

Peak wavelength vs. case temperature characteristics. (a) Mode hops in the output spectrum of a single mode LD. (b) Restricted mode hops and none over the temperature range of interest (20 - 40°C). (c) Output spectrum from a multimode LD.

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Si integrano sistemi di raffreddamento termoelettrico (celle Peltier) nel package dei laser !

Other structures

Quantum well lasers

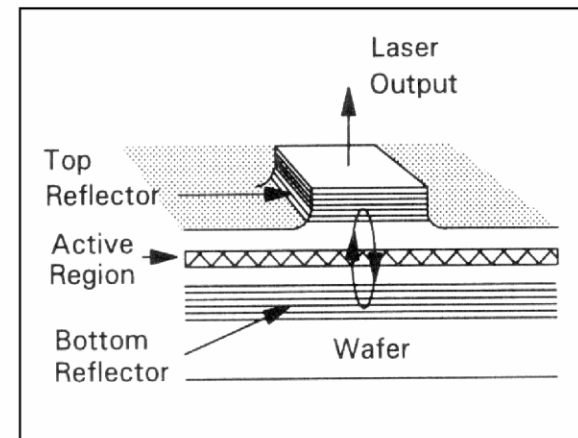
- ❖ MBE, MOCVD: thin layered structures, < 20 nm
 - ❖ Quantum mechanical phenomena start to affect the energy-level structure
 - ❖ **Quantum wells** created
 - ❖ Carriers and photons tightly confined in the active layer
 - ❖ Low threshold current and high output power

Diode laser arrays

- ❖ A single index-guided laser: $P_{\max} \sim 100 - 200$ mW
- ❖ Even more than 100 lasers may be fabricated on the same chip: $P > 10$ W
 - ✓ phases coupled \rightarrow partially coherent source
 - ✓ individual lasers may be separately modulated (in, e.g., laser printers)

Microlasers

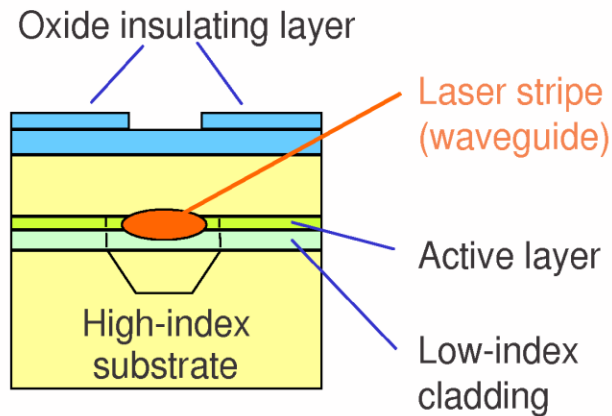
Vertical Cavity Surface Emitting Lasers (VCSEL)



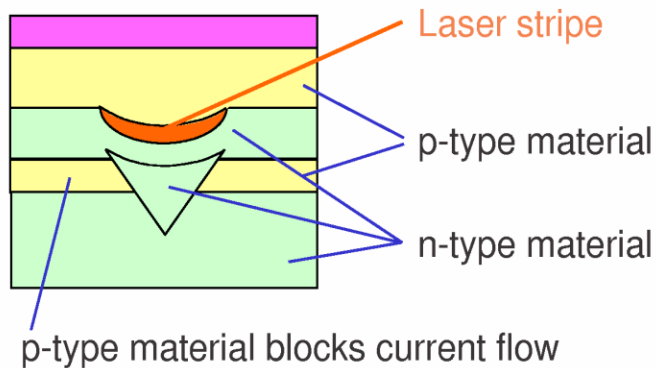
- ✓ Height a few μm
- ✓ Diameter $5 - 10 \mu\text{m}$
- ✓ 2-D arrays
- ✓ Single longitudinal mode

