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# Design and Simulation of Low Threshold Nanowire Photonic Crystal Surface Emitting Lasers

**Authors :** Balthazar Temu, Zhao Yan, Bogdan-Petrin Ratiu, Sang Soon Oh, Qiang Li

**Abstract :** Nanowire based Photonic Crystal Surface Emitting Lasers (PCSELs) reported in the literature have been designed using a triangular, square or honeycomb patterns. The triangular and square pattern PCSELs have limited degrees of freedom in tuning the design parameters which hinders the ability to design high quality factor (Q-factor) devices. Nanowire based PCSELs designed using triangular and square patterns have been reported with the lasing thresholds of 130 kW/□cm□^2 and 7 kW/□cm□^2 respectively. On the other hand the honeycomb pattern gives more degrees of freedom in tuning the design parameters, which can allow one to design high Q-factor devices. A deformed honeycomb pattern device was reported with lasing threshold of 6.25 W/□cm□^2 corresponding to a simulated Q-factor of 5.84X□10□^5.Despite this achievement, the design principles which can lead to realization of even higher Q-factor honeycomb pattern PCSELs have not yet been investigated. In this work we show that through deforming the honeycomb pattern and tuning the heigh and lattice constants of the nanowires, it is possible to achieve even higher Q-factor devices. Considering three different band edge modes, we investigate how the resonance wavelength changes as the device is deformed, which is useful in designing high Q-factor devices in different wavelength bands. We eventually establish the design and simulation of honeycomb PCSELs operating around the wavelength of 960nm , in the O and the C band with Q-factors up to 7X□10□^7. We also investigate the Q-factors of undeformed device, and establish that the mode at the band edge close to 960nm can attain highest Q-factor of all the modes when the device is undeformed and the Q-factor degrades as the device is deformed. This work is a stepping stone towards the fabrication of very high Q-factor, nanowire based honey comb PCSELs, which are expected to have very low lasing threshold.

**Keywords :** designing nanowire PCSEL, designing PCSEL on silicon substrates, low threshold nanowire laser, simulation of photonic crystal lasers
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