Single Frequency Lasers
Read: Kasip, Chapter 4
Yariv, Chapter 15,16
Coldren/Corzine Chapter 3,5
Agrawal/Dutta Chapter 6,7,8

ECE 162C

Lecture #14

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Single Longitudinal Mode Lasers

- A technique is needed to filter the gain or loss so only one mode reaches threshold.
- Possibilities:
  - Short cavity lasers
  - Coupled cavity lasers (3 or 4 mirror cavities)
  - Grating feedback
    - Distributed feedback (DFB)
    - Distributed Bragg Reflector (DBR)
    - Bulk grating (external cavity)
    - Vertical Cavity Surface Emitting Laser (VCSEL)

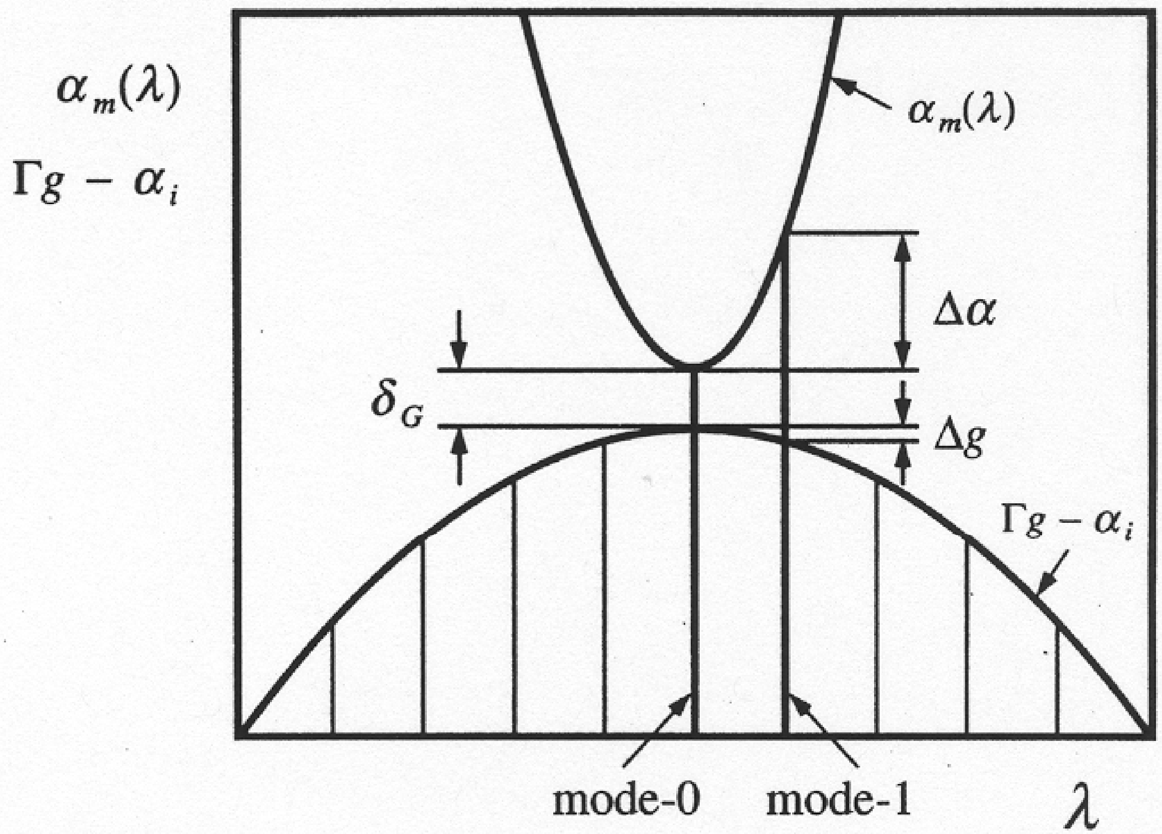
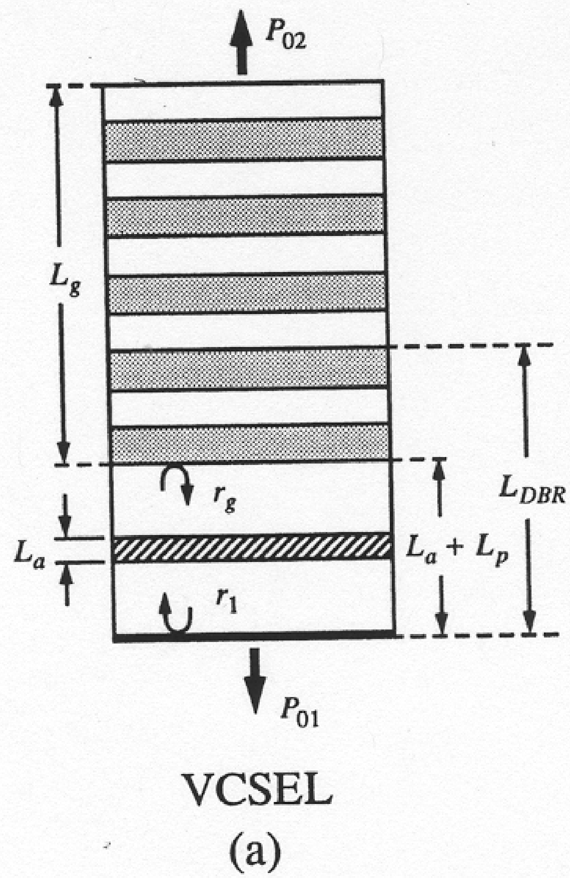


FIGURE 3.20 Definition of gain and loss margins for use in MSR calculations.

