Preface

The GaN-based materials system has provided over a decade of surprises, from the initial breakthroughs with visible light-emitting diodes (LEDs) to laser diodes, solar-blind ultraviolet (UV) detectors to microwave power electronics and then to solid-state UV light sources and white lighting. Even recently, the bandgap of InN was determined to be closer to 0.7 eV rather than the value of 1.9 eV accepted for many years. The areas mentioned above have been extensively covered in other books and in the literature. The purpose of this volume is to cover some of the newer areas of research and development for GaN, such as sensors, megawatt electronics, and gate dielectrics for transistors and spin-transport electronics (or spintronics), along with advances in processing of the material. GaN-based visible LEDs and laser diodes are already commercialized for a variety of lighting and data storage applications. This materials system is also showing promise for microwave and high-power electronics intended for radar, satellite, wireless base stations, and utility grid applications, for biological detection systems, and for a new class of spintronics in which the spin of charge carriers is exploited. The explosive increase in interest in the AlGaInN family of materials in recent years has been fueled by the application of blue–green–UV LEDs in full-color displays, traffic lights, automotive lighting, and general room lighting using so-called white LEDs [1]. In addition, blue–green laser diodes can be used in high storage-capacity digital versatile disks (DVDs) systems. AlGaN-based photodetectors are also useful for solar-blind UV detection and have applications as flame sensors for control of gas turbines or for detection of missiles. There are currently major development programs in the United States for three newer applications for GaN-based materials and devices, namely:

i. UV optical sources capable of operation down to 280 nm for use in airborne chemical and biological sensing systems, allowing direct multi-wavelength spectroscopic identification and monitoring of UV-induced reactions.
ii. Power amplifiers and monolithic microwave integrated circuits (MMICs) for use in high-performance radar units and wireless broadband communication links and ultra-high-power (>1 MW) switches for control of distribution on electricity grid networks.

iii. Room-temperature, ferromagnetic semiconductors for use in electrically controlled magnetic sensors and actuators, high-density, ultra-low-power memory and logic, spin-polarized light emitters for optical encoding, advanced optical switches and modulators, and devices with integrated magnetic, electronic, and optical functionality. There is currently a lot of interest in the science and potential technological applications of spintronics, in which the spin of charge carriers (electrons or holes) is exploited to provide new functionality for microelectronic devices. The phenomena of giant magnetoresistance and tunnelling magnetoresistance have been exploited in all-metal or metal–insulator–metal magnetic systems for read/write heads in computer hard drives, magnetic sensors, and magnetic random access memories. The development of magnetic semiconductors with practical ordering temperatures could lead to new classes of device and circuits, including spin transistors, ultra-dense non-volatile semiconductor memory, and optical emitters with polarized output.

In addition, there is increasing interest in use of GaN-based structures for increasing the sensitivity, selectivity, and reliability of sensor devices while keeping their fabrication at low cost. There is still a lack of fundamental understanding of the physical/chemical/biological phenomena at the origin of the sensing mechanism in most cases. The GaN has potential for chemical sensors and field effect transistor (FET) devices, magnetic sensors, radiation sensors, acoustic sensors, mechanical sensors, and biosensors.

It is hoped that this volume will prove useful to researchers entering these new areas.

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Gainesville, Florida, USA

Stephen J. Pearton
Cammy R. Abernathy
Fan Ren

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