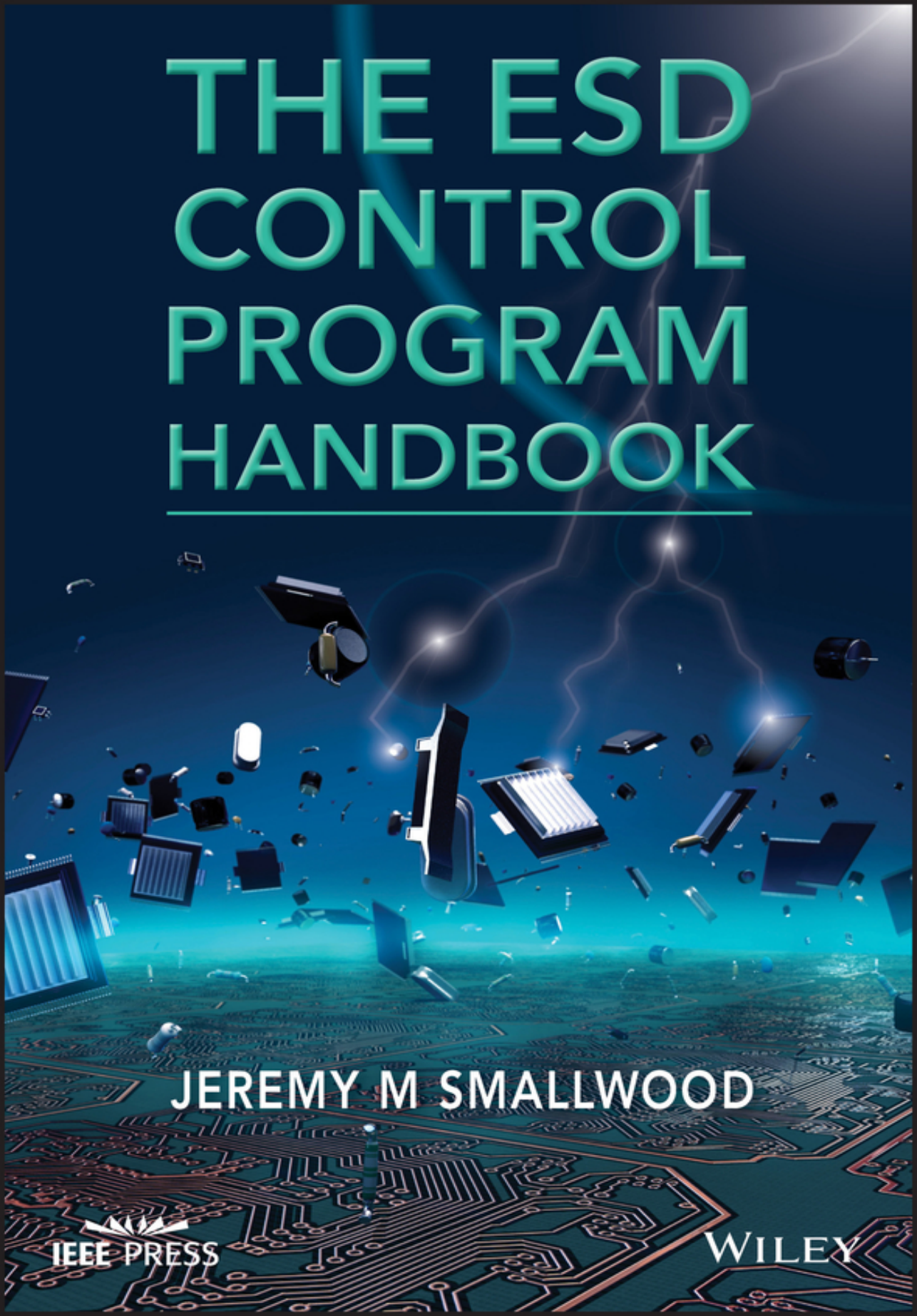
THE ESD CONTROL PROGRAM HANDBOOK



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To Jan, who has often put up with my grumpy non-communication while I've been writing this book. To Alia, now making her own life journey. To Caroline, who tragically died so young.

To the subject of electrostatics and ESD, that has kept me occupied, perplexed and challenged for many hours.

To the many people who have attended my courses and asked so many awkward questions that helped me understand while trying to explain. To my fellow ESD practitioners whose opinions and expertise give us many interesting, and sometimes heated, debates – and who mainly agree the answer to most electrostatic questions is – "it depends."

Contents

Introduction

Electrostatic discharge (ESD) can damage or destroy many types of modern electronic components, or modules or assemblies containing electrostatic discharge–susceptible (ESDS) components.

