測之研究

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離子感測場效電晶體(Ion-sensitive Field Effect Transistor, ISFET)是由 Bergveld 在1970 年首先提出，由於它的尺寸小，反應速度快、可承受外部應力，且與現今的 CMOS 製程相容，所以在現在的感測元件開發中具有相當大的潛力。ISFET的主要結構是電解質-絕緣層-半導體(electrolyte-insulator-semiconductor, EIS)，藉由研究EIS 電容結構的特性，我們可以了解不同材料的離子感測性質。傳統上，大部份材料都是使用濺鍍和電漿輔助化學氣相沉積製程，需要高真空系統、靶材等昂貴的設備和材料。

於本論文我們提出溶膠-凝膠法在EIS電容結構上，製作二氧化鋯感測層作pH感測特性研究。本實驗可成功利用濃度及旋塗次數控制膜厚，並結合氧電漿和熱退火處理製作出具有高介電係數的二氧化鋯感測層。為了讓製程成本降低且方法簡便，

使用銀網版印刷電極作為EIS電容及 $\text{Ag}/\text{Ag}_x\text{O}$ 參考電極的基板材料，更具有延伸電極的優點。另外，本實驗同時研究二氧化鋯pH感測器的非理想特性，包含遲滯效應和時漂效應，以對薄膜品質和感測性質有進一步了解。

在酵素生物感測的應用上，我們結合了尿素酶和二氧化鋯pH感測器作尿素檢測的應用。酵素EIS結構的尿素生物感測器可用來量測不同濃度的尿素電位差分析，濃度範圍約在3到40 mM。本研究在製程上的優點是便宜、簡便及低溫，並發展出溶膠-凝膠法製作二氧化鋯感測層在pH量測及尿素生物感測的應用。



The study of sol-gel-derived ZrO₂ sensing film based on electrolyte–insulator–semiconductor for pH detection and urea biosensing

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ABSTRACT

ISFET(Ion-sensitive Field Effect Transistor) was first developed by Bergveld in 1970s, and because of its small size, fast response, rigidity and compatibility with standard CMOS process, ISFET is an attractive candidate of modern sensor device. By studying the characteristics of EIS capacitor, we can understand the nature of ion sensitivity to different materials. Traditionally, the majority of sensing membranes are fabricated by sputter and PECVD process, which require high vacuum systems, targets and other expensive equipment and materials.

In this study we propose the ZrO₂ high- κ materials which act as pH sensitive layers of EIS capacitor by the sol-gel processes. This experiment can successfully control the thickness by concentration and the number of spin-coating of solution, and then

combined with oxygen plasma and thermal annealing to produce a high- κ ZrO₂ sensing layer. In order to reduce the cost and simplify the procedure, Ag screen-printed electrode (Ag-SPE, Zensor Inc.) was used as the substrate for extending electrode of EIS capacitor and Ag/Ag_xO reference electrode. In addition, this study will examine the non-ideal phenomena of ZrO₂ EIS capacitor, including hysteresis and drift effects, to study the quality of ZrO₂ film and have a better understanding of sensor properties.

As a demonstration case of EnFET-based biosensing, urea detection was performed by configuring a hybrid structure encompassing the EIS-based pH sensor. The enzymatic EIS-based urea biosensor allowed the potentiometric analysis of urea, at concentrations ranging from 3 to 40mM. The attractive features in this study are low cost, flexible, easy fabrication and low processing temperature, and the present work has provided some fundamental data for the use of ZrO₂ thin film for EIS-based pH detection and the extended application for biosensing.



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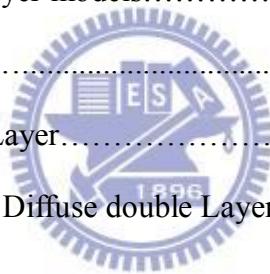
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