D9-052

作品名稱	智慧CMOS放藥系統單晶片 Smart CMOS Drug Delivery SoC
隊伍名稱	451 男孩 451Boy
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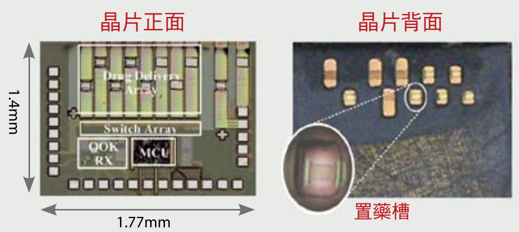
作品摘要

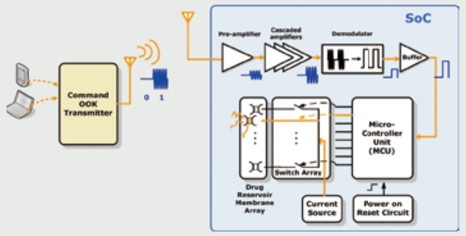
本作品提出一種醫療用的系統晶片(SoC)，具備植入人體提供藥物釋放的功能，能藉由精密的控制來提升藥物治療的效果。

此植入式CMOS系統晶片集合了眾多無線控制/驅動電路，以及一個藥物傳遞陣列(drug delivery array)，為首款此類晶片。SoC可釋放如nonapeptide leuprolide acetate、硝化甘油等藥物，可應用於局部診斷或是癌症的治療，也可為心臟病患者提供即時處置。系統能透過微創手術植入人體，所具備的無線功能也可讓醫療人員對病患進行非侵入性治療。SoC將提供在成本、尺寸與功耗條件上優於現有技術的方案，以標準0.35微米CMOS製程技術生產，晶片面積為1.77mm×1.4mm。

至於裝置內的藥物儲存槽則會以相容CMOS的後製程來製造，可透過晶片上微控制器來進行尋址的動作。此外一個開關移鍵調變(OOK)無線電路也會整合在晶片中，用以接收外部的指令；一旦收到無線指令，就會弄破藥物儲存槽外覆蓋之薄膜，將所需藥物注入人體。



圖一、智慧CMOS釋藥系統晶片照



圖二、智慧CMOS釋藥系統架構圖

覆蓋在每個藥物儲存器外部的金屬薄膜會在藥物傳遞陣列上排列成圖案，以導通電流到薄膜上。該種薄膜由多層次的鈦與白金組成，是使用後段IC深層乾式蝕刻技術，從晶片背面形成藥物儲存槽，再透過相容CMOS的後段IC微影技術與剝離製程(lift-off processes)來實現，其晶片照如(圖一)所示。而鈦與白金是相容於CMOS製程的，已被應用於標準CMOS製程製造金屬矽化物或擴散障蔽層。同時，這些材料也具有生物相容性。

在運作時，一個RS232規格的外部指令訊號會無線傳送到該SoC，並由OOK接收器接收解調；然後晶片上微控制器會根據解調後的指令，透過所指定的開關把電流傳送到所選擇之藥槽外部薄膜，使其活化破裂並釋出藥物，其系統架構如(圖二)所示。在進行活化的電流傳出後，從薄膜破裂到釋出藥物所需時間約50毫秒。

指導教授

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- 專長領域：LNA、MIXER、VCO、PLL等CMOS射頻積體電路的設計以及ADC、PGIA、FILTER等類比積體電路設計。目前更致力於生醫方面跨領域系統整合之前瞻性研究。

Abstract

An implantable system-on-a-chip (SoC) capable of drug delivery within a living person that has shown potential for improving the effectiveness of drug therapy through precision control is proposed.

This implantable CMOS SoC features monolithic integration of a wireless controller/actuation circuitry and a drug delivery array and is the first one of its kind. By releasing drugs such as nonapeptide leuprolide acetate or nitroglycerin, the SoC could be used for applications such as the localized diagnosis and therapy of cancers or providing immediate treatment for heart attack victims. The system can be implanted through minimally invasive surgery. Its wireless capability enables doctors to make non-invasive therapy modification. The proposed SoC offers lower system cost, smaller device size and lower power consumption than existing technologies. The device is realized in standard 0.35-micron CMOS technology with a die size of 1.77mm x 1.4mm.

Drug reservoirs within the device are fabricated by CMOS-compatible post-IC processing and addressable by an on-chip microcontroller. An on-off-keying (OOK) wireless circuit is also integrated in the same die for receiving external commands. Drugs are released into the body by the rupturing of membranes covering the drug reservoir following receipt of the wireless commands.

The metal membranes capping each reservoir are patterned on the array for directing electrical current to the top of the membranes. The membranes—multiple layers of titanium and platinum—are realized by post-IC photolithography and lift-off processes while the cavities for reservoirs are formed by CMOS compatible post-IC deep dry etching from the backside of the die. The die photo is shown in Figure.1. Note that titanium and platinum are CMOS compatible, having been used in standard CMOS process for metal silicides or diffusion barrier. The materials are also biocompatible.

Figure 2 illustrates the architecture of the wireless drug delivery system. During operation, an external OOK command signal in RS232 format is wirelessly transmitted to the SoC and then received and demodulated by the OOK receiver. According to the demodulated command, the integrated MCU activates the selected drug cell by applying current to its membrane through a switch, leading to the rupture of membrane and the release of drug. The membrane failure which releases the drug occurs about 50 milliseconds after the activation current is applied.