Chapter 12
PHOTONIC AND OPTOELECTRONIC INTEGRATED CIRCUITS

12.1 INTRODUCTION
During the late 1980s and early 1990s, there has been a significant number of developments in the technology of optical and electronic integration of semiconductor lasers and other related devices on a single chip. These chips allow higher levels of functionality than that achieved with single devices. For example, lasers and electronic drive circuits have been integrated, serving as simple monolithic lightwave transmitters. Similarly, optical detectors have been integrated with amplifier circuits based on field-effect transistors (FETs) or heterojunction bipolar transistors (HBTs). Such integrated devices serve as the front end of a receiver. In addition to being a technological achievement in the area of photonics, optoelectronic integration is expected to bring down the system cost. The name photonic integrated circuit (PIC) is generally used when all the integrated components are photonic devices, e.g., lasers, detectors, amplifiers, modulators, and couplers. The name optoelectronic integrated circuit (OEIC) is used when the components are a combination of photonic and electronic devices. Several review articles have been published on PICs and OIECs.¹-⁴ This chapter provides an overview of the technology involved and discusses the properties of some important integrated circuits.

12.2 PHOTONIC INTEGRATED CIRCUITS

12.2.1 Arrays
The simplest of all photonic integrated circuits are one-dimensional arrays of lasers, LEDs, or photodetectors.⁵-⁷ These devices are fabricated exactly the same way as individual devices except the wafers are not scribed to make single-device chips but left in the form of a bar. A schematic of a laser array
is shown in Fig. 12.1. Individual elements are isolated by etching V-shaped grooves between the emitters.

Arrays of lasers or LEDs can be used as sources for dense parallel optical interconnection, a technology finding application in the next generation of computing and switching systems. A necessary requirement for the array technology is low power consumption and the absence of cross talk between the individual elements of the array. The former requirement arises from the limited heat-transfer capacity of the transmitter and receiver module under typical operating conditions and environment. The power consumption problem is considerably reduced if low-threshold lasers are used. Such lasers (threshold current \( \sim 1 \) mA) have been fabricated both for the AlGaAs and the InGaAsP material systems. In both cases, the lasers have multiquantum-well (MQW) active regions, short cavity lengths and high-reflectivity facet