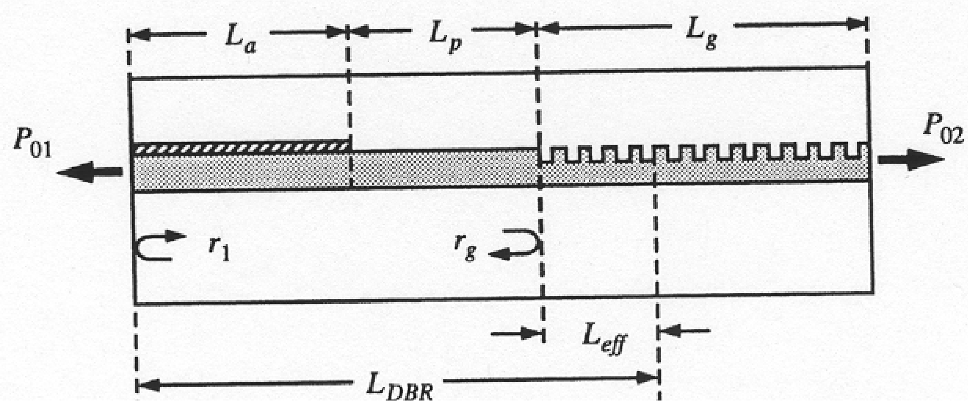
net modal gain for the main mode, $\delta_G = \alpha_m(\lambda_0) - [\Gamma g(\lambda_0) - \alpha_i]$, the loss

VCSEL



P_{02}
L_g
L_{DBR}
r_g
L_a
$L_a + L_p$
r_1
P_{01}
VCSEL
(a)

DBR



L_a
L_p
L_g
P_{01}
P_{02}
r_1
r_g
L_{eff}
L_{DBR}

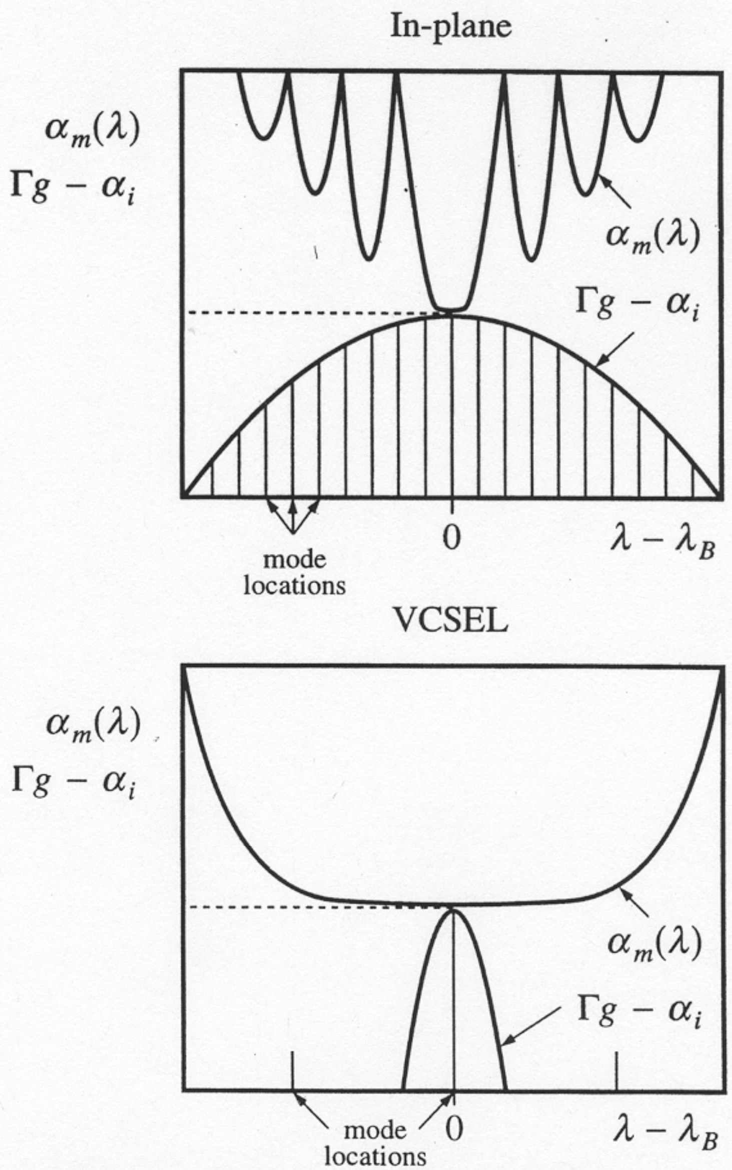


FIGURE 3.15 Schematic illustration of how a single axial mode is selected in an in-plane

