中文摘要

微機電系統 MEMS 是以半導體產業中的平面製造觀念爲基礎的一種整合技術。因爲製程及材料大部分都和積體電路(IC)的製造相同，所以微機電系統中的各種感測器或致動器的發展，均以和 IC 整合而形成智慧型的模組或系統作爲最終目標。當微系統的技術越來越成熟時，各種利用微感測器或微傳感器所形成的智慧型網路或系統應用也隨之而生。在這些應用上，每一個標器或節點的模組都可能有微型獨立電源的需求。拜先進的超大型積體電路與 CMOS 技術所賜，現今這些微系統節點的電能需求已降至數十微瓦的程度。因此利用微機電技術，將環境中的能源轉換成電能來使用取代傳統電池成爲可行且更爲長久可靠的方式。

本篇論文中，我們提出了一種靜電式微機電振動電能轉換器的設計與製造。其運作原理在於，利用由振動驅動的可變電容器的改變，搭配直流電壓源，產生交流電流輸出。轉換器的核心可變電容部分是透過 SOI 晶片搭配深蝕刻製程，製造梳齒狀電極而成。轉換器目標是在 3.3V 輸入電壓、一立方公分的體積限制下，設計出可將生活中普遍存在的振動轉換爲可用之電源供應器。

系統分析及模擬平台已建立來加速元件的設計，元件設計、製作及測試平台亦架設完成。根據設計，轉換器在 3.3V 的輸入電壓下，輸出電能爲 32.34 微瓦(電能密度每立方公分 29.6 微瓦)。元件成品大小約 $0.7\times1.2\times1.3\ cm^3$ 。元件測試及量測顯示，寄生電容電阻的存在影響了轉換器電性，使元件無法理想的運作。但透過振動驅動測試與頻率分析得到元件共振頻率與振幅，機械特性及製程條件的影響已量測並驗證。

Abstract

Micro-Electro-Mechanical System (MEMS) is a technology platform based on the planar fabrication processes in the IC industry. Because most of the materials and processes are similar to those used in IC fabrication, the goal of MEMS actuators, sensors, and micro systems development is the integration with circuits to form a smart module or system. When micro systems become more mature, various smart networks employing micro sensors or transducers have been proposed. In these applications, every node may have the need of an independent power supply. Recent advances in the low power VLSI design and CMOS technology have reduce the power consumption of the micro system nodes to tens to hundreds of microwatts. Therefore, to scavenge and transform the energy in the environment into electricity becomes feasible power source.

This thesis presents an electrostatic vibration-to-electric energy converter based on the MEMS technology. The device contains a vibration driven variable capacitor that can produce an AC current output from a DC voltage source. The core of the converter is the variable capacitor formed by comb fingers fabricated in an SOI wafer by the deep etching process. For a 3.3 V supply voltage and $1cm^3$ chip size constraints, optimal design parameters were found from theoretical calculation and Simulink simulation. In the current design, the calculated output power is 32.34μW (power density $29.6\mu W/cm^3$). The fabricated device has a size of $0.7\times1.2\times1.3\ cm^3$. Measurement results show that the parasitic resistance influences the characteristics of the converter, and thus the power output measurement could not be conducted. However, the mechanical characteristics were measured and discussed.

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