Time domain travelling wave model of QD-DFB lasers with inhomogeneously broadened gain material

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DFB lasers with quantum dot material have recently entered in the market as new devices for future high speed communication. Despite the several experimental results reported in the literature, only few theoretical models [1,2] have been presented for designing and understanding the device performance. We have developed a time domain travelling model [3] to study the static and dynamic characteristic of the QD-DFB lasers, including the calculation of the lasing spectra below and above threshold, the intensity and frequency modulation response as well as the NRZ direct modulation response (ie: eye-diagram) and chirp. The model includes a detailed description of the QD optical susceptibility accounting for the inhomogeneous broadening of the emission line caused by the QD size dispersion, the spontaneous emission noise, the carrier dynamics in the QD confined states, in the wetting layer and in the SCH as well as the carrier and photon distribution along the laser cavity (spatial hole burning effect). The model can be applied to the simulation of various QD-DFB and QD-DBR lasers or other multi-section structures with an integrated grating. We report here the simulation results of a QD-DFB laser 300µm long, with HR/HR (0.9/0.7) facets, grating coupling coefficient K=10 cm-1 similar to the one presented in [1]. We show in Fig.1 the calculated L-I characteristics with the spectra below and above threshold and in Fig.2 the IM and FM response for a current injection of 15mA. As a second example of the model application we show in Fig.3 the effect of the homogeneous broadening linewidth on the single mode or multi-mode emission of the laser.

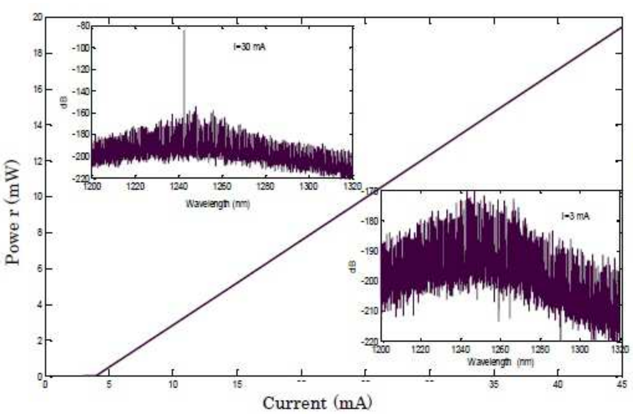

Fig. 1 Power vs current characteristic of the QD-DFB laser; the insets are calculated spectra below (I=3mA) and above threshold (I=30mA).

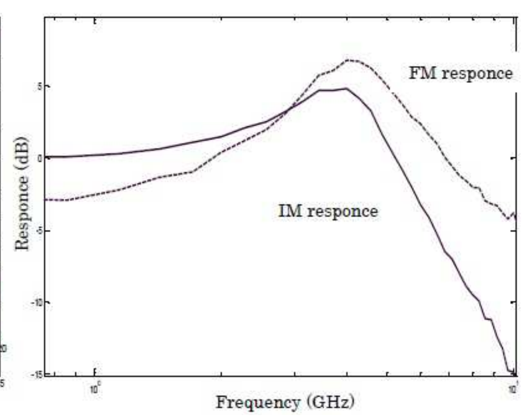

Fig.2 Intensity modulation (IM) and frequency modulation (FM) responce of the QD-DFB laser calculated at 15mA.

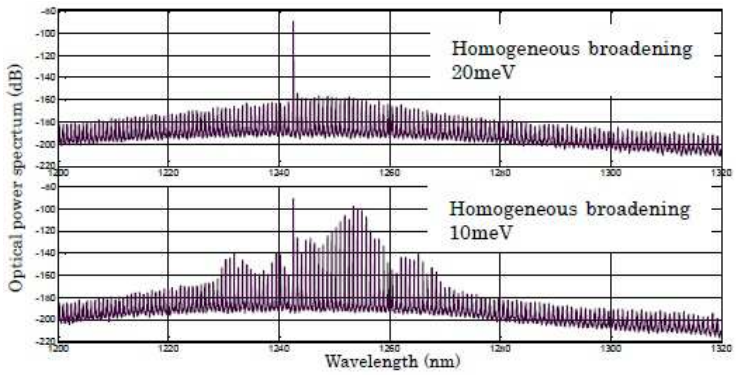

Fig. 3 Optical output spectrum at I=15 mA calculated for the case of homogeneous broadening linewidth of 20 meV and 10 meV.

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[2] M. Ishida et al., *J. Appl. Phys.* **101**, 013108 1-6 (2007).
[3] M. Rossetti et al, *IEEE J. Quantum. Electron.*, (2010), accepted for pubblication.

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