CThM **2:30 pm–4:00 pm**
Rooms 314/315

Distributed Feedback Lasers

John Connolly, *David Sarnoff Research Center, Presider*

CThM1 [83]

First observation of changing coupling coefficients in a gain-coupled DFB laser with absorptive grating by automatic parameter extraction from subthreshold spectra

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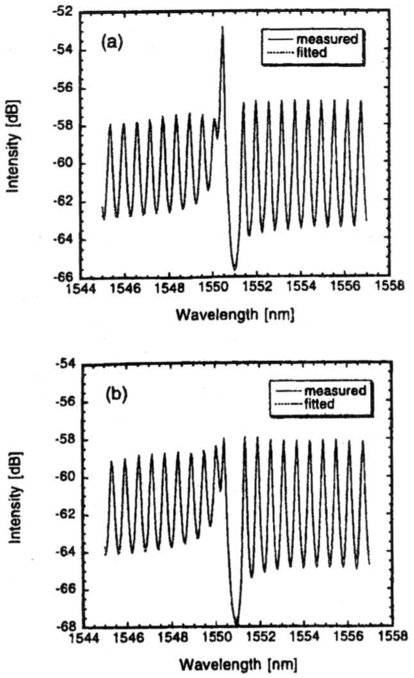
Determination of device parameters in distributed feedback (DFB) lasers is very important for optimization of laser characteristics and system design. Although the coupling coefficient is the most important parameter, its determination has only been possible in AR-coated index-coupled DFB lasers. Moreover, this is not an easy task or not very accurate if there are facet reflectivities remaining.

Recently, we reported a simple coupling coefficient evaluation method that is applicable to both index- and gain-coupled DFB lasers with facet reflection. The method made use of numerical fitting of theoretical subthreshold spectrum into experimental one by the least square-error algorithm.[1] In this paper, we describe the first observation of changing coupling coefficients in a gain-coupled DFB laser with an absorptive grating resulting from saturable absorption, which was made possible by improving the parameter extraction program significantly.

Our parameter extraction program, based on the coupled wave equations and the transfer matrix analysis, is able to determine the following parameters; index- and gain-coupling coefficients, effective refractive index and its wavelength dispersion, grating facet phases, and gain profile. In upgrading the previously reported one, emphasis has been placed on increasing the robustness and reliability of the fitting results as well as making it automatic. Consequently, the only thing that users are requested to do in this version is to provide the program with subthreshold spectra from optical spectrum analyzers. Then, the program automatically extract initial values for each parameter and does fitting to obtain final values. Typical time needed is 1 to 5 minutes in most IBM-compatible personal computers.

The sample measured here was a 1.55 μm InGaAsP/InP compressively strained MQW gain-coupled DFB laser of absorptive grating type, with cleaved facets and a 550-μm-long cavity. One good way of checking the reliability of the parameters fitting is to extract parameters from the front facet spectrum and from the rear facet one independently, and compare the corresponding values (asymmetry in the facet phase gives rise to different front- and rear-facet spectra). Figure 1 shows the measured and fitted spectra from the front (a) and rear (b) facets of the same device. The extracted parameters by these fittings are listed in Table 1. Although the fittings were done independently and the shapes of the spectra were different, the extracted parameters agreed well. The reliability of this method is confirmed thereby.



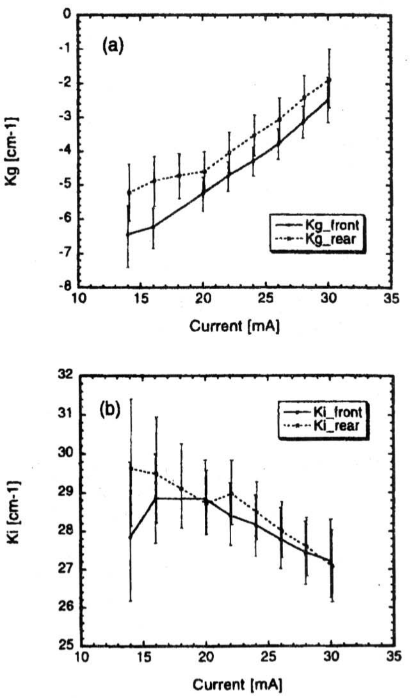
CThM1 Fig. 1 Measured and fitted subthreshold spectra of a 1.55-μm gain-coupled DFB laser; (a) for the front facet and (b) for the rear facet.

CThM1 Table 1 Parameters extracted from the subthreshold spectra in Fig. 1.

Parameter [unit]	front	rear
net gain g_1 [cm^{-1}]	1.2	0.9
gain curvature g_2 [μm^{-1}eV^2]	9	14
gain peak wavelength λ_p [nm]	1556	1553
refractive index n_1	3.27	3.27
$dn/d\lambda$ [μm^{-1}]	-0.250	-0.249
index coupling coefficient κ_i [cm^{-1}]	28.1	28.5
gain coupling coefficient κ_g [cm^{-1}]	-4.3	-3.5
rear facet phase [degree]	181	178
front facet phase [degree]	149	148

$$g = g_1 - g_2\left(E - \frac{hc}{q\lambda_p}\right)^2, \qquad n = n_1 + \frac{dn}{d\lambda}(\lambda - \lambda_{Bragg})$$

Next we measured injection current dependence of gain- and index-coupling coefficients, κ_g (a) and κ_i (b), in the same laser, the result of which is shown in Fig. 2. The minus sign of κ_g indicates "anti-phase" complex coupling. The magnitudes of both κ_g and κ_i become smaller as injection current increases. This can be attributed to absorption saturation in the grating; the increasing number of photons in the cavity as current injection makes absorption coefficient of the grating smaller, thus decreasing $|\kappa_g|$. The refractive index of the grating becomes smaller at the same time to result in the κ_g drop. To the best of our knowledge, this is the first demonstration of observing such coupling coefficient changes in DFB lasers. This information is very useful for discussing single mode stability.



CThM1 Fig. 2 Injection current dependence of the gain-coupling (a) and index-coupling (b) coefficients in the same laser. Fitting error bars are also shown.

In summary, we have developed a reliable and automatic parameter extraction program for DFB lasers. By making use of this program, we observed, for the first time we believe, changing gain- and index-coupling coefficients in a 1.55-μm gain-coupled DFB laser of absorptive grating type, which could result from absorption saturation of the grating. This work was supported by the NEDO R&D Program #C-300, and the Mombusho Grant-in-Aid #08555011 and #08044123.

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1. G. Morthier, K. Sato, R. Baets, T. K. Sudoh, Y. Nakano, K. Tada, in *Optical Fiber Communication Conference*, Vol. 8, 1995 OSA Technical Digest Series (Optical Society of America, Washington DC, 1995), p. FC3.

CThM2 **2:45 pm**

Low-threshold narrow-linewidth InGaAs-GaAs ridge-waveguide DBR lasers with first-order surface gratings

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Distributed Bragg reflector (DBR) lasers in the InGaAs/GaAs/AlGaAs material system are attractive sources for many applications including LIDAR systems, wavelength division multiplexing (WDM) local area networks, and