Examples of index-guided laser structures

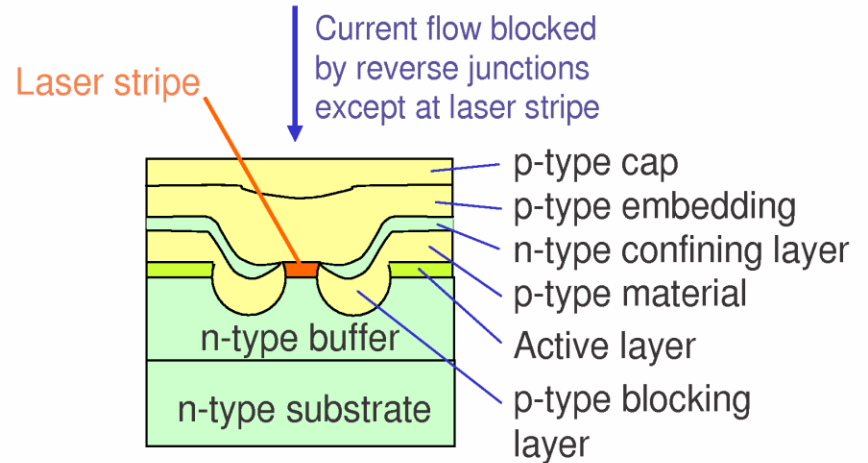
Channeled substrate planar laser



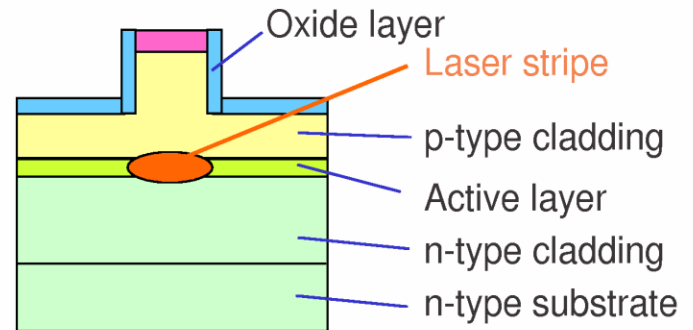
Buried crescent laser

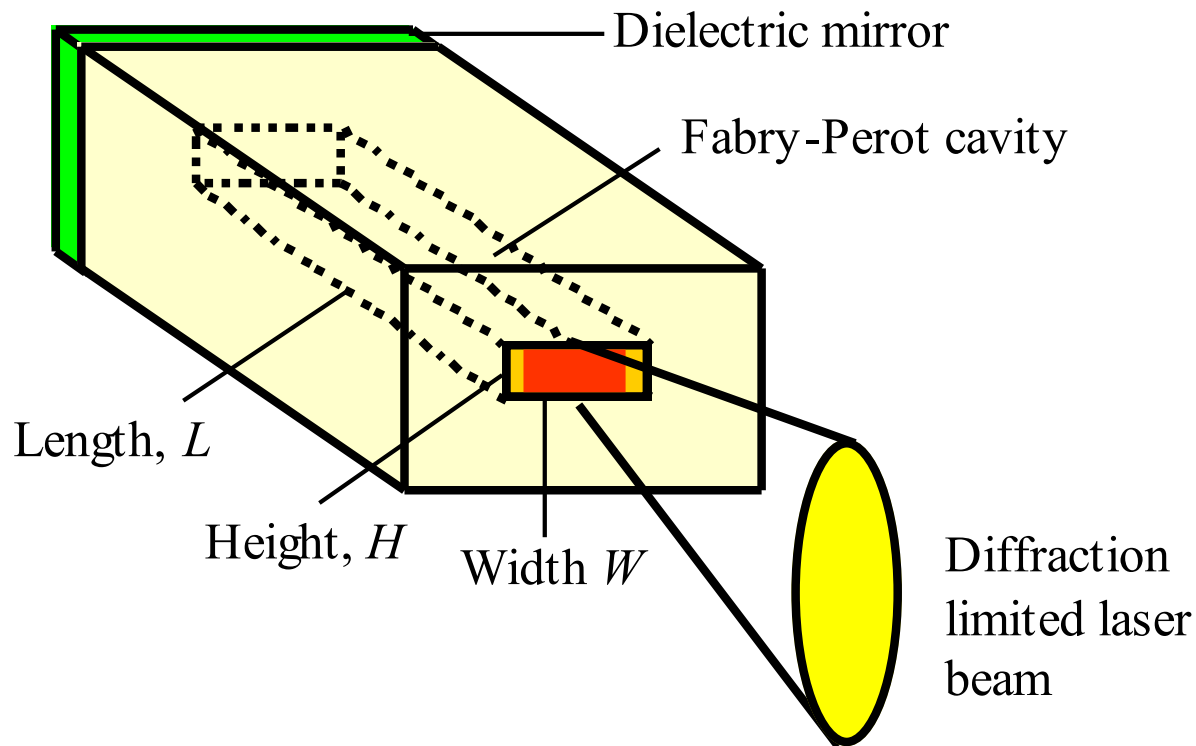