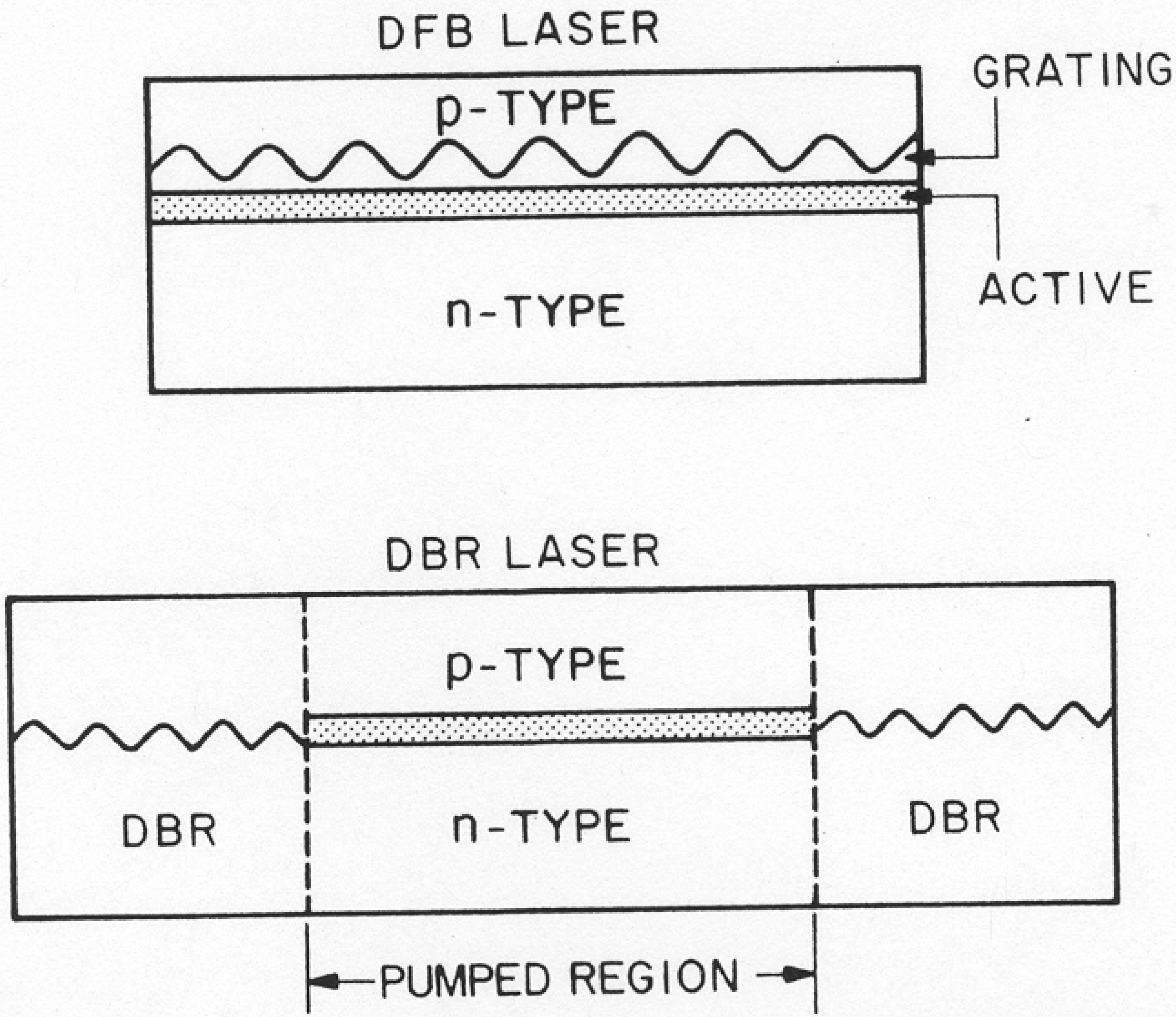
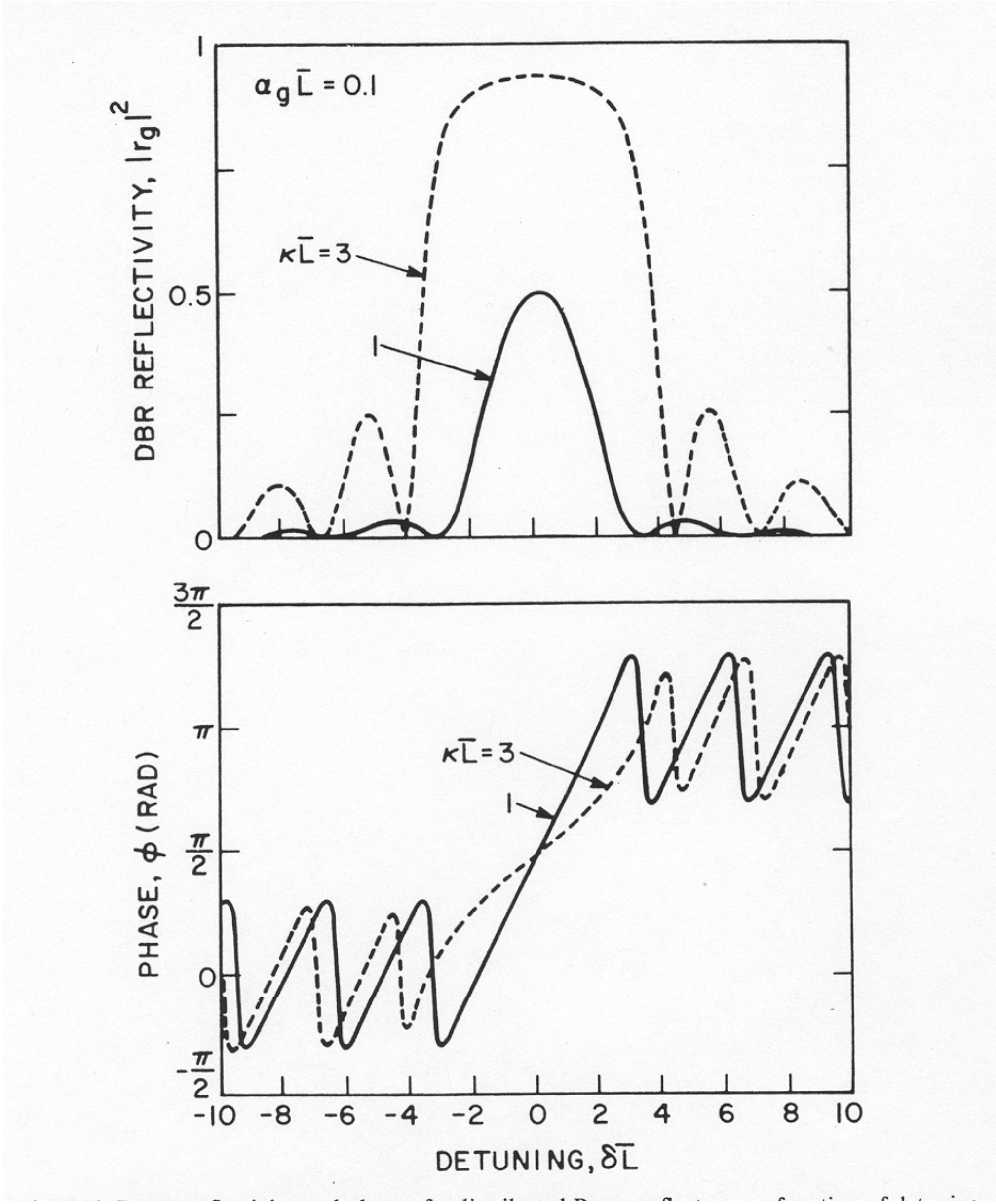
