Preface

The motivation for writing this book stems from many years of involvement in the radiation effects field, as well as concerns about the applicability of conventional reliability models to long-duration space missions where component failure can potentially bring the mission to a premature end. It was also influenced by the difficulty of dealing with the wide range of materials used in compound semiconductors, as well as in understanding the very different types of electronic devices that have been developed for those materials.

Reliability and radiation effects are both important for spacecraft. Both areas are far more complex for the semiconductor technologies available today compared to those found on earlier spacecraft. This is particularly true for devices that use compound semiconductors, which have not been studied as thoroughly as those using silicon.

Reliability and radiation effects both require a knowledge of semiconductor physics and device structures that goes beyond the minimum level required for circuit design. The purpose of this book is to discuss both topics in a cohesive manner, pointing out specific areas where there are interactions between the two disciplines. The book begins with background material on semiconductor physics and devices, emphasizing topics such as heterostructures and modulation-doped field-effect transistors that are less familiar to many engineers and designers. This is followed by three chapters on reliability, starting with basic reliability concepts and models, which are then applied to specific types of compound semiconductor transistors and optoelectronics.

The last half of the book discusses radiation effects. Chapter 8 reviews radiation environments near the earth, along with a brief discussion of terrestrial radiation environments. The next chapter discusses the physical processes involved when radiation interacts with solids and semiconductors, providing the background for later chapters that discuss radiation damage in electronic and optoelectronic devices. There is a separate chapter on optocouplers because they use both silicon and compound semiconductor devices, with many different design options that influence radiation sensitivity.

The last chapter discusses the effects of single energetic particles on compound semiconductors. Although this usually produces short-duration transient effects, in some cases devices are permanently damaged by such particle strikes.

Compound semiconductors evolve rapidly, using new materials and device concepts to take advantage of the unique properties of the many different materials that are available to improve device performance. Although this is beneficial from the standpoint of performance, it increases the difficulty of writing a book of this type. Hopefully the emphasis on the underlying physics and mechanisms will make it useful for many years, providing the background and level of understanding that is needed to apply the disciplines of reliability and radiation effects to more advanced devices.