Dual-channel planar buried-heterostructure laser



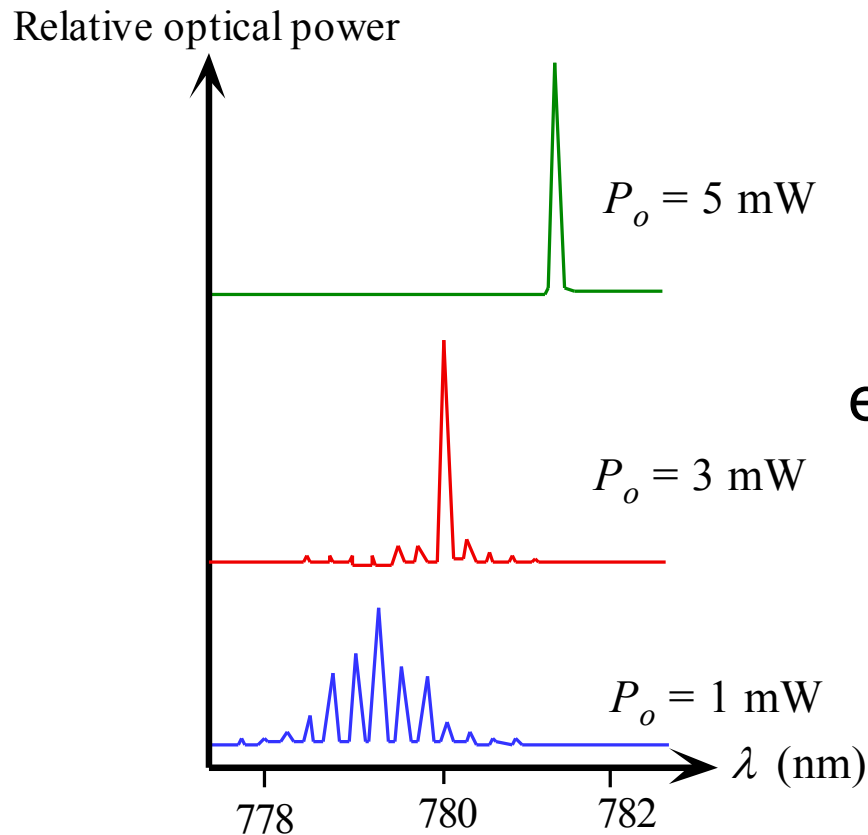
Ridge waveguide laser





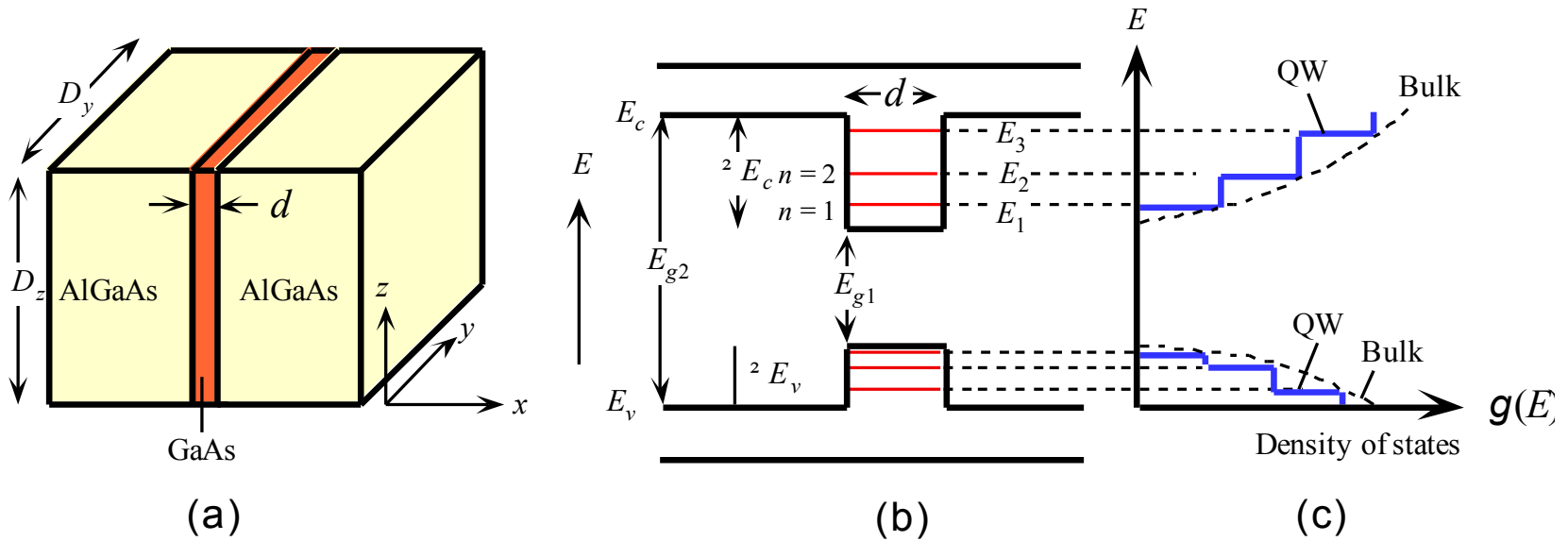
H e W definiscono i modi trasversali, L i modi longitudinali. Al diminuire di H cresce la diffrazione