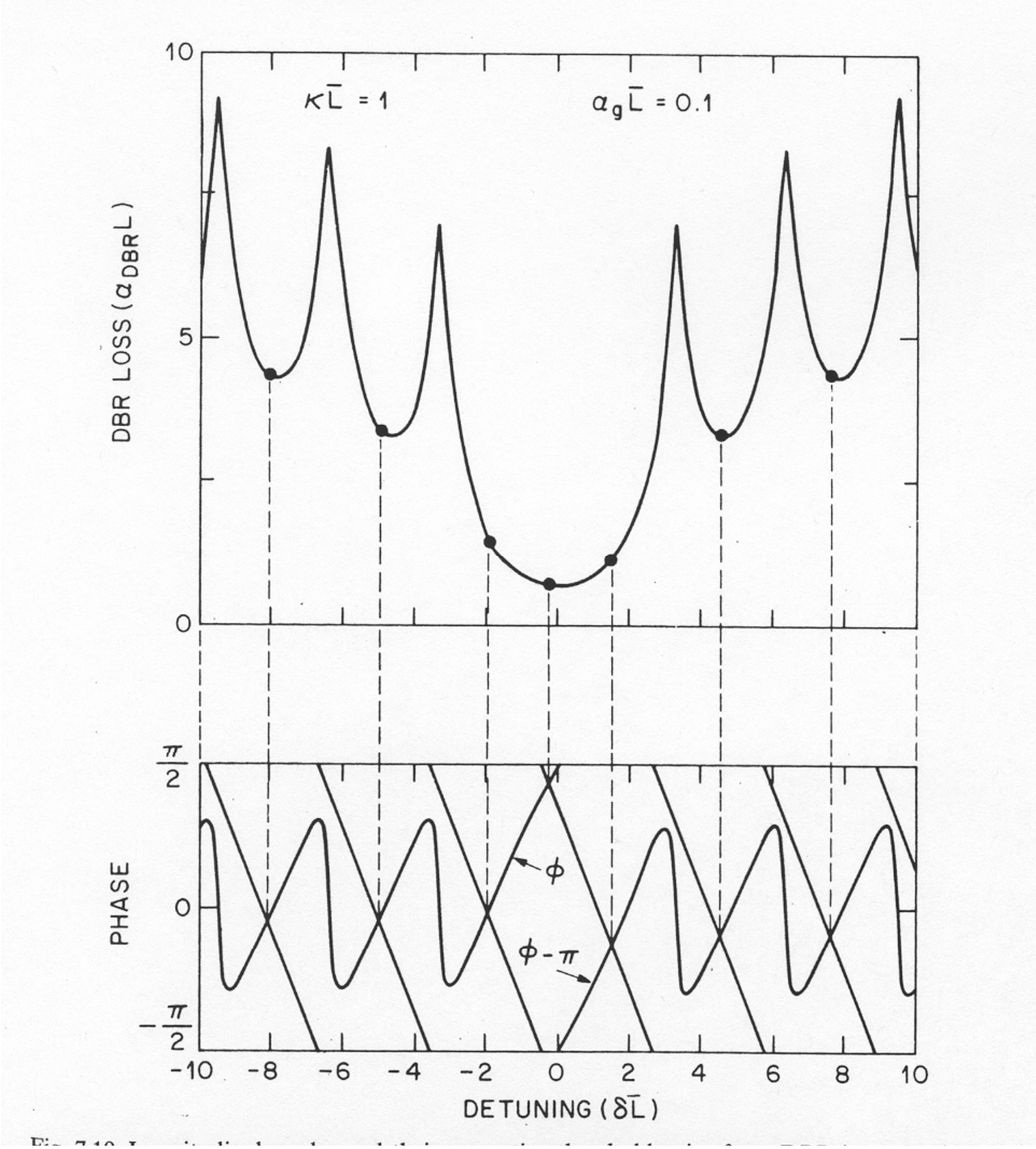