In electronics manufacturing, sensitivity to ESD became a general concern after the adoption of metal-oxide-semiconductor (MOS) transistor technology exacerbated by decreasing internal physical size of semiconductor component features and the rise of integrated circuits (ICs). The first Electrical Overstress/Electrostatic Discharge Symposium in the USA was organized in 1979 (Reliability Analysis Center 1979). The 1980 Symposium (Reliability Analysis Center 1980) shows papers on topics as diverse as theory and practice, device failure analysis studies, failure mechanisms and modeling, design of device protective networks, and implementing ESD controls, facility evaluation and effective training. Standards and technical handbooks also emerged around this time. The standards gave requirements for an ESD control program, while the technical handbooks gave technical data and tutorial material useful for educating the user and developing the ESD control program. ElectroStatic Attraction (ESA) of contaminant particles is a problem for manufacturers of semiconductor devices and displays. For operating electronic systems, ESD provides a source of electromagnetic interference (EMI) that can result in system crash, malfunction or data corruption.

Thus, the issues of ESD in electronic components and systems give two areas of interest. Issues of ESD control during electronic component, assembly and system manufacture are largely concerned in preventing damage in the unpowered non-operational state and ensuring that product reaches the customer in good condition without compromise to appearance or reliability. This area can itself be further subdivided into

- Electrostatic and ESD issues affecting product yield and quality during semiconductor wafer scale fabrication
- ESD issues affecting product yield and quality during component, assembly and system manufacture and assembly, sometimes known as “factory issues”
- Design of semiconductor devices to withstand ESD up to target levels

ESD interference and damage during working electronic system operation is generally viewed as part of ElectroMagnetic Compatibility (EMC) and the responsibility of a different

community. In some areas (e.g. Europe) electronic products are subject to ESD immunity test as part of their evaluation for fitness to be placed on the market (and qualification for CE marking) (Williams 2007).

Nevertheless, there is some overlap and often confusion between these areas. EMI caused by ESD in the manufacturing process can cause interference to product testers and lead to rejection of product and hence reduction of yield. In ESD test in EMC, ESD applied to exposed circuit connectors can lead to component or system hardware failure and may lead to requirements for ESD robustness of components that connect to the outside world.

This book is largely concerned with the development and maintenance of an ESD control program for protection of ESD susceptible components and assemblies during electronic system and assembly manufacture. This is the so-called "factory issues" area of ESD control. It is intended that the book can be used as a handbook or practical guide for personnel working in ESD control in electronics or other companies that handle unprotected ESD susceptible parts. At the same time, sufficient background information and technical explanation is given to enable the user to understand the principles and practice of effective ESD control.

Personnel working in this field can have a wide variety of technical background and do not necessarily have strong electronics or electrical understanding. Many will not have had opportunity to attend courses on ESD control other than basic ESD awareness. It is surprising that at the time of writing very few University electronics related courses offer any modules on ESD control. Conversely there are as yet few industry courses available that deal with the subject in any depth other than basic ESD awareness. Worldwide, there are still only a very few courses and qualifications available to those who wish to obtain a good grounding in the field.

So, I have attempted to present the subject with a minimum of theory to make it accessible to those who do not have a strong relevant theoretical background. This is balanced by sufficient description of background theory for understanding the material presented, with references and a bibliography of further reading for those who wish to go into the subject in greater depth. The intention is to reveal and clarify the principles behind an area often considered a mysterious "black art." In many ways, I have tried to write the book I would have liked to have found when I started learning about ESD control in the electronics industry.

A widespread current approach to development of an ESD control program is to comply with the requirements of an ESD control standard such as ANSI/ESD S20.20 or IEC 61340-5-1. It is often thought that this is sufficient to ensure that product ESD damage is brought under control. While this can be successful, if applied with insufficient knowledge it can lead to a program that is not well optimized or fails to address all the ESD threats (Smallwood et al. 2014; Lin et al. 2014). With knowledge and understanding an optimized and effective ESD control program may be achieved and maintained, often with lower costs. Nevertheless, compliance with an ESD control standard is advantageous and can help demonstrate, especially to customers, the seriousness with which ESD control is treated in the facility. Development of an ESD control program in compliance with the most widely used and respected ESD control standards 61340-5-1 and S20.20 is therefore discussed in some length. Properly specified ESD control programs compliant with these standards are held to be adequate to protect ESD sensitive devices with withstand voltages down to 100 V Human Body Model (HBM), while also addressing basic ESD risks due to charged metal objects and charged devices.