The laser diode has proved to be an enduring device. Whilst at the most fundamental level its operation is very simple, using a two-level transition normally within a p–n junction, the device has proved to be complex to develop. As a result, despite being invented not long after the first laser, room-temperature continuous-wave operation took several years to develop and robust single-mode operation was only achieved using distributed feedback structures yet later.

Since then, a large number of variants of the basic laser diode structure have been developed. A wide range of materials has been used to enable lasing action across a range of wavelengths and the use of quantum wells and dots within active regions has generated many technological advances. Advanced laser structures have been developed for ensuring high-performance laser diode operation in terms of spectral and beam quality of the laser output. A key feature of the diode laser is its ability to allow high-speed direct modulation and, hence, a range of structures has been developed to allow both short-pulse and high-frequency modulation.

The result of this period of development is that laser diodes now find widely varying applications. They are the dominant optical sources in optical communications and storage and are increasingly being used in sensing and in high-power applications.

A full treatment of the laser diode must consider many aspects and, hence, in this section, following a treatment of the basic principles of the device, chapters concentrate on spectral control in laser diodes and their high-speed and high-power operation. Special attention is then given to laser devices able to operate in the red, in the blue and at long wavelengths, where unipolar devices have been demonstrated. Finally, advanced laser diode devices, able to carry out signal-processing functions, are reviewed and novel silicon-based diode lasers are described.