Enhanced Modulation Bandwidth in CCIG lasers

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We investigated the extended modulation bandwidth (EMB) conditions in a Coupled Cavity Injection Grating (CCIG) laser (see inset in Fig. 1c) combining the results of a static and a dynamic analysis. The static laser threshold conditions allow determining in the CCIG parameters space the values required to have two adjacent cavity longitudinal modes with small spectral separation, while the Finite Difference Time Domain (FDTD) program verifies the existence of EMB due to photon-photon resonance (PPR) between the lasing and the adjacent mode.

Exploiting coupled modes equations and transfer matrix formalism, we end up with a round trip gain function such as $G(\lambda) = |G| e^{i\varphi}$, where |G| is the round trip gain and φ is the phase function. The lasing mode is found solving the resonance conditions $|G| = 1, \ \varphi_m = 2m\pi$ where *m* is an integer, whereas all other modes, at the same carrier density, have $|G| < 1,$ $\varphi_n = 2n\pi, \ n \neq m.$ Refractive index dispersion and variation with injection, sections losses and gain are all taken into account. When the lasing mode is near enough in frequency to a deep minimum of the reflectivity function, a second non-lasing mode, with an acceptable gain margin, may eventually lye beside it, below the free-spectral-range (FSR), significantly en-hancing the modulation bandwidth by PPR. From investigating these conditions we pointed out a method to obtain such an occurrence with considerations on ratios among section lengths L_A, L_G and L_P defined in Fig.(1c, inset). To explore this occurrence, variation of one FSR in mode position is obtained varying by injection the effective index $\Delta\bar{n}_{A,P}$ in active and phase sections of a quantity given by $\Delta\bar{n}_{A,P} = (2L_{A,P} / \lambda_{Bragg})x_{A,P}$, where the normalized effective index variations $x_{A,P}$ vary in the interval [-0.5, 0.5]. Frequency separation Δf between the lasing and the first competing mode is reported in color-maps as in

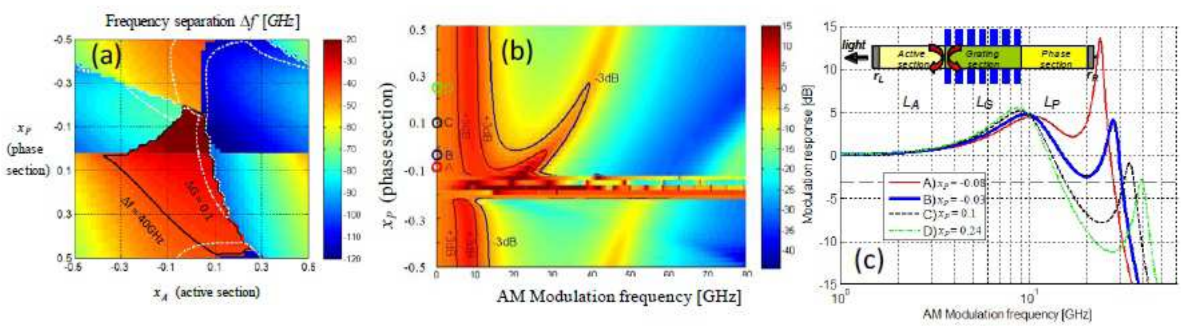

Fig.1.(a) Frequency separation map and (b) intensity modulation responses map, calculated for $x_A = 0$ and values of the normalized parameter x_P ranging from -0.5 and 0.5, for an as-cleaved CCIG with $L_A/L_G/L_P$ = 200/600/10 µm. (c) Cuts of the map reporting the IM responses for several values of x_P. In the inset, a scheme of CCIG is reported.

Fig. 1(a); then, with the FDTD program, the intensity modulation responses are calculated for different values of one of the normalized parameters as in Fig. 1(b) where the PPR peak can be seen approaching the photon-carrier resonance peak when x_P reduces. Cuts of Fig.1b are reported in Fig. 1(c).
The method applies to other multiple cavity lasers, e.g. DFB with external feedback [1].

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[1] M. Radziunas, A. Glitzky, U. Bandelow, M. Wolfrum, U. Troppenz, J. Kreissl, and W. Rehbein, *IEEE J. of Sel. Topics in Quantum Electron.* **13**, 136 (2007).