國立陽明交通大學

電子研究所

碩 士 論 文

Institute of Electronics

National Yang Ming Chiao Tung University

Master Thesis

具強度偵測功能的靜電放電事件偵測器電路設計以應用於製造場所靜電放電控制

Design of ESD-Event Detector with ESD Level Detection for Manufacturing Field Control

研 究 生：林子晰 (Lin, Tz-Hsi)

指導教授：柯明道 (Ker, Ming-Dou)

中 華 民 國 一一三 年 三 月

March 2024

具強度偵測功能的靜電放電事件偵測器電路設計

以應用於製造場所靜電放電控制

Design of ESD-Event Detector with ESD Level Detection for Manufacturing Field Control

研 究 生：林子晰　　Student: Tz-Hsi Lin

指導教授：柯明道教授　　Advisor: Prof. Ming-Dou Ker

國 立 陽 明 交 通 大 學

電子研究所

碩 士 論 文

A Thesis
Submitted to
Institute of Electronics
College of Electrical and Computer Engineering
National Yang Ming Chiao Tung University
in Partial Fulfillment of the Requirements
for the Degree of
Master of Science
in
Electronics Engineering

March 2024
Hsinchu, Taiwan, Republic of China

中 華 民 國 一一三 年 三 月

具強度偵測功能的靜電放電事件偵測器電路設計以應用於製造場所靜電放電控制

研究生：林子晰　　指導教授：柯明道 教授

國立陽明交通大學

電子研究所

摘要

近年來，IC 和半導體製造廠對於靜電放電監控引起了廣泛關注。在這些場合，天線和示波器通常被用來測量靜電放電時產生的輻射電磁場，以監測工廠中的靜電放電事件。這促使提出一個靜電放電事件偵測器的構想，旨在能夠快速且準確地辨識天線測量到的瞬態電壓波形，不僅能檢測事件的發生與否，還能測量事件的大小。

在這份論文中，設計了一種利用天線收集訊號的靜電放電事件偵測器，並在單晶片中實現。這款偵測器可用於監測並發出警報，以應對 IC 製造環境中的靜電放電事件。

該靜電放電事件偵測器通過檢測訊號的峰對峰值幅度和持續時間，確定天線訊號是否為靜電放電所產生的脈衝。它包括對數放大器、電壓緩衝器、快閃式數位類比轉換器和時間鑑別器。對數放大器的操作頻率設計在 DC 到 450 兆赫，解調天線訊號的峰對峰值，並使用快閃式數位類比轉換器判斷靜電放電事件的訊號強度。隨後，時間鑑別器通過訊號的持續時間識別靜電放電事件訊號。整個靜電放電事件偵測器採用 0.18-μm CMOS 製程，整合在單晶片中，總面積為 968 × 723 平方微米，並在 1.8 伏特電源下操作，耗能為 4.43 毫瓦。

在實地測試中，該偵測器成功檢測到由靜電槍、人體放電模式（HBM）測試儀或電場感應元件充電模式（CDM）測試儀產生的高頻瞬態訊號。透過這款靜電放電事件強度偵測器，一個偵測系統被提出，透過 Arduino 開發版將偵測器輸出的訊號即時上傳到雲端，使使用者能夠在任何地方透過網路實時監控靜電放電事件。

總結而言，本文提出的靜電放電事件檢測器在 IC 和半導體製造工廠中能夠提供實時的靜電放電監控。透過測得的靜電放電事件大小，該系統能夠提供即時且適當的回饋，以應對不同程度的事件。

關鍵詞/字 — 靜電放電事件強度偵測器、對數放大器、快閃式數位類比轉換器、靜電放電電磁場

Design of ESD-Event Detector with ESD Level Detection for Manufacturing Field Control

Student: Tz-Hsi Lin Advisor: Prof. Ming-Dou Ker

Institute of Electronics
National Yang Ming Chiao Tung University

Abstract

In recent years, there has been widespread attention to electrostatic discharge (ESD) monitoring in integrated circuits (IC) and semiconductor manufacturing plants. In such scenarios, antennas and oscilloscopes are widely used to measure electromagnetic radiation produced during electrostatic discharge, enabling the monitoring of ESD events in factories. This prompted the conceptualization of an ESD-event detector designed to rapidly and accurately identify transient voltage waveforms received by antennas, not only detecting the occurrence of events but also measuring their magnitude.

In this paper, an ESD-event level detector is designed, utilizing antennas to collect signals. This detector can be used to monitor and issue alerts to address ESD events in IC manufacturing environments. The ESD-event level detector determines whether the antenna signal is a pulse generated by ESD by detecting the peak-to-peak voltage and duration of the signal. It includes a logarithmic amplifier, voltage buffer, flash analog-to-digital converter (ADC), and time discriminator. The logarithmic amplifier's operating frequency is designed to be in the range of DC to 450 MHz, demodulating

the antenna signal's peak-to-peak value and using the flash analog-to-digital converter to determine the signal strength of electrostatic discharge events. Subsequently, the time discriminator identifies ESD-event signals based on signal duration. The entire ESD-event level detector is implemented in a 0.18-μm CMOS process, integrated into a chip with a core area of only 550 × 305 square micrometers, and operates at a power consumption of 4.43 mW under a 1.8-V power supply.

During field tests, the detector successfully detected high-frequency transient signals generated by electrostatic guns, human body model (HBM) testers, or charged device model (CDM) testers. Using this ESD-event level detector, a detection system is proposed that uploads the detector's output signals to the cloud in real-time via an Arduino, allowing users to monitor ESD events from anywhere through the Internet.

In conclusion, the proposed ESD-event level detector can provide real-time ESD monitoring in semiconductor and IC manufacturing plants. Through the measured magnitude of ESD events, the system can offer timely and appropriate feedback to address events of varying magnitude.

Keywords – ESD-event level detector, logarithmic amplifier, flash analog-to-digital converter, ESD radiation field.