

Preface

Silicon carbide (SiC) has emerged as a uniquely versatile semiconductor material, extending far beyond its established role in high-power electronics. In addition to its exceptional electrical, thermal, and mechanical properties, SiC hosts optically addressable point defects, most notably silicon vacancies, that exhibit remarkable quantum behaviour. These quantum defects enable applications in quantum sensing and communication, spin-based information processing, and photonic devices, while the intrinsic stability and reliability of SiC make it particularly attractive for operation in extreme environments characterised by high temperature, intense radiation, and severe electrical stress. This combination of material durability and quantum functionality places SiC at the forefront of both advanced electronics and emerging quantum technologies.

This special edition explores the broad spectrum of phenomena that govern the performance, reliability, and functionality of SiC-based devices under demanding conditions. The volume addresses fundamental topics such as the electrical and optical properties of SiC, quantum defects in the form of silicon vacancies and divacancies, and techniques of optical and electrical measurements used to characterise defect states relevant to quantum sensing and light-emitting applications. Device structures including SiC MOSFETs, trench SiC MOSFETs, CMOS circuits, tunnelling diodes, PIN diodes, Zener diodes, and operational amplifiers are examined to illustrate the diversity of technologies enabled by this wide-bandgap semiconductor.

A major focus of the book is the interaction between radiation and semiconductor devices. In this regard, device structures including SiC MOSFETs, trench SiC MOSFETs, CMOS circuits, tunnelling diodes, PIN diodes, Zener diodes, and operational amplifiers are examined. High dose-rate irradiation effects are discussed in relation to gate oxide degradation, threshold voltage instability, channel-length-dependent instability, dopant contamination, and device failure mechanisms such as single-event burnout. Particular attention is given to radiation tolerance, resistance degradation, and long-term reliability, which are critical for applications SiC devices in space systems, nuclear instrumentation, defence electronics, and high-energy physics.

Technology Computer-Aided Design (TCAD) and simulation methods are presented as indispensable tools for understanding physical phenomena, predicting device degradation, and implementing radiation-hardening design strategies.

This edition provides a comprehensive framework for developing robust SiC devices capable of operating in both quantum applications and harsh radiation environments.

We hope the presented research results will serve as a valuable resource for researchers, engineers, and graduate students working at the intersection of wide-bandgap semiconductors, quantum technologies, and radiation-hardened electronics. The contributions collected here demonstrate the extraordinary potential of SiC to support future advances in sensing, computation, energy conversion, and electronics designed for the most demanding operational conditions.