

國立臺灣師範大學電機工程學系

碩士論文

指導教授：林群祐 博士

積體電路在嚴苛環境下的靜電放電研究

ESD Research of Integrated Circuits under Harsh Environment

研究生：林健群 撰

中華民國 112 年 6 月

積體電路在嚴苛環境下的靜電放電研究

學生：林健群

指導教授：林群祐 博士

國立臺灣師範大學電機工程學系碩士班

摘要

本論文旨在研究不同尺寸之靜電放電防護元件及各種靜電放電防護電路受到環境因子影響，而導致之靜電放電防護能力變化。現今系統單晶片技術的蓬勃發展，在 IC 系統廠將一整個電子系統整合到單一晶片的 IC 中，因此單一顆晶片即為一個系統。在晶圓代工廠製造 IC 後，需要通過元件層級的靜電放電測試來確保 IC 元件的可靠度，而在系統組裝成產品到消費者手中，需要通過系統層級的靜電放電測試標準 (IEC 61000-4-2) 來確保產品在較潮濕或炎熱的地區不會影響消費者的體驗，因此本研究採用系統層級的靜電槍來進行實測，實測待測物在高濕及高溫環境下的靜電放電耐受度。在論文第二章以矽控整流器 (SCR) 作為靜電放電防護元件來測試環境相對濕度對待測物之影響。在論文第三章則以輸出級的靜電放電防護電路來測試環境溫度對其之影響，待測物為電源端到地的靜電放電防護電路。

依據本論文第二章及第三章的量測結果，在高溫環境下，待測物的電荷載流子遷移率會隨溫度上升而增加，當靜電槍接觸到待測物時，靜電放電會對其造成嚴重損害。在高濕環境下，待測物表面會形成一層水，這層水的表面張力會縮短靜電槍和待測物的非接觸放電距離，導致待測物的靜電放電耐受度下降。本研究對於日後需要了解環境溫度及環境相對濕度對 IC 之影響有所幫助。

關鍵字：靜電放電，系統層級的靜電放電，環境的溫度，環境的相對濕度

ESD Research of Integrated Circuits under Harsh Environment

Student : Chien-Chun Lin

Advisors : Dr. Chun-Yu Lin

Department of Electrical Engineering
National Taiwan Normal University

Abstract

This thesis is to study the effect of environmental factors on the different sizes of electrostatic discharge (ESD) protection components and various ESD protection circuits. Environmental factors will cause changes in ESD protection ability. With the rapid development of system-on-chip (SOC) technology, an entire electronic system is integrated into a single chip in an integrated circuit (IC) system factory. Thus, a single chip is a system. It is necessary to pass the component-level ESD test to ensure the reliability of the component after the chip is manufactured in the wafer foundry. The system is assembled into a product before delivering to the consumer. It needs to pass the system-level ESD test. The system-level ESD test standard, IEC 61000-4-2, ensures that the product does not affect the consumer experience in high humidity or hot regions. Therefore, this study uses a system-level electrostatic gun (ESD gun) for an actual measurement. The test is to measure the ESD robustness of the devices under test (DUT) under a high humidity and high temperature environment. Chapter 2 uses the silicon-controlled rectifiers (SCR) as ESD protection components to test the effects of ESD robustness under ambient relative humidity. In Chapter 3, the ESD protection circuit of the output stage is used to test the effects of ESD robustness under the ambient temperature. The DUT is the ESD protection circuit from the power supply (V_{DD}) to the ground (V_{SS}).

According to the measurement results in Chapter 2 and Chapter 3, the charge carrier mobility of the DUT will increase with the temperature rise under the high

ambient temperature. The ESD current will cause severe damage to it when the ESD gun contacts the DUT. A layer of water will form on the surface of the DUT under the high ambient relative humidity. The surface tension of this layer of water will shorten the air discharge distance between the ESD gun and the DUT to a certain extent. A shorter air discharge distance will lead to a decrease in the ESD robustness of the DUT. This study will help in understanding the effects of ambient temperature and ambient relative humidity on ICs.

Keywords: electrostatic discharge (ESD), system-level ESD, ambient temperature, ambient relative humidity.

