COST MP 0702 WG2 PC-VCSEL exercise

Maciej Dems*, Tomasz Czyszanowski, Krassimir Panajotov

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Vertical Cavity Surface Emitting Lasers (VCSELs) are modern constructs which offer several advantages to classical edge-emitting lasers. However they introduce some new problems, of which one of the most important is the problem with achieving good horizontal electromagnetic field confinement and hence single-mode operation with large output powers. One of the recent solutions to this problem is the application of photonic-crystal structure.

The goal of this exercise is to check for the reliability and compare different numerical approaches that are capable of optical modeling of VCSELs with photonic crystal structure. As various models have different compexity and introduce different assumptions it would be interesting to know how accurate and efficient are those models for this particular problem.

Definition of the structure

The proposed device is an arsenide VCSEL designed for operation at 980 μm. The structure details are presented in table 1. Inside the cavity it has three 8 nm wide $In_{0.2}Ga_{0.8}As$ quantum wells with two 5 nm GaAs barriers.

Table 1: Structure details. Its schematic view is presented in Fig. 1

	Thickness [nm]	Material	Refractive index
		Air	1.00
Top DBR	69.40	GaAs	3.53
24 pairs	79.55	AlGaAs	3.08
Cavity	121.71	GaAs	3.53
	$3 \times 8.00 + 2 \times 5.00$	QW/GaAs	$3.56 + j\,n_g$ for $r < a$; $3.56 - 0.01j$ for $r \geq a$ / 3.53
	121.71	GaAs	3.53
Bottom DBR	79.55	AlGaAs	3.08
29 pairs	69.40	GaAs	3.53
Substrate		GaAs	3.53

The photonic crystal consists of three rings of air holes etched in top DBRs with single defefect cavity in the center (fig. 2). The task is to compute **resonant wavelength** and the **threshold gain** for every combination of the following parameter values:

- PC lattice pitch a [µm]: 2.0, 4.0, 7.0;

*maciej.dems@p.lodz.pl

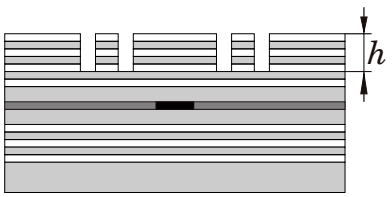

Figure 1: Schematic VCSEL structure

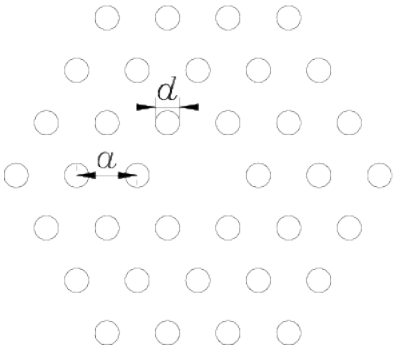

Figure 2: Photonic crystal structure

- hole diameter d/a: 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8;
- etching depth h: whole structure; cavity only; number of top DBR pairs ranging from 24 to 10.

The gain apperture is always assumed to be equal to the pitch (see table).