微機械邏輯閘

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中文摘要

半導體經過數十年的發展，已經成為舉足輕重的產業。然而普遍存在於半導體元件的問題“漏電流”(Leakage current)，僅跟隨著電晶體微小化(Scale down)的過程跟著降低，問題並未完全解決。直到最近 5 年來可攜式裝置(Mobile devices)的盛行，此一問題獲得重視，而相關的研究，解決辦法也陸續提出。微波微機械開關(RF MEMS Switch)的研究即是其中之一。這種簡易的機械式開關，具有高絕緣性(high isolation)、低耗能(low power consumption)、低耗損(low insertion loss)、可批次製造、線性化…等，因此也被廣泛的運用在各領域如：濾波器(Filters)、相位調整器(Phase shifters)、可調式天線(Tunable antennas)。然而目前這類開關只有 on 與 off 的功能，僅能取代部分半導體元件的功能。基於這樣的理由，我們研發具邏輯功能之微機械開關，冀望能與傳統 IC 邏輯閘直接替換，並將此命名為微機械邏輯閘。由於此元件結合微機械開關的優點與 IC 邏輯閘的功能，我們預期此元件將比微波微機械開關更容易且廣泛的被使用。

在本篇論文中，提出了構想中微機械邏輯閘的設計雛型，並以軟體模擬驗證其性能，如驅動電壓、共振頻率、及不同訊號輸入下，邏輯閘是否可以正確切換。最後再以面型加工(Surface micromachining)的方式嘗試製造此元件，雖然未獲成功的結果，但也證明製程的可能性；並由製造結果觀測，歸納出失敗的因素，替後續的製造提出解決方案，以期能增加元件的良率。

MEMS Logic Gate

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Abstract

Semiconductor technology has been the key to the industry development for the past several decades. However, the existing problem “leakage current” in IC transistors, although it has been reduced at the pace of Moss law, didn’t get solved completely. This problem didn’t get its attention until the widely spreading of the mobile devices in the last 5 years. Microelectromechanical System (MEMS) microswitch has been developed as one of the major means to solve this problem, particularly by the researchers in the RF community. MEMS microswitches have the advantages of high isolation, low insertion loss, low power consumption, and the ability to integrate with other solid-state devices. Therefore, they are currently in-use in a variety of applications, such as filters, phase shifters, and antennas, as well as in lower frequency amplifications.

Although the microswitch is promising, the limited function of the switch, which consists of “on” and “off” only, can only be implemented for some specific functions. To broaden the applications for microswitch, we developed a mechanical structure that can perform logic function the same as solid state logic gate does. The proposed microswitch is a tiltable structure and actuated by electrostatic force, and we name it MEMS logic gate.

Due to multiple advantages and functionality of MEMS logic gate, we expect a great potential for this MEMS device.

In the dissertation, we present the prototype of MEMS logic gate. Then we use software to verify the performance such as drive voltage, resonance frequency, and confirm that if the device can switch correctly. Finally, we use surface micromachining to manufacture the device. Although we can't fabricate the device in the end, we still testify the possibility. By concluding the troubleshooting from previous experience could be very helpful to improve yield in the future.

Acknowledgement

我的論文能夠順利完成，首先得感謝我的父母，不辭勞苦無怨無悔的付出，讓我沒有後顧之憂，能夠心無旁騖於學業。接著要感謝我的指導教授 陳宗麟老師在課業上的悉心指導，在我困難的時候，能適時的提供我方向，讓我能夠逐一克服，也教導我做研究應該具備的正確態度。

在無塵室一起打拼的朋友們，子元、俊凱、宜達、業達，謝謝你們陪我度過了這段苦悶的時光。還有交大奈米中心 SRC，以及技術員徐阿姨、黃阿姨、還有范小姐，也謝謝你們熱心的提供技術上的支援與建議；國家奈米元件實驗室 NDL 以及胡淑芬 博士和眾多工程師不厭其煩的給予製程上的協助，也在此一併感謝。

最後要謝謝實驗室的學長、同學與學弟，在這兩年中彼此的砥礪；對於我最親愛的家人，以及默默支持我的朋友們，我研究生涯中最大的支柱，謹以此論文獻給你們。

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