The laser cavity definitions and the output laser beam characteristics.

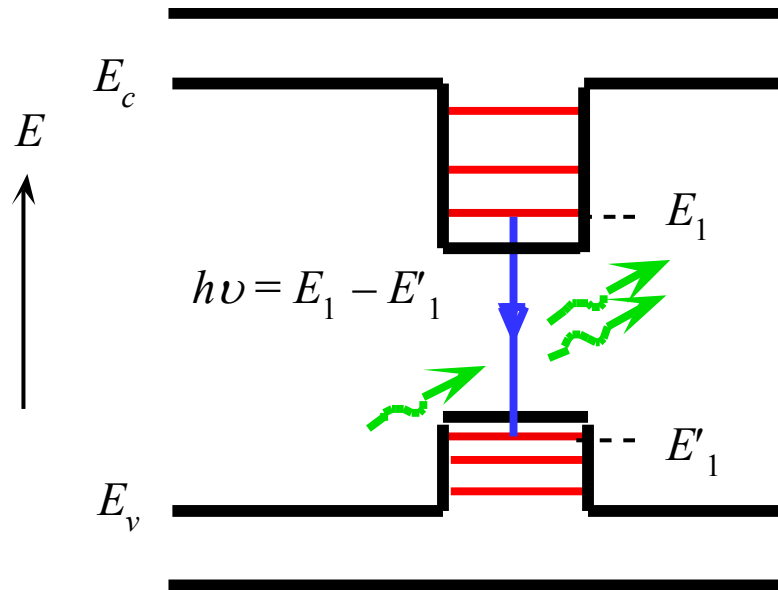


effetto del confinamento
ottico

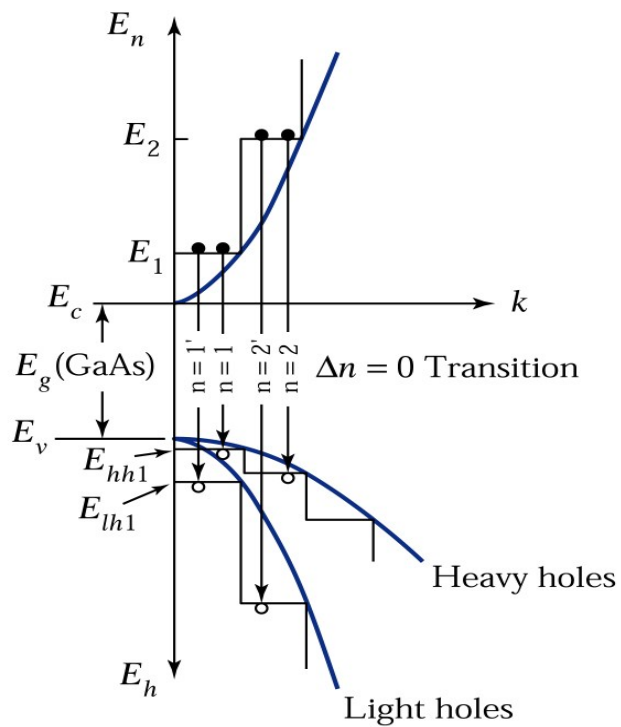
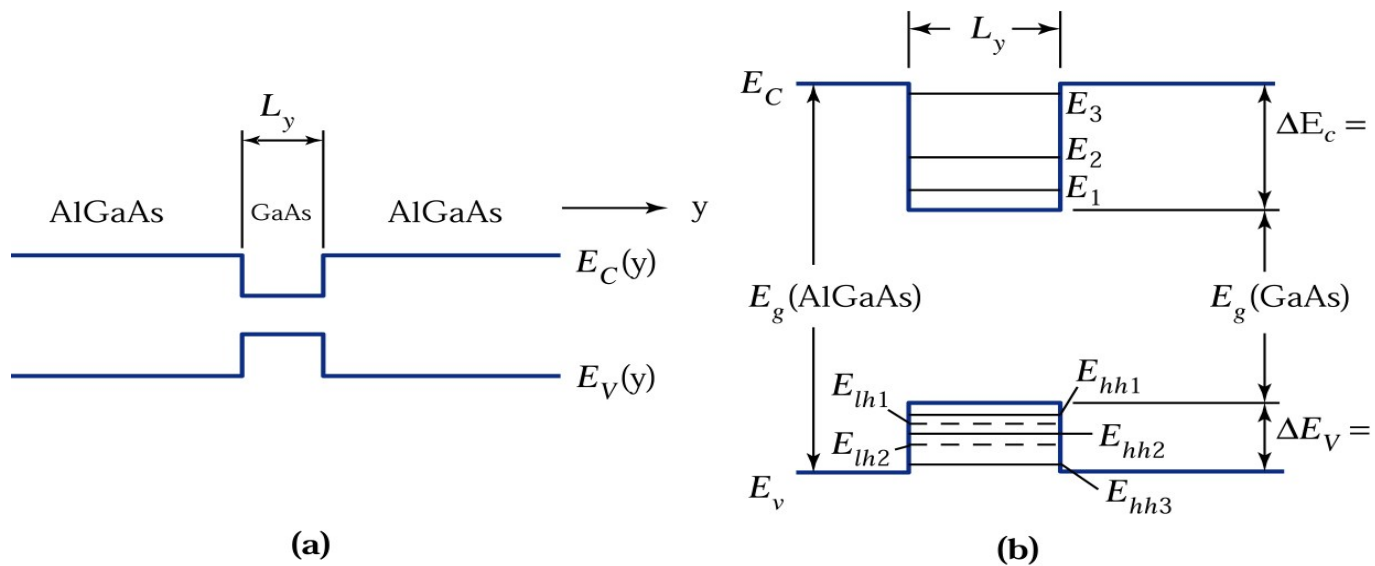
Output spectra of lasing emission from an index guided LD. At sufficiently high diode currents corresponding to high optical power, the operation becomes single mode. (Note: Relative power scale applies to each spectrum individually and not between spectra)



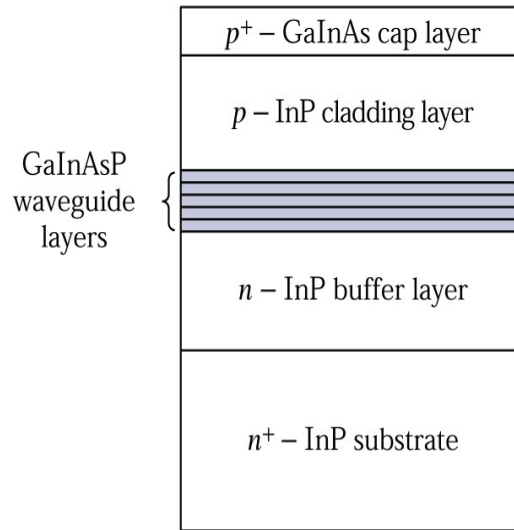
A quantum well (QW) device. (a) Schematic illustration of a quantum well (QW) structure in which a thin layer of GaAs is sandwiched between two wider bandgap semiconductors (AlGaAs). (b) The conduction electrons in the GaAs layer are confined (by ${}^2 E_c$) in the x -direction to a small length d so that their energy is quantized. (c) The density of states of a two-dimensional QW. The density of states is constant at each quantized energy level.



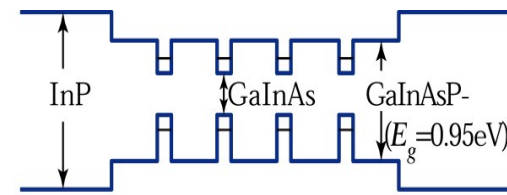
In single quantum well (SQW) lasers electrons are injected by the forward current into the thin GaAs layer which serves as the active layer. Population inversion between E_1 and E'_1 is reached even with small forward current which results in stimulated emissions.