Fig. 7.1 Schematic illustration of distributed-feedback (DFB) and distributed Bragg reflector (DBR) semiconductor lasers. Different refractive indices on opposite sides of the grating result in a periodic index perturbation that is responsible for the distributed feedback. Shaded area shows the active region of the device.

DBR: Dependence on grating reflectivity



DBR: Match phase and loss



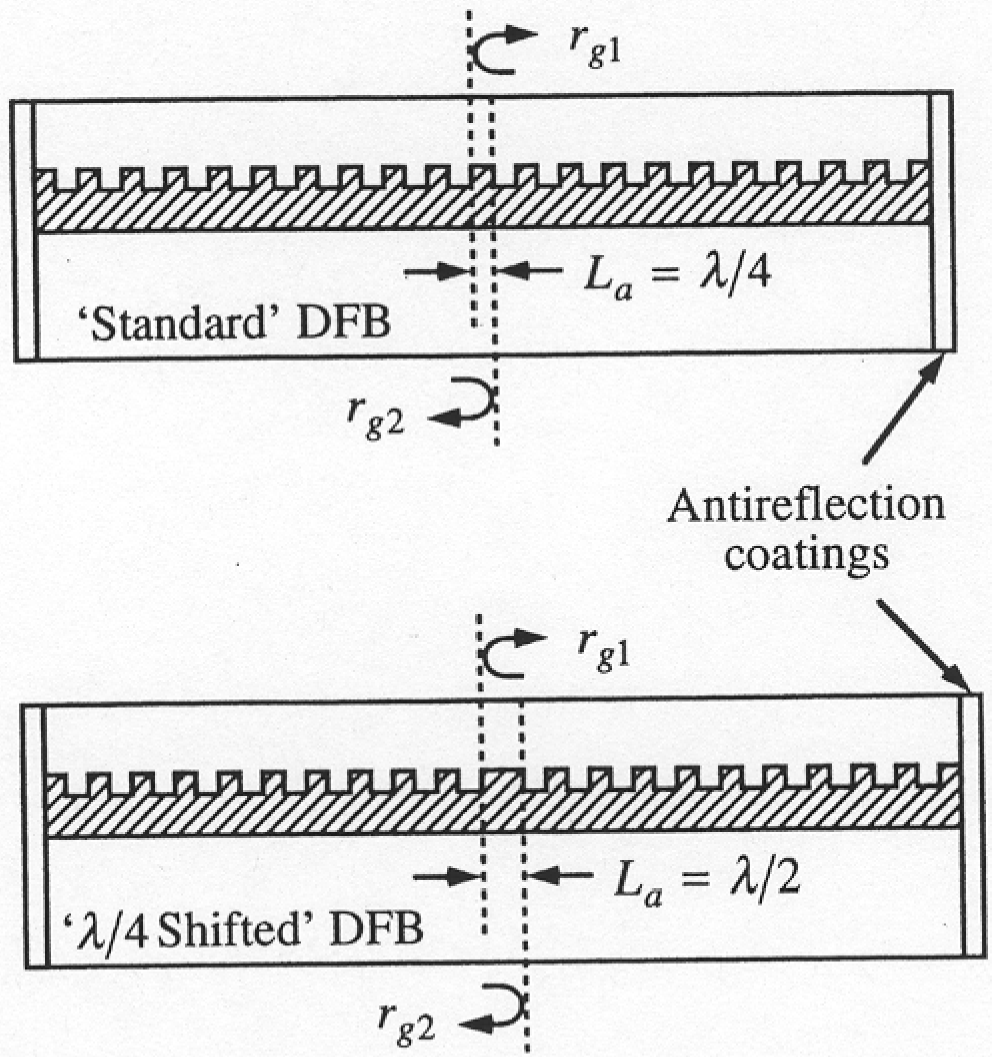
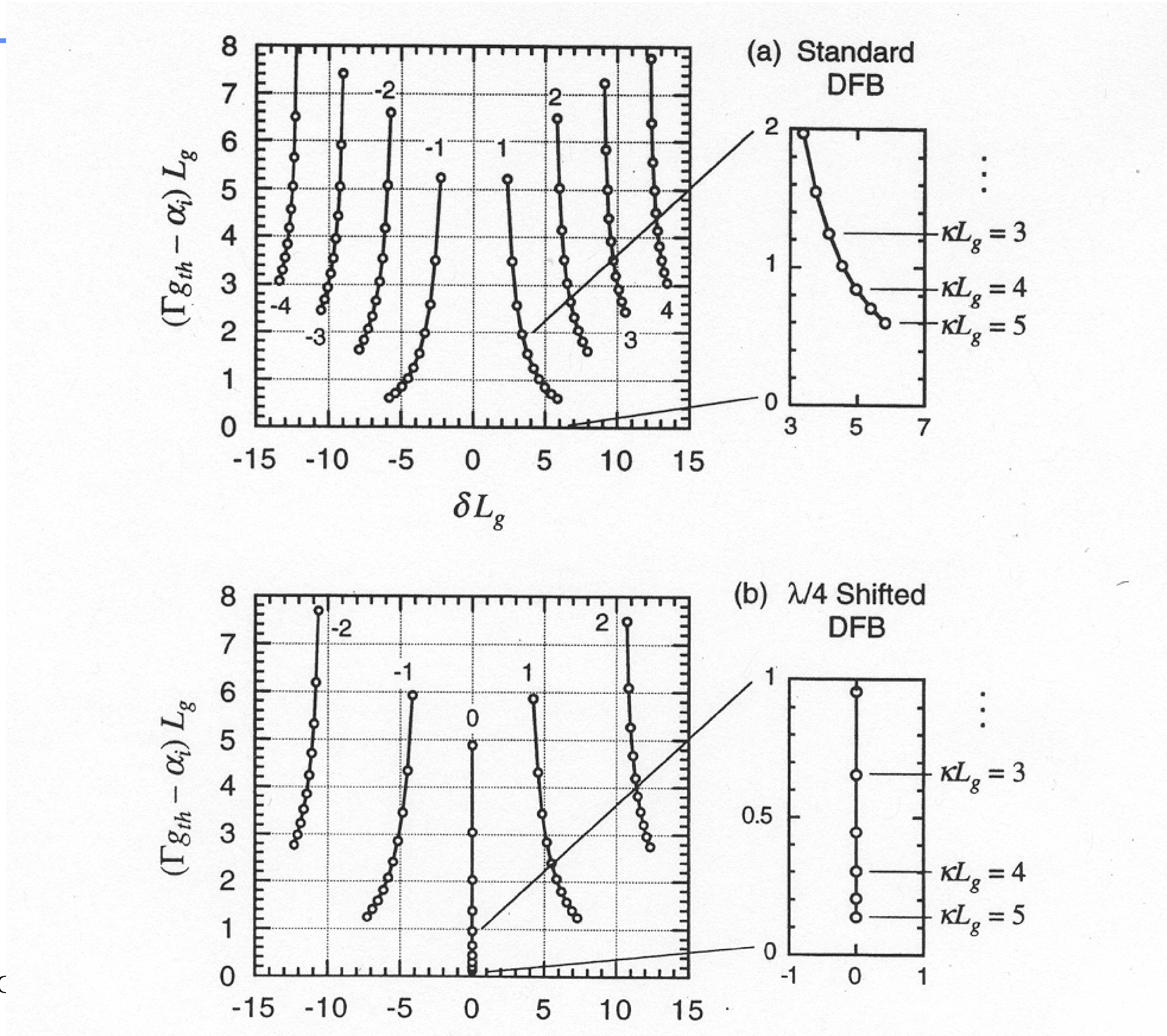
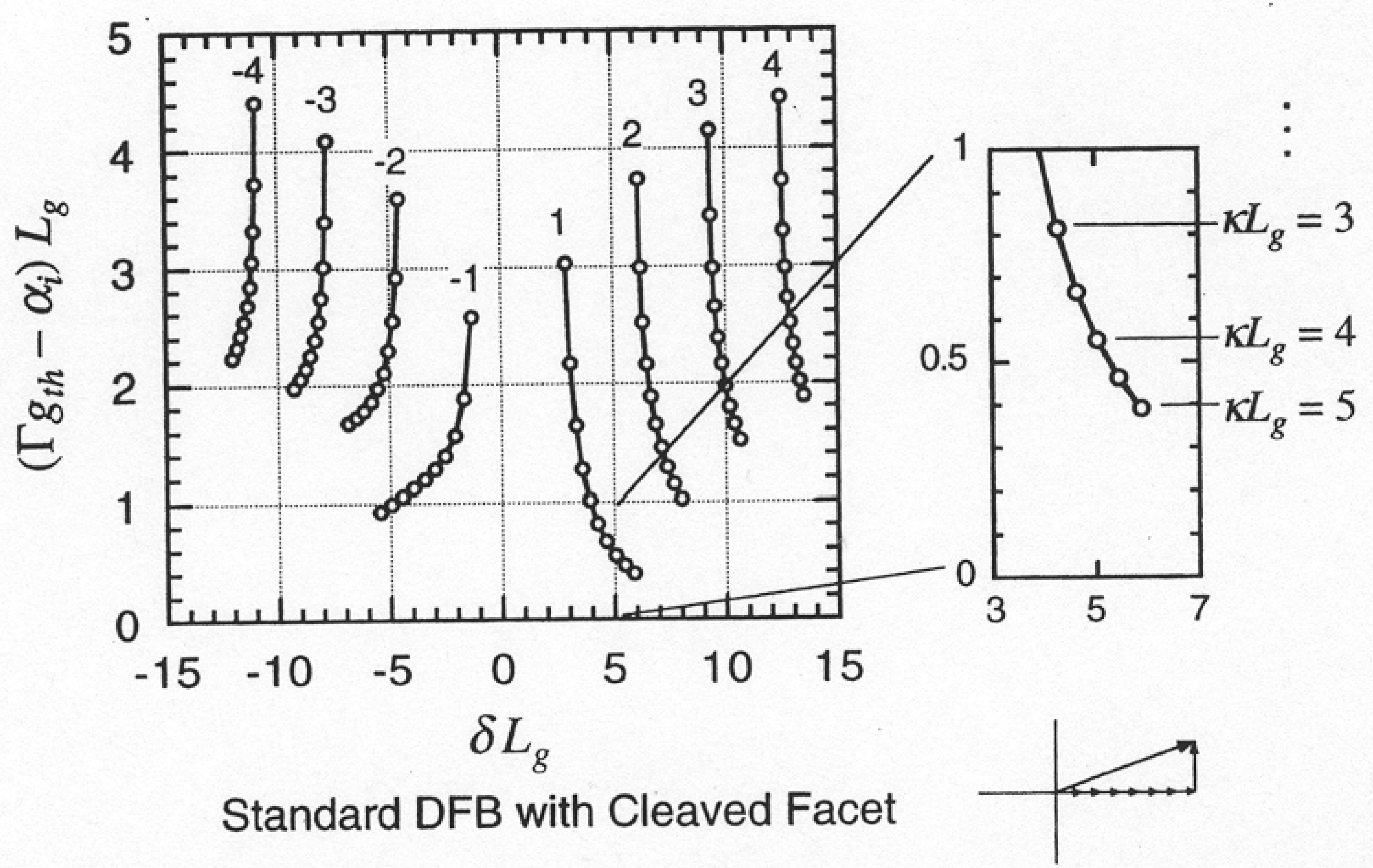


