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Designing Electrically Pumped Photonic Crystal Surface Emitting Lasers Based on a Honeycomb Nanowire Pattern

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Abstract : Photonic crystal surface emitting lasers (PCSELs) has recently become an area of active research because of the advantages these lasers have over the edge emitting lasers and vertical cavity surface emitting lasers (VCSELs). PCSELs can emit laser beams with high power (from the order of few milliwatts to Watts or even tens of Watts) which scales with the emission area while maintaining single mode operation even at large emission areas. Most PCSELs reported in the literature are air-hole based, with only few demonstrations of nanowire based PCSELs. We previously reported an optically pumped, nanowire based PCSEL operating in the O band by using the honeycomb lattice. The nanowire based PCSELs have the advantage of being able to grow on silicon platform without threading dislocations. It is desirable to extend their operating wavelength to C band to open more applications including eye-safe sensing, lidar and long haul optical communications. In this work we first analyze how the lattice constant , nanowire diameter, nanowire height and side length of the hexagon in the honeycomb pattern can be changed to increase the operating wavelength of the honeycomb based PCSELs to the C band. Then as an attempt to make our device electrically pumped, we present the finite-difference time-domain (FDTD) simulation results with metals on the nanowire. The results for different metals on the nanowire are presented in order to choose the metal which gives the device with the best quality factor. The metals under consideration are those which form good ohmic contact with p-type doped InGaAs with low contact resistivity and decent sticking coefficient to the semiconductor. Such metals include Tungsten, Titanium, Palladium and Platinum. Using the chosen metal we demonstrate the impact of thickness of the metal for a given nanowire height on the quality factor of the device. We also investigate how the height of the nanowire affects the quality factor for a fixed thickness of the metal. Finally, the main steps in making the practical device are discussed.

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