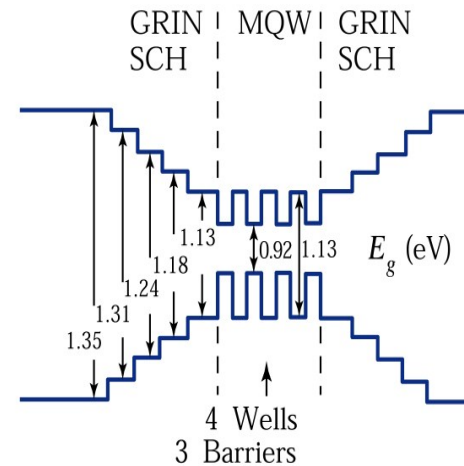
(c)



(a)

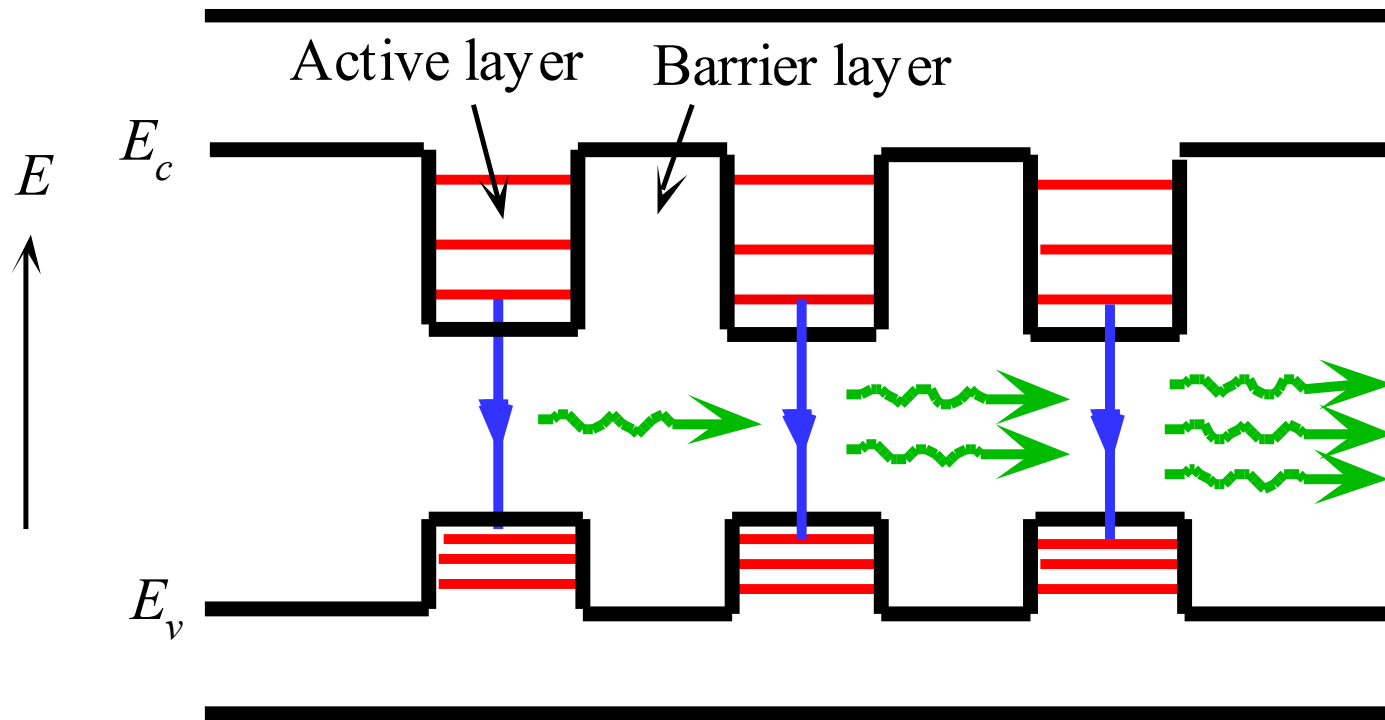


(b)



(c)

Figure 9.29. (a) Schematic of the cross-section of an GaInAs/GaInAsP multiple-quantum-well laser structure. (b) Schematic of the bandgaps of the SCH-MQW layers shown in (a). (c) GRIN-SCH-MQW structure with thin layers of increasing bandgaps to approximate the graded-index change.²⁰



A multiple quantum well (MQW) structure. Electrons are injected by the forward current into active layers which are quantum wells.

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