FIGURE 3.17 Standard and quarter-wave shifted DFB lasers. The entire length is filled with active material embossed with a grating.



(a) Standard DFB
$(\Gamma g_{th} - \alpha_i) L_g$
δL_g
-4
-3
-2
-1
1
2
3
4
$\kappa L_g = 3$
$\kappa L_g = 4$
$\kappa L_g = 5$
(b) λ/4 Shifted DFB
$(\Gamma g_{th} - \alpha_i) L_g$
-2
-1
0
1
2
$\kappa L_g = 3$
$\kappa L_g = 4$
$\kappa L_g = 5$

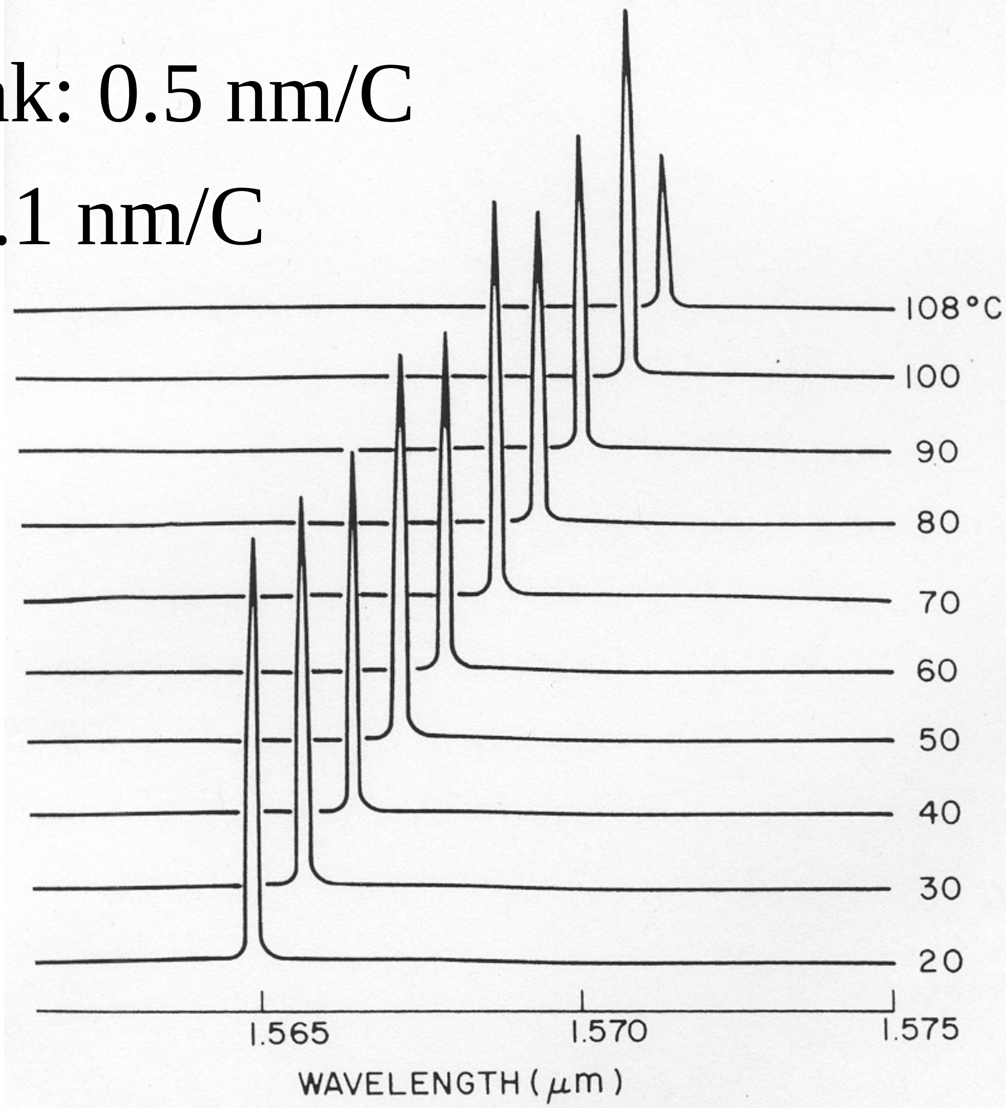


IGURE 3.19 Normalized plot of threshold modal gain and threshold wavelength for ifferent modes of a standard DFB laser with κL_g ($\equiv 2mr$) ranging from 5 to 0.5 in 0.5 ıcrements. One end of the laser is AR coated and the other end is cleaved such that he facet reflection (with a field magnitude of 0.565) is 90° out of phase with the small rating reflections (as illustrated in the lower right corner). Here $\delta = \beta - \beta_0$, where β ; the average propagation constant of the grating.

DFB Temperature Dependence

Gain peak: 0.5 nm/C

Mode: 0.1 nm/C



›ngitudinal-mode spectra of the DCPBH DFB laser shown in Fig. 7.11 at several s. The laser maintains the same longitudinal mode while its wavelength shifts

