Preface

This book, entitled Silicon Light Emitting Diodes and Lasers, reviews the use of an indirect transition-type semiconductor to construct light emitting devices, which has not been possible with conventional methods employed in materials science and technology. Silicon (Si) and related crystals, which are typical popular indirect transition-type semiconductors, are considered here. The light emitting devices that are examined are light emitting diodes (LED) and diode lasers.

These devices can be fabricated using dressed photons (DPs) and dressed-photon–phonons (DPPs) via a novel method known as DPP-assisted annealing. Besides the fabrication step, DPs and DPPs are also used in the operation of the fabricated device. It should be pointed out that the fabricated devices exhibit a novel and unique property called "photon breeding", which originates from the DPs and DPPs. In photon breeding, the photon energy and photon spin of the light emitted from the device are identical to those of the light that irradiates the crystal during the DPP-assisted annealing. Due to this unique property, which is based on novel fabrication and operation principles, it would be appropriate to call this novel device "the third light source", after LEDs and lasers. More concretely, it should be called "a photon breeding device", as represented by the subtitle of this book, Photon Breeding Devices using Dressed Photons.

In order to review the fabrication and operation of photon breeding devices, Chap. 1 surveys the problems with conventional LEDs and lasers (the first and second light sources) and presents solutions that can be achieved by utilizing DPs and DPPs. After presenting definitions of the DP and the DPP, the photon breeding phenomenon is reviewed. Chapter 2 describes the fabrication and operation of a visible LED using Si crystal. Chapter 3 describes those of an infrared LED using Si crystal. In the same chapter, the spatial distribution of the dopant atoms is analyzed, and a description is given of how to control the polarization of the emitted light. Chapter 4 discusses the strength of the phonon coupling, the contribution of multimode coherent phonons, and how to control the light emission spectral profile. Chapter 5 reviews infrared lasers using Si crystal, demonstrating a low threshold current density and a high output power. Chapter 6 surveys LEDs fabricated using

SiC crystal, which is also an indirect transition-type semiconductor. Emission of visible, ultraviolet, and broad-spectrum light is also demonstrated. The first half of Chap. 7 is devoted to LEDs using GaP crystal, an indirect transition-type semiconductor, and the second half is devoted to LEDs using ZnO crystal. Finally, Chap. 8 reviews three examples of other novel photon breeding devices. The first is an optical and electrical relaxation oscillator, and the second is an infrared photodetector with optical amplification, which have been fabricated using Si crystal. The last is a novel optical polarization rotator, using ZnO crystal and also SiC crystal. Appendices A—E are devoted to reviewing details of the features of DPs and relevant phenomena.

Photon breeding devices using Si and other crystals are expected to bring about a major paradigm shift in the design, fabrication, and operation of photonic devices and their applications. This book will provide scientific and technical information on these devices to scientists, engineers, and students who are and will be engaged in this field.

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