DFB Yield: Dependence on Mirror Phase

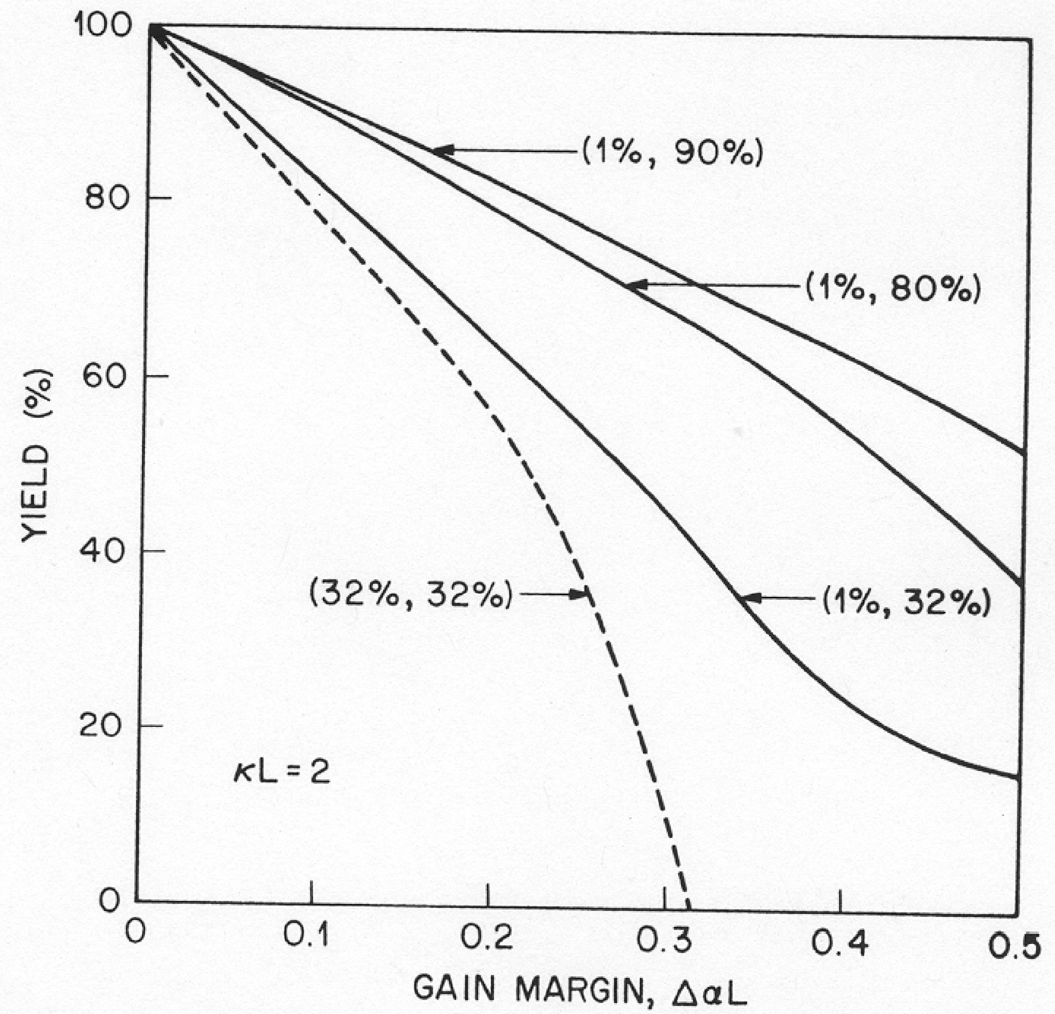
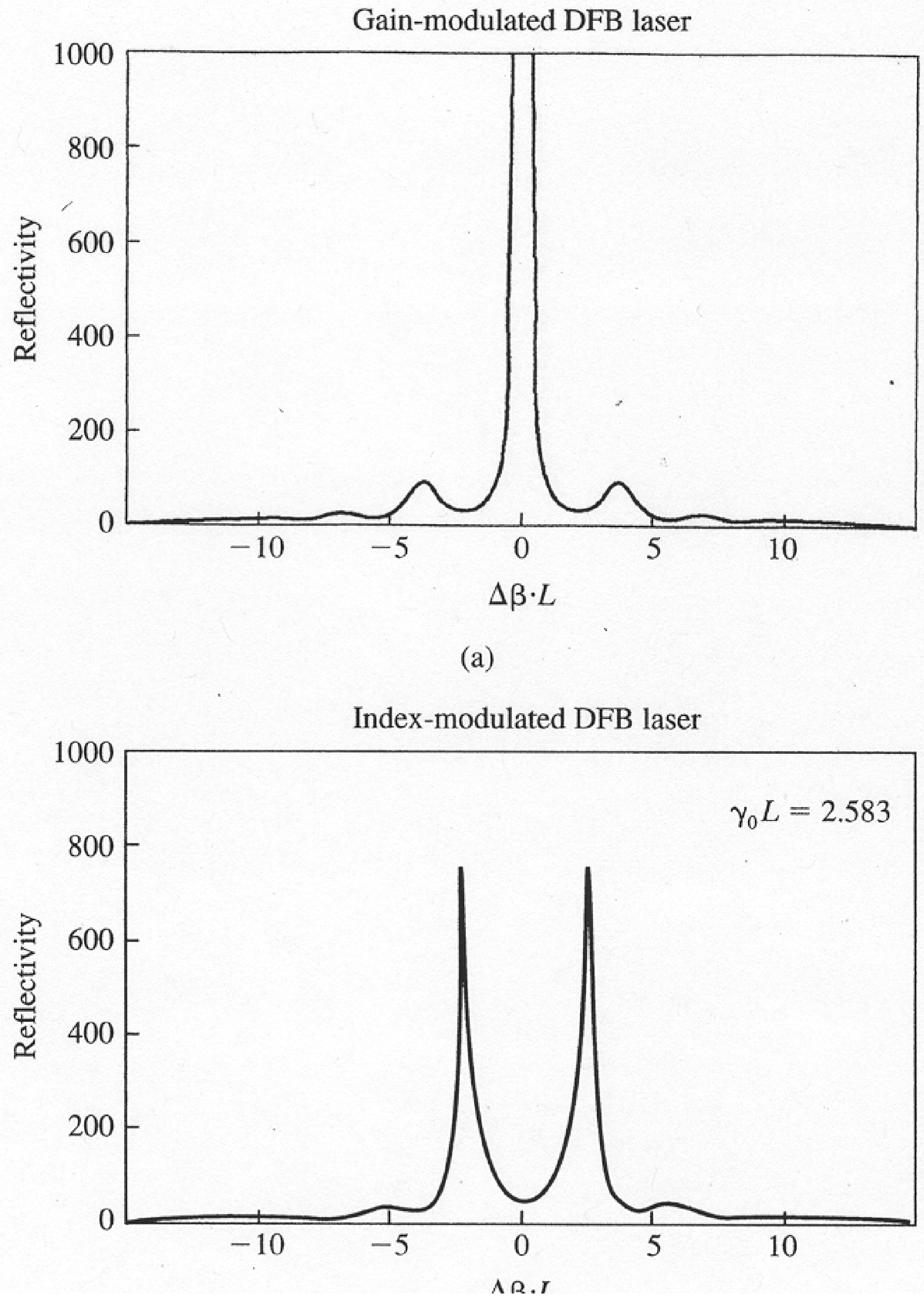


Fig. 7.13 Yield calculated for DFB lasers as a function of the gain margin $\Delta\alpha L$ for several combinations of the facet reflectivities (given in parentheses).


Gain-modulated DFB laser
1000
800
600
400
200
0
Reflectivity
−10
−5
0
5
10
Δβ·L
(a)
Index-modulated DFB laser
1000
800
600
400
200
0
Reflectivity
γ0L = 2.583
−10
−5
0
5
10

Coupled Cavity Lasers